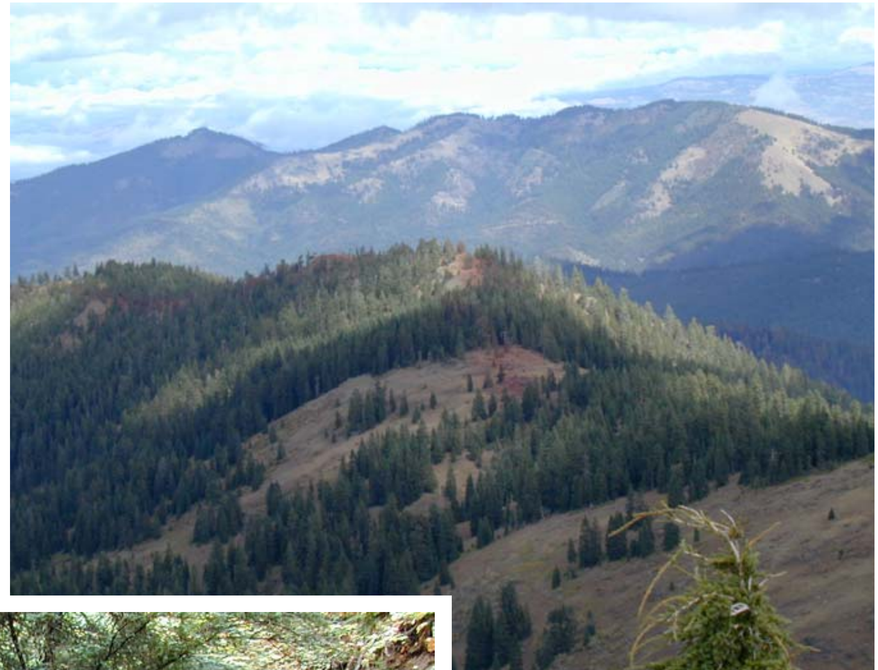
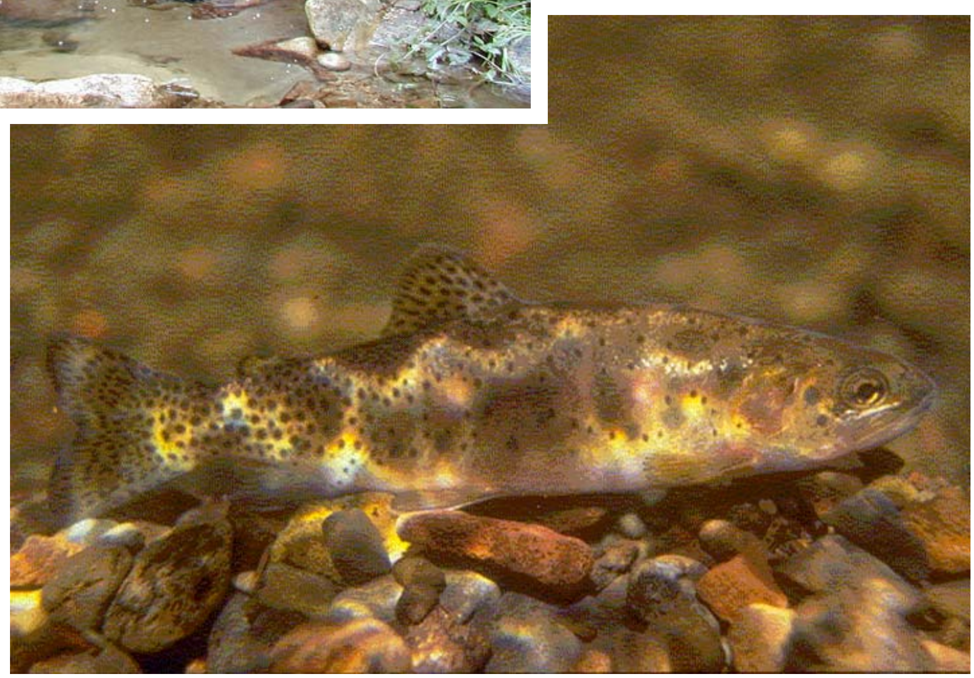
Sufficiency Analysis:

A Statewide Evaluation
of Forest Practices Act
Effectiveness in
Protecting Water Quality





by:
Oregon Department
of Forestry
and
Oregon Department of
Environmental Quality

The Oregon Department of Forestry and Department of Environmental Quality Sufficiency Analysis: A Statewide Evaluation of FPA Effectiveness in Protecting Water Quality is also available on the Department of Forestry's web page at http://www.odf.state.or.us/DIVISIONS/protection/forest_practices

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Oregon Department of Forestry and Department of Environmental Quality Sufficiency Analysis:

A Statewide Evaluation of FPA Effectiveness in Protecting Water Quality

Produced by:
The Oregon Department of Forestry and
Department of Environmental Quality

October 2002

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"STEWARDSHIP IN FORESTRY"

Memorandum

Date: October 17, 2002

To: Interested Parties

Subject: **Oregon Department of Forestry and Department of Environmental Quality Sufficiency Analysis: A Statewide Evaluation of Forest Practices Act Effectiveness in Protecting Water Quality**

The Oregon Department of Forestry (ODF) and Department of Environmental Quality (DEQ) are pleased to present this joint evaluation of the sufficiency of the Forest Practices Act (FPA) to protect water quality. In recent years increased attention has been given to the development of Total Maximum Daily Loads (TMDLs) and the listing of 303(d) water quality limited streams in the state of Oregon under the Clean Water Act. This presented new opportunities for the ODF and DEQ to move forward together to address water quality issues on nonfederal forestlands. This report represents the culmination of four years of work by our departments, pursuant to an April 1998 Memorandum of Understanding.

The ODF is the designated management agency by statute for regulation of water quality due to nonpoint source discharges or pollutants resulting from forest operations on forestlands. The Board of Forestry, in consultation and with the participation and support of the Environmental Quality Commission, has adopted water protection rules for forest operations (ORS 527.765). Forest operators conducting operations in accordance with the FPA are considered to be in compliance with Oregon's water quality standards (ORS 527.770).

This report draws on available research and monitoring data relevant to current forest practices, and demonstrates overall program adequacy at the statewide scale with due consideration to regional and local variation in effects. This analysis is based on the premise that achieving the goals and objectives of the Forest Practices Act will ensure the achievement and maintenance of water quality goals. Conclusions include the finding that there is some risk current protection may not be sufficient at a site-specific scale for some small and medium streams, however, the significance and scope of this risk is uncertain.

The purpose of the recommendations included in this report is to ensure that the FPA goals and objectives, and thus water quality standards, are being met. The Board of Forestry will consider the recommendations in light of the relevant social, economic, and environmental context of the FPA. Accordingly, the recommendations are offered to highlight general areas where current practices are either sufficient or could be improved in order to better meet the FPA goals and objectives and in turn provide added assurance of meeting water quality standards.

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EXECUTIVE SUMMARY

Background

In recent years, increased attention has been given to the development of Total Maximum Daily Loads (TMDLs) and the listing of 303(d) water quality limited streams[1] in the state of Oregon under the Clean Water Act. This has presented new opportunities for the Oregon Department of Forestry (ODF) and the Department of Environmental Quality (DEQ) to move forward together to address water quality issues on non-federal forestlands. To adequately address these issues, the ODF and DEQ have agreed through an April 1998 Memorandum of Understanding (MOU) to jointly evaluate the sufficiency of the Forest Practices Act (FPA) to protect water quality. The MOU outlines five specific water quality parameters that will be addressed: temperature, sedimentation, turbidity, aquatic habitat modification, and bio-criteria.

The purpose of this sufficiency analysis, as described the MOU (Appendix D) is to determine:

(a) The adequacy of the FPA pursuant to ORS 527.765 in the achievement and maintenance of water quality standards, with due consideration to regional and local variation in effects;
(b) If forest practices contribute to identified water quality problems in listed water quality limited streams; and
(c) If so, to determine whether existing forest practice rules provide sufficient control to assure that water quality standards will be met so that waters can be removed from the 303(d) list.

Consistent with the MOU, water quality parameters not specifically addressed in the sufficiency analysis "are generally not attributable to forest management practices as regulated by the EPA." Given the lack of any significant information on "other" parameters that might be influenced by current practices since the drafting of the MOU, the ODF and DEQ have agreed that an evaluation of parameters beyond those specifically listed in the MOU is not warranted at the time of this evaluation. The intent of the MOU and the focus of this report is on those parameters where it is known that forest practices have in some cases caused documented changes in water quality conditions.

