

**Proposal for a TFW Monitoring Strategy to
Determine the Effectiveness of Forest Practices
in Protecting Aquatic Resources**

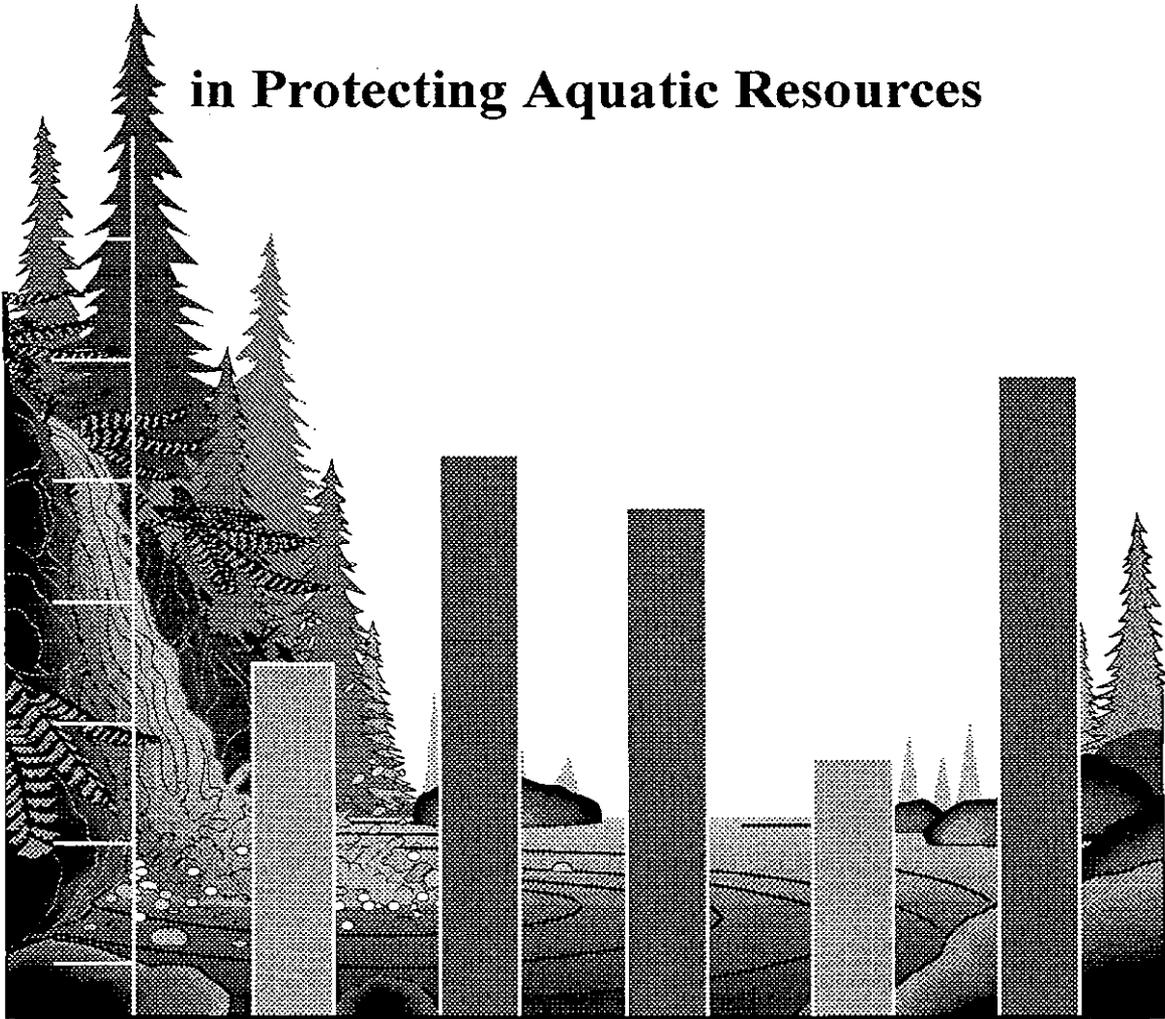
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November 12, 1996

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for the

TFW Monitoring Steering Committee

November 12, 1996

EXECUTIVE SUMMARY

The purpose of this "white paper" is to present a monitoring strategy designed to answer questions regarding the effectiveness of forest practices in protecting aquatic resources on state and private land in Washington State. The strategy was developed by the TFW Monitoring Steering Committee in response to a request from the TFW Policy Committee water quality subcommittee.

The white paper identifies effectiveness monitoring goals, objectives and issues; presents a framework for a monitoring strategy; discusses options for implementation and concludes with a proposal for a pilot project. A review of effectiveness monitoring programs in other states and descriptions of monitoring approaches for eight monitoring objectives are included as appendices.

Effectiveness monitoring programs in seven states and one Canadian province were examined to identify suitable models for Washington. Some were inappropriate because they relied on subjective evaluations or did not address salmonid habitat issues important in Washington. Programs in Oregon, California and Alaska were most relevant but were not entirely suitable because they are not tailored to two unique features of Washington's forest management system, our Watershed Analysis process and our TFW cooperative management system. Our strategy is designed to utilize these assets while drawing on applicable elements of the other programs.

The focus of our effectiveness monitoring strategy is eight key monitoring objectives based on important questions monitoring should answer. These objectives address the effectiveness of:

1. riparian measures to maintain or restore stream temperature;
2. riparian measures to maintain or restore large woody debris;
3. measures to reduce or eliminate management-induced mass wasting;
4. measures to reduce management-induced surface erosion;
5. measures to reduce management-induced changes in hydrology;
6. measures to maintain or restore fish passage;
7. measures to prevent adverse impacts from forest chemicals; and
8. forest practices when applied on a watershed-scale in avoiding harmful cumulative effects to salmonid habitat and water quality.

To evaluate effectiveness we must determine if practices were done properly (implementation monitoring), whether they had the desired effect on input processes, stream channels and habitat (effectiveness monitoring), and whether the desired conditions actually provide for protection of aquatic resources (validation monitoring). To accomplish this, we recommend a monitoring strategy with an implementation element, an input process element, a resource trend element, a validation element and a supporting research element. Primary emphasis is placed on monitoring input processes and triggering mechanisms because they are directly affected by forest practices and can be monitored for a reasonable cost. Secondary emphasis is placed on more expensive monitoring of trends in aquatic resource conditions because resource protection and recovery is the fundamental management objective. We envision applied research where scientific investigation is needed to interpret monitoring results or determine why effectiveness varies.

We propose to evaluate effectiveness by determining whether forest practices measures are

successful in maintaining or restoring desired resource conditions (water quality standards or Watershed Analysis resource conditions indices) or avoiding adverse changes in input processes. An alternative approach (utilized in Alaska) of comparing stream reaches affected by management practices with unmanaged reaches or basins appears unfeasible in Washington due to the scarcity of comparable undisturbed sites in many regions of the state where forest management occurs.

Several scenarios for implementation of the monitoring strategy were examined. We recommend a multi-objective, watershed-based strategy implemented through TFW by the CMER Monitoring Steering Committee. The watershed-based approach is most compatible with Watershed Analysis (WA). We recommend a strong linkage with WA because many resource assessment products provide a "current condition baseline" for input process and resource conditions that can be repeated to determine changes over time. This approach will reduce monitoring start-up costs and provide information needed for the WA five year review process. We propose initial monitoring of a "core" sub-group of watersheds where WA has been done, selected from regions across the state. Implementation can be expanded in stages by adding other issues or watersheds needed to evaluate management programs such as standard rules, Total Daily Maximum Load agreements (TMDLs) or Habitat Conservation Plans (HCPs).

Many TFW participants would have roles in implementation of this strategy. Project design and data analysis, storage and interpretation would be the responsibility of the TFW Ambient Monitoring program, under direction of the Monitoring Steering Committee (MSC). TFW participants could participate in collecting monitoring information, reviewing results and developing adaptive management alternatives. The MSC would be responsible for finalizing effectiveness evaluations and convening adaptive management advisory committees, consisting of TFW participants, as needed. CMER would review and approve information and recommendations provided by MSC and forward them to the TFW Policy Committee for consideration and appropriate action.

The entire set of monitoring objectives and issues we identified are too numerous to handle simultaneously and must be prioritized. We recommend tackling riparian measures, sediment, fish passage and resource conditions initially because:

1. these issues are relevant to future TFW policy discussions,
2. they will be important issues in Watershed Analysis five year reviews,
3. baseline information is available from Watershed Analyses, and
4. monitoring approaches and methods are available.

We recommend beginning implementation with a two-year pilot project conducted by the TFW Monitoring Steering Committee to address priority effectiveness issues. The pilot would focus on evaluating the effectiveness of Watershed Analysis prescriptions in watersheds approaching the five year review and comparing the effectiveness of standard rules applied under similar conditions. Forested watersheds from both the east side and west side would be selected to provide a regional perspective on effectiveness. WAUs representative of other management programs such as TMDLs or HCPs could be added at a future date, with priority placed on those approaching the Watershed Analysis five year review.

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INTRODUCTION

In May, 1996 the Timber Fish and Wildlife Policy Committee's water quality subcommittee sent a memo to the TFW Cooperative Monitoring, Evaluation and Research Committee (CMER) requesting a strategy to answer the following question:

"What is the effectiveness of cooperative and regulatory measures for protection and recovery of the public resources of water and fish (aquatic resources) affected by forest practices (pursuant to the forest practices, water pollution and hydraulic acts)?"

CMER assigned this task to the Monitoring Steering Committee. This document contains our response to the TFW Policy Committee. The purpose of this document is to:

- examine past efforts to evaluate forest practices effectiveness in Washington and other states
- establish goals and objectives for a TFW effectiveness monitoring program
- design a framework for the monitoring strategy and identify components it should contain
- define the scope of the monitoring strategy
- define effectiveness and establish criteria for evaluating it
- identify specific effectiveness monitoring questions and issues and identify the information needed to answer these questions
- develop specific monitoring approaches for each question, and
- discuss options for implementing the TFW effectiveness monitoring strategy

Background on Effectiveness Monitoring and Adaptive Management

Adaptive management is a fundamental principle underlying the TFW forest management system. When the TFW management system was developed, the participants realized that their ability to make management decisions was limited by lack of adequate scientific information. Development of programs and practices to protect aquatic resources was guided by available information, and the management structure was designed to be flexible and respond to new scientific information as it became available. Effectiveness monitoring is an essential component of successful adaptive management. Adaptive management consists of a cycle involving four stages: 1) planning; 2) implementation, 3) monitoring, and 4) evaluation. The results of the evaluation are then used to make improvements, and the cycle begins again. In practice, emphasis typically is placed on planning and implementation, while monitoring and evaluation of results are neglected. This proposal presents recommendations and options for development of a monitoring and evaluation component to support TFW adaptive management.

History of Effectiveness Monitoring and Evaluation in Washington

Past effectiveness monitoring and evaluation efforts in Washington State have focused on the effectiveness of the best management practices (BMPs) that are incorporated into the forest practices rules to protect water quality. Prior to TFW, forest practices effectiveness monitoring was primarily conducted by the Washington Department of Ecology with EPA Clean Water Act funding. Examples of the projects conducted included studies of: 1) the adequacy of Washington's forest practices rules and regulations in protecting water quality (Sachet et al.,

1980), 2) stream side management zones (Hobbs and Halbach, 1981), 3) slash removal (Task LSD Subcommittee, 1979) and 4) road construction and operation (Wooldridge, 1979a; 1979b). Since TFW was implemented in 1988, a series of effectiveness studies have been sponsored by the TFW Cooperative Monitoring, Evaluation and Research Committee's water quality steering committee. These projects have been conducted by the Department of Ecology. Topics that have been examined include BMPs for aerial application of pesticides (Rashin and Graber, 1993); effectiveness of riparian management zones in protecting stream temperature (Rashin and Graber, 1992), and effectiveness of BMPs to control surface erosion (Rashin et al., 1994).

Effectiveness Monitoring in Other States

We also reviewed effectiveness monitoring programs in other states to determine the applicability of their strategies and methods to effectiveness monitoring in Washington State. Programs from South Carolina, Florida, Idaho, Montana, Alaska, British Columbia, Oregon and California were reviewed. A summary of this information can be found in Table 1. Detailed descriptions of these programs are located in Appendix A.

South Carolina, Florida, Idaho, Montana and British Columbia lack a process-based evaluation procedure that encompasses causal linkages between forest practices, triggering mechanisms, watershed input processes and effects on salmonid habitat. Consequently, they are not suitable templates for evaluating the effectiveness of relatively sophisticated management programs, such as Watershed Analysis being implemented in Washington State.

Programs in Oregon, California and Alaska (Sealaska Co.) examine the effects of forest practices on watershed processes and salmonid habitat. Each contains technical components that may be useful for effectiveness monitoring in Washington. None provide an entirely suitable model for effectiveness monitoring in Washington because they do not incorporate two assets unique to Washington: our Watershed Analysis procedure and our cooperative TFW management structure.

Summary of Background Information

In summary, past monitoring efforts in Washington State have not yet answered many questions about forest practices effectiveness for several reasons. Limited availability of funding has restricted the number and scope of past effectiveness studies. The past emphasis of the TFW Ambient Monitoring program has been on development of methods and support of cooperator efforts to assess the status of resource conditions rather than on evaluating effectiveness. CMER has not systematically identified effectiveness questions and developed an organized strategy to pursue them. While past TFW efforts provide a foundation to build on, a coordinated strategy that focuses efforts on unanswered questions is needed to guide future action. Other states provide useful examples of effectiveness monitoring programs, however a custom monitoring strategy is needed to take advantage of the unique aspects of Washington's forest practice management system.

Table 1. Summary of effectiveness monitoring programs in other states and provinces.

State/Province	Purpose	Monitoring objectives and issues	Approach	Effectiveness determination	Single vs multi-objective	Watershed vs site-by-site	Who does it?	Adaptive Management	Advantages (A) / Disadvantages (D)
MT, ID	Determine effect of forest practices on water quality.	Sediment input from forest roads, RMZs, and harvest units. Riparian shade, LWD, and toxic chemicals.	Subjective questionnaire completed by team of professionals in field.	Mt-compliance equals effectiveness Id- various stakeholders review data and reach consensus on effectiveness.	Single	Site by site	State agency	Mt- no formal process. ID- Dept. of Env'r. Quality submits recommendations to Forestry Board	MT and ID: A- quick, low cost. D- subjective, narrow scope.
FL, SC	Determine effect of forest practices on water quality.	BMP compliance for roads, stream crossings, log decks, SMZs, & harvesting. Other objectives: sediment input, slash input; riparian canopy cover, vegetative cover and bank stability.	Compliance questionnaire done by team of professionals in field. Quantitative data for bioassessment and habitat. Florida compares managed vs. reference conditions.	Compliance = effectiveness for both states. FL- gets bioassessment data and determines effectiveness later. S.C.- 75-77% of reference condition.	Multiple objective assessment of cumulative effects.	Site by site	State agency	No formal process.	Florida: A- establishes baseline conditions, long term trends, produces biennial conclusions. Statewide. D- subjective, narrow scope, unclear linkage to forest practices and rules. SC: A- cheap, quick, statewide. D- subjective, narrow scope, unclear linkage to forest practices and rules.
OR	Determine effects of forest practices on water & air quality, forest prod. & wildlife.	Riparian LWD, shade, snags. Sediment (surface erosion and mass wasting). Stream temperature.	Quantitative monitoring data collection for resource condition & input processes.	Data compared with objectives in rules, state water quality standards or with scientific literature	Multiple objectives with separate monitoring projects.	Flexible, site by site with storm impacts by watershed.	State agency	Yes: Results forwarded to State Board of Forestry.	A- LWD modeling, desired future condition written into forest practice rules, multi-objective, long term, design flexibility, adaptive management mechanism. D- stakeholders not involved,
CA	Determine effect of forest practices on water quality and fish habitat.	Surface erosion from roads, stream crossings, and skid trails. Mass wasting. Riparian shade/stream temperature, LWD and nutrients.	Quantitative data for resource conditions. Semi-quantitative survey by team for hillslope processes, compliance, & overall effectiveness.	In stream: still resolving this question. Hillslope: professional judgement of field observation.	Multiple objectives that vary by watershed based on resource risk assessment.	Watershed	State agency	They have a feedback mechanism, but no formal process.	A- Multi-objective, sophisticated, objective data includes input process and resource condition monitoring. D- Expensive, requires high level of training and quality assurance/control.
AK	Determine effect of forest practices on water quality and fish habitat.	Riparian LWD, density, loading, recruitment, and blowdown. Sedimentation: bank erosion, pool area and spacing, bed substrate.	Quantitative data comparing changes in resource conditions following logging with unmanaged systems.	Significance of detected change in logged basins vs. pre-harvest and unlogged basins.	Multiple objectives, but each objective implemented separately.	Watershed	Private Co.	No formal process.	A- Multi-objective design, objective data, long term study of unmanaged baseline conditions and trends. Covers whole SE region. D- expensive, data highly variable and difficult to interpret, no adaptive mgt.
B. C.	Effect of forest practices on critical resources	Resource problems determined by district, region, and HQ managers.	Approach varies depending on the problem being pursued.	Information will be evaluated by agency committee.	Single objective, determined regionally	Site by site Admin. Unit	Provincial government.	Specialists recommend changes to government.	A- Addresses specific problems identified by field personnel. D- lack of coordination and efficiency.

PROPOSED TFW EFFECTIVENESS MONITORING STRATEGY

In developing our proposed TFW effectiveness monitoring strategy, we have been guided by a philosophy that the monitoring program should be a practical management tool designed to: 1) provide answers to specific questions about the effectiveness of forest practices in protecting aquatic resources, 2) document trends in the conditions of aquatic resources in managed forest watersheds, and 3) produce information that identifies why practices are or are not effective so that suggestions for improving effectiveness can be provided for use in adaptive management.

In this section, we focus on identifying the questions that effectiveness monitoring needs to answer and the information that is needed to answer them. We identify goals and objectives for the program, lay out a framework for the monitoring strategy and necessary components, and discuss how to define and evaluate effectiveness.

Effectiveness Monitoring Goal and Objectives

The goals and objectives are directed at providing information needed to evaluate the effectiveness of forest practices in protecting or restoring aquatic resources. To provide direction for the monitoring strategy, we began by establishing a goal based on the question posed by the TFW Policy Committee. The proposed goal for the TFW effectiveness monitoring strategy is:

To determine the effectiveness of cooperative and regulatory measures for protection and recovery of aquatic resources affected by forest practices conducted on state and private lands in Washington State.

To accomplish this goal we identified a series of objectives built around eight functional questions that monitoring should answer about the effects of forest practices on aquatic resources. Following the process-based approach used in Watershed Analysis, each objective is based on a causal linkage between forest practices and associated changes in watershed input processes and aquatic resources. For each objective, a series of site-specific monitoring issues, watershed scale monitoring issues and research questions are identified. The specific issues break each monitoring objective into smaller, manageable pieces and provide a focus for developing testable hypotheses and designing efficient sampling programs to provide the information needed.

Table 2 presents the eight monitoring objectives and the specific monitoring and research issues identified for each. Due to the large number of potential monitoring issues identified, it will be necessary to prioritize issues to develop a monitoring strategy that is feasible to implement.

Detailed descriptions of the proposed monitoring approach and effectiveness evaluation for each objective are presented in Appendix B. The monitoring approaches are designed to determine:

- which regulatory programs and voluntary measures produce the desired effect;
- how the effectiveness of various measures and programs compares, and why they vary;
- how regional and local factors such as climate, geology, hydrology, elevation and vegetation influence effectiveness;
- how effectiveness varies over time.

Table 2. Eight key effectiveness monitoring objectives and associated monitoring and research issues.

Objectives	Monitoring Issues	Research Issues
Objective 1. To determine if forest practices are effective in maintaining (or restoring) desirable stream temperatures.	<ol style="list-style-type: none"> 1. Are various riparian management measures effective in meeting shade targets? 2. Are riparian management measures effective in meeting water quality standards for stream temperature? 3. How do factors such as water type, channel width, elevation and aspect influence effectiveness? 4. How does the effectiveness of RMZs change over time? 5. How is the capability of riparian stands to provide shade and maintain suitable stream temperatures changing over time on a watershed scale? 	<ol style="list-style-type: none"> 1. What effect does riparian harvest adjacent to Type 4 and 5 waters have on on-site and downstream water temperatures? 2. What is the effect of canopy removal on winter stream temperature? 3. Is shade the only major RMZ influence on stream temperature? 4. Are water quality standards set at appropriate levels to protect aquatic resources? 5. What is the best way to measure shade? 6. Is shade provided by brush and deciduous trees comparable in function to shade provided by conifers? 7. How do channel morphology and other site-specific factors influence the effectiveness of shade? 8. How does debris flow disturbance influence stream temperature regimes? 9. What is the effect of coarse sediment buildup on stream temperatures?
Objective 2. To determine if riparian management measures are effective in maintaining (or restoring) large woody debris recruitment over time.	<ol style="list-style-type: none"> 1. Are RMZ measures along fish-bearing waters effective in providing large woody debris recruitment to channels of various widths? 2. How effective are riparian stand conversion practices? 3. How effective are road location and construction practices at avoiding impacts to riparian LWD recruitment? 4. How does riparian harvest on Type 4 and 5 waters affect LWD recruitment and loading? 5. How is the capability of riparian stands to recruit LWD changing over time on a watershed scale? 	<ol style="list-style-type: none"> 1. Does artificially placed LWD function effectively in channels? 2. How do LWD recruitment rates from RMZs compare with LWD export and decay rates in stream channels? 3. How much LWD recruitment is needed in Type 4 and 5 waters? 4. What are the effects of riparian timber harvest along Type 4 and 5 waters on indigenous organisms? 5. Are WA resource condition indices for LWD adequate to protect aquatic resources? 6. What proportion of LWD originates from mass wasting under natural conditions? 7. How can future LWD recruitment and LWD loading be modeled and predicted? 8. Do minimum width RMZs on Type 3 waters < 5 feet provide adequate LWD? 9. What are LWD recruitment rates in east side forests?
Objective 3. To determine if forest practices are effective in reducing or eliminating management-induced mass wasting and debris flows.	<ol style="list-style-type: none"> 1. Are timber harvest measures effective at preventing management-induced mass wasting? 2. Are road construction practices effective at preventing management-induced mass wasting? 3. Are road maintenance procedures effective at preventing management-induced mass wasting on existing roads? 4. Are selective harvest techniques effective at preventing deep-seated landslides? 5. Are methods used to identify areas of mass wasting hazard effective? 6. What is the recovery time for stream channels and habitat affected by mass wasting? 7. Is the rate of management-induced mass wasting decreasing over time on a watershed scale? 8. How widespread is habitat disturbance from mass wasting on a watershed scale? 	<ol style="list-style-type: none"> 1. How is the movement of deep seated landslides affected by forest management practices such as road construction and timber harvest?

Objectives	Monitoring Issues	Research Issues
Objective 4. To determine if forest practices are effective in reducing management-induced surface erosion.	<ol style="list-style-type: none"> 1. Are road design and construction practices effective at preventing surface erosion on new roads and landings? 2. Are culvert spacing requirements effective in preventing erosion of road surfaces and ditch lines? If surface erosion does occur, is it delivered to stream channels? 3. Does road maintenance prevent surface erosion on existing roads? 4. Are timber harvest practices effective at preventing surface erosion? 5. Is surface erosion decreasing over time on a watershed scale? 	<ol style="list-style-type: none"> 1. How can the background rate of sediment production in forested landscapes be better determined? 2. Is there a correlation between the density of roads in a watershed and the amount of surface erosion and resource effects? 3. How can the effect of various levels of surface erosion on aquatic resources be determined? 4. What is the relationship between basin-wide background sediment yield and the effects of surface erosion generated sediment on water quality and aquatic organisms?
Objective 5. To determine if forest practices measures are effective in reducing management-induced changes in hydrologic response.	<ol style="list-style-type: none"> 1. How effective are road construction and drainage disposal practices in preventing excessive interception, diversion, and concentration of road drainage to individual hazard areas? 2. To what extent are forest practices effective in preventing cumulative impacts from excessive interception, diversion, and concentration of road drainage to hazard areas? 3. How effective are road construction practices in providing for adequate maintenance of wetland hydrologic function? 4. How effective are Rain-on-snow regulations and prescriptions in preventing damage to resources from increases in peak flows? 	<ol style="list-style-type: none"> 1. How does snow water accumulation vary by canopy density and physiography in each of the forest cover types commonly found in Washington? 2. How does the timing and rate of snow melt vary by canopy density and physiography in each of the forest cover types commonly found in Washington? 3. Under what conditions do changes in snow accumulation and melt result in adverse material impacts to aquatic resources? 4. Under what conditions do road drainage networks produce changes in runoff or stream discharge of sufficient magnitude to cause adverse material impacts to aquatic resources?
Objective 6. To determine if forest practices are effective maintaining or restoring fish passage.	<ol style="list-style-type: none"> 1. How effective are culvert installation practices in allowing for adult and juvenile migration of anadromous and resident salmonids? 2. What is the effect of forest practice related fish passage blockages on the distribution of salmonids on a watershed scale? 	<ol style="list-style-type: none"> 1. What is the best method of identifying passage blockage for each salmonid species? 2. What factors cause culverts to become barriers over time and how can they be avoided? 3. What are the best techniques to provide fish passage at road crossings in high gradient streams?
Objective 7. To determine if forest practice measures are effective in preventing adverse impacts to water quality and aquatic organisms from the use of forest chemicals.	<ol style="list-style-type: none"> 1. How effective are aerial application measures to prevent entry of forest chemicals into stream channels, lakes and wetlands? 2. How effective are aerial application operators at identifying and avoiding Type 4 and 5 waters without surface water? 3. How effective are ground application techniques at preventing chemical input into stream and wetlands? 4. What percentage of the stream network is affected by chemicals in a given year? 	<ol style="list-style-type: none"> 1. Do large-scale applications of forest fertilizer cause downstream effects such as eutrophication? Under what conditions? 2. What are appropriate measures of effects of forest chemicals on aquatic organisms? 3. How significant are post-application rainfall events as a source of chemical input to stream systems? 4. Does application of persistent chemicals lead to accumulation in surface or groundwater? 5. Do forest herbicide applications change the composition of RMZs and WMZs? 6. What are the effects of silvicultural use of highly toxic pesticides on aquatic systems?
Objective 8. To determine if forest management programs are effective in maintaining (or restoring) salmonid habitat and water quality when cumulative effects are considered.	<ol style="list-style-type: none"> 1. Are aquatic resources (salmonid habitat, water quality, aquatic organisms) receiving adequate protection from cumulative effects of forest practices? 2. How are aquatic resource conditions responding to forest management programs over time? 	<ol style="list-style-type: none"> 1. How should trends in aquatic resources other than salmonids be addressed? 2. Can the effectiveness of measures applied during conversion of forest lands to other uses be monitored by examining resource trends over time? 3. Are stream channel and habitat restoration activities effective in increasing productive aquatic habitat? 4. What are appropriate methods of assessing resources trends and cumulative effects on a watershed scale? 5. Can trends in resource abundance be used to measure effectiveness?

Approach to TFW Effectiveness Monitoring

This section provides information on the overall approach to accomplishing the effectiveness monitoring goals and objectives presented in the previous section, including the framework and scope of the monitoring strategy and an approach to evaluating effectiveness.

Conceptual Framework and Elements of the TFW Effectiveness Monitoring Program

Some forest practices affect aquatic resources directly. An example of a direct effect is an improperly installed culvert that blocks salmon migration. Monitoring of direct effects is usually straightforward because there is a direct causal linkage between practice and effect, and the effect usually takes place on-site. However, forest practices more frequently impact aquatic resources indirectly by altering physical processes that maintain fish habitat and water quality. Examples of physical inputs that can be altered by forest practices include sediment (mass wasting and surface erosion), large woody debris recruitment, hydrology, and solar energy. For example, failure of a saturated road fill can trigger a landslide that delivers sediment to a stream channel, altering downstream spawning and rearing habitat. In this case, the effect travels along a causal linkage between the practice (logging road), the input process (landslide), the stream channel and the fish habitat (Figure 1). Impacts on aquatic resources may be separated in time and space from the practices that initiated them and may be integrated with effects of other activities and natural events, making monitoring and interpretation of resource effects problematic.

In these situations, it is possible to monitor for changes in either the input processes or resource conditions (Table 3). Monitoring of input processes is advantageous because: 1) the linkage between practice and input process is usually direct and occurs on-site; 2) feedback on effectiveness can be obtained without waiting for resource damage to occur; and 3) monitoring of input processes is relatively inexpensive. However, input process monitoring requires assumptions about the effect of altering the input processes on aquatic resources and doesn't provide information on resource condition trends. Monitoring of resource conditions is advantageous because it provides direct reading on the resources of concern to resource managers and the public. However, it is often more expensive than input process monitoring. Because the linkage to specific practices is also less direct, it is often difficult to separate the effects of specific practices from the effects of other activities and natural variation.

In order to answer effectiveness monitoring questions thoroughly and efficiently, we recommend a monitoring strategy that combines monitoring of input processes and resource conditions along with a supporting research component. We propose an approach with the following elements:

- Implementation element. This element is needed to determine where and when activities are occurring and whether they are conducted according to the specified requirements or prescriptions, etc. Some of this information is already collected by DNR.
- Input process element. Monitoring of input processes and triggering mechanisms provides information on the effects of forest practices on LWD recruitment, shade, sediment, and hydrology. Input process monitoring is the core component of our strategy because it provides extensive information rather quickly and inexpensively. This permits evaluation of practices on a statewide scale to identify any major effectiveness problems and allows comparison of various measures and programs over a range of local and regional conditions.

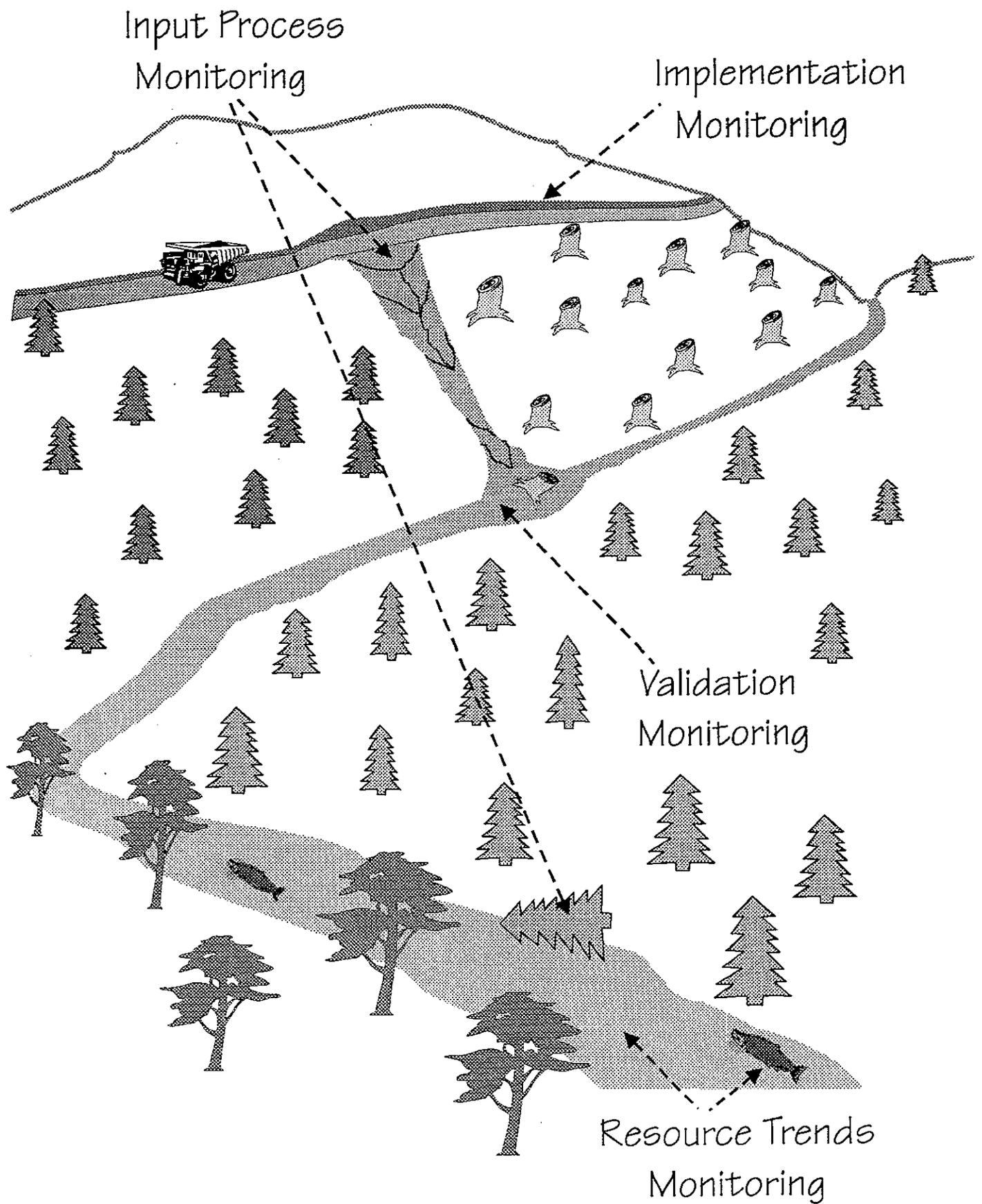


Figure 1. Conceptual Monitoring Model on the Landscape.

Forest Management Processes	Practices	Watershed Processes	Input Factors	Habitat/Resource Condition	Beneficial Uses
WATERSHED ANALYSIS STANDARD RULES ROAD MAINTENANCE PLANS ALTERNATE PLANS HABITAT CONSERVATION PLANS (HCP's) HYDRAULIC PROJECT APPROVALS SHORELINES 303D-TMDL's VOLUNTARY MEASURES	Harvest Thinning Road building Road Maintenance Chemical applications etc.	Surface erosion Road erosion Mass wasting Riparian shade LWD recruitment Channel function Hydrology	WOOD WATER COARSE SEDIMENT FINE SEDIMENT HEAT CHEMICALS	Physical habitat features Channel features Riparian condition Water quality parameters Water quantity Fish passage	FISH NON-FISH AQUATIC LIFE WATER SUPPLY PUBLIC WORKS
Implementation Monitoring				Validation Monitoring	
			Effectiveness Monitoring		
Research					

Table 3. Elements of the Effectiveness Monitoring Strategy.

- Resource trend element. The resource trend element involves the establishment of a network of sites to monitor trends in habitat and water quality. Resource trend monitoring will provide information on changes in the condition of critical aquatic resources in response to disturbance and recovery, and will help evaluate the cumulative effects of multiple forest practices.
- Validation element. This element will be used to validate relationships between the altered input processes and resource conditions, verifying predicted changes in resource conditions due to changes in input processes.
- Supporting research element. This element provides focused research in situations where better knowledge of the factors affecting the causal linkage is needed. This will improve our ability to design and interpret input process monitoring results in terms of resource effects, increase confidence in our ability to understand and evaluate causal linkages, and help determine why measures are effective in some situations and not others.

This balanced approach has a number of advantages. It uses resources effectively by placing emphasis on input process monitoring, which can be applied over large areas relatively inexpensively, allowing comparison of measures and programs across regional boundaries. Input process monitoring will be anchored by a network of more intensive in-stream monitoring sites used to validate the assumptions of input process monitoring and detect cumulative effects by documenting changes in resource conditions. The research component would be focused on investigating “key situations” where understanding of causal mechanisms is inadequate to interpret monitoring results or determine why effectiveness varies.

The monitoring strategy will not be complete without adaptive management feedback mechanisms to translate findings into refinements in practices that improve effectiveness. A number of potential mechanisms exist for various programs and measures, such as the Watershed Analysis five year reviews, plan-specific evaluation procedures for Habitat Conservation Plans (HCPs) and Total Maximum Daily Load Agreements (TMDLs), and the Forest Practices Board (FPB) process for revising the standard rules and FPB manual. Determining the linkages between a TFW effectiveness monitoring strategy and adaptive management processes is an important issue with both technical and policy aspects that will require participation by the TFW Policy Committee.

Scope of the TFW Effectiveness Monitoring Strategy

To define the scope of the TFW effectiveness monitoring strategy, we carefully examined the Policy Committee’s question for guidance and defined the terms “forest practices”, “cooperative and regulatory measures”, and “water and fish (aquatic resources)”.

Forest practices are defined in the Washington Forest Practice Act and Forest Practices Rules as: “Any activity conducted on or directly pertaining to forest land and related to growing, harvesting, or processing timber, including but not limited to: road and trail construction; harvesting, final and intermediate; precommercial thinning; reforestation; fertilization; prevention and suppression of diseases and insects; salvage of trees; and brush control.”

The following cooperative and regulatory measures were taken from the Forest Practices Act and rules and should be evaluated as they apply to the protection of aquatic resources:

- Standard forest practices rules
- Watershed Analysis prescriptions
- Voluntary protection measures (such as Resource Management Plans)
- Alternate plans
- Road maintenance and abandonment plans
- “Orphaned roads” hazard reduction plans (only 1 exists)

The following programs or measures are also included because they can affect how forest practices are conducted in some circumstances:

- Clean Water Act TMDLs agreements related to forest practices and aquatic resources
- Hydraulic Project Approvals (HPAs) related to forest practices
- Shorelines Management Act provisions related to forest practices and aquatic resources
- Habitat Conservation Plans (HCPs) related to forest practices and aquatic resources
- Voluntary aquatic habitat restoration measures on forest lands

Although the stated intent of the Forest Practices Act is to protect fisheries, water quality and water quantity, these terms are not specifically defined in the Act or the forest practice rules. The rules contain a definition for “resource characteristics”, measurable characteristics of fish, water and capital improvements, that is used in Watershed Analysis. Resource characteristics include physical fish habitat (including temperature and turbidity); turbidity in hatchery water supplies; and turbidity and volume for areas of water supply. The rules also address water quality, stating that “promulgation of all forest practices regulations shall be accomplished so that compliance with such forest practices regulations will achieve compliance with the water quality laws”. Forest practices rules pertaining to water quality protection are co-adopted by the Washington Department of Ecology.

Based on this information, we defined water and fish as:

- physical fish habitat for anadromous fish and resident game fish
- turbidity affecting hatchery and public water supplies
- water volume (for areas of physical fish habitat and water supplies)
- state water quality parameters relating to the physical, biological and chemical integrity of water bodies

Defining and Evaluating Effectiveness

Determining what constitutes “effectiveness” and how it can be measured is a critical step in developing an effectiveness monitoring strategy. It is often unclear what level of protection is intended to be afforded by forest practices rules or management programs. Without an agreed upon definition of effectiveness and criteria to measure it, questions about effectiveness can not be answered. Webster defines effective as “producing a decided, decisive, or desired effect”. Based on Webster’s definition, and the information above, a working definition of effectiveness is:

“Forest practice measures are effective if they achieve desired fish habitat, water quality and water quantity conditions.”

When current conditions are already in the desirable range, effectiveness is accomplished by applying forest practices in a manner that prevents significant impacts to fish habitat, water quality and water quantity, or changes in the watershed input processes that affect these conditions. When current conditions are below target, this is accomplished by preventing significant impacts and allowing, or stimulating, natural recovery processes.

Evaluation of the effectiveness of forest practices has several aspects:

- Are potential effects of specific forest practices addressed by regulatory/voluntary measures?
- Were the measures implemented properly? (implementation monitoring)
- Do the measures achieve the desired effect on input processes, stream channels and habitat over time? (effectiveness monitoring and baseline/trend monitoring)
- Are the desired conditions adequate to provide resource protection and recovery (validation monitoring).

There are several possible approaches to measuring effectiveness.

- Where natural systems exist in conjunction with managed areas, it may be possible to measure changes in resource conditions in managed systems and compare them with changes in natural systems to determine the effects of forest practices. This approach requires the existence of natural systems with similar climate, physiography and channel characteristics to those of the managed systems. Since natural systems are increasingly rare in Washington State, particularly in areas of intensive forest management, this approach does not appear to be feasible in many areas of state and private forest land in Washington State.
- Another approach to evaluating effectiveness is to compare conditions following forest practices with established target (desired) conditions. This approach is used in Watershed Analysis and the state water quality standards. This approach is advantageous in situations where natural systems are not available for comparison. However it can provide misleading results if the target conditions: 1) are too general and do not reflect local variation in conditions due to factors such as geology, hydrology or climate, or 2) do not adequately characterize the complex interactions within natural systems that create productive habitats.
- Finally, it may be possible to evaluate effectiveness by measuring changes over time following forest practices. This approach is particularly useful when resource conditions are below target at the time the practice occurs. In these situations, the practice is effective if it allows, or encourages, improvement over time.

We believe the last two approaches are most useful for evaluating effectiveness on state and private forest land in Washington State. These approaches require that the "desired effect" is known, and progress towards achieving it can be measured. This implies that there are goals or targets for protection and recovery of aquatic resources and changes in watershed input. In the absence of a known desired effect, determining effectiveness becomes more subjective and arriving at conclusions is difficult.

The following attributes should be used to establish "desired effects" for aquatic resources and watershed input processes. Target conditions to evaluate effectiveness should be relevant to aquatic resources, sensitive to forest practices, linked to management programs, and feasible to measure.

Fish habitat. Watershed Analysis uses resource condition indices (criteria for salmonid habitat attributes) to evaluate stream channels. Examples of resource condition indices include: pool frequency, surface area and cover; abundance of LWD and key LWD pieces; spawning gravel quantity, quality, scour and fine sediment levels; access to spawning areas; and presence of winter rearing and adult holding habitat. Resource condition indices are used in the Watershed Analysis review process to evaluate effectiveness (WAC 222-22-090).

Water quality. The Washington Department of Ecology adopts state water quality standards pursuant to the federal Clean Water Act. Forest Practices rules are designed so compliance with the regulations will achieve compliance with water quality laws. Therefore, it is appropriate to use numeric and narrative state water quality standards to evaluate protection and restoration of water quality. Examples of applicable numeric standards include stream temperature and turbidity. An example of an applicable narrative standards is, “deleterious material concentrations shall be below those which have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive biota dependent on those waters, or adversely affect the public health...”.

Water volume. Water volume is mentioned as a parameter in the resource characteristics section of the forest practices rules but there is no goal or standard for measuring effectiveness. Establishing a “desired effect” for water volume is necessary before effectiveness can be monitored. Where instream flows are established, they provide a target for low flow water volume. Evaluation of changes in magnitude and frequency of storm events is a possible approach to evaluate peak flow effectiveness. Water volume also affects water quality parameters such as temperature and sediment, so it is integrally connected to the evaluation of water quality.

Watershed input processes. Watershed Analysis identifies several key input processes that affect fish habitat and water quality including mass wasting, surface erosion, peak flows, solar radiation and large woody debris recruitment. Monitoring of the input processes is efficient because they are directly affected by forest practices and effectiveness can be assessed without waiting for downstream resources impacts to occur. Establishing a “desired effect” for input processes is necessary before effectiveness can be monitored. Effectiveness in the context of input processes typically is approached in terms of delivery, i.e. whether the practice causes an adverse change in watershed inputs to the stream channel.

IMPLEMENTATION

After identifying and prioritizing monitoring objectives and developing monitoring approaches, the next step is to implement the monitoring program. In developing implementation options, we were confronted with issues such as determining the appropriate roles for various TFW parties, identifying an organizational structure and overcoming the logistical challenges of a statewide sampling program. The purpose of this section is to identify important attributes of a TFW effectiveness monitoring program, discuss the pros and cons of various implementation scenarios, recommend a preferred option for implementation and propose a pilot implementation project.