The overall goal of the water protection rules as stated in Oregon Administrative Rules (OAR 629-635-0100 (7)) is to provide resource protection during operations adjacent to and within streams, lakes, wetlands and riparian management areas so that, while continuing to grow and harvest trees, the protection goals for fish, wildlife, and water quality are met.

> (a) The protection goal for water quality (as prescribed in ORS 527.765) is to ensure through the described forest practices that, to the maximum extent practicable, non-point source discharges of pollutants[2] resulting from forest operations do not impair the achievement and maintenance of the water quality standards.

[1] Water quality limited streams are those waters included on the 303(d) list maintained by the DEQ. These are waterbodies currently identified as not meeting water quality standards (see Appendix E).
[2] Non-point source discharges are those originating from diffuse sources across the landscape and cannot be traced to a single point or descrete activity.

> (b) The protection goal for fish is to establish and retain vegetation consistent with the vegetation retention objectives described in OAR 629-640-0000 (streams), OAR 629-645-0000 (significant wetlands), and OAR 629-650-0000 (lakes) that will maintain water quality and provide aquatic habitat components and functions such as shade, large woody debris, and nutrients." OAR 629-635-0100 (7)

State policy on water pollution control for state and private forestlands originates from the Environmental Quality Commission (EQC) and applicable administrative statutes:

> "To protect, maintain and improve the quality of the waters of the state for public water supplies, for the propagation of wildlife, fish and aquatic life and for domestic, agricultural, industrial, municipal, recreational and other legitimate beneficial uses." [ORS 468B.015(2)]

> "Implementation of any limitations or controls applying to nonpoint source discharges or pollutants resulting from forest operations are subject to ORS 527.765 and 527.770." [ORS 468B.110 (2)]

Consistent with these statutes, the FPA is Oregon's water quality standard compliance mechanism with respect to forest operations on state and private forestlands:

> "The State Board of Forestry shall establish best management practices and other rules applying to forest practices as necessary to insure that to the maximum extent practicable nonpoint source discharges of pollutants resulting from forest operations on forestlands do not impair the achievement and maintenance of water quality standards established by the Environmental Quality Commission for the waters of the state. Such best management practices shall consist of forest practices rules adopted to prevent or reduce pollution of waters of the state. Factors to be considered by the board in establishing best management practices shall include, where applicable, but not be limited to:
>
> (a) Beneficial uses of waters potentially impacted;
> (b) The effects of past forest practices on beneficial uses of water;
> (c) Appropriate practices employed by other forest managers;
> (d) Technical, economic and institutional feasibility; and
> (e) Natural variations in geomorphology and hydrology." [ORS 527.765 (1)]

> "A forest operator conducting, or in good faith proposing to conduct, operations in accordance with best management practices currently in effect shall not be considered in violation of any water quality standards." [ORS 527.770]

These Oregon administrative rules are designed to achieve water quality goals consistent with the relevant statutes, ORS 468B.015(2), 468B.110 (2), 527.765, and 527.770 cited above. It is in this regulatory and policy context that applicable water quality standards and the FPA are implemented to address water quality protection for waters of the state.

Most of the parameters addressed in this sufficiency analysis are inter-related, and forest management activities often have the potential to affect more than one parameter at the same time. For example, habitat can be modified with changes in sedimentation and turbidity, and sedimentation can influence stream temperature by altering channel dimensions and subsurface hydrology, thus affecting the net heat load to the stream. It is logical to take a holistic approach and consider water quality conditions as a result of all the parameters interacting collectively rather than attempting to consider each parameter wholly independent of the others. Accordingly, this report takes a broad approach to examining the sufficiency of the FPA and considers the multiple factors and functions by evaluating water quality standards primarily through the FPA rule objectives.

Given the consistency between the FPA and state water quality statutes and their respective administrative rules, achieving FPA goals, as articulated in the administrative rules, will ensure achieving and maintaining water quality goals and water quality standards to the maximum extent practicable. This sufficiency analysis will therefore consider the adequacy of the rules in achieving the objectives and goals of the FPA. If current practices are meeting FPA objectives and goals, state water quality standards will be met as well. If the ODF and DEQ find FPA objectives and goals are not being met, the BOF will create or modify statewide or regional rules, or design other effective measures to address the water quality impairment.

In analyzing natural resource data and attempting to draw specific cause-and-effect conclusions between human activities and natural resource conditions, the quality and/or quantity of data necessary for a high level of scientific certainty is often not available. This effort at evaluating the sufficiency of the FPA is no exception. Available data pertinent to direct cause-and-effect linkages between the FPA and quantitative water quality conditions is very limited.

There are at least two general points of view regarding such scientific uncertainty. One is to assert that since it cannot be determined with certainty that a set of practices *is* achieving a given water quality standard, a conservative approach should be taken and the rules changed to provide a higher level of protection in case a significant risk does, in fact, exist. Another view is to assert that since it cannot be determined with certainty that a set of practices *is not* achieving a given water quality standard, there is no reason for a change in practices until further monitoring and/or research can prove that a significant risk does, in fact, exist. Both points of view are valid when scientific findings are uncertain, and values and beliefs play a large role in how these points of views utilize limited scientific information.

One task of the ODF and DEQ sufficiency analysis is to present and analyze all of the applicable science and information. Following the completion of this analysis, the Board of Forestry will consider the recommendations in light of the relevant social, economic, and environmental context of the FPA. The goal of this approach is to utilize the recommendations so that outcomes are consistent with both the scientific information and the existing socio-economic framework of the FPA.

Social, Economic, and Environmental Framework

For the report recommendations to be acted upon following its completion, a review of the legal and policy setting, Oregon's forest land base, and forest ecosystem dynamics will need to be considered by the Board of Forestry in reviewing the adequacy of the FPA in meeting water quality standards "to the maximum extent practicable" as defined by state statute. Appendix A provides this review and describes the overall context in which the FPA operates. There are different environmental, social, and economic implications, depending on the interpretation of "maximum extent practicable," and these implications should be considered for this evaluation to result in an outcome that does not create unintended negative consequences for resource protection. For example, increased forestry regulations in Washington state, combined with development pressures, are partly responsible for ten-times the area of forestlands being converted to other land uses as compared to Oregon over the last decade. While these increased regulations may have resulted in some increase in resource protection for forestlands at a site-specific level, it may have been at the cost of losing an area of land (400,000 acres) to other uses that may not provide as high a level of resource protection as forestlands. Taking into account the social, economic, and environmental aspects in evaluating FPA-sufficiency early on can help to avoid this type of unintended negative consequence, while also ensuring that statutory obligations are met.

Current Scientific Knowledge

Appendix B is a review and summary of the current scientific findings and monitoring results relevant to specific forest practice issues directly related to achieving water quality goals. Each of the water quality parameters that are the subjects of this report are linked to specific forest practice issues that address those parameters. The forest practice issues reviewed here include stream temperature, large wood, forest roads, landslides, and fish passage. The technical information included in this section of the report is used as the basis of the evaluations and recommendations developed in the remainder of this report, and they are referenced accordingly.

Description of Pollution Control Mechanisms

Appendix C describes the current pollution control mechanisms implemented to meet or exceed current water quality standards. These mechanisms include both the FPA and Oregon Plan voluntary measures. They are organized under the same forest practice issues outlined in Appendix B.

Evaluation

The following conclusions apply to all applicable standards (temperature, sedimentation, turbidity, aquatic habitat modification, and bio-criteria).

Site-Specific Evaluation

Current protection requirements may be inadequate in the following areas:

- Standards for some medium and small Type F streams in western Oregon may result in short-term temperature increases at the site level. However, the significance and scope of this increase is uncertain, and it may be offset at the landscape scale by other factors. Relevant to the habitat modification standard and criteria, large wood potential for some of these streams are less than what was assumed under the 1994 rules.

- Standards for some small Type N streams may result in short-term temperature increases at the site level that may be transferred downstream (this may impact water temperature and cold-water refugia) to fish-bearing streams. The significance and scale of this change is uncertain, and it may be offset at the landscape scale. Relevant to the habitat modification standard and criteria, large wood potential delivered by debris torrents (typically in areas of very steep topography) along these streams may be less than optimal.