Important Characteristics of a TFW Effectiveness Monitoring Implementation Effort

Some attributes of a successful TFW effectiveness monitoring program are listed below.

- Personnel. Production of the high quality monitoring data needed to evaluate effectiveness requires dependable, stable, well-trained personnel, with expertise in data collection methods. Dedication and commitment to the job are essential.
- Logistics. Effectiveness monitoring will require sampling of representative conditions in forested watersheds across the state. The implementation effort needs to have efficient data collection capability throughout the state.
- Data Quality. Evaluation of forest practice effectiveness requires high quality, consistent, accurate, repeatable data that is comparable between regions and years. Data should be collected with standard, repeatable methods, backed by a thorough training and quality assurance program.
- Data Analysis, Storage and Access. Effectiveness monitoring will generate large amounts of data requiring analysis and storage. A stable location for the database/information center and a long-term commitment to maintain the system are needed. Ease of access is critical.
- Data Interpretation and Evaluation. Objective data interpretation and evaluation are critical functions in effectiveness monitoring. Clear definition of roles and responsibilities and established procedures for fair and efficient evaluation are crucial to success. A procedure to interpret data, judge effectiveness, and review results needs to be established.
- Adaptive Management. Processes and procedures for using information developed by effectiveness monitoring to modify and refine forest practice measures should be identified. The appropriate parties to develop and implement recommendations will vary depending on the management program.
- Participation. Successful implementation of a TFW effectiveness monitoring program and adaptive management process depends on active participation from TFW parties. The program must offer a framework that provides opportunities for (and encourages) TFW participants to identify and prioritize monitoring questions and issues, participate in study design and site-selection, collect and access data, review effectiveness evaluations and participate in developing solutions.
- Funding. Implementation of an effectiveness monitoring program will require a substantial commitment of resources over an extended period of time. Stable, long-term sources of core funding and contributions and participation from a range of interested parties will be needed.
- Coordination With Other Monitoring Programs. To maximize efficiency, the TFW effectiveness monitoring program should coordinate and collaborate with other monitoring programs within and outside the state.
- Landowner incentives. The program should incorporate incentives that encourage landowner participation.

Discussion of Implementation Issues

We identified several key issues that present choices on how the effectiveness monitoring implementation effort could be structured and organized. A discussion of these issues follows, including advantages and disadvantages of various options relative to the attributes identified in the previous section.

Scenarios for Roles and Responsibilities in Program Implementation

Two models for implementation of an effectiveness monitoring program have been identified. Scenario 1 places a state agency in the lead role with primary responsibility for all aspects of effectiveness monitoring. This model is based on states such as Oregon, where monitoring is implemented by the state Department of Forestry. Under this option an appropriate state agency (WDNR, WDOE or WDFW) would be responsible for operating the monitoring program, including sampling design, data collection, evaluation and adaptive management. Results would be reported directly to the Forest Practices Board. TFW parties would have an advisory role with opportunities to participate in data collection and public review of evaluations.

Advantages:

- State agency would take ownership in the project and responsibility for funding.
- Streamline organizational structure with clear responsibilities.

Disadvantages:

- Lack of ownership and limited participation opportunities for TFW participants.
- More difficult to establish cooperative relationship with TFW participants.
- Narrow funding base.

Scenario 2 is to use the TFW CMER participants and program. Under this option the program would be run under auspices of the TFW Monitoring Steering Committee. The TFW Ambient Monitoring Program would be responsible for monitoring design and the core data collection effort. Participation of TFW parties in monitoring would be actively encouraged. Evaluation of effectiveness would be accomplished through CMER. Recommendations would be forwarded to the TFW Policy Committee and affected jurisdictions. This option is quite different from the effectiveness monitoring programs implemented by other states.

Advantages:

- Takes advantage of existing CMER/MSM monitoring structure and experience.
- Incorporates opportunities for participation and communication with TFW participants, potentially increasing support for the program.
- Opens up opportunities for a broader funding base.
- Takes advantage of the participation of key decision-makers in the TFW Policy Committee.

Disadvantages:

- Long-term future of CMER and the monitoring steering committee is uncertain.
- Ability of CMER to evaluate effectiveness is untested.
- It is uncertain how various jurisdictions would respond to effectiveness information developed by CMER.

Scenarios for Organization of Tasks: Single Objectives vs. Coordinated Monitoring

Earlier we identified eight effectiveness monitoring objectives based on questions the monitoring program should answer about riparian shade, LWD recruitment, mass wasting, surface erosion, hydrology, fish passage, forest chemicals and trends in aquatic resource conditions. An important organizational issue is whether to isolate each objective/question and develop separate projects for each, or to approach them in a coordinated fashion. Past effectiveness monitoring efforts in

Washington have tackled effectiveness issues separately, with projects developed for single issues. In contrast, Watershed Analysis takes a more holistic approach to management, and Watershed Analysis monitoring plans address issues in a coordinated manner.

Scenario 1. Implement separate projects for each monitoring objective.

Advantages:

- Flexibility to select objectives, fund them separately, and spread implementation over time.
- The limited scope of single objective projects makes them more manageable.
- Ability of personnel to specialize in one type of data collection and analysis.

Disadvantages:

- Lack of coordination among objectives inhibits analysis of cumulative effects and interaction between processes and effects.
- Inefficiencies associated with time and cost of starting short-term, single objective projects.
- Problems recruiting and training quality personnel for short-term seasonal/temporary employment.
- Loss of opportunity to use data to support multiple monitoring objectives.

Scenario 2. Implement a coordinated monitoring effort to achieve multiple monitoring objectives.

Advantages:

- Easier logistics and greater efficiency because of ability to use regional teams to do a variety of monitoring activities year-round.
- Greater data collection efficiency and data quality from having committed personnel.
- Better capability to analyze cumulative effects and watershed-scale questions.
- Greater efficiency because some data can be used to support multiple objectives.

Disadvantages:

- More planning is necessary to coordinate effort among various objectives and manage more complex projects.
- Personnel must be trained to collect a variety of different types of data.
- Greater funding commitment is required to initiate multiple monitoring objectives simultaneously.

Scenarios for Geographic Organization of the Implementation Effort

Another important issue is how to deploy the sampling effort across the state. This issue is somewhat related to the project organization issue discussed above. Two options have been identified, selecting random sampling sites throughout the state for each project, or focusing monitoring efforts in selected watersheds or WAUs in each region of the state.

Scenario 1. State-wide, random sampling approach to monitoring.

Advantages:

- Random sampling method provides potential to draw statistically valid conclusions on conditions throughout state.
- Large pool of potential sampling sites.

Disadvantages:

- The logistics of sampling scattered sites is more difficult and expensive.
- Not effective for holistic understanding of watershed processes and forest practices effects.

Scenario 2. Regional, watershed-based monitoring approach.

Advantages:

- Better linkage with Watershed Analysis.
- Logistics are easier and more efficient because sampling for multiple objectives occurs in one watershed.
- Conducive to providing a better understanding of multiple impacts on a watershed scale.
- The number of watersheds sampled can be expanded incrementally if cooperator interest or funding increases.

Disadvantages:

- Selected watersheds may not be representative of conditions in all watersheds.

Recommended Approach for Implementing the TFW Effectiveness Monitoring Strategy

Our recommendation is to: establish a multi-objective, regional watershed-based monitoring strategy implemented on a pilot project basis by TFW CMER and the Monitoring Steering Committee.

Our preference for this option does not mean that the other scenarios have fatal flaws. We believe an effectiveness monitoring program incorporating other implementation options is also viable.

We recommend implementing the monitoring strategy as a TFW CMER program because it takes advantage of CMER technical expertise and existing TFW monitoring structure and experience. This option should create a greater comfort level with TFW participants based on familiarity with CMER and the TFW Policy Committee. Evaluating effectiveness in the TFW CMER arena and forwarding recommendations to the TFW Policy Committee will increase opportunities for participation by interested TFW parties.

A coordinated monitoring plan for multiple objectives will take advantage of logistical and personnel advantages and enhance understanding of cumulative effects. We recommend using a regional, watershed-based approach because it is most compatible with Watershed Analysis and the multi-objective coordinated monitoring recommended above, and will allow synthesis of information on a watershed scale. Establishing a regional, watershed-based effectiveness monitoring strategy will maximize opportunities for TFW parties such as tribes, industry, environmental organizations and state agencies to participate in local monitoring activities. These efforts would be coordinated with the monitoring activities of other TFW participants.

Since no single monitoring approach will be appropriate for all objectives, the monitoring strategy should provide flexibility to accomplish various objectives most efficiently.

Roles and Responsibilities

The recommended implementation option provides roles and responsibilities for a wide range of participants in the monitoring strategy (Figure 2). A discussion of these roles follows:

TFW Policy Committee

- determine priorities for the effectiveness monitoring program
- determine appropriate action based on information and recommendations from CMER
- oversee implementation of adaptive management

CMER

- review and approve monitoring study design, sampling plans, data interpretation
- review and approve MSC effectiveness evaluations and recommendations of adaptive management advisory committee and forward to TFW policy group for action
- act on budget requests from monitoring steering committee
- review and approve project reports

Monitoring Steering Committee

- finalize effectiveness evaluations
- review and approve monitoring study design, sampling plans, data interpretation
- review and approve project reports and recommendations
- convene adaptive management advisory committee as needed

Adaptive Management Advisory Committees

- convened by the CMER Monitoring Steering Committee
- composed of TFW participants and others with scientific and operational expertise
- address specific problems and develop recommendations to improve effectiveness

TFW Ambient Monitoring Program Manager

- provide statewide interpretation of data, initial effectiveness evaluation
- oversee regional implementation efforts, supervise regional coordinators, technical staff
- produce technical reports
- review and coordinate regional study design, sampling plans
- project administration

Regional Coordinators

- communicate with regional TFW cooperators, encourage participation and coordinate cooperative monitoring efforts
- provide regional study design, sampling plans, study site selection
- direct field sampling, supervise/provide logistical support and administration for field teams
- provide regional data analysis, effectiveness evaluation and report preparation

TFW Participants

- participate in monitoring activities
- review and provide feedback on regional study design, sampling plans
- review effectiveness evaluation, participate in developing solutions
- potential source of funding and in-kind support

Other Affected Agencies

- act on adaptive management recommendations
- provide feedback on project design and results
- potential source of funding and in-kind support

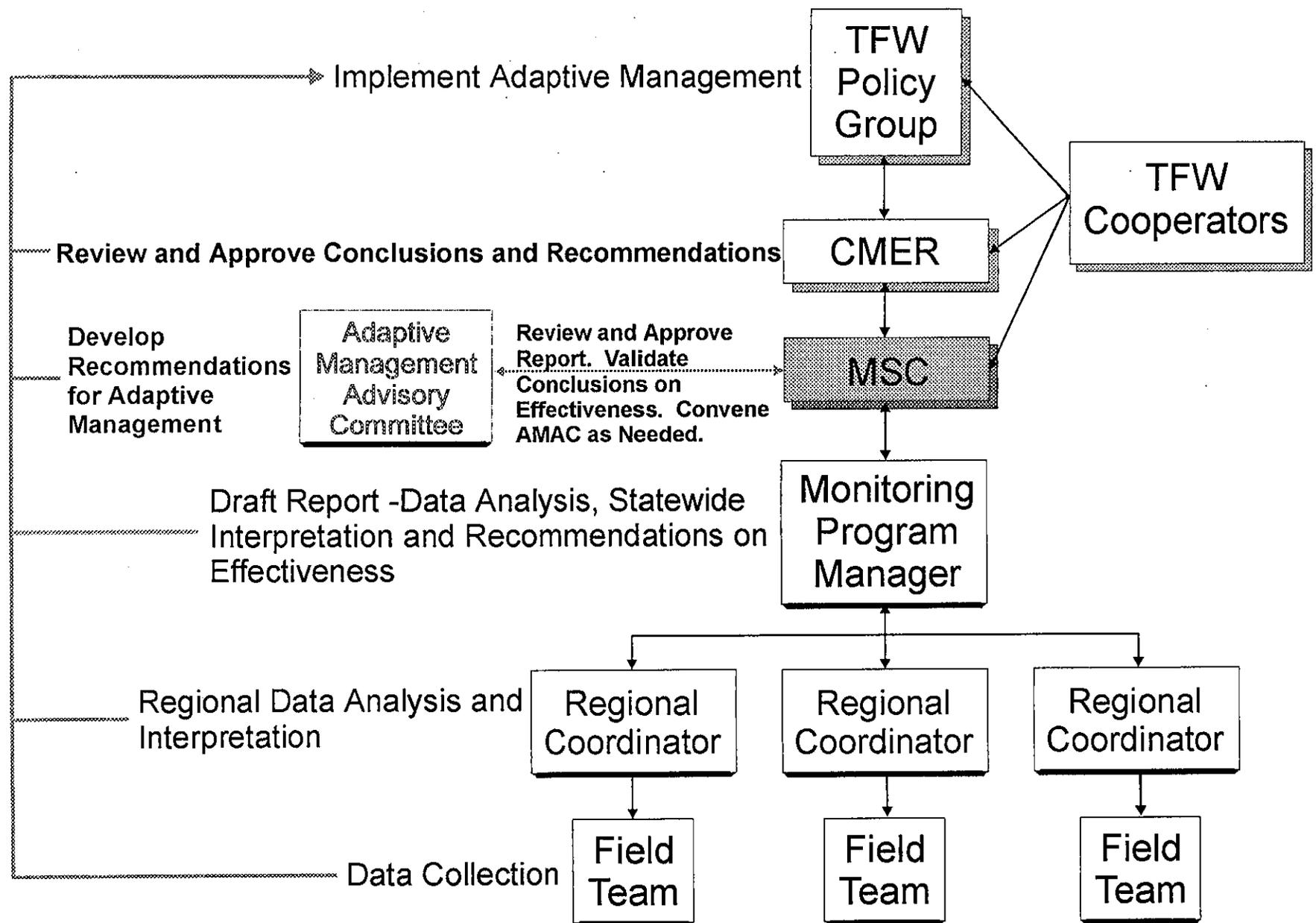


Figure 2. Proposed TFW Effectiveness Monitoring Strategy Roles and Responsibilities.

As an alternate approach, the effectiveness monitoring program could also be successfully implemented by one or more state agencies. Opportunities for TFW participation could be incorporated in this scenario, however they would be more limited than in the recommended option above. For example, CMER could provide input on technical aspects of the monitoring program and the conclusions reached about effectiveness, while the TFW Policy Committee could act as a sounding board for adaptive management recommendations.

Process for Evaluating Effectiveness and Developing Adaptive Management Recommendations

Following data collection, initial analysis and interpretation of data would be done by the TFW Ambient Monitoring Program and reports would be submitted to the Monitoring Steering Committee (MSC), CMER and TFW participants for review. These reports would summarize monitoring data and assess whether the information is adequate to draw conclusions regarding effectiveness. If the information was determined to be adequate, recommendations on effectiveness based on the established criteria would be included in the report. If necessary, recommendations for focused research would be included. It would be the responsibility of the MSC to review the information in the report and the comments received, and determine whether the conclusions drawn about effectiveness were valid. The committee can request additional monitoring or develop a proposal for focused research if needed. Following review by CMER and the MSC, a final report would be developed based on the findings of the MSC. MSC would also pass on research proposals to CMER.

In cases where the practices were found to be ineffective (or partially effective), the monitoring steering committee would establish an adaptive management advisory committee to provide recommendations on how to change practices to achieve the desired conditions. The committee would be composed of: 1) people with scientific expertise in the appropriate disciplines; 2) people with operational experience applying the practices being examined; 3) representatives of resource management organizations; and 4) representatives of landowners and operators. It would be the responsibility of this group to evaluate options and report back to the MSC with options for changes in practices to achieve effectiveness. The Monitoring Steering Committee would be responsible for reviewing the report, attaching their recommendations and submitting them to CMER. Following CMER review and approval, the package would be submitted to the TFW Policy Committee for action.

Linkage with Watershed Analysis

The monitoring strategy proposed would be closely linked with Watershed Analysis. Watershed Analysis is a unique resource for effectiveness monitoring in Washington State. Linking effectiveness monitoring to Watershed Analysis provides a number of benefits. Much of the information collected during Watershed Analysis is useful for monitoring purposes. Using this information reduces the time and cost of monitoring, providing additional benefit for the initial expenditure of time and money invested in conducting Watershed Analysis. Information collected during the assessment process can be used as a monitoring baseline for current conditions, allowing trends to be detected by repeating the measurements over time. Table 4 shows various products of the Watershed Analysis assessment modules that can be used as monitoring tools to achieve various effectiveness monitoring objectives. In addition, the cause and effect relationships

identified in the causal mechanism reports and linkages between multiple factors developed during synthesis will help with interpretation of monitoring results on a watershed scale. Finally, the Watershed Analysis five year review process provides a means of utilizing effectiveness monitoring information for adaptive management.

Table 4. Some Watershed Analysis standard products and their potential usefulness for effectiveness monitoring.

MONITORING OBJECTIVE	WA PRODUCT NAME	WHAT IS IT?	USE IN MONITORING?
1. STREAM TEMPERATURE	Map D-4. Target and estimated canopy closure.	Shows the target shade level based on stream class and elevation; also shows actual shade estimated from aerial photos.	Measure shade at harvest sites to determine if approaching target shade or moving away. Document trends in shade on watershed scale over time.
2. LWD	Map D-1 Riparian condition.	Shows species, density, and age of stream side vegetation from aerial photos.	Measure/count LWD recruitment to determine if approaching or moving away from target riparian LWD recruitment situations.
3. MASS WASTING	Map A-1. Mass Wasting Inventory.	Shows all landslides, debris flows, etc. from examination of aerial photos over time.	Determine association of site activity with mass wasting events. Document trends on watershed scale over time.
4. SURFACE EROSION	Roads spreadsheets. Background calculations.	Spreadsheets show how much sediment is contributed to streams from road system; background rate provides context for evaluating hazard from the level of sediment from roads.	Re-evaluating road sediment from time to time will allow determination of trends in road sediment; background rate provides context in which to evaluate importance of road sediment contributions.
5. HYDROLOGIC RESPONSE/ROADS	Not usually evaluated in WA (could be added as a standard product of WA).		Need to evaluate road drainage network for potential hydro impacts.
6. FISH PASSAGE	None required, though often evaluated when considered a problem (could be added as a standard product of WA).		Need to evaluate where there are blockages to fish passage if not evaluated for WA; re-evaluate after changes are made to blockages.
7. CHEMICALS	Not evaluated in WA; will be partially included in new Water Quality module.		Need to determine what to evaluate.
8. CUMULATIVE EFFECTS	All WA products.	Current conditions of inputs and resources; cause-and-effect linkages synthesized from information produced.	Forms the foundation for effectiveness evaluation of other issues; WA automatically re-evaluated on 5-yr interval.

Selection of Sampling Areas

Given the large amount of state and private forest land in Washington, it is impossible to sample all or most streams or sites where forest practices occur. Consequently, an effectiveness monitoring strategy that relies on sub-sampling is essential. Our strategy proposes to maximize efficiency by concentrating intensive monitoring in a sub-sample of forested watersheds. We recommend dividing the forested portions of the state into regions which are further sub-divided into WAUs (10,000-60,000 acre sub-basins delineated for conducting Watershed Analysis).

Within each region, a core set of WAUs would be selected to represent:

- Different management practices and programs
- Physiographic, hydrologic and climatic conditions in the region
- Land ownership and forest practices operations in the region
- Areas of critical resources such as fish stocks of special interest, water supplies etc.

The number and location of WAUs selected for monitoring may initially vary for different monitoring objectives. For example, it may be possible to cover a much larger area with an aerial photo inventory of mass wasting than with stream surveys to monitor in-channel habitat trends. However, it is our goal to conduct as many monitoring activities as possible in the same WAUs to focus monitoring efforts, increase efficiency, and enhance our understanding of the interaction between various forest practices on a watershed scale. We recognize that it may be advantageous to utilize alternate sampling designs in some situations where the watershed-based sampling scheme is not conducive to achieving the objective.

The choice of WAUs as the sampling unit also allows for monitoring efforts to be increased incrementally by adding WAUs as additional resources become available. Additional WAUs could also be added as more Watershed Analyses are completed or HCPs are brought on line.

Under this system, evaluating the effectiveness of various programs and practices would initially be done regionally using the results of monitoring in representative WAUs within each region. Regional information would be compiled to evaluate and compare effectiveness.

Coordination With Other Monitoring Efforts

Implementing the TFW Effectiveness Monitoring Strategy through CMER's Monitoring Steering Committee will take advantage of the existing expertise and infrastructure within the TFW Ambient Monitoring Program. Organizing the monitoring effort on a regional/watershed basis with a regional monitoring coordinator will facilitate coordination with local monitoring efforts. One of the duties of the regional monitoring coordinator would be to identify local monitoring efforts and to promote cooperation between local efforts and the TFW effectiveness monitoring program. In addition, opportunities exist for coordination on a broader scale. We are currently establishing communication with the federal team developing a monitoring program for the Northwest Forest Plan in order to explore the possibility of collaboration. Opportunities to collaborate with monitoring efforts by the Oregon Department of Forestry, USFS, EPA, WDOE, USGS, tribes and timber industry should be explored.

Pilot Project Proposal

We recommend a strategy of staged implementation for the effectiveness monitoring program, beginning with an initial pilot project. A pilot project has the following advantages:

- allows testing and refinement of the effectiveness monitoring strategy before resources are committed to a full-scale monitoring effort;
- produces initial data that can be used to further prioritize monitoring issues and efforts;
- provides a product that demonstrates the utility of the monitoring program and could be used in efforts to obtain additional funding;
- allows time to organize, coordinate and fund participation by TFW cooperators in a larger scale effort.

Pilot Project Description

The pilot project would focus on evaluating the effectiveness of Watershed Analysis prescriptions in watersheds approaching the five year review and comparing the effectiveness of standard rules applied under similar conditions. Forested WAUs from both the east side and west side would be selected to provide a regional perspective on effectiveness. Priority monitoring objectives include riparian function (LWD and stream temperature), sediment, fish passage and aquatic habitat condition. WAUs representative of other management programs such as TMDLs or HCPs could be added at a future date, with priority placed on those approaching the Watershed Analysis five year review

Staged Implementation

Following the pilot project, the program will be revised as necessary and can be implemented on a larger scale. Implementation can be scaled up over time as shown in Table 5, allowing improvements to be made as experience is gained. Following the pilot stage, we recommend funding a core-level program that includes regional coordinators with field crews and aerial photo, database and GIS support. The priority of the core effort would be to focus on evaluation of standard rules and WAUs with Watershed Analyses to provide data for the five year reviews.

Regional coordinators are a key element in successful implementation of the effectiveness monitoring strategy. Through contact with personnel from industry, tribes, environmental groups, regional WDNR, WDFW and WDOE offices, an extensive amount of additional monitoring support and effort can be generated.

Barriers to Implementation

Several potential barriers to implementation have been identified.

Funding. Funding the recommended effectiveness monitoring program will involve substantial costs. A rough estimate of personnel requirements has been provided in Table 5. Estimating costs more precisely will require more detailed development of sampling plans.

Table 5. Rough estimate of the personnel requirements (FTEs) to implement effectiveness monitoring in incremental stages.

	Stage 1 (2 regions)^a	Stage 2 (3 regions)^b	Stage 3 (6 regions)^c	Stage 4 (6 regions, 12 crews)^c
Program management	1.0	1.0	1.0	2.0
Database/GIS support	0.5	0.5	1.0	1.0
Aerial photo interpretation	0.5	0.5	1.0	1.0
Regional monitoring coordinators	1.0	3.0	3.0	6.0
Field crews				
Field scientists	2.0	3.0	6.0	12.0
Field technicians	2.0	3.0	6.0	12.0
Total FTEs	7.0	11.0	18.0	34.0

^a east side and west side regions; ^b east side, coastal, and west cascade regions; ^c northeast, east cascades, northwest cascades, southwest cascades, Olympic and Willapa regions.

Logistics. The logistics of coordinating effectiveness monitoring data collection around the state are intimidating. We believe the regional structure suggested above, and the emphasis on participation by local TFW cooperators is the most efficient means of overcoming logistical challenges.

Technical Capability. Implementation of the proposed TFW effectiveness monitoring program will require a scientific understanding of the relationship between forest practices and the resources of concern, as well as significant technical capability to collect, analyze, interpret and present information so valid conclusions can be drawn. Utilization of the existing TFW Ambient Monitoring Program infrastructure will provide some of the necessary technical capability, including standard methods, a database for data storage and analysis, training, and quality assurance. Use of these services will increase efficiency and reduce start-up time and cost. However, additional methods for collecting data on input processes and channel conditions are needed. For some objectives, such as LWD recruitment, further development of predictive models of the relationship between riparian stand characteristics and LWD recruitment and loading is needed. In addition, a substantial list of research issues has been identified for each of the objectives. Coordination with the CMER research program will be necessary to accomplish the necessary supporting research. Additional analytical tools are available through the Salmon/Steelhead Inventory and Assessment Program (SSHIAP) being implemented through NWIFC.

Access to Sites

Access to monitoring sites will be necessary to successfully undertake an effectiveness monitoring plan. Provisions for obtaining access to monitoring sites will need to be addressed prior to implementation.

How to Proceed

We suggest the following steps to proceed with implementation of the monitoring strategy.

1. Response from the TFW Policy Committee to CMER providing feedback on the white paper.

We need to know:

- Does the recommended strategy meet your needs? If not, do you prefer one of the other options? What revisions would you like to see, and why?;
 - Did we identify the important objectives and issues you are interested in? Would you like to add, delete or prioritize objectives?;
 - Should we make the revisions and proceed with the next stage of development of the effectiveness monitoring strategy?
2. CMER/MSR prioritizes objectives, develops details of the pilot effectiveness monitoring program including cost estimates, methods, selection of pilot watersheds and identification of partners and submits it to TFW Policy Committee for review.
 3. Identification of funding for the pilot monitoring effort.
 4. Implementation of the pilot monitoring program.
 5. Evaluation of the pilot monitoring program.
 6. Decision on future direction.

REFERENCES

Hobbs, D. and T.M. Halbach. 1981. Stream side management zone inventory. Report DOE 81-12. Washington Department of Ecology. Olympia.

Rashin, E., C. Clishe and A. Loch. 1994. Effectiveness of forest road and timber harvest best management practices with respect to sediment-related water quality impacts. Interim Report No. 2. TFW-WQ8-94-001. Wash. Dept. Natural Resources. Forest Practices Division. Olympia.

Rashin, E. and C. Graber. 1992. Effectiveness of Washington's forest practice riparian management zone regulations for protection of stream temperature. Report TFW-WQ6-92-001. Wash. Dept. Natural Resources. Forest Practices Division. Olympia.

Rashin E. and C. Graber. 1993. Effectiveness of best management practices for aerial application of forest pesticides. Report TFW-WQ1-001. Wash. Dept. Natural Resources. Forest Practices Division. Olympia.

Sacher, J., S. Keller, A. McCoy, T. Orr, and N. Wolff. 1980. An assessment of the adequacy of

Washington's forest practices regulations in protecting water quality: summary report. Report DOE 80-7. Washington Department of Ecology. Olympia.

Task LSD Subcommittee. 1979. Forest practice demonstration project: logging slash and debris. Report DOE 79-5a-4. Washington Department of Ecology. Olympia.

Wooldridge, D.D. 1979a. Forest road construction and suspended sediment, Campbell Creek, Skagit River basin. Report DOE 79-5a-2. Washington Department of Ecology. Olympia.

Wooldridge, D.D. 1979b. Suspended sediment from truck traffic on forest roads, Meadow and Coal Creeks. Report DOE 79-5a-3. Washington Department of Ecology. Olympia.

APPENDIX A

EFFECTIVENESS MONITORING PROGRAMS

IN OTHER STATES AND PROVINCES

Mike Gough- Washington Department of Natural Resources

and

Charlene Rodgers- The Evergreen State College

INTRODUCTION

Effectiveness monitoring programs in other states and provinces were investigated to identify programs which could serve as models for Washington and provide policy makers with perspective on how these states perceive and implement effectiveness monitoring. We were able to find and review a total of eight programs; however more may exist. Upon review we found the California, Oregon, and Sealaska programs to be useful models and focused our analysis upon them. Although programs from other states and British Columbia were not as applicable to Washington State, we have included descriptions to provide perspective.

DESCRIPTION OF PROGRAMS

Table A-1 summarizes monitoring approaches and implementation options for all eight effectiveness monitoring programs. In addition, we have supplied a list of contacts for each program at the end of the document. Descriptions of each of the programs follow. Due to similarities in monitoring approach, the discussion for two sets of programs (South Carolina/Florida and Montana/Idaho) are combined.

South Carolina and Florida

The information on these programs was derived from publications produced by South Carolina (Adams and Hook, 1993) and Florida (Vowell, 1994). In addition, personal interviews involving Tim Adams (South Carolina Forestry Commission) and Jeff Vowell (Florida Division of Forestry) were also conducted.

South Carolina and Florida have developed and implemented similar effectiveness monitoring programs. Both rely on stewardship and believe industry and small land owners recognize the importance of BMPs. Characteristics of their monitoring programs include an easily implemented plan and a simple design that can produce quick assessments at low cost. Due to differences in prevalent resource protection issues and terrain, the design, analysis, and range of monitoring objectives in these programs do not provide suitable models for Washington.

Purpose and Goals

South Carolina and Florida's effectiveness monitoring programs focus on the ability of their BMP's to protect water quality. South Carolina's effectiveness monitoring program was a one time effort intended to determine if the BMPs were effective. The program may also be used in emergency situations where sudden impacts to resource conditions might occur or where the effects of storm events might need to be determined and related back to BMP effectiveness. Florida intends to establish baseline conditions and would like their monitoring efforts to become long-term. This will help them determine natural variability and filter out any changes that might not be attributable to management activities. In addition, the establishment of long-term trends

Table 1. Summary of effectiveness monitoring programs in other states and provinces.

State	Purpose	Monitoring objectives and issues	Approach	Effectiveness determination	Single vs multi-objective	Watershed vs site-by site	Who does it?	Adaptive Mgmt.	Advantages (A) / Disadvantages (D)
MT, ID	Determine effect of forest practices on water quality.	Sediment input from forest roads, RMZs, and harvest units. Riparian shade, LWD, and toxic chemicals.	Subjective questionnaire by team of professionals.	Mt-compliance equals effectiveness Id- various stakeholders review data and reach consensus on effectiveness.	Single	Site by site	State agency	Mt- not formal ID- Dept. of Envr. Quality submits recommendations to Forestry Board	MT. and ID: A- quick, low budget D- subjective, narrow scope
FL, S. C.	Determine effect of forest practices on water quality.	BMP compliance for roads, stream crossings, log decks, SMZs, & harvesting. Others objectives: sediment input, slash input; riparian canopy cover, vegetative cover and bank stability.	Compliance questionnaire done by team of professionals. Quantitative data for bioassessment and habitat. Florida compares managed vs. reference conditions.	Compliance = effectiveness for both states. FL- gets bioassessment data and determines effectiveness later. S.C.- 75-77% of reference condition.	Multi-objective assessment of cumulative effects.	Site by site	State agency	No formal basis.	Florida: A-establishes baseline conditions, long term trends, produces biennium conclusions. Statewide program. D- subjective, narrow scope, unclear linkage to forest practices rules. SC: A-cheap, quick, statewide program. D- subjective, narrow scope, unclear linkage to forest practices and rules.
OR	Determine effects of forest practices on water/air qual., forest prod. & wildlife.	Riparian LWD, shade, snags. Sediment, (surface erosion and mass wasting). Stream temperature.	Quantitative monitoring data collection for resource condition & input processes.	Data compared with objectives in rules, state water quality standards or with scientific literature	Multiple objectives with separate monitoring projects.	Flexible, site by site with storm impacts by watershed.	State agency	Yes: State Board of Forestry	A- LWD modeling, desired future condition written into forest practice rules, multi-objective, long term 3 yr study, design flexibility. D- other stakeholders not involved, inefficient use of resources.
CA	Determine effect of forest practices on water quality and fish habitat.	Surface erosion from roads, crossings, & skidding. Mass wasting; Riparian shade/stream temperature, LWD & nutrients.	Quantitative data for resource conditions. Semi-quantitative survey by team for hillslope processes, compliance, & overall effectiveness.	In stream: still resolving this question. Hillslope: professional judgement of field observation	Multi-objective. Objectives vary by watershed based on resource risk assessment.	Watershed	State agency	They have a feedback mechanism, but no formal process.	A- Multi-objective, sophisticated, objective data includes input process and resource condition monitoring. D- Expensive, requires high level of training and quality assurance/control.
AK	Determine effect of forest practices on water quality and fish habitat.	Riparian: LWD, density, loading, recruitment, blowdown Sedimentation: bank erosion, pool area & spacing & bed substrate.	Quantitative data for resource conditions.	Significance of detected change vs. natural reference basins, pre-harvest, and unlogged basin data.	Multi-objective, but each objective implemented separately.	Watershed	Private Co.	No formal process.	A- Multi-objective design, objective data, long term study of unmanaged baseline conditions and trends. Covers whole S.E. region. D- expensive, data highly variable and difficult to interpret, no adaptive mgt.
B. C.	Effect of forest practices on critical resources	Resource problems determined by district region HQ managers.	Dependent on problem pursuing; data collection to subjective review.	Information will be evaluated by agency committee.	Single objective, determined regionally	Site by site Admin. Unit	Province	Specialists recommend changes to government.	A- Addresses specific problems identified by field personnel. D- lack of coordination and efficiency.

will increase their ability to detect residual (historical land use) impacts. They are interested in refining BMPs via an informal feedback loop similar to the adaptive management loop we have in Washington.

Criteria/objectives

South Carolina and Florida focused on evaluating the effectiveness of BMPs for roads, stream crossings, log decks, harvesting operations, and stream side management zones in preventing sediment input to stream channels. They also looked at in-stream slash accumulation and riparian canopy and vegetative cover. To detect a habitat response due to input variables and resource conditions they used three approaches: 1) a BMP compliance inspection, 2) a stream habitat assessment, and 3) benthic macroinvertebrate monitoring.

Approaches

Both South Carolina and Florida indirectly test effectiveness using a BMP compliance inspection consisting of a subjective questionnaire. They were able to assess the effectiveness of each BMP category as well as cumulative effectiveness.

Another result of the compliance inspection is creation of a state-wide pool of managed sites with good BMP compliance. From this pool, South Carolina and Florida randomly select sites to be evaluated for effectiveness. Once the sites have been determined they conduct benthic macroinvertebrate monitoring and a habitat assessment. Measurements are taken and the sites are scored. South Carolina determines effectiveness by dividing the site score by its reference site score. They have set an effectiveness threshold at 75-77% of reference condition. After this, they determine if there is a relationship between compliance and BMP effectiveness. Although South Carolina looked at each BMP category and in-stream objective separately, they determined overall BMP effectiveness by assessing cumulative BMP compliance and in-stream effects of logging practices and by applying a weight-of-evidence test to all three approaches to give one overall effectiveness rating.

Florida has not determined what constitutes effectiveness. They want to establish benchmark conditions and compare both pre- and post-harvest data between control sites and treatment sites. In doing so, they will be able to establish a realistic effectiveness level and account for natural variation under normal conditions.

Results

South Carolina has completed their monitoring effort and has developed a series of recommendations to improve BMP compliance. They have also identified critical factors affecting BMP compliance, including: erosion hazard ratings, logging during dry vs. wet conditions, terrain types, presence of perennial streams, percent of on-site skidding impact, and percent of site area associated with jurisdictional wetlands. They also found a significant relationship between BMP compliance and BMP effectiveness. Florida has no results to date.

Conclusions

Although South Carolina made an effectiveness determination and Florida wishes to, the effectiveness monitoring programs they have developed were not designed to address input processes, triggering mechanisms, causal linkages, and the effects on salmonid habitat. Many effectiveness questions that Washington needs to answer are not addressed by these programs.

Montana and Idaho

All material (except where noted) for this description of the programs in Montana and Idaho was derived from the Montana 1994 Forestry BMP Audits Final Report (Frank, 1994) and the Idaho 1992 Forest Practices Water Quality Audit (Hoelscher and Colla, 1993). Montana and Idaho have very similar forest practice effectiveness monitoring programs. Therefore, a summary of both programs will be presented here, noting differences where appropriate.

Purpose

The Montana and Idaho effectiveness monitoring programs focus on protection of soil and water resources. Subjective audits are conducted on a biennial basis in Montana and a quadrennial basis in Idaho. In both states, volunteer professionals participate in six-member teams that perform visual assessments of timber harvested areas. Part of the auditing goal is to discover and publicize differences in forest practice implementation and effectiveness between land ownership types.

Implementation Choices

Audit sites are selected from areas harvested during the previous two years. Sites must have a stream on or within 150-200 feet of the unit. A proportional sample is selected randomly from each of four land ownership categories including non-industrial private, industrial private, federal, and state. Idaho further stratified their sample sites by regions that differ in soil, geology, and administration.

The possibility of inconsistency due to the subjective nature of the audit is reduced through training. All team members participate in the first audit of the year in an effort to calibrate their responses. Discussions are held about individual team member ratings and methods are developed to increase consistency.

The questionnaire contains questions related to each BMP. Team members rate implementation and effectiveness of each BMP on a 4-5 point scale. The ratings related to forest practice impacts on soil and water range from "improved protection of soil and water" to "prolonged negative impacts on soil and water". Categories of BMPs rated include road planning, design, construction and maintenance, harvest design, and treatment of slash and debris. Specific riparian BMPs also address shade and hazardous/toxic chemicals in both states and LWD in Idaho.

Effectiveness Determination

Upon completion of the auditing process, data is analyzed, summarized and reported. An assumption that where there is compliance there is effectiveness underlies the auditing process in both states. The data is presented in the form of implementation and effectiveness percentages by land ownership. Data is categorized by land ownership type to focus education and compliance efforts. The process does not use statistical analysis to infer differences. In Montana, no effectiveness threshold has been developed. Judgment on acceptability is left to the reader. Montana perceives its monitoring role as a vehicle to inform the public and relies on the public to take action when the results show ineffectiveness (M. Lennon, Montana Forestry Division, phone conversation, October 2, 1996). On the other hand, effectiveness determination is made by consensus in Idaho (B. Hoelscher, Idaho Division of Environmental Quality, phone conversation, October 16, 1996). Representatives from various interest groups convene and determine if the audit results show an acceptable level of effectiveness.

Adaptive Management

Montana does not have a formal adaptive management process to facilitate possible rule changes, though occasionally, decisions are made to change forest practice rules to increase rule effectiveness (M. Lennon, Montana Forestry Division, phone conversation, October 2, 1996). Idaho on the other hand, has an active feedback loop which has resulted in rule changes. In Idaho the monitoring program is implemented by the Department of Environmental Quality. DEQ staff analyze data and develop recommendations for possible rule changes. Recommendations are then delivered to the Forest Practice Act Advisory Committee in the Department of Lands. If the recommendations are approved they are sent on to the Land Board (which includes members from each stake-holder group) who are responsible for final approval and instigation of rule changes (B. Hoelscher, Idaho Division of Environmental Quality, phone conversation, October 16, 1996).

Conclusions

Idaho's and Montana's effectiveness monitoring programs do not provide a suitable model for a program in Washington State. Their monitoring programs are not based on watershed processes and do not have the scope and complexity required for monitoring the variety of management processes utilized in Washington. The monitoring tool is a subjective questionnaire that may introduce bias. The monitoring is short term because each site is assessed only once. The scope of the monitoring is narrow with an almost exclusive focus on sedimentation. Adaptive management and effectiveness determination are not well defined in Montana.

The one aspect of Idaho's program that may be of interest to Washington is their consensus method of effectiveness determination. Members from each stake-holder group participate, providing various perspectives which when linked can lead to a balanced and more meaningful outcome for the effectiveness determination. It may be beneficial to further investigate this approach.

British Columbia

The foundation of British Columbia's forestry activities is different from any of the States reviewed in our effectiveness monitoring research. British Columbia leases its forest land to tenants who manage the land for a specific tenure. The leasing system has not precluded the need for forest practice rules (which they call "code"), or compliance, implementation and effectiveness monitoring. These systems are in their infancy; the forestry code was implemented only one year ago. Compliance in the sense of contract compliance has been ongoing for years, and implementation and effectiveness monitoring of the new code are in the planning process. A strategy and plan for implementation and effectiveness auditing has been written and submitted for approval. The hope is that a pilot project will be launched in the spring of 1997 (B. Story, B.C. Ministry of Forests, phone conversation, October 16, 1996). British Columbia's monitoring program is currently untested, but the inclusion of field personnel in problem discovery is a component that would be useful in Washington.

Purpose/Objectives

British Columbia's implementation and effectiveness monitoring are closely linked and will be investigating internal administration of the entire program as well as on-the-ground forest practices. The purpose of auditing is to gage the efficiency of forest practice application processing, determine effects of forest code on critical resources, and insure that the entire monitoring program is being administered competently. The auditing will be conducted for the sake of internal feedback. There is no law requiring auditing and there does not seem to be a perceived need to provide public information (B. Story, B.C. Ministry of Forests, phone conversation, October 28, 1996).

Approach

On the ground effectiveness monitoring will be conducted project-by-project. District managers will request auditing when a problem (such as blowdown of riparian leave trees) is observed in the field. Projects will be prioritized and audits will be conducted by headquarters professional staff. Regional management and headquarters staff can also identify problems to investigate. Generally, the auditing will only take place in the district which generated the request. Visual observations will be recorded when local managers visit and review tenants. Auditing by headquarters' staff will take place every three to four years. At this time quantitative measures will be taken if a problem cannot be solved without more scientific data (B. Story, B.C. Ministry of Forests, phone conversation, October 16, 1996).

Adaptive Management

Adaptive management is an integral part of British Columbia's program. Specialists in the Ministry of Forestry will review data generated by annual and periodic audits. When a need for code change exists, the specialists will make recommendations to the legislature. Effectiveness of the code will be determined by consensus of the specialist team members (B. Story, B.C. Ministry of Forests, phone conversation, October 16, 1996).

Conclusions

It appears that British Columbia is developing a viable program for their Province. It is too early to determine how successful British Columbia's effectiveness monitoring will be, but Washington can learn from one aspect of their program. The involvement of field personnel in problem discovery and requesting monitoring assistance is very valuable. Critical issues and problems can be missed when a program is designed from the top down with little to no involvement of front line employees. Overall, British Columbia's program does not provide a template for Washington, but it does highlight the importance of field personnel involvement.

Oregon

Oregon has developed a flexible, statistically based effectiveness monitoring program which can provide valuable ideas for Washington. Differences in available resources and the availability of Watershed Analysis in Washington, preclude the use of Oregon's effectiveness monitoring program as a complete template for Washington. However, Oregon's program contains specific components that can help guide Washington in development of an effectiveness monitoring program.