For large Type F streams, shade levels appear to be adequate, and large wood outputs for these streams is consistent with that assumed under the 1994 rules.

With the exception of the issue of wet-weather hauling and steep-slope ground skidding and those areas noted above, the FPA appears to be adequate when implemented successfully.

Holistic Evaluation

Over time and space the forested landscape changes. Disturbance is an important process for maintaining productivity and resetting the environment, but it can also have a number of impacts to water quality parameters. Human activities can alter the frequency and magnitude of disturbance relative to historical patterns. While some human activities, like timber harvesting, may be more frequent than historical rates of disturbance, harvesting may also be less intense of a disturbance as compared to, for example, historical wildfire. Other impacts, like fire suppression, may reduce the frequency of disturbance, but result in somewhat more intense disturbances when fires do occur. The frequency and intensity of the event can influence vegetative and other disturbance recovery. Human activities to reduce adverse effects, therefore, need to be evaluated against historical patterns of disturbance.

The current distribution of forest stand age classes, the levels of tree stocking in managed plantations, and fire suppression have resulted in well-stocked, dense, closed canopy conifer stands across a larger portion of the forested landscape than has historically occurred. Thus the current rules and practices likely result in an increased level of shade at a landscape scale. At a site-specific scale, however, some level of risk exists along some streams, as noted in the next section. The significance of this risk in terms of influencing stream temperatures at a watershed (or sub-basin) scale is uncertain.

More arguably, higher conifer stocking levels across the landscape in upland and riparian areas may result in an increased potential for large wood delivery. The likelihood of such additional stocking resulting in increased large wood production is dependent upon the harvest levels, retained trees, natural mortality and other disturbance events. Until the sizes of riparian trees increase through normal growth volume may be limited, even though the number of trees may be relatively high. Nonetheless, current practices are likely sufficient at a landscape scale.

Temperature

The following is an evaluation of the temperature standard by specific stream types and sizes:

Medium and small Type F streams: Current research and monitoring results show that current RMA prescriptions for western Oregon may result in short-term temperature increases on some Type F streams; however the significance of the potential temperature increases at a watershed (or sub-basin) scale is uncertain.

Small Type N streams: Current research and monitoring results show current practices may result in short-term (two to three years) temperature increases on some Type N streams. The significance of potential temperature increases on Type N streams to downstream fish-bearing streams and at a watershed (or sub-basin) scale is uncertain.

All other streams: Influences on stream temperatures from shade levels resulting from specific BMP prescriptions for the other stream category types have not been assessed due to a lack of relevant data. However, in light of the data and findings specific to medium and small Type F streams, and given the higher level of vegetation retention on large Type F streams, it is likely that the standard is being met on large Type F streams.

Sedimentation Standard

The intent of the sedimentation standard as it applies to the FPA is to minimize soil and debris entering waters of the state. (OAR 629-30-000(3)) With the exception of wet-weather road use, complying with the road construction and maintenance rules currently in place is likely to result in meeting water quality standards. The rule and guidance recommendations described in the next section of this report will work towards ensuring the goals of the FPA and water quality standards are being met.

Turbidity Standard

Given the lack of quantitative data to specifically address the turbidity numeric standard, the turbidity standard is evaluated qualitatively. The intent of the turbidity standard, as it applies to the FPA, is to minimize soil and debris entering waters of the state. (OAR 629-30-000(3)). Both the FPA and water quality standards are being met when unfiltered surface runoff from road construction is entering applicable waters of the state and there is a visible difference in the turbidity of the stream above and below the point of delivery of the runoff for less than a two- or four-hour duration (depending on the stream grade and with all practicable erosion controls in place). When unfiltered surface runoff from general road use is minimized, and/or if all applicable BMPs have been applied, both the FPA and water quality standards are being met as well.

With the exception of wet-weather road use, complying with the road construction and maintenance rules and guidance currently in place is likely to result in meeting water quality standards. The rule recommendations will help improve compliance and implementation of the FPA to ensure the goals of the FPA and thus water quality standards are being met. Specific to wet-weather hauling, construction and maintenance standards should be developed for roads at risk for sediment delivery. Prohibiting hauling during periods of wet weather on road systems that have not been constructed with specific standards for surface materials, drainage systems, or other alternatives (paving, increased numbers of cross drains, sediment barriers, settling basins, etc.) will also minimize delivery of sediment streams.

Habitat Modification Standard

The FPA standard as it relates to habitat modification is "to grow and retain vegetation [along fish-bearing streams] so that, over time, average conditions across the landscape become similar to those of mature streamside stands;" and "to have sufficient streamside vegetation [along non fish-bearing streams] to support functions and processes that are important to downstream fish use waters and domestic water use."(OAR 629-640-0000)

The following is an evaluation of the habitat modification standard described above by specific stream types and sizes:

Medium and small Type F streams: Monitoring data indicates the assumptions used to determine basal area targets for small and medium streams in western Oregon may not be consistent with what the RMAs are capable of growing along these streams. The data also shows that 60 percent of harvest operations occurring along fish-bearing streams do not result in management within the RMAs. There is a reasonable possibility that, under the current rules, some of these streams are not likely to result in the "desired future condition" in a timely manner, as described in the goals of the FPA.

Small Type N streams: There is increasing scientific evidence that small non-fish-bearing streams prone to debris flows provide an important source of large wood for downstream fish habitat. While these streams are providing some level of functional large wood inputs and shade production under the current rules, the rules were not specifically designed to retain significant sources of large wood and shade in these areas. There is a reasonable possibility that, under the current rules, some of these streams are not likely to adequately support functions and processes important to downstream fish use waters, as described in the goals of the FPA.

All other streams: Influences on habitat modification resulting from specific best management practices for the other stream category types have not been assessed since they were considered a lower priority. However, given the higher level of vegetation retention on large Type F streams, and in light of the data and findings specific to medium and small Type F streams, it is likely the standard is being met on these streams.

Fish passage blockages: Since 1994, the FPA has required juvenile fish passage be provided on all fish-bearing streams. Current monitoring information does not indicate Forest Practices policies need to be significantly changed on how to install fish-passable stream crossings. With few exceptions, it appears when the guidelines are implemented correctly, the success rate is high for creating conditions believed to provide a high likelihood of fish passage.

Biocriteria Standard

This standard is consistent with multiple FPA purposes and goals that refer to the sound management of soil, air, water, fish and wildlife resources, while at the same time ensuring the continuous growing and harvesting of forest tree species. Given the general nature of this standard and the lack of specific criteria to use in evaluating this standard, biocriteria cannot be explicitly evaluated at this time. It is reasonable to assume that, given the inter-related nature of the temperature, sediment, turbidity and habitat modification parameters relative to biocriteria, to the extent these other parameters are being met, the biocriteria standard is likely to be met as well.

<u>Recommendations</u>

The FPA goals and objectives, as well as most of the state water quality standards and criteria being evaluated in this analysis (temperature and turbidity being the exceptions), are qualitative in nature. Thus, conclusions regarding the effectiveness of the rules in meeting the goals and objectives are qualitative as well. Available data relevant to those quantitative water quality standards (i.e. temperature and turbidity) is inadequate to draw specific and comprehensive conclusions about the adequacy of current practices; therefore, the evaluation of these criteria is also qualitative.

Data in many areas is lacking and, in many cases, not comprehensive. In light of this, any policy decisions made when this report is completed will depend upon professional judgement consistent with available scientific information. As the Board of Forestry considers these recommendations, social and economic factors, along with the scientific evidence on the adequacy of current practices presented here, will be considered as well.

The following recommendations are offered to highlight general areas where current practices could be improved upon to better meet the FPA goals and objectives and, in turn, provide greater likelihood of meeting water quality standards.

Recommendation #1: The RMA basal area retention standards should be revised, where appropriate, to be consistent with achieving characteristics of mature forest conditions in a timely manner; and to ensure that RMAs are providing desirable amounts of large wood and shade over space and time.

Recommendation #2: Revise current practices so desirable amounts of large wood are available along small stream channels that can deliver debris torrents to Type F streams. Ensure that adequate shade is maintained or rapidly recovered for riparian areas along small perennial Type N streams with the potential to impact downstream Type F waters.

Recommendation #3: Provide additional large wood to streams by actively placing the wood in areas where it will provide the greatest benefits to salmonids.