Purpose/Structure:

The purpose of Oregon's monitoring program is to assess and provide timely information about the effect of Oregon's forest practice rules on forest and soil productivity, fish and wildlife, water quality, and air quality. The monitoring coordinator oversees the program, prioritizes projects, analyzes data and gives direction to Forest Practices staff, a monitoring assistant, and seasonal personnel. The Oregon Board of Forestry is apprised of ongoing activities and provides guidance and input to the monitoring processes from beginning to end. Housing the monitoring project under the Department of Forestry has been beneficial because it provides more control over objectives, methods and results than when work is contracted out or performed by volunteers who may have their own agenda (L. Dent, Oregon Dept. of Forestry, phone conversation, October 7, 1996).

Adaptive Management

The monitoring program has an active adaptive management component or "feedback loop" with the Oregon Board of Forestry, the primary vehicle for policy establishment and change. The monitoring coordinator reports the effectiveness monitoring findings and recommendations to the Board of Forestry annually. Recently, Oregon's adaptive management process produced a more refined water classification system and changes in riparian management areas (RMA) to protect newly classified streams (Lorenson et al., 1994).

Implementation Choices

Oregon views monitoring needs holistically but available funding limits the number and magnitude

of monitoring projects performed in any one year. Monitoring is implemented on a project-by-project basis. Specific parameters are used to monitor for each desired effect. Oregon's monitoring focus varies from process based to effect based. The monitoring program is flexible, applying the most appropriate approach to each project.

Oregon is divided into seven georegions based on ecological similarity. Monitoring sites are deployed throughout those georegions to obtain statistically valid samples. The resulting site distribution and use of repeatable monitoring protocols allows for discovery of variability between georegions, which is a goal of Oregon's monitoring program (L. Dent, Oregon Dept. of Forestry, letter, 1996). Differences between georegions are considered important because they may translate into differences in forest practice rules for different ecological areas. Most of the monitoring takes place on a site level, but the monitoring program was designed to be flexible and is not locked into one spatial scale. For example, stream temperature monitoring occurs on a basin scale while the 1996 storm monitoring was conducted on a watershed scale (L. Dent, Oregon Dept. of Forestry, phone conversation, October 25, 1996).

Data is collected one year before harvest and two years after harvest. Longer term monitoring will be necessary to accurately determine some impacts but waiting to adjust forest practice rules until definitive data is in, can cause unnecessary degradation of the resource (L. Dent, Oregon Dept. of Forestry, phone conversation, October 7, 1996). A balance must be struck between obtaining statistically conclusive data and making policy decisions regarding forest practice rules. Timely information is a key element of the overall monitoring program goal. Monitoring, unlike research, is a process whereby conclusions must sometimes be drawn from strong evidence without the benefit of rigorous statistical proof.

The forest practices effectiveness monitoring program has not established reference sites, but is working with the Oregon Department of Environmental Quality (DEQ) to obtain data from DEQ's reference sites. Currently, the monitoring program is not addressing cumulative effects. The program assumes that use of BMPs will prevent site level impacts and ultimately cumulative impacts (L. Dent, Oregon Dept. of Forestry, letter, 1996).

Oregon recognizes the advantage of cooperative monitoring and has made preliminary attempts to establish relationships with other monitoring agencies. Initial efforts have encountered difficulties because other agencies (such as the United States Forest Service) have different objectives and management practices (L. Dent, Oregon Dept. Forestry, phone conversation, October 16, 1996).

Current Projects

Current projects include monitoring for road drainage and sediment delivery to channels, riparian function, stream temperature, 1996 storm impacts, and fish presence and passage through culverts. Each of these monitoring projects has its own monitoring protocol, which is used throughout the state. Functional questions are developed for each project prior to implementation. Current questions include the following:

- 1) Are the rules effective at minimizing delivery of fine sediment to stream channels?
Parameters: Frequency and function of road drainage features, fill depths and slopes, sediment delivery to channels, and sediment delivery throughout a watershed.

- 2) Are the riparian protection rules maintaining stream temperatures at pre-harvest condition and/or the DEQ water quality standard?

Parameters: Stream and air temperature, and physical riparian conditions.

- 3) How have the forest practice rules prevented or contributed to the effects of the 1996 storm?

Parameters: Distribution and management correlation of road-related landslide and washouts, non-road related landslides, channel modification, large woody debris, shade, torrent jams and changes in fish habitat.

- 4) Are the riparian rules protecting LWD recruitment, shade and wildlife habitat?

Parameters: Number, volume, length, and diameter of trees providing potential LWD, shade, numbers and sizes of snags, and terrestrial down woody debris.

- 5) What are the distribution of fish populations throughout the forest? Do current culvert regulations provide fish passage?

Parameters: Culvert characteristics, installation specifications, slope, elevation difference between culvert and channel bed, and water velocity.

Effectiveness Determination

The effectiveness monitoring program is structured to gage the ability of forest practice rules to achieve their desired effects (L. Dent, Oregon Dept. of Forestry, letter, 1996). Oregon recently began to institute objective-based forest practice rules which include descriptions of desired results and desired future conditions. For example, the rules state that specific riparian rules "are designed to achieve and maintain a desired future condition similar to mature forests with an emphasis towards conifer species" (Lorenson et al., 1994). Upon initiation of a particular monitoring project, the rules pertaining to that project are segregated into "desired result" components. Monitoring then is designed to test for the achievement of those components. The enumeration of desired results and future conditions facilitates rule effectiveness determination.

Completion of data collection for each monitoring project leads to analysis and rule effectiveness determination. Statistical analysis may validate relationships or trends or may be inconclusive. When the analysis is inconclusive, there may still be a strong correlation that would influence the monitoring staff to recommend rule changes to policy. There may also be a determination that more data needs to be collected to make a final judgment. If analysis of data shows that the goals of the forest practice rules are met and that scientific or regulatory standards are met, the monitoring coordinator proclaims the rules effective. Then the effectiveness determinations are presented to the Board of Forestry who has ultimate responsibility for making needed changes.

Conclusion

Oregon's monitoring program has been successful to date. A statewide riparian rule effectiveness study concluded that the 1980 riparian rules provided insufficient shade protection for class II streams, had a negative effect on future supply of LWD and had insignificant impact on snags in the riparian areas (Mormon, 1993). Results from current monitoring programs are not in.

The overall design of the program has many benefits. Designing specific monitoring projects for each monitoring concern allows for flexibility. The monitoring projects can have varying spatial and temporal approaches. Recognizing that time is necessary to obtain statistically significant

data, they have implemented a pre- and post-harvest monitoring program that lasts at least three years. They have also developed a LWD modeling procedure to facilitate prompt decision making without decades of data collection.

Oregon's program cannot be taken as a complete template for Washington's monitoring program. Oregon does not have an participatory management structure like Washington's Timber, Fish, and Wildlife (TFW) cooperative forest management system, nor do they have a formal Watershed Analysis process. The existence of TFW and Watershed Analysis presents Washington with monitoring opportunities no other state has. Washington can, however, look to Oregon for monitoring protocols and statistical analysis procedures, a long term monitoring outlook, LWD modeling procedures, effectiveness criteria, and landowner participation policies.

Southeast Alaska

The information on Alaska was derived from one publication (Martin, 1996) and a series of personal interviews with Doug Martin, lead consultant for the program.

The Alaska Forest Resources and Practices Act and Regulations have been in effect since 1990. They identify best management practices designed to protect and maintain fish habitat and water quality from the effects of timber harvest activities. Sealaska Co. (a private land management company) and the Alaska Forestry Association developed and initiated a monitoring program in 1992 to demonstrate the effectiveness of the BMPs outlined in this act. To date this monitoring effort is still ongoing.

Because Sealaska is a private land management firm some aspects of interest to Washington, such as adaptive management and effectiveness thresholds, are not included in their program. Their program has been in progress for 4 ½ years and has confirmed and identified some of the problems inherent in a multi variant statistical study. They have made annual changes and recommendations to methodologies, data collection techniques, and study design. We should look at these for direction and learn from their experiences. In addition, they implemented their project in much the same way as the TFW Monitoring Steering Committee would like to do.

Purpose/Goals

The purpose of Sealaska's program is to see if Alaska's BMPs maintain or restore fish habitat and water quality. Their emphasis is on demonstrating whether current BMPs work and to determine if they are being over-regulated. Other goals are to establish baseline conditions, identify large and immediate impacts, and determine long-term effectiveness trends. In addition, they would like to combine efforts with the State of Alaska in order to ensure data compatibility, increase the number of sites sampled, establish statewide quality control and increase efficiency.

Criteria/Objectives

Sealaska's program is designed in a coordinated fashion and includes all of Washington's eight monitoring objectives except forest chemicals. In addition, they have left road BMPs out of their analysis until a larger data set exists. They attempt to relate changes in ecosystem components (input variables) to fish habitat responses (resource conditions), using the result as an indicator of riparian buffer BMP effectiveness. In doing so they employ a three step program:

- 1) Determine whether fish habitat conditions have changed as a result of timber harvest.
- 2) Determine whether habitat quality (i.e., beneficial use) has been significantly affected (degraded or improved) by timber harvest.
- 3) Identify specific categories of BMPs that are not protecting fish habitat.

Sealaska has not identified effectiveness thresholds. Instead, they evaluate the significance of any impairment observed as a means of determining effectiveness. They assess significance by determining the length of stream affected above (if a management induced barrier to fish passage exists) and below the impairment in question. Although their monitoring occurs on the watershed or basin level, they determine effectiveness on a case-by-case basis.

Approaches

Two approaches are used. Both require multiple years of pre- and post-harvest data.

- 1) The first approach compares habitat conditions in multiple pre- and post-harvest basins. As a result, they identify what kind of logging effects are present in different geographic areas under different geologic and hydrologic conditions. In addition, they can identify immediate or major habitat disturbances occurring during BMP implementation and deal with potential problems promptly. They can also use this information to create a benchmark and identify the time required for recovery to occur following harvest activity.
- 2) The second approach compares pre- and post-harvest habitat conditions within each basin. This approach accounts for spatial variability, eliminates assumptions about pre-harvest conditions, and provides a strong test of BMP effectiveness. If replicate basins or replicate reaches (containing one to many similar channel types and sequences) are available, comparisons can be made between basins with different hydrologic and geographic parameters. This is similar to the first approach, but provides stronger inferences because it tests effectiveness using a series of parameters within one basin. This approach has the capability to identify subtle yet significant changes and impairments that can only be detected over long time periods.

Results

Sealaska has accumulated four years worth of data. Despite having taken 100,000 measurements resulting in 50,000 records, they are still working on the first step of their program, determining if fish habitat has changed as a result of timber harvest. This is primarily due to the high variability in their results, which limits their ability to detect change and increases the chances of reaching false conclusions. The variability is attributed to methodology, data collection, variability between

basins and reaches, and larger scale natural variability. Nevertheless, they have improved their data set and have recommendations for further improvement. The two most apparent and controllable recommendations include more years of data, a better data collection strategy and improved training.

Implementation Options

Sealaska chose to establish a multi-objective, regional watershed-based monitoring program. Since they are a private company, they neither fall into a state agency operated or collectively operated (state, tribal, environmental, and private) effectiveness monitoring program. However, the private consultant in charge of Sealaska's effectiveness monitoring program said if this were a government operated program he would have utilized a group much like TFW/CMER. He thought it was very important to collectively employ state agencies, environmental groups, tribal groups, and private industry.

Conclusions

Sealaska's design covers most resource conditions of interest in Washington. They have continually improved their monitoring protocols and data set. Their use of extensive pre- and post-harvest data allows them to detect pre-logging (natural) trends and variability, establish benchmark conditions, identify long-term trends associated with management effectiveness and distinguish them from natural variability. Although this monitoring program does not currently address the relation between forest practices and input process triggering mechanisms, they collect quantitative data on habitat and channel conditions. Consequently, we can increase our ability to attain a quality data set and successfully implement our effectiveness monitoring program by reviewing Sealaska's current approaches and methodologies and learning from their experience.

California

Although we were unable to review California's entire effectiveness monitoring program, we examined a pilot study to determine California's ability to effectively implement the in-stream monitoring component (Rae, 1995; Lee, 1996). From this information we concluded that California's program provides a useful model for effectiveness monitoring in Washington because it incorporates many of the objectives, approaches, and concepts discussed in Washington's effectiveness monitoring proposal. A very basic description of this program is presented along with a discussion of the pilot study.

Effectiveness Monitoring

In 1993 the Monitoring Study Group developed an effectiveness monitoring plan for forest practices in California entitled Assessing The Effectiveness of California's Forest Practices Rules in Protecting Water Quality: Recommendations for a Pilot Monitoring Project and a Longer Term Assessment Program. The goal is to assess the short- and long-term effectiveness of California's

Forest Practice Rules to protect water quality and fisheries. They intend to do this by adopting implementation, effectiveness, and project monitoring programs (Lee, 1996). The effectiveness monitoring component covers most of the objectives outlined in Washington's effectiveness monitoring draft plan. In addition, California has designed their effectiveness monitoring program to quantitatively and semi-quantitatively monitor for input process, near-stream processes and resource conditions. As a result of this monitoring effort California hopes to provide effectiveness determinations that will enable the Board of Forestry to strengthen the Forest Practice Rules and Regulations where necessary (Lee, 1996).

Pilot monitoring program: in-stream component

Before implementing a long-term effectiveness monitoring program, California first wanted to develop and test the methods needed. Critical elements of the in-stream component that we evaluated include: 1) procedures for selecting sample sites, 2) effectiveness evaluation techniques approved by the Monitoring Study Group, 3) field sampling protocols, 4) training materials, 5) quality control/assurance, 6) data management systems, 7) analytical techniques, and 8) personnel. As a result of this study they were able to identify an extensive list of problems and means of resolving them. They also developed an extensive list of implementation recommendations for both short- and long-term monitoring for each category. A majority of the aspects tested in this pilot are not bound by geographic limitations. Therefore, much of this information is applicable to Washington and should be reviewed further.

Conclusions

Although the review of California's pilot study was brief, it is apparent California has developed an impressive effectiveness monitoring program. The strategy and coverage parallels Washington's proposal and more. It involves monitoring of input processes, near-stream processes, and in-stream conditions. They have completed a pilot study assessing critical components of their program and have made recommendations and refinements to their long-term monitoring program. California should seriously be considered as a model for Washington.

SUMMARY OF CONCLUSIONS BASED ON REVIEW OF EXISTING PROGRAMS

Washington is proposing a process-based monitoring program that examines causal linkages between forest practices, triggering mechanisms, watershed input processes, and effects on salmonid habitat. We determined the programs developed by California, Oregon, and the Sealaska Co. are the most useful models for Washington. Several others, including British Columbia and Idaho, have unique features that should also be considered. None of these programs should be viewed as a completely suitable model for Washington. Each contains strengths and unique components, and all provide perspective and insight.

The California, Oregon and Sealaska programs are all designed to test the effectiveness of BMPs to protect fish habitat and water quality, issues that are relevant to Washington. They also employ quantitatively monitoring of input processes and resource response. All have broad-based objectives that are similar to Washington's eight functional questions. Both California and

Oregon monitor for input processes and resource conditions. Sealaska, on the other hand, has focused their efforts on monitoring long-term changes in habitat and channel conditions associated with forest practices.

These three programs have accumulated extensive monitoring experience. A pilot monitoring program has been completed in California and recommendations to improve future implementation were developed. A successful approach for monitoring riparian rule effectiveness was developed in Oregon and they are currently monitoring sediment delivery, stream temperature, storm effects and fish passage. Oregon has demonstrated flexibility in tailoring monitoring approaches for each issue. A unique feature of Oregon's riparian assessment procedure is the use of a LWD recruitment model to determine future levels of LWD based on current riparian stand characteristics. This model would be a valuable resource for Washington. Sealaska has collected a relatively long-term (4 years) data set for pre-and post-logging channel and habitat conditions. By reviewing Sealaska's approaches and methodologies, we can increase our ability to obtain quality data.

None of these programs incorporate a cooperative monitoring structure, although that issue is being explored in Alaska. Oregon provides the most useful model of successful adaptive management due to the integration of the monitoring program with the state Board of Forestry, which uses monitoring information in making management decisions.

British Columbia's untested monitoring program contains a component worthy of attention. Field personnel are involved in problem discovery and request monitoring assistance for those problems. When front-line employees are included in the monitoring process, a better picture of priorities can be developed.

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REFERENCES

- Adams, T. and D. Hook. 1993. Implementation and effectiveness monitoring of forestry best management practices on harvested sites in South Carolina. Monitoring Report Number: BMP-1. South Carolina Forestry Commission. Columbia.
- Dent, L. Oregon Dept. of Forestry. October 2, 1996. Letter written to Charlene Rodgers explaining effectiveness monitoring program.

- Dent, L. Oregon Dept. of Forestry. October 7, 1996. Phone interview by Charlene Rodgers.
- Dent, L. Oregon Dept. of Forestry.(October 25, 1996). Phone interview by Charlene Rodgers.
- Frank, G. 1994. The 1994 forestry BMP audits final report: forestry best management practices implementation monitoring. Montana Department of State Lands, Forestry Division.
- Hoelscher, Brian. (October 16, 1996). Phone interview by Charlene Rodgers.
- Hoelscher, B. and J. Colla. 1993. Forest practices water quality audit: 1992. Idaho Department of Health and Welfare, Division of Environmental Quality.
- Lee, G. 1996. Pilot monitoring program summary and recommendations for the long-term monitoring program: executive summary. Draft Rept. CDF Interagency Agreement No. 8CA27982.
- Lennon, Mark. (October 2, 1996). Phone interview by Charlene Rodgers.
- Lorensen, T., C. Andrus and J. Runyon. 1994. The Oregon Forest Practices Act water protection rules: scientific and policy considerations. Oregon Department of Forestry.
- Martin, D.J. 1996. Fish habitat and channel conditions for streams on forested lands of coastal Alaska: an assessment of cumulative effects. Review Draft Report, Project 51-002. Sealaska Corporation and the Alaska Forest Association.
- Mormon, D. 1993. Riparian rule effectiveness study. Oregon Department of Forestry.
- Munn, J. 1996. Hillslope monitoring program overview. California Department of Forestry. Sacramento.
- Rae, S.P. 1995. Board of Forestry pilot monitoring program reports: in-stream component. Final Report. Contract #8CA28103. California Department of Fish and Game. Sacramento.
- Story, Brian. (October 16, 1996). Phone interview by Charlene Rodgers.
- Story, Brian. (October 28, 1996). Phone interview by Charlene Rodgers.
- Vowell, J. Unpubl. 1994. Project 4: Silviculture Best Management Practices (BMP) Effectiveness. Florida Department of Agriculture and Consumer Services, Division of Forestry.

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APPENDIX B

Description of Monitoring Approaches for the Eight Monitoring Objectives

OBJECTIVE 1. STREAM TEMPERATURE AND RIPARIAN SHADE

Background Information

Shade provided by riparian vegetation helps to regulate stream temperatures in forested areas by reducing the solar radiation reaching the stream. Removal or disturbance of the vegetation providing shade can result in increases in stream temperatures. Many aquatic organisms, including salmonids, are sensitive to increases in stream temperatures. When water temperatures exceed the optimal temperature ranges of aquatic organisms increased stress, susceptibility to disease, and reproductive problems can occur.

Forest Practices Influencing Stream Temperature and Riparian Shade

The amount of shade provided by riparian stands is affected by forest practices that affect the number, size, and species of riparian trees. The main forest practices affecting riparian shade include:

- timber harvest or thinning adjacent to streams,
- forest roads at stream crossings or in riparian areas adjacent to streams,
- forest practices contributing to debris flows that damage riparian vegetation and alter channel morphology.

Programs/Measures to Protect or Restore Riparian Shade on State/Private Forest Land

Forest Practice Standard Rules

- Establish RMZs on all fish bearing waters (Type 1-3) and Type 4 waters where necessary to protect public resources.
- RMZ width varies within a minimum-maximum range depending on water type and extent of wetland vegetation.
- Must leave adequate trees within RMZ to meet site-specific shade requirements using Forest Practices Board Manual method or temperature model to determine adequate shade.
- Roads designed to minimize stream crossings and avoid riparian or wetland management zones.

Watershed Analysis

- All Type 1-3 streams, and Type 4 streams which contribute over 20 % of the flow are assessed.
- Aerial photos are used to assess current shade.
- Site specific prescriptions are written for segments where current shade is inadequate to meet temperature standards.

Habitat Conservation Plans

- HCPs that address salmonids contain a riparian management strategy.
- Provisions of the riparian strategies vary in details of RMZ width and “leave tree” requirements. All meet standard rules, and may exceed standard rules if maximum RMZ widths are greater.

Past Effectiveness Evaluations and Adaptive Management

Changes to the Forest Practices Rules in 1988 as a result of the TFW agreement established Riparian Management Zones (RMZs) on fish-bearing streams (Type 1-3 waters). The RMZ requirements included retention of 50% of existing shade or 75% of existing shade on temperature sensitive streams (those exceeding the forest practice temperature criteria). This regulation was evaluated by the TFW Water Quality Steering Committee in two subsequent projects. Sullivan et al. (1990) did a conceptual evaluation of effectiveness with data used to develop the TFW temperature model. They concluded that the regulation was insufficient to maintain stream temperature within water quality standards in many situations because: 1) the regulation was based on a percentage of existing shade rather than actual shade needed, and 2) because the regulations did not reflect variation in the amount of shade needed due to differences in elevation. A field study of effectiveness by Rashin and Graber (1992) subsequently documented that the regulation was ineffective in some situations, especially at low elevations, and sites with low to moderate shade, narrow RMZs or beaver ponds. In 1992 the regulations were revised to require a fixed amount of shade that varies by elevation and water quality classification of the stream. In 1993 field data collected by TFW cooperators was examined at a TFW temperature workshop. The data indicated that changes in the eastern Washington shade requirements were needed. Changes to the eastern Washington shade requirements were made in 1994. The effects of removal of riparian shade on stream temperature in non-fish bearing streams further downstream was evaluated in 1991 (Caldwell et al., 1991). Changes to the shade requirements for temperature sensitive water are currently being discussed. No formal evaluation of the current regulations (west side or east side) has been undertaken.

Effectiveness Monitoring Goal

To determine if forest practices conducted adjacent to streams are effective in maintaining (or restoring) adequate shade to maintain desirable stream temperatures.

Effectiveness Monitoring and Research Issues

Site-specific Effectiveness Monitoring Issues

- Are the riparian management measures prescribed by various management programs (standard rules, Watershed Analysis, HCPs) effective in meeting the shade targets established by the Forest Practices Board manual temperature screen?
- Are the riparian management measures prescribed by various management programs (standard rules, Watershed Analysis, HCPs) effective in meeting the water quality standards for stream temperatures?
- How is effectiveness in meeting shade and stream temperature requirements affected by factors such as water type, channel width, elevation and aspect?

- How does effectiveness in meeting shade and stream temperature targets change over time following timber harvest?

Watershed Scale Monitoring Issues

- Is the capability of riparian stands to provide shade and maintain suitable stream temperatures improving over time on a watershed scale?

Research Issues:

- What effect does riparian harvest adjacent to Type 4 and 5 waters have on summer stream temperatures, both on-site and in downstream fish-bearing waters?
- What effect does removal of various types of riparian cover have on winter stream temperatures?
- Is shade the only significant RMZ influence on stream temperature?
- Are water quality standards set at appropriate levels to protect aquatic resources?
- What is the best way to measure shade?
- Is shade provided by brush and deciduous trees comparable in function to shade provided by conifers?
- How do channel morphology and other factors (e.g. groundwater) influence the effectiveness of shade in maintaining suitable water temperatures?
- How does debris flow disturbance influence stream temperature regimes?
- What is the effect of coarse sediment build-up on stream temperatures?

Effectiveness Evaluation and Monitoring Approach for Site-Specific Monitoring Issues

Monitoring Approach. To address site-specific effectiveness issues related to riparian shade and stream temperature, we propose a monitoring approach that begins with an initial reconnaissance of riparian shade and stream temperature. This would be followed by a more intensive, focused investigation of specific problem areas in future years. The initial assessment would consist of sampling sites selected from current forest practice applications. Sampling populations would be stratified by management factors such as:

- management regime (standard rules, WA, HCPS)
- region, WAU
- water type (1, 2 and 3)
- elevation
- water quality classification and physical factors such as channel width and vegetative community

Evaluation procedure. Data used to evaluate effectiveness will include:

- canopy closure (riparian shade)
- channel width and depth

- stream temperature

Individual practices will be evaluated on the basis of whether they are successful in meeting:

- target shade requirements determined using the Forest Practices Board (FPB) manual temperature screen.
- the state water quality standard for water temperature.

Information on post-harvest riparian shade will be evaluated using the FPB temperature screen and TFW TEMP model to predict if stream temperatures will exceed water quality standards. Stream temperature data will be used to verify whether water quality standards are attained.

Data for individual sites will be sorted and stratified by factors such as management program, region, water type, elevation and riparian vegetation community type. Effectiveness will be reported as the percentage of sites in various categories that meet target shade and stream temperatures. This will allow comparison of effectiveness between different management programs and identify site-specific factors that are influencing effectiveness.

Effectiveness Evaluation and Monitoring Approach for Watershed Scale Monitoring Issues

Monitoring Approach. To address watershed-scale issues we propose a monitoring approach that uses remote aerial photograph interpretation to evaluate riparian shade combined with in-channel temperature data. Riparian shade would be assessed using the aerial photo interpretation methods in the Watershed Analysis riparian function module for all Type 1-3 waters and some Type 4 waters. Stream channels in the basin would be stratified by water type, width and channel classification. Sampling reaches would be randomly selected and sampled for stream temperature.

Evaluation Procedure. Selected WAUs would be evaluated by the percentage of stream length with good, fair or poor shade and percentage of basin stream length meeting water quality standards for stream temperature. The percentage of riparian areas affected by various activities (timber harvest, roads, agriculture, development) would be tabulated to rank the level of disturbance by various activities.

References

Caldwell, J., K. Doughty and K. Sullivan. 1991. Evaluation of downstream temperature effects of Type 4/5 waters. Report TFW WQ5-91-004. Wash. Dept. Nat. Resources. Forest Practices Division. Olympia.

Rashin, E. and C. Graber. 1992. Effectiveness of Washington's forest practice riparian management zone regulations for protection of stream temperature. Report TFW-WQ6-92-001. Wash. Dept. Nat. Resources. Forest Practices Division. Olympia.

Sullivan, K., J. Tooley, K. Doughty, J.E. Caldwell, P. Knudsen. 1990. Evaluation of prediction models and characterization of stream temperature regimes in Washington. Report TFW-WQ3-90-006. Wash. Dept. Nat. Resources. Forest Practices Division. Olympia.

OBJECTIVE 2. RIPARIAN LARGE WOODY DEBRIS RECRUITMENT

Background Information

Large woody debris (LWD) plays an important role in stream channels of the Pacific Northwest. Large, stable LWD pieces and accumulations perform a variety of functions including control and storage of sediment and nutrients, energy dissipation, formation of pools and creation of diverse hydraulic and habitat conditions throughout stream systems. Pools and cover associated with LWD increase the summer and winter rearing capacity of stream channels for salmonid species such as coho and older age classes of cutthroat and steelhead by providing deep water habitat, cover from predators and protection from high flows. Increased habitat diversity associated with LWD provides habitat for a variety of aquatic organisms. Much of the LWD in stream channels comes from riparian forests through recruitment processes such as bank erosion, wind throw, and mass wasting.

Forest Practices Affecting Large Woody Debris Recruitment

Large woody debris recruitment from riparian stands is affected by forest practices that alter the density, size, and species compositions of riparian forest stands. The main forest practices affecting LWD recruitment include:

- timber harvest or thinning adjacent to streams.
- forest roads at stream crossings or in riparian areas adjacent to streams.

Programs/Measures to Protect or Restore LWD Recruitment on State/Private Forest Land

Management strategies typically address LWD recruitment by prescribing a riparian management zone (RMZ), an area adjacent to stream channels which is managed to provide trees for future LWD recruitment. RMZs are defined as either a fixed width from the edge of the stream channel or a variable width within a range determined on the basis of site-specific conditions. Harvest within RMZs is typically allowed, but minimum numbers of trees must be left standing. The number, size, and species of trees that are required to be left typically varies. Recruitment of LWD from RMZs occurs via natural processes. Artificial enhancement of in-channel LWD is not typically required but may occur under voluntary restoration measures.

Forest Practices Standard Rules

- Establishes RMZs on all fish bearing waters (Type 1-3) and Type 4 waters where necessary to protect public resources.
- RMZ width varies within a minimum-maximum range depending on water type and extent of wetland vegetation.
- Leave tree requirements vary by region (western and eastern Washington), water type and channel morphology (gravel/cobble; boulder/bedrock).

- Roads designed to minimize stream crossings and avoid riparian or wetland management zones

Watershed Analysis

- Riparian function module evaluates short-term and long-term LWD recruitment potential.
- Recruitment potential is evaluated based on the stand characteristics including tree size, density and dominant vegetation type.
- Recruitment potential, channel sensitivity and in-channel LWD loading are used to determine LWD recruitment hazard.
- Site-specific prescriptions are developed by prescription teams to minimize or prevent and avoid impact depending of recruitment potential and channel sensitivity.

Habitat Conservation Plans

- HCPs that address salmonids contain a riparian management strategy.
- Provisions of the riparian strategies vary in details of RMZ width and leave tree requirements, however most exceed standard rule leave tree requirements for LWD recruitment.

Past Effectiveness Evaluations and Adaptive Management

- The 1988 revisions to the Forest Practices rules established Riparian Management Zones on fish-bearing waters with leave tree requirements for LWD recruitment. No evaluation of effectiveness has been done for these regulations.
- No evaluation of the effectiveness of Forest Practices rules on road location has been done.
- The WA riparian module received major revision in 1996 as a result of comments from analysts. Changes were made in the assessment methodology and hazard rating procedure.
- No assessment of WA riparian prescription effectiveness has been done.
- No evaluation of the effectiveness of HCP riparian strategies has been done.

Effectiveness Monitoring Goal

To determine whether riparian management measures applied when forest practices are conducted adjacent to streams are effective in maintaining (or restoring) riparian forest stands that provide adequate large woody debris recruitment to maintain or restore critical functions including pool formation, sediment storage and routing, and channel stability.

Effectiveness Monitoring and Research Issues

Site-specific Effectiveness Monitoring Issues

1. Are riparian management measures along fish-bearing waters effective in providing stands with an adequate number of trees of suitable size and species to maintain target in-channel LWD loading levels over time (where loading is adequate) or to restore LWD loading to

target levels (where loading is below target)?

- Do riparian stands left in RMZs maintain suitable rates of survival, growth and vigor following timber harvest to produce adequate numbers of trees of suitable size and species for LWD recruitment?
 - How does the abundance of functional LWD in fish-bearing waters respond to riparian management practices over time?
2. How effective are riparian stand conversion practices (e.g. conifer introduction into alder dominated riparian stands) in producing the number, size and species of trees needed for LWD recruitment?
 3. How effective are road location and construction practices at maintaining adequate recruitment of LWD from RMZs?
 4. How do riparian management practices on Type 4 and 5 waters affect LWD recruitment and functions?

Watershed Scale Monitoring Issues

5. How is the capability of riparian stands to recruit LWD changing over time on a watershed scale due to timber harvest and forest road construction?

Research issues

6. Does artificially placed LWD function effectively in stream channels?
7. How do LWD recruitment rates from RMZs compare with LWD export and decay rates in various channel types?
8. How much LWD recruitment is needed in Type 4 and 5 waters to maintain morphological structure and ecological function?
9. What are the effects of riparian timber harvest along Type 4 and 5 waters on the indigenous organisms?
10. Are Watershed Analysis resource condition indices for LWD set at appropriate levels to protect aquatic resources?
11. What proportion of in-channel LWD originates from large mass wasting events?
12. How can future LWD recruitment and loading be modeled and predicted?
13. Do minimum RMZs on Type 3 waters < 5 feet provide adequate LWD recruitment?
14. What are LWD recruitment rates in eastside forests?

Effectiveness Evaluation and Monitoring Approach for Site-Specific Monitoring Issues

Issue 1: Effectiveness of RMZs on fish-bearing waters for LWD recruitment

Monitoring Approach. To address site-specific effectiveness issues related to riparian LWD recruitment from RMZs on fish-bearing waters, we propose a monitoring approach that begins with a reconnaissance assessment of riparian stand composition and in-channel LWD to identify

situations where LWD recruitment is inadequate. This would be followed by a more intensive, focused investigation of specific situations which lead to inadequate LWD recruitment. The initial assessment could be combined with the initial assessment proposed for riparian shade and stream temperature to increase efficiency.

To address site-specific issues related to riparian harvest above, we propose a monitoring approach that looks at three aspects of LWD recruitment from riparian stands:

- comparison of pre- and post-harvest riparian stand characteristics to determine how harvest affects recruitment potential.
- projected and actual riparian stand survival, growth and recruitment over time to see how recruitment and recruitment potential change over time.
- changes in LWD loading in the stream channel to help determine if riparian management maintains or restores in-channel LWD loading targets.

Sampling sites would be selected from current forest practices. Sampling populations would be stratified by:

- management program (standard rules, WA, HCP).
- region (eastern Washington, western Washington).
- water type.
- elevation.

Regional and physiographic factors that would be used to further stratify the sampling population include:

- channel type (boulder/bedrock, gravel/cobble as described in the forest practices rules).
- vegetative community.
- channel width.

Evaluation Procedure. Data used to evaluate effectiveness will include:

- actual and projected LWD recruitment based on riparian stand characteristics following timber harvest; such as number, diameter, species and distance from stream.
- growth, mortality and recruitment for riparian stand over time.
- in-channel LWD loading.

Information on post-harvest stand characteristics and in-channel LWD loading will be input into a riparian model to project future LWD recruitment. This information will be used to:

- determine if riparian stands are capable of maintaining LWD loading at target levels, or if below target,
- determine if, and when, riparian stands will be able to restore LWD loading to target levels.

Additional data will be collected over time to validate initial model projections and refine effectiveness evaluations.

An effectiveness call will be made for each RMZ surveyed. If in-channel LWD loading is on target, an initial effectiveness call will be based on whether the trees remaining in the RMZ are

projected to maintain on-target LWD loading levels over the next rotation. If in-channel LWD loading is initially below target, the initial effectiveness call will be based on whether the RMZ is predicted to increase LWD to target levels. In this case, effectiveness will be qualified by the predicted number of years required to achieve target LWD loading levels. As additional visits are made to the site over time, updated information will be used to validate the initial model predictions and evaluate and modify the initial effectiveness calls if needed.

Data for individual sites will be sorted by factors such as management regime, region, water type, and riparian vegetation community. Effectiveness will be reported as the percentage of sites in various categories that meet target LWD loading levels (Watershed Analysis resource condition indices). This will allow comparison of effectiveness between different management programs and identify site-specific factors that are influencing effectiveness.

Issue 2. Effectiveness of riparian stand conversion treatments in producing conifer stands.

Monitoring Approach. To evaluate the effectiveness of riparian stand conversion treatments, surveys of conversion sites would be conducted over time to document:

- riparian stand characteristics prior to treatment.
- initial response and survival of conifers following treatment.
- changes in stand composition and LWD recruitment potential over time.

Study sites would be randomly selected from groups stratified by management program and type of treatment. Stand conversion often occurs as a voluntary option (Watershed Analysis) or as part of restoration projects independent of the forest practices application process. In order to select study sites it will be necessary to determine when and where these practices are occurring.

Evaluation Procedure. Evaluation of stand conversion measures would be based on their effectiveness in increasing potential LWD recruitment over prior stand conditions, and in increasing in-channel LWD loading to target levels.

Issue 3. Effectiveness of road location and construction practices at avoiding impacts to LWD recruitment from riparian stands.

Monitoring Approach. Because little information is available on the magnitude of impacts to LWD recruitment from road location and construction, we propose a two step approach to monitoring that would begin by determining the extent of impacts to riparian LWD recruitment potential from existing roads, followed by examination of impacts from new applications for road construction.

- Step 1 consists of a reconnaissance level survey of several WAUs using aerial photo techniques to determine the extent of existing impacts to riparian LWD recruitment potential from existing roads. This information would be collected in conjunction with the evaluation of riparian stands conducted for issue 5 (below).
- Step 2 consists of an evaluation of proposals for new road construction and road

reconstruction. A sub-sample of applications for road construction along Type 1-4 waters would be randomly selected and evaluated to determine the extent to which current road construction is impacting future LWD recruitment potential.

Evaluation Procedure. Information from the aerial photo assessment would be evaluated on the basis of the number and percentage of stream miles affected (see issue 5 below). Information from the review of proposals for new road construction would be evaluated on the basis of the severity of impact (length of stream affected, area of RMZ occupied by right-of-way, distance from stream) and the extent to which impacts were minimized.

Issue 4. Effects of riparian management practices adjacent to Type 4 and 5 waters on LWD recruitment and LWD loading levels.

Monitoring Approach. Little information is available on the effect of timber harvest practices on LWD recruitment and LWD loading levels in Type 4 and 5 waters. The monitoring approach is to collect baseline information on changes in riparian stand characteristics, LWD recruitment potential and in-channel LWD loading following timber harvest. Sample sites would be selected from timber harvest applications for units with Type 4 or 5 waters around the state.

Evaluation Procedure. Since there are currently no target levels for LWD loading in Type 4 and 5 waters, evaluation of changes in LWD recruitment and loading documented in this project is contingent on research proposed to determine needed levels of LWD loading in Type 4 and 5 waters (see research issues).

Effectiveness Evaluation and Monitoring Approach for Watershed Scale Monitoring Issues

Issue 5. How is the capability of riparian stands to recruit LWD changing over time on a watershed scale due to timber harvest and forest road construction?

Monitoring Approach. To address this issue we propose a monitoring approach that uses remote aerial photograph interpretation to evaluate riparian LWD recruitment potential on a watershed scale combined with in-channel LWD data from a sub-sample of stream segments. Riparian recruitment potential would be assessed using the aerial photo interpretation methods in the Watershed Analysis riparian function module for all Type 1-3 waters. Stream channels in the basin would be stratified by water type and channel classification and sampling reaches would be randomly selected and sampled for in-channel LWD.

Evaluation Procedure. WAUs would be evaluated by the percentage of stream length with good, fair or poor recruitment potential and percentage of basin stream length with good, fair or poor LWD loading using the Watershed Analysis resource condition indices for LWD. The percentage of riparian areas affected by various activities (timber harvest, roads, agriculture, development) would be calculated to rank the level of disturbance by various activities.

OBJECTIVE 3. MASS WASTING AND DEBRIS FLOWS

Background Information

Mass wasting is a dominant source of sediment input to forest streams in the Pacific Northwest. Common mass wasting processes in this region include: shallow-rapid landslides, debris flows, deep seated slumps and earthflows. Past studies show that the rate of mass wasting associated with clearcuts and logging roads is higher than in areas of mature forest. Some of the mechanisms that trigger mass wasting events following timber harvest include loss of root strength and increased soil moisture. Trigger mechanisms associated with forest roads include road-fill failures, cut-slope failures, and concentration of drainage onto unstable soils (Pentec, 1991). Sediment delivery to stream channels can cause a suite of changes to channel morphology and salmonid habitat, including channel widening, increased bank erosion, decreased pool volume, decreased surface particle size, and increased fine sediment and scour in salmonid spawning gravel.

Forest Practices Affecting Mass Wasting Rates

- forest road and landing location and construction
- forest road and landing maintenance
- forest road abandonment
- timber harvest practices

Programs/Measures to Prevent Mass Wasting on State/Private Forest Land

Forest Practices Standard Rules

- require SEPA review (Class IV special) for road construction in slide prone areas.
- encourage avoidance of steep, unstable slopes for road and landing construction, and establish standards for design and construction of road prisms, cut slopes, fills and drainage structures to reduce likelihood of mass wasting.
- establish minimum requirements for maintenance of road surfaces, ditches and culverts.
- allow DNR to require road maintenance plans when potential for damage to public resources exists.
- establish requirements for location, construction and rehabilitation of rock quarries, gravel pits, borrow pits and spoil disposal areas.
- contain provisions for skid trail location, design maintenance and abandonment.
- contain provisions for landing clean-up and drainage, and slash disposal.

Watershed Analysis

- mass wasting module includes inventory of past mass wasting and identification of mass wasting hazard areas.

- site-specific mass wasting prescriptions that address triggering mechanisms are written for mass wasting hazard areas. The goal of prescriptions is to prevent and avoid, or minimize, mass wasting depending on an analysis of hazard and resource sensitivity.

HCPs

- most HCPs to date rely on Watershed Analysis, riparian buffers and road maintenance plans to address mass wasting.
- the DNR HCP uses a mass wasting model developed by Susan Shaw to identify mass wasting hazards but has no process to develop prescriptions for those areas is identified.

Past Effectiveness Evaluations and Adaptive Management

A limited evaluation of mass wasting was done as part of the effectiveness monitoring program in the late 1970s (Sachet et al., 1980). A theoretical (conceptual) evaluation of the effectiveness of best management practices in the Washington forest practices rules for controlling sediment input was undertaken for the TFW Water Quality Steering Committee (Pentec, 1991). This report evaluates the expected effectiveness of individual forest practices rules. Four major problems are identified, including: 1) the rules for preventing mass wasting depend upon accurate recognition of unstable sites and may require more training in geotechnical assessment methods than is typical for foresters; 2) most rules designed to protect watercourses from erosion generally cover only Type 1-3 waters, although Type 4 and 5 waters make up a majority of the drainage network and play a significant role in erosion and transport of sediment in mountain watersheds; 3) many forest practices rules encourage diversion of water from road surface runoff onto the forest floor, however concentration of flows on steep slopes can trigger landslides and debris flows; and 4) many rules fail to identify the potential for expanding up slope contributing drainage areas through poor placement of logging roads and culverts. No changes in the standard rules have been made in response to these recommendations.

Effectiveness Monitoring Goal

To determine if forest practices are effective in reducing or eliminating management-induced mass wasting and debris flows that deliver fine and coarse sediment to stream channels.

Effectiveness Monitoring and Research Issues

Site-specific Effectiveness Monitoring Issues

1. Are timber harvest measures effective at preventing management-induced mass wasting?
2. Are road construction practices effective at preventing management-induced mass wasting on new roads?
3. Are road maintenance practices effective at preventing management-induced mass wasting on

existing forest roads?

4. Are selective harvest techniques effective at preventing management-induced mass wasting in hazard areas for deep-seated landslides?
5. Are methods used to identify areas of mass wasting hazard effective?
6. What is the recovery time for stream channels and habitat affected by mass wasting?

Watershed scale issues:

7. Is the rate of management-induced mass wasting decreasing over time on a watershed scale.
8. How widespread is habitat disturbance from mass wasting on a watershed scale.

Research issues:

9. How is the movement of deep seated landslides affected by forest management practices such as road construction and timber harvest (clearcut and partial cut)?

Proposed Effectiveness Monitoring and Evaluation Approach for Site-Specific and Watershed Scale Issues

To address site-specific monitoring issues, we recommend using a landslide inventory approach as proposed by Pentec (1991) and as applied in the Watershed Analysis mass wasting assessment module (WFPB, 1995).

Monitoring approach. The Watershed Analysis mass wasting assessment procedure involves conducting an aerial photo analysis of mass wasting features on a watershed scale. For each mass wasting feature identified in the aerial photo inventory size, mass wasting process, apparent associated land use activity, sediment delivery to stream channels, elevation, soil and geology are recorded. The aerial photo analysis would be followed by field visits to selected mass wasting features to verify physical site conditions, triggering mechanisms and sediment delivery.