Recommendation #4: Reduce the delivery of fine sediment to streams by installing cross drains to keep drainage waters from eroding slopes. This will allow filtering of sediments and infiltration of drainage water into undisturbed forest soils. Cross drains should not be confused with stream crossing culverts. Cross drains take water from the road surface and ditch and route it under/across the road, discharging the water downslope from the road.

Recommendation #5: Develop specific standards for roads that will be actively used during the wet season. This would include a requirement for durable surfacing of roads in locations where fine sediment can enter streams. This would also include ceasing to haul if roads have not been constructed with effective surface materials, drainage systems, or other alternatives (paving, increased numbers of cross drains, sediment barriers, settling basins, etc.) that minimizes delivery of sediment into streams.

Recommendation #6: Develop specific guidance describing how roads in critical locations would be reviewed to reduce road length, and determining when, despite the relocation, the road location would pose unacceptable risk to resources and not be approved.

Recommendation #7: Construct stream crossings that adequately pass large wood and gravel downstream, and provide other means for passage of large wood and sediment at those crossings that restrict passage. The transport mechanisms for large wood and gravel should include both stream storm flows and channelized debris flows. This would reduce the risk of debris backing up behind the structure, potentially resulting in catastrophic sediment delivery caused by washouts.

Recommendation #8: Develop specific steep-slope, ground-based, yarding practices, or add a prior approval requirement for ground skidding in high-erosion hazard locations.

Recommendation #9: Manage locations most prone to landslides (high-risk sites) with techniques that minimize impacts to soil and water resources. To achieve this objective, best management practices to protect landslide-prone terrain currently in guidance should be incorporated into the forest practice rules, while developing a better case history for evaluating the effectiveness of those practices. These standard practices are designed to minimize ground alteration/disturbance on high-risk sites from logging practices.

Recommendation #10: Provide for riparian functions along stream reaches above impassable stream crossing structures that have a high probability of recolonization by salmonids once the structure is replaced/improved. If an upstream reach has the capacity to be a fish-bearing stream, but is currently a non-fish-bearing stream because a stream crossing structure cannot pass fish, the forest practices rules should be amended so the upstream reach is classified as a fish-bearing stream.

Recommendation #11: Facilitate the identification, prioritization, and restoration of existing culverts that currently do not pass fish. Culvert replacement should be accelerated above what is currently being done, specifically for family forestland owners who often do not have adequate resources to address this issue in a timely manner.

Recommendation #12: Provide a more effective and efficient means of classifying streams for "fish use." Revise the forest practice rule definition of Type F and Type N streams using a physical habitat approach to classify fish-use and non-use streams.

Compliance and Effectiveness Monitoring

The goal of the ODF forest practices monitoring program is to evaluate the effectiveness of the forest practice rules. Monitoring results are used to guide future management practices through the rule revision process. The goal includes a commitment to address specific Oregon Plan issues. The forest practices monitoring strategy is currently being revised. The key areas identified for improvement include:

- Building understanding, acceptance and support for the monitoring strategy.
- Using random sample design to select all sites. This has been used for two current projects.
- Combining monitoring efforts at each site to increase efficiency (i.e. compliance monitoring and riparian function at the same site)
- Increasing coordination with other Oregon Plan monitoring efforts, most notably DEQ and ODF&W.
- Addressing issues at a watershed scale.
- Improving communication of project status and results, both internally and externally using newsletters and project publications.

The following are specific recommendations for future monitoring:

1. Maintain a riparian monitoring program that continues to monitor the effectiveness of riparian prescriptions and riparian functions to ensure water quality goals are achieved in the future.

2. Monitor improvement of forest roads at a landscape level, looking specifically at implementation of the road hazard and risk reduction project.

3. Evaluate the need for further road compliance and effectiveness monitoring following the completion of the BMP compliance monitoring project relating to road BMPs. Also evaluate the progress and effectiveness of current voluntary efforts under the Oregon Plan to upgrade existing culverts that do not pass fish.

4. Monitoring of watershed-scale effects relative to current practices along small Type N streams should be a priority to help narrow the current level of uncertainty.

The following are remaining issues identified in this report that may warrant future examination as additional information is available:

- Is the occurrence of blowdown having an effect on meeting the goal of achieving "over time, average conditions across the landscape become similar to those of mature forest conditions" in RMAs?

- Are current forest practices meeting the water quality standard with respect to cold-water refugia? (This analysis will not be possible until the DEQ develops the specific guidance necessary to identify cold-water refugia on the ground that can be evaluated against the standard.)

- What effect, if any, are current practices along small non-fish-bearing streams having on downstream sediment regimes?

The Board of Forestry is currently deliberating the recommendations introduced by the Forest Practices Advisory Committee (FPAC) in September 2000. The process of implementing changes to current BMPs will occur over the next few years and is likely to consist of both regulatory and non-regulatory measures. The ODF monitoring program is also beginning a new series of effectiveness monitoring projects to evaluate BMP sufficiency in protecting riparian functions and water quality. There may also be some issues with water quality parameters that are not specifically addressed in this report that could have an unknown potential for current practices to cause changes in water quality conditions. In these cases, the DEQ will coordinate with the ODF and its monitoring program to address these parameters as concerns are identified and documented. Specific details of future monitoring efforts will be determined once the FPAC recommendations are developed further and implemented. ODF's monitoring strategy will continue to be developed at that time.

INTRODUCTION

Background

In recent years, increased attention has been given to the development of Total Maximum Daily Loads (TMDLs) and the listing of 303(d) water quality limited streams[3] in the state of Oregon under the Clean Water Act. This has presented new opportunities for the Oregon Department of Forestry (ODF) and the Department of Environmental Quality (DEQ) to move forward together to address water quality issues on non-federal forestlands. To adequately address these issues, the ODF and DEQ have agreed through an April 1998 Memorandum of Understanding (MOU) to jointly evaluate the sufficiency of the Forest Practices Act (FPA) to protect water quality. The MOU outlines five specific water quality parameters that will be addressed: temperature, sedimentation, turbidity, aquatic habitat modification, and bio-criteria.

The purpose of this sufficiency analysis, as described the MOU (Appendix D) is to determine:

(a) The adequacy of the FPA pursuant to ORS 527.765 in the achievement and maintenance of water quality standards, with due consideration to regional and local variation in effects;
(b) If forest practices contribute to identified water quality problems in listed water quality limited streams; and
(c) If so, to determine whether existing forest practice rules provide sufficient control to assure that water quality standards will be met so that waters can be removed from the 303(d) list.

The MOU provides four potential outcomes of the sufficiency analysis, as well as other water quality evaluation efforts regarding Total Maximum Daily Loads (TMDLs) and water quality management plans (WQMPs) for 303(d) listed water bodies.

> (a) For basins where agreement is reached that water quality impairment is not attributable to forest management practices, the forest practice rules will constitute the water quality compliance mechanism for forest management practices on nonfederal forestland. ODF will not participate in the development of the TMDL or WQMP except as requested to assist DEQ and as ODF budgeted resources permit. If the basin associated with a listed waterbody is entirely or almost entirely on federal land or non-forestland, ODF will have little or no involvement.
>
> (b) For basins where water quality impairment is attributed to the long-term legacy of historic forest management and/or other practices, but ODF and DEQ jointly agree that the forest practice Best Management Plans (BMPs) are now adequately regulating forest management activities and not adding to further degradation of water quality, the forest practice rules will be designated in the water quality management plan as the mechanism to achieve water quality compliance for forest operations. ODF will participate with the other Designated Management Agencies (DMAs) in developing the water quality management plan as necessary.

[3] Water quality limited streams are those waters included on the 303(d) list maintained by the DEQ. These are waterbodies currently identified as not meeting water quality standards (see Appendix E).

(c) For basins where water quality impairment may be attributable to forest management practices and ODF and DEQ cannot agree that the current BMPs are adequately regulating forest management activities, the current forest practice rules will be designated in the water quality management plan as the mechanism to achieve water quality compliance for forest operations. However, ODF will design and implement a specific monitoring program as part of the basin plan to document the adequacy of the best management practices. The schedule and scope of the monitoring program will be jointly agreed to by DEQ and ODF. During the interim, while monitoring is being conducted, the current rules will constitute the water quality compliance mechanism. If the monitoring results indicate that changes in practices are needed in a basin, the DEQ and the Board of Forestry (BOF) will use OAR 629-635-120 to create watershed specific protection rules or use other existing authority to ensure that forest management activities do not impair water quality.