Evaluation procedure. The number of mass wasting features and landslide rate would be calculated and stratified by land use activity category (clear cut 0-20 yr, clear cut >20 yr, partial cut, road, stream crossing, landing, wildfire, mature forest, non-forest land use) and physical factors such as geology, soil, slope and elevation.

The effectiveness of forest practices for roads and timber harvest in preventing mass wasting could be determined as follows:

- The mass wasting inventory is performed over the entire photo record, so a rate of failure over time intervals of around 10 years could be developed, and trends monitored. Effectiveness would be determined by establishing the desired trend, and charting progress toward or away from that trend. Interpretation of trends would involve an understanding of weather, wildfire, and any other confounding influences on landslide rate.

- For new mass wasting sites whose apparent cause was a forest practice, compliance with rules or prescriptions would be determined, and if in compliance, the site characteristics would be recorded. As sites around the state are found to be in compliance, but still failing, some determination of the characteristics of sites that fail could be made. Effectiveness, in this case would be determined by how frequently a particular rule or prescription failed to prevent mass wasting. A rate of failure that is unacceptable should be established to measure against.
- For each watershed where monitoring is carried out, a sediment budget, slightly more sophisticated than standard Watershed Analysis, could be developed to provide a backdrop for evaluating the significance of management-induced sediment sources in the basin (mass wasting and surface erosion). An effectiveness rating would be determined by the level of increase in management-induced sediment over the background sediment rate.

These effectiveness measures could be used separately or as a comprehensive plan. Any evaluation of effectiveness requires something to be measured against; either a desired trend, an acceptable limit, or an acceptable change over background.

References

Pentec Environmental Inc. 1991. Methods of testing effectiveness of Washington Forest Practices Rules and Regulations with regard to sediment production and transport to streams. Report TFW-WQ8-91-008. Washington Dept. Nat. Resources. Forest Practices Div. Olympia.

Sachet, J., S. Keller, A. McCoy, T. Orr, and N. Wolff. 1980. An assessment of the adequacy of Washington's forest practices regulations in protecting water quality: summary report. Report DOE 80-7. Washington Department of Ecology. Olympia.

Washington Forest Practices Board. 1995. Washington Forest Practices Board manual: standard methodology for conducting Watershed Analysis under Chapter 222-22 WAC. Version 3.0. Washington Dept. Nat. Resources. Forest Practices Div. Olympia.

OBJECTIVE 4. SURFACE EROSION

Background Information

Surface erosion is a widespread source of fine sediment input to drainage systems. Wherever the protective vegetation and mat of decaying vegetation is removed from the forest floor during harvest or site preparation, soil erosion can occur. The processes that contribute to surface erosion once soil is exposed include rainsplash, sheetwash, gullying, and dry ravel (Pentec, 1991). The severity of erosion is related to the steepness and length of slope of the area of exposed soil. If left undisturbed, exposed soil tends to become revegetated, though rates vary depending on site characteristics such as adequate moisture, steepness, and soil type. In harvest units, soil exposed during harvest may provide a temporary source of erosion, ending when the site becomes revegetated. Forest roads, however, tend to be chronic sources of fine sediment because the surface is not allowed to "heal itself". Erosion rates on forest roads are strongly linked to traffic, surfacing material, and maintenance.

In forested watersheds surface erosion occurs on road prisms, cut banks, ditches and fill slopes, unvegetated landslide and debris flow scars, and soils exposed by timber harvest. Delivery of the fine sediment produced by surface erosion to stream channels can increase suspended sediments and turbidity, increase fine sediment levels in spawning gravel, and cause changes in the composition of macro-invertebrate communities.

Forest Practices Contributing to Surface Erosion

- forest road construction, maintenance and abandonment
- landing construction, maintenance and abandonment
- skid trail construction, maintenance and abandonment
- timber harvest practices (tractor skidding and cable yarding)
- slash burning
- mechanical site preparation

Programs/Measures to Reduce Surface Erosion on State/Private Forest Land

Forest Practices Standard Rules

- require out sloping or ditching of roads and installation of cross drains and relief culverts. Water must be diverted onto the forest floor rather than into stream channels.
- require re-vegetation of exposed soils following road construction.
- require stabilization and erosion control of spoil piles.
- specify maintenance requirements for active, inactive and abandoned roads.
- allow DNR to require development and implementation of a road maintenance and abandonment plans where the potential for damage to public resources exists.

- seek to minimize soil disturbance and compaction for cable yarding, tractor logging and skidding.

Watershed Analysis

- the surface erosion assessment module identifies potential for erosion on roads, skid trails and harvest units.
- the potential for hill slope erosion in harvest units is determined by evaluating soil type, slope, protective cover, and human activity.
- the potential for erosion of roads is determined by evaluating the area in roads, the erodibility of parent material, precipitation zone, road design, and the protective capability of cover materials and the amount of traffic the road receives.
- estimated sediment production from forest activities is compared with estimated background rates to identify erosion hazard areas (sub-basins where land-use related sources increase total yield by >100% are HIGH hazard, where increase is between 50% and 100%, a MODERATE hazard call is made).
- site-specific prescriptions are written for moderate and high hazard sub-basins.

HCPs

- Most HCPs rely on Watershed Analysis, riparian buffers, road maintenance plans and standard forest practices rules to address surface erosion issues. DNR also identifies an undefined "landscape planning" process as a potential means of addressing surface erosion.

Past Effectiveness Evaluations and Adaptive Management

A study of the effectiveness of forest practice rule BMPs in protecting water quality was conducted in the 1970's (Sachet et al., 1980).

A theoretical (conceptual) evaluation of the effectiveness of best management practices in the Washington forest practices rules for controlling sediment input was undertaken for the TFW Water Quality Steering Committee (Pentec, 1991). They evaluate the expected effectiveness of individual forest practices rules in preventing surface erosion. Several problems with the forest practices rules were identified:

- 1) The rules require diversion of ditch water onto the forest floor but do not address the possibility of gully erosion occurring when water is diverted onto steep slopes;
- 2) the grass seeding required is not effective at controlling short-term surface erosion;
- 3) there is no requirement to re-vegetate abandoned temporary approaches and water crossings;
- 4) re-vegetation of road surfaces should be required as a part of road abandonment procedures;
- 5) abandoned skid trails should be re-vegetated; and
- 6) landslide scars should be rehabilitated.

A current study headed by Ed Rashin at DOE is evaluating effectiveness for some surface erosion rules. The field work is complete and a report is due out for CMER review in early 1997.

Effectiveness Monitoring Goal

To determine if forest practices are effective in limiting management-induced surface erosion that delivers fine sediment to stream channels to levels adequate to avoid impairment of salmonid habitat or water quality.

Effectiveness Monitoring and Research Issues

Effectiveness Monitoring Issues

1. Are road design and construction practices effective at preventing surface erosion on new roads and landings?
 - Are culvert spacing requirements effective in preventing erosion of road surfaces and ditch lines?
 - If surface erosion does occur, is it delivered to stream channels?
2. Are road maintenance practices effective at preventing surface erosion on existing forest roads?
 - If surface erosion does occur, is it delivered to stream channels?
3. Are timber harvest practices effective at preventing hill slope surface erosion? If surface erosion does occur, is it delivered to stream channels?

Watershed scale monitoring issues:

4. Is the amount of surface erosion decreasing over time on a watershed scale?

Research issues:

5. How can the background rate of sediment production in forested landscapes be better determined?
6. Is there a correlation between the density of roads in a watershed and the amount of surface erosion and resource effects?
7. How can the effect of various levels of surface erosion on aquatic resources be determined?
8. What is the relationship between basin-wide background sediment yield and the effects of surface erosion-generated sediment on water quality and aquatic organisms.

Proposed Effectiveness Monitoring and Evaluation Approach for Site-Specific Issues

To address site-specific monitoring issues, we recommend the approach proposed by Pentec (1991) which involves conducting field visits to roads, landings, skid trails and harvest units to assess the severity of erosion associated with these forest practices.

Monitoring approach. For a state-wide approach, sites (or basins) would be stratified by physiographic region, geology, hill slope gradient and land management categories. Within a

watershed, sampling would be stratified within the basin by geology, slope steepness, and management activities.

New road construction. Sites to evaluate new road construction practices would be selected from current forest practices applications and visited during the first major storm period following construction, with follow-up monitoring to identify sites with chronic erosion and sediment delivery. Strata for land management categories include: roads constructed under standard rules, roads constructed under alternate plans, and roads constructed under Watershed Analysis prescriptions.

Existing roads. Segments of existing roads could be randomly selected and visited during periods of the year when surface erosion occurs. Strata for land management categories include: road use (active, inactive, abandoned) and management program (standard rules, roads maintained according to DNR approved road maintenance plans, roads maintained according to Watershed Analysis prescriptions, and roads abandoned according to DNR approved road abandonment plans).

Timber harvest practices. Sites to evaluate timber harvest practices would be selected from current forest practice applications and visited during the first major storm season following harvest. Strata for land management categories are divided by harvest type (clearcut, partial cut) type or yarding systems use (cable, tractor, skidder) and by management program (standard rules, alternate plans, Watershed Analysis prescriptions and HCP provisions).

Evaluation procedure. The amount of surface erosion for various sites could be estimated by measuring removal of soil from its source. Examples of types of measures to be considered include: number and cross-sectional area of rills, approximate depth of sheetwash erosion, and extent of armoring (Pentec, 1991). For roads, establishing a barrier, such as a fabric fence or a weir, in the ditch near its entry point to the stream system, can trap sediment for measurement. Barriers can be established at other points of entry, such as fill slopes that deliver directly to streams.

Avoidance of chronic erosion may be a suitable criteria for evaluating effectiveness. The effectiveness of these forest practices in controlling surface erosion needs to be evaluated against a backdrop of the sediment budget for the basin in which the sites occur. Establishing at least the general rates of sediment entry to the stream system from various sources, types and sizes of sediment, storage and movement through the basin and effects on aquatic resources provides for a comparison and determination of the relative importance of various sediment sources.

Proposed Effectiveness Monitoring and Evaluation Approach for Watershed-Scale Issues

Monitoring approach. To address the watershed scale issue, we propose to use the approach recommended by Pentec (1991) and utilized in the Watershed Analysis surface erosion assessment

module. This approach involves preparing an estimate of total surface erosion input into stream channels by determining the number and length of road segments delivering sediment to stream channels, and applying estimated erosion rates to determine a total surface erosion rate for the watershed. This would have to be coupled with an evaluation of compliance to determine if sediment sources were a result of non-compliance or ineffectiveness of rules or prescriptions. Results of the Watershed Analysis surface erosion assessment could be used as a current land-use baseline from which trends could be determined as future estimates are made.

Evaluation procedure. Individual sites can be reviewed for effectiveness once compliance has been established. Each site can be evaluated as a source of sediment. Determination of effectiveness would rely on developing criteria to establish whether the amount of sediment entering the stream at a site renders the rules effective or ineffective. Avoiding chronic erosion and sediment delivery may be a suitable criteria for effectiveness.

Results of iterative estimations of erosion rates at 5-10 year intervals could be used to evaluate whether surface erosion from forest practices was increasing or decreasing over time on a watershed scale. Effectiveness could be determined by establishing the desired trend, and charting progress toward or away from that trend. Interpretation of trends would involve an understanding of weather, wildfire, and any other confounding influences on surface erosion.

A background rate could be established for each basin where monitoring is carried out. Forest practice contributions of sediment could be evaluated against that background rate. An acceptable rate of erosion over background would need to be determined for the effectiveness evaluation criteria, as is done in Watershed Analysis.

As with mass wasting, these effectiveness measures could be used separately or as a comprehensive plan. Any evaluation of effectiveness requires something to be measured against; either a desired trend, an acceptable limit, or an acceptable change over background. Surface erosion and mass wasting would be considered together when comparing to the background rate.

References

- Pentec Environmental Inc. 1991. Methods of testing effectiveness of Washington Forest Practices Rules and Regulations with regard to sediment production and transport to streams. Report TFW-WQ8-91-008. Washington Dept. Nat. Resources. Forest Practices Div. Olympia.
- Sachet, J., S. Keller, A. McCoy, T. Orr, and N. Wolff. 1980. An assessment of the adequacy of Washington's forest practices regulations in protecting water quality: summary report. Report DOE 80-7. Washington Department of Ecology. Olympia.

OBJECTIVE 5. HYDROLOGY

Background Information

Forest practices can alter the hydrologic response of a watershed (the amount of water delivered to a particular location, considered on an annual, seasonal, or storm-event basis) by increasing snow accumulation and rate of snowmelt, reducing evapotranspiration, or by more efficiently conveying runoff to stream channels.

The standard method for the hydrology assessment in the Watershed Analysis Manual assumes that “the greatest likelihood for causing significant, long-term cumulative effects on public resources via alteration of forest hydrologic processes is through the influence of timber harvest on snow accumulation and melt during rain-on-snow (ROS) storm events” (WFPB, 1995). Opening of the forest canopy by timber harvest can cause greater snow accumulation in winter and increased rates of snowmelt during “warm” winter storms or during the spring snowmelt period (Coffin and Harr, 1992). These increases may translate into increases in magnitude and/or frequency of peak flows sufficient to adversely impact aquatic resources, primarily through increases in the amount, extent, and/or frequency of bed scour or bank erosion.

The loss of forest cover may reduce rates of interception and evapotranspiration, leaving more water to enter the ground. Water yield generally increases for several years after logging, with the most pronounced relative increases occurring during the summer and early fall months (Rothacher, 1970, 1971; Harr et al., 1979, 1982). These increases tend to diminish quickly with the establishment of riparian vegetation but may provide short-term benefit to fish where low-flow augmentation occurs. In some cases, decreases in summer water yields have been attributed to harvesting in areas where fog-drip is an important precipitation component (Harr, 1982), and in response to establishment of phreatophytic hardwoods in the riparian zone (Hicks, et al., 1991).

Compaction of soil on roads and skid trails reduces local infiltration, increasing the likelihood of overland flow at the expense of slower subsurface pathways. Road drainage networks alter the routing of surface and subsurface runoff through forest terrain at a local scale, and may contribute to gully formation and mass wasting below roads. Routing of storm runoff is altered by ditches which collect flow from road surface runoff, in some cases augmented by subsurface flow intercepted by the road cut (Megahan, 1972). Changes in hydrologic response at a watershed scale may occur if sufficiently large portions of the road drainage network deliver to stream channels (Jones and Grant, 1996).

Note: Changes in hydrologic response sufficient to cause adverse material impacts to aquatic resources have been assumed to occur under certain circumstances (e.g. in association with timber harvest in the transient snow zone), yet conclusive evidence linking cause to effect (or relative effect, as other factors, such as sediment input, also come into play) has yet to be provided. Consequently, discussion of effectiveness monitoring is constrained by a lack of understanding regarding the relative magnitude of changes in hydrologic response caused by forest practices.

Forest Practices Affecting Hydrologic Response

- * timber harvest in the transient snow zone
- * road construction/road drainage

Programs/Measures to Prevent Adverse Changes in Hydrologic Response Due to Forest Practices on State/Private Forest Land

For timber harvest in the transient snow zone:

Standard (FPA) rules - WAC 222-22-100(2) gives DNR the option of limiting the size of clearcuts in the “significant rain-on-snow zone” where it determines, using “local evidence”, that peak flows have resulted in material damages to public resources.

Watershed Analysis resource assessment - The hydrologic change module quantitatively evaluates potential additional runoff generated by rain-on-snow events, and sensitivity of public resources to resulting increases in peak flows.

Watershed Analysis prescriptions - Several Watershed Analyses have had prescriptions which addressed a hydrology causal mechanism. These prescriptions typically imposed limits on the proportion of young (<10-15 years) and/or intermediate (15-35 years) stands in basins identified as being susceptible to unacceptable peak flow increases.

For road construction and management of road drainage:

Standard (FPA) rules - WAC 222-24: 020(3,5,6); 025(5-9); 030(6b); 035(2c,d); 040(1b, 2); 050(1-5). Provide for proper road location; sizing, frequency, and proper construction of road drainage elements; disposal of road drainage in hazard areas, and development of road maintenance and abandonment plans to reduce road-related hazards.

Watershed Analysis prescriptions - Prescriptions have been developed which included specific measures designed to address road location, disposal of drainage, and development of road maintenance and abandonment plans.

For protection of wetland hydrologic function:

Standard (FPA) rules - WAC 222-24: 010(1-3); 020(2); 025(9,10); 030(6b). Provide for mitigation of road impacts, maintenance of wetland hydrologic function, and replacement or enhancement of lost wetland function.

Past Effectiveness Evaluations and Adaptive Management

Pentec (1991) includes a conceptual evaluation pertaining to the hydrologic effects of road drainage. The current WQSC sediment BMP study is assessing the effectiveness of road drainage design in terms of sediment delivery.

Proposed Effectiveness Evaluation: Forest practice-induced changes in hydrologic response (Peak Flows).

Given the uncertainty as to the true magnitude of the change in hydrologic response and resulting resource impacts associated with forest practice-induced increases in rain-on-snow generated peak flows, it is unlikely that a meaningful evaluation of the effectiveness of any measures implemented to address this issue is currently possible. Efforts in this area should be focused on conducting necessary research to determine if and under what conditions forest practices alter hydrologic response sufficiently to cause resource impacts. See the "Research Issues" section for further discussion.

Proposed Effectiveness Evaluation: Management of road drainage

Effectiveness Monitoring Goal

To determine if measures implemented to provide for proper disposal of road drainage are resulting in a reduction in delivered sediment from mass wasting events and road erosion associated with interception, diversion and concentration of road drainage. Goals developed in the mass wasting and surface erosion issue discussions are also germane to this issue.

Site-specific Effectiveness Monitoring Issues

How effective are road construction and drainage disposal practices (as prescribed in the forest practice rules and Watershed Analysis prescriptions) in preventing excessive interception, diversion, and concentration of road drainage to areas capable of delivering sediment to vulnerable aquatic resources via mass wasting, surface erosion and channel erosion processes?

Monitoring Approach. Road segments in areas of high mass wasting and/or surface erosion potential or in locations adjacent to streams would be randomly selected for study. Segments would be segregated according to geologic (rock type, mass wasting process, road traffic) and climatic (precipitation intensity/duration/ frequency) factors, as well as regulations in effect at the time of road construction.

Evaluation procedure. Evaluation should be conducted in association with, or as a part of, field-based effectiveness monitoring procedures for mass wasting and surface erosion.

Information would be collected on:

- Road construction details - sidecast/endhaul, road surfacing, traffic, cut bank length, slope;
- Cross section type - inslope, outslope, w/or w/o ditch;
- Ditch relief culverts - size, spacing, slope, inlet condition (reduced effective diameter, siltation), outlet condition (discharge onto hazard area, causing erosion of sediment);
- Maintenance frequency/quality;
- Estimated contributing drainage area (before/after road construction);
- Mass wasting - type, size, timing, estimated contributing factors, delivered to vulnerable resource;
- Surface erosion - erosional processes, contributing factors, amount of sediment production, amount delivered to channel network.

This information may be used in two ways:

- statistical comparison of sediment production/delivery associated with road drainage according to geologic, climatic, and road construction factors;
- calibration and validation of hydraulic routing, surface erosion, and/or mass wasting models for use in simulation of local and cumulative effects of existing and proposed road networks.

Watershed Scale Effectiveness Monitoring Issues

To what extent are forest practice rules and Watershed Analysis prescriptions effective in preventing cumulative impacts caused by excessive interception, diversion, and concentration of road drainage to hazard areas (i.e. areas susceptible to increased delivery sediment to vulnerable aquatic resources via mass wasting, surface erosion and channel erosion processes)?

Monitoring approach and evaluation procedure

Evaluation should be conducted in association with, or as a part of, field-based effectiveness monitoring procedures for mass wasting and surface erosion.

Results from the site-specific study are compiled for individual basins, and cumulative impacts are assessed using channel condition and fish habitat diagnostic procedures. Comparison with historical road construction practices requires sufficient historical information on channel condition and fish habitat; this may be difficult or impossible to acquire. Adequate accounting of spatial variations in physiography, temporal variations in climate, and "background" levels of sediment input are required. Watershed scale modeling and/or comprehensive sediment budgeting may be required to estimate the relative contribution of road drainage system compared to other factors contributing to delivery of sediment and channel erosion.

Proposed Effectiveness Evaluation: Wetland Road Crossings

Effectiveness Monitoring Goal

To determine if measures implemented to allow for road crossing of forested wetlands provide for adequate maintenance of wetland hydrologic function.

Site-Specific Effectiveness Monitoring Issues

How effective are road construction practices (as prescribed in the forest practice rules and Watershed Analysis prescriptions) in providing for adequate maintenance of wetland hydrologic function?

Monitoring approach and evaluation procedure. This element is still under development.

Research Issues

1. How does snow water accumulation vary by canopy density and physiography (elevation, slope, aspect, climatic region) in each of the forest cover types commonly found in Washington?
2. How does the timing and rate of snow melt vary by canopy density and physiography (elevation, slope, aspect, climatic region) in each of the forest cover types commonly found in Washington?
3. Under what conditions do changes in snow accumulation and melt result in changes in runoff or stream discharge of sufficient magnitude to cause adverse material impacts to aquatic resources?
4. Under what conditions do road drainage networks produce changes in runoff or stream discharge of sufficient magnitude to cause adverse material impacts to aquatic resources?

References

Coffin, B.A. and R.D. Harr. 1992. Effects of forest cover on volume of water delivery to soil during rain-on-snow. Timber/Fish/Wildlife Report No. SH1-92-001. Washington Department of Natural Resources. 118 pp.

Harr, R. D. 1982. Fog drip in the Bull Run Municipal Watershed, Oregon. Water Resources Bulletin 18(5):785-789.

Harr, R.D., R. L. Fredriksen, and J. Rothacher. 1979. Changes in streamflow following timber harvest in southwestern Oregon. USDA Forest Service Research Paper PNW-249. Pacific Northwest Forest and Range Experiment Station. Portland OR. 22 pp.