(d) For basins where both ODF and DEQ agree that there are water quality impairments due to forest management activities even with FPA rules and BMPs, the DEQ and the BOF will use OAR 629-635-120 to create watershed specific protection rules or use other existing authority to ensure that forest management activities do not impair water quality.

This sufficiency analysis of the FPA will determine which of the four scenarios listed above may exist at a regional or statewide level. If the DEQ and ODF find current practices are responsible for water quality impairments, the BOF will create or modify statewide or regional rules, or design other effective measures to address the impairments. Table 1 lists the parameters the sufficiency analysis will evaluate, the applicable water quality standard and/or criteria for these parameters, and associated FPA goals and objectives.

Consistent with the MOU, water quality parameters not listed in Table 1 "are generally not attributable to forest management practices as regulated by the EPA." Given the lack of any significant information on "other" parameters that might be influenced by current practices since the drafting of the MOU, the ODF and DEQ have agreed an evaluation of parameters beyond those specifically listed in the MOU is not warranted at the time of this evaluation. Therefore, since "it is generally accepted that forest management practices have in some cases caused documented changes in temperature, habitat modification, sedimentation, turbidity, and bio-criteria," these specific parameters are the focus of this sufficiency analysis (April 1998 MOU, p.3). Standards for these parameters are defined (in brief) in Table 1, along with broad FPA goals and objectives that address them. Some issues with "other" parameters (e.g. chemical drift along Type N streams) may have unknown potential for current practices to cause changes in water quality conditions. In these cases, the DEQ will coordinate with the ODF and its monitoring program to address them as concerns are identified. The intent of the MOU and the focus of this report, however, are based on those parameters where it is known that forest practices have, in some cases, caused documented changes in water quality conditions. In such cases, the DEQ will coordinate with the ODF and its monitoring program to address these parameters as concerns are identified in the context of meeting water quality standards.

Table 1. Water quality parameters, applicable standards and/or criteria, and applicable FPA rule objectives. (See Appendix E and F for a complete description of the standards and criteria.)

<table>
<tr><th>Para-meter</th><th>Paraphrase of State Standards and/or Criteria</th><th>FPA Goals and Objectives</th></tr>
<tr><td>Temperature</td><td>Various numeric and narrative standards to protect beneficial uses.

OAR 340-41-(basin)(2)(b)</td><td>“The desired future condition for streamside areas along fish use streams is to grow and retain vegetation so that, over time, average conditions across the landscape become similar to those of mature streamside stands.” OAR 629-640-0000(2)

“The desired future condition for streamside areas that do not have fish use is to have sufficient streamside vegetation to support functions and processes that are important to downstream fish use waters and domestic water use . . .” OAR 629-640-0000(4)</td></tr>
<tr><td>Sedimentation</td><td>The formation of [any] deposits deleterious to fish or other aquatic life or injurious to public health, recreation, or industry shall not be allowed.
Documentation should indicate that there are conditions that are deleterious to fish or other aquatic life.
OAR 340-41-(basin)(2)(j)</td><td rowspan="2">“The purpose of the road construction and maintenance rules is to . . . provide the maximum practical protection to maintain forest productivity, water quality, and fish and wildlife habitat.” OAR 629-625-0000(3)

“The purpose of the harvesting rules is to establish standards for forest practices that will maintain the productivity of forestland, minimize soil and debris entering waters of the state, and protect wildlife and fish habitat.” OAR 629-630-0000(3)</td></tr>
<tr><td>Turbidity</td><td>A systematic or persistent increase (of greater than 10%) in turbidity due to an operational activity that occurs on a persistent basis (e.g. dam release or irrigation return, etc).
OAR 340-41-(basin)(2)(c)</td></tr>
<tr><td>Habitat Modification</td><td>The creation of . . . conditions that are deleterious to fish or other aquatic life . . . shall not be allowed.
Documentation that habitat conditions are a significant limitation to fish or other aquatic life.
OAR 340-41-(basin)(2)(i)</td><td rowspan="2">“The desired future condition for streamside areas along fish use streams is to grow and retain vegetation so that, over time, average conditions across the landscape become similar to those of mature streamside stands.” OAR 629-640-0000(2)

“The desired future condition for streamside areas that do not have fish use is to have sufficient streamside vegetation to support functions and processes that are important to downstream fish use waters and domestic water use . . .” OAR 629-640-0000(4)

“The purpose of the road construction and maintenance rules is to . . . provide the maximum practical protection to maintain forest productivity, water quality, and fish and wildlife habitat.” OAR 629-625-0000(3)

“The purpose of the harvesting rules is to establish standards for forest practices that will maintain the productivity of forestland, minimize soil and debris entering waters of the state, and protect wildlife and fish habitat.” OAR 629-630-0000(3)</td></tr>
<tr><td>Biological Criteria</td><td>Waters of the state shall be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.
OAR 340-41-027</td></tr>
</table>

The overall goal of the water protection rules, as stated in Oregon Administrative Rules (OAR 629-635-0100 (7)), is to provide resource protection during operations adjacent to and within streams, lakes, wetlands and riparian management areas so that, while continuing to grow and harvest trees, the protection goals for fish, wildlife, and water quality are met protection goals for fish, wildlife, and water quality are met.

> "(a) The protection goal for water quality (as prescribed in ORS 527.765) is to ensure through the described forest practices that, to the maximum extent practicable, non-point source discharges of pollutants[4] resulting from forest operations do not impair the achievement and maintenance of the water quality standards.
>
> "(b) The protection goal for fish is to establish and retain vegetation consistent with the vegetation retention objectives described in OAR 629-640-0000 (streams), OAR 629-645-0000 (significant wetlands), and OAR 629-650-0000 (lakes) that will maintain water quality and provide aquatic habitat components and functions such as shade, large woody debris, and nutrients." OAR 629-635-0100 (7)

State policy on water pollution control for state and private forestlands originates from the Environmental Quality Commission (EQC) and applicable administrative statutes:

> "To protect, maintain and improve the quality of the waters of the state for public water supplies, for the propagation of wildlife, fish and aquatic life and for domestic, agricultural, industrial, municipal, recreational and other legitimate beneficial uses." [ORS 468B.015(2)]
>
> "Implementation of any limitations or controls applying to nonpoint source discharges or pollutants resulting from forest operations are subject to ORS 527.765 and 527.770." [ORS 468B.110 (2)]

Consistent with these statutes, the FPA is Oregon's water quality standard compliance mechanism for forest operations on state and private forestlands:

> "The State Board of Forestry shall establish best management practices and other rules applying to forest practices as necessary to insure that to the maximum extent practicable nonpoint source discharges of pollutants resulting from forest operations on forestlands do not impair the achievement and maintenance of water quality standards established by the Environmental Quality Commission for the waters of the state. Such best management practices shall consist of forest practices rules adopted to prevent or reduce pollution of waters of the state. Factors to be considered by the board in establishing best management practices shall include, where applicable, but not be limited to:
>
> (a) Beneficial uses of waters potentially impacted;
> (b) The effects of past forest practices on beneficial uses of water;
> (c) Appropriate practices employed by other forest managers;
> (d) Technical, economic and institutional feasibility; and

[4] Non-point source discharges are those originating from diffuse sources across the landscape and cannot be traced to a single point or discrete activity.

(e) Natural variations in geomorphology and hydrology." [ORS 527.765 (1)]

"A forest operator conducting, or in good faith proposing to conduct, operations in accordance with best management practices currently in effect shall not be considered in violation of any water quality standards." [ORS 527.770]

These Oregon administrative rules are designed to achieve water quality goals consistent with the relevant statutes, ORS 468B.015(2), 468B.110 (2), 527.765, and 527.770 cited above. It is in this regulatory and policy context that applicable water quality standards and the FPA are implemented to address water quality protection for waters of the state.

Most of the parameters addressed in this sufficiency analysis are inter-related, and forest management activities often have the potential to affect more than one at the same time. For example, habitat modification can occur with changes in sedimentation and turbidity, and sedimentation can influence stream temperature where changes in sedimentation alter channel dimensions and subsurface hydrology, thus affecting the net heat load to the stream. It is logical to take a holistic approach and consider water quality conditions as a result of all the parameters interacting collectively rather than attempting to consider each parameter independently.

For example, the FPA goal for managing riparian forests along fish-use streams takes a holistic approach incorporating multiple riparian functions to achieve the desired condition. This condition is to grow and retain vegetation so that, over time, average conditions across the riparian landscape become similar to those of mature, unmanaged riparian stands. This goal is based on the following considerations (Lorensen et al., 1994):

(1) Mature riparian stands can supply large, persistent woody debris necessary to maintain adequate fish habitat. A shortage of large wood currently exists in streams on nonfederal forestlands due to historic practices and a wide distribution of young, second-growth forests. For most streams, mature riparian stands are able to provide more of the functions and inputs of large wood than are provided by young second-growth trees.

(2) Historically, riparian forests were periodically disturbed by wildfire, windstorms, floods, and disease. These forests were also impacted by wildlife such as beaver, deer, and elk. These disturbances maintained a forest landscape comprised of riparian stands of all ages ranging from early successional to old-growth. At any given time, however, it is likely that a significant proportion of the riparian areas supported forests of mature age classes. This distribution of mature riparian forests supported a supply of large, persistent woody debris that was important in maintaining quality fish habitat.

The Independent Multidisciplinary Science Team (IMST) has recommended that "the goal of management and policy should be to emulate (not duplicate) natural process within their historic range." This is consistent with the FPA goals, assuming mature forests were historically a significant proportion of riparian landscapes.

Accordingly, this report takes a broad approach to examining the sufficiency of the FPA and considers multiple factors and functions by evaluating water quality standards primarily through the FPA rule objectives. Figure 1 illustrates the various BMPs, and their relationship to water quality parameters analyzed in this report. Table 2 provides a brief description of the function pathways that provide a link between the water quality parameters and specific forest practices.

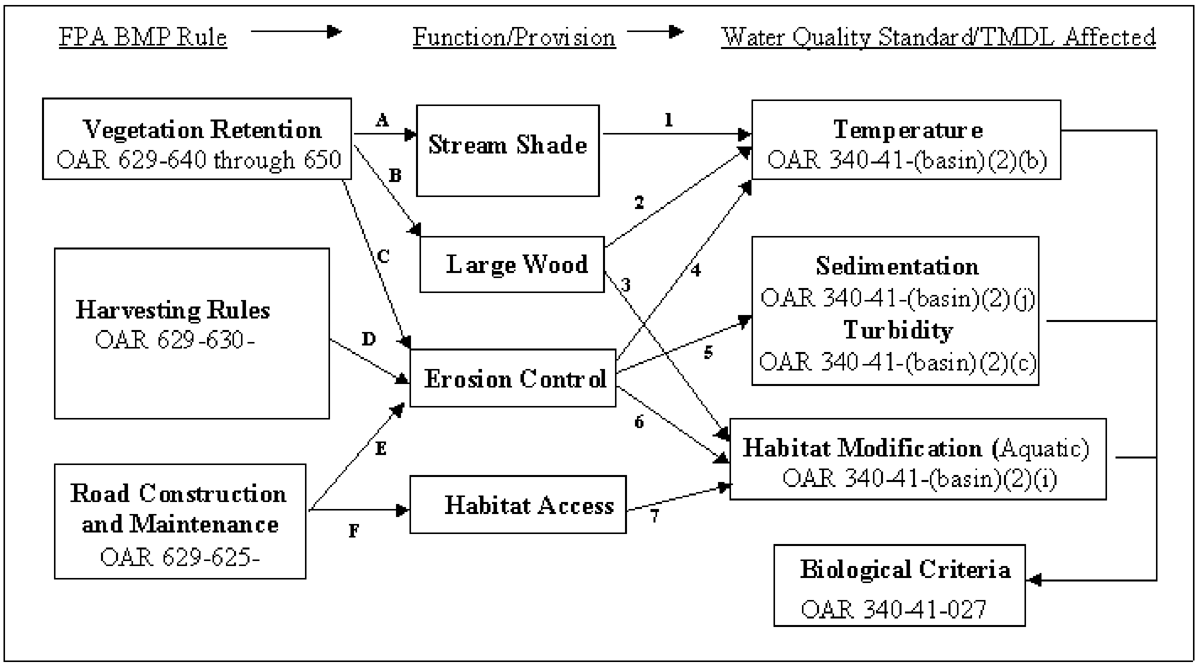

Figure 1. Water quality function pathways between the FPA and water quality criteria and standards.

Overview

With the exception of temperature and turbidity, the water quality standards for all parameters in Table 1 are to protect against those conditions that are "detrimental" or "deleterious" to fish or aquatic communities. This level of protection is comparable to the "fishable/swimmable " standard derived from the Federal Clean Water Act, as well as the water quality goals described in ORS 468B.015(2) and 468B.110 (2). The FPA has specific goals to address resource protection designed to be consistent with federal and state water quality goals. Specifically, the regulation of forest practices in the State of Oregon must be "consistent with sound management of soil, air, water, fish and wildlife resources . . . that assures the continuous benefit of those resources for future generations of Oregonians"(ORS 527.630(1)).

It is evident the goals and objectives of the FPA administrative rules are consistent with state water quality goals to protect beneficial uses. Temperature and turbidity are the only two parameters that have specific numeric criteria not directly comparable with the FPA goals and objectives, and these two parameters are evaluated to the extent possible, given available data. However, where data is lacking relative to quantitative standards, the evaluation of the sufficiency of current practices in meeting state water quality goals and standards, as articulated in ORS 468B.015(2), is done through an evaluation of how well current practices are meeting the FPA goals.

Table 2. Overview of potential water-quality-protective functions related to forest practices (see Figure 1).

Flowchart Pathway	*Function/Provision Description for Specified Parameter*
	Water Temperature
A1	Retained trees and understory vegetation in riparian areas adjacent to streams provide shade to streams. Shade reduces heat loading from solar radiation at levels corresponding to the percent effective shade on the stream, and can attenuate diurnal maximum and minimum stream temperatures.
B2	Large wood, placed or fallen into streams from retained riparian vegetation and positioned in the stream channel, may increase the complexity of in-channel habitat, creating pools and riffles. Deep-water areas of cooler temperatures, or cold-water refugia, can also result from large wood in streams.
C4	Vegetation retention on banks can decrease channel bank erosion and prevent channel widening. Narrow channels receive less solar radiation and stream heating relative to wider channels (all else being equal).
D4, E4	Road construction and maintenance practices that minimize sediment inputs to streams, such as location, drainage control, hard surfacing, and choice of hauling time, may prevent channel widening and temperature increases as described in C4.
	Sedimentation and Turbidity
C5	Vegetation retention on banks can decrease channel bank erosion, decreasing sediment inputs.
D5, E5	Road construction and maintenance practices that minimize sediment inputs to streams, such as location, drainage control, hard surfacing, and choice of hauling time, reduce undesirable levels of sediment and turbidity inputs.
	Habitat Modification
B3	Tree retention in riparian areas may provide future recruitment of large wood to streams. Historically, large wood in channels recruited from fallen trees has been a valuable component of aquatic habitat. Managed placement of large wood can be an effective means to accelerate inputs.
C6, D6	Large wood, placed or fallen into or near streams from retained riparian vegetation may serve to trap sediments in place, influencing habitat quality.
E6	The movement of large wood and sediment downstream is an important function that provides for, and maintains, fish habitat. Stream crossings that are designed to accommodate this function can have a positive influence on habitat quality.
F7	Culverts that block fish passage reduce the amount of fish habitat available.
	Biological Criteria
Interrelated	Forest practices that influence water quality with respect to temperature, sedimentation, turbidity, and habitat modification may also affect biotic populations with respect to the biological criteria standard.

Given the consistency between the FPA and state water quality statutes, the achievement of FPA goals, as articulated in the administrative rules, will ensure water quality goals are achieved. Thus, this sufficiency analysis will consider the adequacy of the rules in achieving the objectives and goals of the FPA, thereby determining their sufficiency in meeting water quality standards. If current practices are meeting FPA objectives and goals, state water quality standards will be met as well. If the DEQ and ODF find FPA objectives and goals are not being met, the Board of Forestry will create or modify statewide or regional rules, or design other effective measures to address water quality impairments.

As stated above, to evaluate the sufficiency of the FPA, effectiveness will be measured by how well FPA goals and objectives are met and whether water quality standards are achieved (Figure 2). Where the DEQ and ODF agree current practices will result in meeting water quality standards, condition (a) or (b) of the MOU exists (i.e. no change in the FPA). Where the DEQ and ODF agree that current practices will not result in meeting water quality standards, condition (d) exists (i.e. recommend change in FPA or design other effective measures to address the water quality impairment). In cases where uncertainty prevails, condition (c) will exist. Under condition (c), a specific monitoring program will be implemented to document the adequacy of the FPA.