Harr, R.D., A. Levno, and R. Mersereau. 1982. Streamflow changes after logging 130-year old Douglas fir in two small watersheds. *Water Resources Research* 18(3):637-644.

Hicks, B. J., R. L. Beschta, and R.D. Harr. 1991. Long-term changes in streamflow following logging in western Oregon and associated fisheries implications. *Water Resources Bulletin* 27(2):217-225.

Jones, J.A. and G. E. Grant. 1996. Peak flow responses to clear-cutting and roads in small and large basins, western Cascades, Oregon. *Water Resources Research* 32(4):959-974.

Megahan W. F. 1972. Subsurface flow interception by a logging road in the mountains of central Idaho. *National Symposium on Watersheds in Transition*. American Water Resources Association and Colorado State University. Pp. 350-356.

Pentec Environmental Inc. 1991. Methods of testing effectiveness of Washington Forest Practices Rules and Regulations with regard to sediment production and transport to streams. Report TFW-WQ8-91-008. Washington Dept. Nat. Resources. Forest Practices Div. Olympia.

Rothacher, J. 1970. Increases in water yield following clear-cut logging in the Pacific Northwest. *Water Resources Research* 6(2):653-658.

Rothacher, J. 1971. Regimes of streamflow and their modification by logging. *In* J. Morris (ed.) *Forest Land Uses and the Stream Environment*. Oregon St. Univ. Corvallis. pp. 40-54.

Washington Forest Practices Board. 1995. Washington Forest Practices Board manual: standard methodology for conducting Watershed Analysis under Chapter 222-22 WAC. Version 3.0. Washington Dept. Nat. Resources. Forest Practices Div. Olympia.

OBJECTIVE 6. FISH PASSAGE

Background Information

Salmonid populations inhabiting forested watersheds in Washington often incorporate complex migration patterns into various stages of their life histories. The upstream migration of breeding adults in anadromous stocks is most well-known; however, migration of resident adults to spawning areas, and migration of juvenile resident and anadromous salmonids to suitable rearing and refuge habitats is also of critical importance. When migrations are blocked or impeded by obstructions, the amount of available habitat is reduced, populations may become fragmented (with possible genetic ramifications), and critical life history stages may be adversely impacted.

Fish passage problems attributable to forest practices are primarily associated with culvert installations at stream crossings. Replacement of a portion of a natural stream bed with a culvert generally results in increased velocities, decreased flow depths, and formation of hydraulic "discontinuities" (drops, jumps, and free overfalls) in that portion at a given discharge. These factors collectively serve to block or impede access to some or all of a given species to habitat above the culvert. In addition, changes in sediment dynamics due to culvert installation, maintenance, or failure can cause changes in channel morphology, such as aggradation, that can alter habitat or impede migration off-site. If culverts interfere with natural processes and do not allow passage of water, wood and sediment, they are more likely to require increased maintenance and to cause on- and off-site passage problems.

In addition to culverts, there are additional barriers which may be created as a result of forest practices. These include clogged debris racks, road construction adjacent to streams (creating a velocity barrier as a result of channel constriction, or creating a physical barrier to off-channel habitat) and aggradation of channels due to forest-practices generated sediment.

Forest Practices Contributing to Fish Passage Problems

- culvert and debris rack installation and maintenance

Voluntary or Regulatory Programs/Measures Which Influence How the Practices Are Conducted

Installation of culverts in forest roads is regulated by DNR under the Forest Practices Rules and the Department of Fish and Wildlife under the Hydraulics Project Approval law. Requirements specified in a Hydraulics Project Approval can supersede the Forest Practices Rules.

Forest Practices Standard Rules

Forest Practices Rules govern the installation and maintenance of culverts on forest roads on state and private land. Culvert installation regulations cover culvert size, alignment, slope, protection of fill slopes, and slash clearance. There are two sets of requirements, one that applies to all culvert installations (to protect resident and anadromous fish) and another that contains additional requirements for culverts installed in streams used by anadromous fish. The rules also address maintenance procedures to keep culverts functioning properly. Additional culvert maintenance procedures as well as replacement of problem culverts may be incorporated into road maintenance and abandonment plans.

Watershed Analysis

Assessment of fish migration barriers is part of the fish habitat assessment in Watershed Analysis. However, the manual provides no consistent methodologies for assessing fish passage problems. Most Watershed Analyses utilized existing information on fish passage problems. The Griffin-Tokul Watershed Analysis included a comprehensive inventory of culvert blockages as part of the fish habitat assessment and a voluntary recommendation to correct fish passage problems identified in the inventory.

Habitat Conservation Plans

Most HCPs do not place emphasis on fish passage. Typically, HCPs defer to standard forest practices rules or commit to development and implementation of road maintenance and abandonment plans.

Hydraulic Project Approvals

Hydraulic Project Approvals (HPAs) issued from the Department of Fish and Wildlife are required for projects within stream channels. HPAs can incorporate site-specific requirements or can be issued with generic conditions. Work within the channel can be done in emergency situations with a verbal approval.

Past Effectiveness Evaluations and Adaptive Management

Inventories of culverts in forested watersheds in western Washington conducted by state and federal agencies, the tribes, and private organizations (e.g. Washington Trout) have determined that a majority of culverts block or impede fish passage, leading to a loss of available habitat and fragmentation of salmonid populations. This has led to implementation of projects to replace culverts and restore fish passage in several of the watersheds surveyed.

Effectiveness Monitoring Goals

To determine if forest practices measures prescribed for installation and maintenance of culverts and debris racks are effective in maintaining or restoring passage of adult and juvenile salmonids through road crossings.

To identify fish migration barriers caused by streamside road construction or from channel sediment accumulations originating from forest practices.

Effectiveness Evaluation and Monitoring Approach for Site-Specific Issues

Site-specific issues:

1. How effective are culvert and debris rack installation requirements (past and current) in providing fish passage, both at time of installation and over the life of the culvert?
2. How effective is required culvert and debris rack maintenance in correcting temporary blockages due to obstruction or debris accumulation?
3. How effective are road location and design requirements in preventing fish passage barriers caused by streamside roads?

Watershed scale effectiveness monitoring issues:

4. To what extent are culverts causing loss of available habitat and fragmentation of salmonid populations.
5. How is the number of fish passage blockages changing over time on a watershed scale?
6. Are fish passage barriers created by in-channel sediment accumulations attributable to forest practices?

Research issues:

7. How do road and culvert maintenance practices effect fish passage at existing forest road crossings?
8. Do timber harvest practices contribute to fish passage problems?
9. Are stream clean-out guidelines effective at preventing fish passage problems while maintaining stream channel stability?
10. How do culverts affect aquatic systems such as species distribution, inter-species interactions, host-species interactions and ecology of non-salmonid species?
11. How do culverts affect distribution of nutrients from salmon carcasses through stream networks?
12. How does culvert installation affect channel functions (such as transport of wood, water and sediment) and upstream/downstream channel morphology?
13. What are the effects of culvert installation and maintenance on water quality?
14. What are the genetic ramifications to salmonid populations fragmented by migration blockages?

Effectiveness Evaluation and Monitoring Approach for Site-Specific Issues

Issue 1. Effectiveness of current culvert installation practices when new roads are constructed or existing culverts are replaced

Monitoring Approach. Currently, no monitoring occurs when culverts are installed or replaced to evaluate their effectiveness in providing fish passage. To address this issue we propose a monitoring approach that would involve sampling of culverts on randomly selected segments of new roads and/or of culverts that have been replaced. Culverts would be visited in the field by trained personnel and fish passage would be assessed using a standardized method, such as was developed by Washington Trout and used in the Griffin-Tokul Watershed Analysis. Examples of information collected include current (and previous, applicable) culvert size, length and slope; outlet pool depth and drop height; year of installation; range of expected flows during the migration season; fish species using the culvert; amount of habitat and current or historical habitat utilization above the culvert.

Effectiveness Evaluation. The effectiveness of each new or replaced culvert would be evaluated by estimating hydraulic conditions (flow depth, velocity, and outlet conditions) using the field data. The percentage of effective and ineffective culverts would be calculated for each new road segment or set of replacement culverts examined. Since hydraulic conditions at culverts change over time, iterative surveys at 5-10 year intervals to re-evaluate effectiveness will be necessary.

Issue 2. Effectiveness of culverts on existing forest roads at providing fish passage

Monitoring Approach. To address the issue of fish passage at road crossings on the vast network of existing forest roads, we recommend a comprehensive inventory and assessment of road crossings for each Watershed Administrative Unit (WAU). Initially, a sub-sample of one or more sub-basins within the WAU could be assessed to determine the extent of fish passage problems on existing roads. To conduct the inventory, culverts would be visited in the field by trained personnel and fish passage would be assessed using a standardized method, such as was developed by Washington Trout and used in the Griffin-Tokul Watershed Analysis. In addition, information on the characteristics of the crossing, fish presence, and channel morphology and conditions would be collected. This information would be used to create a database that could be used by landowners to track future culvert maintenance and performance. This data set would also provide a baseline for future monitoring of changes in fish passage (see issue 3, below).

Effectiveness Evaluation. The effectiveness of each existing culvert visited would be evaluated by estimating hydraulic conditions (flow depth, velocity, and outlet conditions) using the field data. The percentage of effective and ineffective culverts would be calculated for each basin examined. The basin wide inventory also provides a database that can be queried to identify patterns in the effectiveness of culverts based on the type of stream channel, the age of the road, and the type of culvert installation used.

Effectiveness Evaluation and Monitoring Approach for Watershed-Scale Issues

Issue 3. Changes in the number of fish passage blockages over time on a watershed scale

Monitoring Approach. Since hydraulic conditions at culverts change over time, there are changes in the number and location of fish passage blockages over time. To track these changes, the initial basin-scale inventory of culverts (issue 2) should be repeated at 5 - 10 year intervals or after significant events.

Effectiveness Evaluation. The results of subsequent inventories will be compared with earlier inventories to determine changes in the number, percentage and location of fish passage blockages over time.

Issue 4. Loss of available habitat and fragmentation of salmonid populations due to migration blockages

Monitoring Approach. The monitoring approach for this issue utilizes information collected during the initial and iterative basin-wide inventories of fish passage at existing road crossings (issues 2 and 3) to map the location of fish passage blockages.

Effectiveness Evaluation. The maps of fish passage blockages will be used to calculate the amount of available habitat lost to various species. In addition, the number and location of areas where salmonid populations are fragmented will be identified. Much of this is being done by, and analysis will be facilitated by, the Salmon and Steelhead Inventory and Assessment Program at the NWIFC.

OBJECTIVE 7. FOREST CHEMICALS

Background Information

A variety of chemicals are used in forest management. Examples of silvicultural chemicals include fertilizers used to stimulate growth of desirable species and pesticides (herbicides, insecticides, fungicides or rodenticides) used to control undesirable species. Entry of chemicals into aquatic systems can affect water quality, potentially posing threats to public water supplies and aquatic organisms.

Forest Chemical Practices Affecting Aquatic Resources

- Aerial, ground or hand application of fertilizers
- Aerial, ground or hand application of pesticides (herbicides, insecticides, fungicides or rodenticides)

Programs/Measures to Protect Aquatic Resources from Contamination by Forest Chemicals on State/Private Forest Land

Forest Practices Standard Rules

- Handling, storage and application of fertilizers and pesticides is addressed in the rules.
- Designed to avoid contamination that would endanger public health, fish, wildlife, aquatic habitat and water quality
- Require hand treatment within riparian and wetland management zones
- Buffers required for aerial application adjacent to type 1, 2 and 3 waters (fertilizers and pesticides) and flowing type 4 and 5 waters (pesticides only)
- Forest practices applications involving aerial application of pesticides are screened to determine their potential for a substantial impact on the environment. Applications deemed to have the potential for a substantial impact on the environment are classified as Class IV special applications and receive SEPA review.

Watershed Analysis

- Identifies vulnerability of public water supplies to nutrient inputs
- Does not currently address pesticide handling, storage or application

HCPs

- Defer to standard rules and company policies and procedures (herbicides, insecticides, fungicides or rodenticides) that are not incorporated into the HCP

Past TFW Effectiveness Evaluations and Adaptive Management

Pesticides

A study of the effectiveness of best management practices (BMPs) for aerial application of forest pesticide was conducted by the Dept. of Ecology for the TFW water quality steering committee (Rashin and Graber, 1993). The report concluded that BMPs ranged from partially effective to ineffective based on three criteria including: 1) whether chemicals detected in streams exceeded water quality standards; 2) whether drift entered the RMZ or stream, and; 3) whether the application was in compliance with label restrictions. Recommendations were developed and have been passed on to the TFW Policy Committee but have not been implemented.

Fertilizer

A study evaluating the effects of aerial application of nitrogen fertilizer in two western Washington watersheds was conducted in 1988 and 1989 (Bisson et al., 1992). Both watersheds (2nd and 3rd order drainages) were entirely treated with urea prills. Streams were not buffered. Although levels of ammonia-N and nitrate-N were significantly elevated over pre-treatment levels and the changes persisted for some time, levels did not exceed water quality standards. It was concluded that water quality impairment would not occur if reasonable precautions were taken to minimize direct entry of urea to streams from aerial application and runoff from storage and handling areas.

Effectiveness Monitoring Goal

The monitoring goal is to determine if forest practice measures are effective in preventing adverse impacts to water quality and aquatic organisms from the use of forest chemicals.

Effectiveness Monitoring and Research Issues

Site-specific Effectiveness Monitoring Issues

1. How effective are aerial application measures at preventing entry of forest chemicals into stream channels, lakes and wetlands?
2. How effective are aerial application operators at identifying and avoiding Type 4 and 5 waters without surface water?
3. How effective are ground application techniques at preventing chemical input into streams and wetlands?

Watershed Scale Effectiveness Monitoring Issues

4. What percentage of the stream network is affected by chemicals in a given year.

Research issues:

5. Do large-scale applications of forest fertilizer cause changes in downstream aquatic resources such as eutrophication?
6. What are appropriate methods to measure the effects of forest chemicals on aquatic organisms?
7. How significant are post-application rainfall events as a mechanism of chemical input to stream systems?
8. Does application of persistent chemicals lead to accumulation of these substances in surface water, tissues or groundwater?
9. Do forest herbicide applications change the species composition of RMZs and WMZs?
10. What are the effects of the application of toxic chemicals (such as those used in management of Christmas tree farms and to control insect outbreaks) on aquatic systems?

Monitoring Approach for Site-specific Issues

Issue 1. Effectiveness of aerial application measures in preventing entry of forest chemicals into stream channels, lakes and wetlands

Changes to aerial pesticide application procedures have been proposed as a result of the 1993 evaluation (Rashin and Graber, 1993). Further testing of the current regulations does not appear warranted at this time. Monitoring should occur once recommendations to alter aerial application procedures have been acted upon.

Issue 2. Effectiveness of aerial application operators at identifying Type 4 and 5 waters with no surface water

Forest practices rules require leaving a 50 foot buffer strip on all typed waters, except portions of Type 4 and 5 waters with no surface water. Changes to the procedures for identifying these stream segments have been proposed. Further testing of the current regulations does not appear warranted at this time. Monitoring should occur once recommendations to alter procedures to identify these stream segments have been acted upon. The Water Quality Steering Committee has proposed a study to evaluate the use of infra-red photography to identify flowing waters, but the study has not been funded.

Issue 3. Effectiveness of ground and hand application techniques at preventing chemical input into streams and wetlands

For ground application of pesticides with power equipment, a 25 foot buffer is required along all Type A and B wetlands and all typed waters except segments of Type 4 and 5 waters with no surface water. Ground application is not allowed in RMZs and WMZs. Hand application is the only techniques allowed in RMZs and WMZs and no buffer is required. No evaluation of the effectiveness of ground application in preventing entry of pesticides into stream channels and

other water bodies has been done on forest lands in Washington.

To evaluate this issue, we recommend sampling of streams flowing through or adjacent to areas treated with ground application of pesticides.

Monitoring Approach

Sites would be selected from forest practice applications submitted for ground application of pesticides. Sites selected should contain streams within or adjacent to the application area. Sites with a variety of RMZ widths should be evaluated, however emphasis should be placed on small Type 3 and type 4 streams where application near the streams is most likely.

Evaluation procedure

Evaluation of effectiveness would follow the procedures used by Rashin and Graber (1993) in the evaluation of effectiveness of aerial pesticide application. The effectiveness of each application would be evaluated on the basis of whether 1) water quality standards were met for the chemical used; 2) direct entry of chemicals into Type 1-3 waters and Type 4 and 5 waters with surface water was avoided, as specified in the forest practices rules; and 3) application was consistent with the EPA-approved pesticide labels.

References

Bisson, P.A., G.G. Ice, C.J. Perrin and R.E. Bilby. 1992. Effects of forest fertilization on water quality and aquatic resources in the Douglas-fir region. Chapter 15 IN: H.N. Chappell, G.N. Weetman and R.E. Miller (eds.). Forest fertilization: sustaining and improving nutrition and growth of western forests. Contribution No. 73. Institute of Forest Resources. College of Forest Resources. Univ. of Washington. Seattle.

Rashin, E. and C. Graber. 1993. Effectiveness of best management practices for aerial application of forest pesticides. Report TFW-WQ1-93-001. Washington Dept. Nat. Resources. Forest Practices Division. Olympia.

OBJECTIVE 8. AQUATIC RESOURCE TRENDS

Background Information and Forest Practices Affecting Aquatic Resource Trends

Aquatic resources are potentially affected by the individual or cumulative effects from forest practices that alter watershed inputs processes related to habitat formation and water quality. Examples of key inputs and delivery processes include sediment (mass wasting and surface erosion processes), water (hydrologic process), LWD (riparian LWD recruitment processes) and solar radiation (riparian shade). Input of chemicals from forest practices is also a concern.

Programs/Measures to Protect or Restore Aquatic Resources on State/Private Forest Land

Most past forest management programs relied upon the use of best management practices to address potential site-specific impacts to aquatic resources. More recent management programs have incorporated a resource assessment procedure and have been designed to identify and address cumulative impacts on aquatic resources (Watershed Analysis), or protect and restore specific aquatic resources (HCPs) or water quality conditions (TMDLs).

Forest Practices Standard Rules

- Relies on site-specific BMPs to protect aquatic resources,
- No assessment of cumulative impacts to aquatic resources or of trends in aquatic resource conditions are required.

Watershed Analysis

- Designed to assess potential cumulative effects of forest practices on input processes and aquatic resources,
- Includes an initial resource assessment procedure, a management prescription process, a voluntary monitoring component and a five year review.

HCPs

- Designed to protect specific aquatic resources,
- Often include monitoring for aquatic resource trends.

TMDLs

- Designed to restore water quality conditions in degraded stream segments,
- Assessment and monitoring procedures tailored to specific project needs.

Past Effectiveness Evaluations and Adaptive Management

The issue of cumulative effects of forest practices on aquatic resources has been a topic of concern and adaptive management for more than 10 years. In 1984, the Forest Practices Board conducted a study to assess the potential for cumulative effects on state and private forest lands in

Washington State (Geppert et al. 1984). In 1992, the Watershed Analysis process was incorporated into the Forest Practices Rules in order to assess and prevent harmful cumulative effects to aquatic resources. In addition, aquatic habitat monitoring through the TFW Ambient Monitoring Program has established a baseline of aquatic habitat conditions on state and private forest lands.

Effectiveness Monitoring Goal

To determine whether forest management programs are effective in maintaining (or restoring) productive salmonid habitat and water quality when the cumulative effects of forest practices are considered on a watershed scale.

Effectiveness Monitoring and Research Issues

Watershed Scale Monitoring Issues

1. Are aquatic resources such as aquatic organisms, aquatic habitat, and water quality receiving adequate protection from cumulative effects of forest practices?
2. How are aquatic resource conditions responding to forest management programs over time on a watershed scale?

Research issues

3. How should trends in aquatic resources other than salmonids be addressed?
4. Can the effectiveness of measures applied during conversion of forest lands to other uses be monitored by examining resource trends over time?
5. Are stream channel and habitat restoration activities effective in increasing productive aquatic habitat?
6. What are appropriate methods of assessing resource trends and cumulative effects on a watershed scale?

Effectiveness Evaluation and Monitoring Approach for Watershed Scale Issues

Monitoring Approach. To evaluate trends in the conditions of aquatic resources over time, we propose a monitoring approach that would involve collection of monitoring information from specific resource trend monitoring sites repeated at periodic intervals.

Sampling will occur in WAUs with significant amounts of state and private forest land. WAUs will be stratified according to physiography and predominant management regime (WA, standard rules, HCPs) and a representative sample selected. In each selected WAU, monitoring sites will

be randomly selected from various gradient classes to track trends in aquatic resources. Additional sites would be selected to track trends in segments with high aquatic resource values (such as critical habitats for salmonid stocks of concern). Information will be collected on water quality parameters, Watershed Analysis resource condition indices linked to the input processes affected by forest practices and aquatic organisms. Examples of factors to be evaluated include: stream temperature; in-channel LWD; frequency, surface area and residual depth of pools; and spawning gravel availability, fine sediment levels and scour. Validation monitoring of aquatic organisms should also be conducted.

Evaluation procedure. Changes in the condition of aquatic resources would be evaluated by comparing conditions against criteria such as indices of resource condition developed for Watershed Analysis and the water quality standards. This information would be used to evaluate overall effectiveness of forest management in maintaining or restoring suitable water quality and habitat conditions over time in various channel types and in segments with high aquatic resource values. As monitoring data becomes available over time, trends in resource conditions would be determined, and tracked, by comparing data from subsequent years with data from the initial sampling period.

References

Geppert, R.R., C.W. Lorenz and A.G. Larson. 1984. Cumulative effects of forest practices on the environment: a state of the knowledge. Unpublished report to the Washington Forest Practices Board by Ecosystems, Inc.