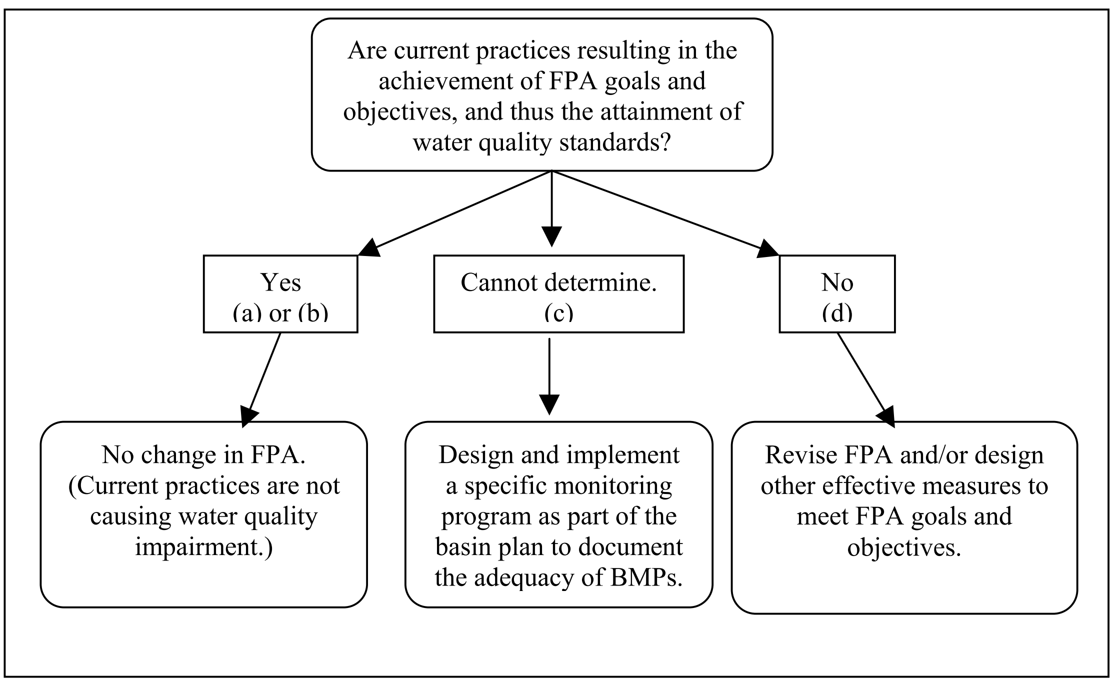

Figure 2: FPA sufficiency analysis flow chart.

In analyzing natural resource data and attempting to draw specific cause-and-effect conclusions between human activities and natural resource conditions, the quality and/or quantity of data necessary for a high level of scientific certainty is often not available. This effort at evaluating the sufficiency of the FPA is no exception. Available data pertinent to direct cause-and-effect linkages between the FPA and quantitative water quality conditions is very limited. Given this fact, it should be acknowledged that assessing the sufficiency of forest practices relative to meeting water quality standards requires an evaluation based on a combination of qualitative and quantitative information. The consideration of social and economic factors required by state statutes is outside the scope of this analysis, where the responsibility rests with the Board of Forestry relative to forest practices on non-federal forestlands. This separate Board of Forestry process will involve taking a comprehensive look at the data, acknowledging the strengths and weaknesses of the scientific findings, and then making a policy determination on what course of action is deemed consistent with the social, economic, and environmental framework under which the FPA currently operates.

There are at least two general points of view regarding such scientific uncertainty. One is to assert that since it cannot be determined with certainty that a set of practices *is* achieving a given water quality standard, a conservative approach should be taken and the rules changed to provide a higher level of protection in case a significant risk does, in fact, exist. Another view is to assert that since it cannot be determined with certainty that a set of practices *is not* achieving a given water quality standard, there is no reason for a change in practices until further monitoring and/or research can prove that a significant risk does, in fact, exist. Both points of view are valid when scientific findings are uncertain, and values and beliefs play a large role in how these points of views utilize limited scientific information.

One task of the ODF and DEQ sufficiency analysis is to present and analyze all of the applicable science and information. Following the completion of this analysis, the Board of Forestry will consider the recommendations in light of the relevant social, economic, and environmental context of the FPA. The goal of this approach is to utilize the recommendations so that outcomes are consistent with both the scientific information and the existing socio-economic framework of the FPA.

<u>Social, Economic, and Environmental Framework</u>

For the report recommendations to be acted upon following its completion, a review of the legal and policy setting, Oregon's forest land base, and forest ecosystem dynamics will need to be considered by the Board of Forestry in reviewing the adequacy of the FPA in meeting water quality standards "to the maximum extent practicable" as defined by state statute. Appendix A provides this review and describes the overall context in which the FPA operates. There are different environmental, social, and economic implications, depending on the interpretation of "maximum extent practicable," and these implications should be considered for this evaluation to result in an outcome that does not create unintended negative consequences for resource protection. For example, increased forestry regulations in Washington state, combined with development pressures, are partly responsible for ten-times the area of forestlands being converted to other land uses as compared to Oregon over the last decade. While these increased regulations may have resulted in some increase in resource protection for forestlands at a site-specific level, it may have been at the cost of losing an area of land (400,000 acres) to other uses that may not provide as high a level of resource protection as forestlands. Taking into account the social, economic, and environmental aspects in evaluating FPA-sufficiency early on can help to avoid this type of unintended negative consequence, while also ensuring that statutory obligations are met.

Current Scientific Knowledge

Appendix B is a review and summary of the current scientific findings and monitoring results relevant to specific forest practice issues directly related to achieving water quality goals. Each of the water quality parameters that are the subjects of this report are linked to specific forest practice issues that address those parameters. The forest practice issues reviewed here include stream temperature, large wood, forest roads, landslides, and fish passage. The technical information included in this section of the report is used as the basis of the evaluations and recommendations developed in the remainder of this report, and they are referenced accordingly.

Description of Pollution Control Mechanisms

Appendix C describes the current pollution control mechanisms implemented to meet or exceed current water quality standards. These mechanisms include both the FPA and Oregon Plan voluntary measures. They are organized under the same forest practice issues outlined in Appendix B.

Evaluation and Recommendations

The remainder of the report evaluates the sufficiency of the FPA in meeting water quality standards and provides recommendations. Following the evaluation and recommendations, the report concludes with a summary of current and future FPA compliance and effectiveness monitoring.

EVALUATION OF POLLUTION CONTROL MECHANISMS

Stream Temperature

In evaluating the effectiveness of the FPA in meeting stream temperature standards, there are specific numeric criteria, as well as narrative water quality standards. The narrative standard of 'no measurable temperature increase' is triggered by any one of several numeric criteria, depending on water quality and/or aquatic habitat conditions (see Appendix E and F). To the extent data is available, the FPA is evaluated relative to these specific standards. Where standard-specific data is lacking, the effectiveness of the rules in achieving the goals of the FPA to protect stream temperature will be evaluated.

<u>Temperature Monitoring Information</u>

The ODF has an ongoing stream temperature-monitoring program that focuses on the effectiveness of RMA prescriptions (Table 3) and riparian conifer restoration (RCR) in maintaining stream temperatures. A report on the results from 1995 monitoring data provides some information on how the rules relative to stream temperatures (Dent and Walsh, 1997). All but one of the monitoring sites included in this study are medium and large streams (under ODF stream classification).

> Results from this monitoring project are limited by a lack of pre-harvest data and by variability among the sample sites. Differences in elevation, harvest methodology, and georegion as well as data collection problems, especially with canopy cover, contributed to a highly variable sample population. However, consistent, if not significant, increases in stream temperature below harvested reaches indicate that the forest protection rules may not always provide adequate protection to meet water quality standards. (Dent and Walsh, 1997)

Temperatures were recorded continuously over the summer season on thirteen stream reaches and at a number of points throughout the Brush Creek watershed. Five of the reaches were managed RMAs and eight of the reaches were riparian conifer restoration sites (a.k.a., hardwood conversions). For each reach, temperature probes were placed in the stream above the harvest unit, immediately below the harvest unit, and downstream of the harvest unit under an unmanaged canopy.

> The water quality standard[5] for seven-day moving average of maximum (64°F) was exceeded more often downstream of harvested units than upstream. On all streams, the standard was exceeded only 9.4 percent of the time. However, only three of the thirteen streams never exceeded the water quality standard[1]. (Dent and Walsh, 1997)

Two types of statistical analyses on this data set resulted in contradictory results. One test was a repeated-measures Analysis of Variance (ANOVA) of the residuals that showed no statistical

[5] The word "standard" in this quotation is acutally referring to a numeric criterion.

effect of the harvest units on stream temperature. Residuals were used to remove the influence of the 'natural' tendency for stream temperatures to increase in the downstream direction in relation to the distance from divide. A repeated-measures ANOVA was also carried out on the raw data (instead of using residuals). This method is a statistical test of the raw data that also has the ability to remove the influence of the 'natural' tendency for stream temperatures to increase in the downstream direction. This second test did show a statistically significant effect from harvesting. Reaches sampled higher in the basin did show a corresponding decrease in temperature 500 feet downstream, while those reaches sampled lower in the basin did not show a decrease in stream temperature 500 feet downstream of treatment. All but one of the stream reaches Dent and Walsh (1997) examined were medium and large streams (by ODF classification), where either an RMA or RCR prescription was applied.

Table 3. Summary of RMA retention requirements under the FPA. See Appendix C for a more detailed description.

Stream Type	Summary of Applicable rules [OAR 629-640-0200].
Small Non-fish bearing (N)	Retention of merchantable trees is not required along small Type N streams in Oregon on private forestlands. Small streams are defined as having an average annual flow of less than two cubic feet per second. Retention requirements for understory vegetation and non-merchantable conifer trees (less than 6 inches DBH) for small Type N streams are as follows: None in the Coast Range and Western Cascades Georegions; all within 10 feet of the of the high water level for eastern Oregon and Blue Mountain perennial streams; portions of perennial streams in the South Coast, Interior, and Siskiyou Georegions.
Small Domestic Use only (D)	20-foot no-cut zone (no retention requirements beyond this zone).
Medium Type N and D	20-foot no-cut zone, 10 live conifers (8 inch DBH or greater), and basal area retention of 50 to 60 sq. ft/ RMA (50 X 1000 ft) dependent on the harvest type, management type, and georegion.
Large Type N and D	20-foot no-cut zone, 30 live conifers (11 inch DBH or greater), and basal area retention of 70 to 160 sq. ft/ RMA (70 X 1000 ft) dependent on the harvest type, management type, and georegion.
Small Fish-bearing (F)	20-foot no-cut zone, and basal area retention of 40 to 50 sq ft/ RMA (50 X 1000 ft) dependent on the harvest type, management type, and georegion. Active management targets, which only apply when the basal area credit prescription is used, are 20 to 30 sq. ft/ RMA (50 X 1000 ft).
Medium F	20-foot no-cut zone, 30 live conifers (8 inch DBH or greater), and basal area retention of 90 to 180 sq. ft/ RMA (70 X 1000 ft) dependent on the harvest type, management type, and georegion. Active management targets, which only apply when the basal area credit prescription is used, are 70 to 160 sq. ft/ RMA (70 X 1000 ft).
Large F	20-foot no-cut zone, 40 live conifers (11 inch DBH or greater), and basal area retention of 170 to 350 sq. ft/ RMA (100 X 1000 ft) dependent on the harvest type, management type, and georegion. Active management targets, which only apply when the basal area credit prescription is used, are 130 to 310 sq. ft/ RMA (100 X 1000 ft).

What about small Type N streams that receive little or no canopy cover retention under the current rules following an adjacent harvest operation? Caldwell et al. (1991) and Robison et al. (1995) provide some information about how current rules for small Type N streams affect stream temperature. Caldwell et al. (1991) examined the extent of temperature increases on "Type 4" streams (comparable to the category of small streams in Oregon) on downstream waters[6].

> In cases where a single stream channel changed from a Type 4 to a Type 3[7] water type, short response distances were seen, in response to changes in the riparian shading levels. Maximum equilibrium temperatures were quickly established dependent on the downstream conditions once the water entered the Type 3 (shaded) reach. The response distance was typically 150 meters or less with no effect on temperature from the harvested Type 4 stream downstream of the response distance. . . . The response of the Type 3 [the downstream receiving stream] never exceeded 0.5°C [1°F] change in temperature attributable to the incoming Type 4 stream. Reasons include the typical small size of the Type 4 tributaries in relation to the Type 3 receiving streams, and the relatively cool temperatures seen in some Type 4 reaches despite total removal of overstory canopy. (Caldwell et al., 1991)

This study also observed that several of the Type 4 stream reaches monitored for temperature exceeded Washington water quality standards, and harvested streams were as much as 2-8°C higher than for streams at similar elevations with mature forest canopies. Despite these increases, the elevated temperatures in many of these streams still remained well below the water quality numeric criteria. However, there were examples in both harvested and forested Type 4 streams where the temperature standard was exceeded.

Robison et al. (1995) conducted a similar study on stream temperature response on small Type N streams in the Oregon Coast Range and Interior Georegions. As with Caldwell et al. (1991), Robison et al., also observed stream temperatures that exceeded the water quality standard in forested stream reaches. There was a total of eight monitoring sites that evaluated stream temperature flowing through clearcut sites.

> In general, maximum water temperatures for streams flowing out of clearcut units were below 60°F. Two clearcut unit streams had maximum water temperatures greater than 60°F [one of which exceeded 64°F]. For most of the clearcut units, there was significant cooling below the unit as the streams re-entered the forest canopy. This finding is consistent with previous temperature monitoring on small headwater streams. (Robison et al., 1995)

Temperature Monitoring Conclusions: Based on ODF monitoring results and other studies, the following general conclusions can be made regarding forest harvesting and stream temperature, as it pertains to the water protection rules.

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[6] Since this study was published, surveys of Type 4 streams in Washington are showing that a substantial number of them are actually fish-bearing streams. Thus, they may, in fact, be more comparable to small Type F streams in Oregon.
[7] Small to medium streams as defined under the FPA.

- For small, headwater streams, while stream temperatures can increase after harvest, there is the potential for temperature increases due to canopy removal to diminish within 500 feet downstream of the harvest activity (Caldwell et al. 1991). It should be noted, however, that magnitude of recovery of cooler temperatures in downstream shaded reaches is highly variable, and dependent on reach-specific heat exchange processes.

- For stream reaches through managed RMAs and RCRs on medium and large streams, Dent and Walsh (1997) found that 90 percent of the time, those streams that were monitored had temperatures at or below the 64°F numeric criteria. Dent and Walsh (1997) could not separate out the proportion of the temperature increase that is attributable to a partial decrease in shade versus the proportion that is attributable to any expected downstream increases in stream temperatures. Further study of the effects of RMA prescriptions and RCRs on stream temperatures with pre-harvest data and a basin-wide perspective is needed to more adequately estimate the range of harvesting effects on stream temperature. The Oregon Department of Forestry will be analyzing their complete temperature monitoring database in 2003. This may help address some of the unresolved issues.

Shade Monitoring Information

To the extent that current practices may result in changes in shade, thereby influencing stream temperatures due to change in solar radiation inputs to the stream, the ODF Technical Report on the Riparian Functions Study (ODF 2001a) provides some additional information relevant to FPA effectiveness (Figure 3). Findings from this study indicate that shade levels along large Type F streams are likely to remain relatively unchanged following harvest activities, where observed variations in shade are within the range of measurement error (± 10%). Most medium Type F streams also did not have changes in shade levels outside the range of measurement error, with only two out of eight sites resulting in shade reductions greater than 10 percent. A substantial proportion of the small Type F streams (four out of nine), exhibited shade reductions in excess of 10 percent in the year following harvest activity.

The ODF Shade Study (ODF 2001b) also provides some additional information relative to FPA effectiveness. (See Appendix I for additional information on this study.) It is important to note this study was not designed to compare pre- and post-harvest conditions, given the fact that data was collected over a single season. There is also a high degree of variability in site characteristics between some sites monitored in this study. Any attempt to draw specific conclusions about the importance of an individual riparian characteristic's influence on shade can be problematic. Despite these caveats, a qualitative comparison of shade conditions observed between site categories is presented in Table 5 and Figure 6 (ODF 2001b). The following are excerpts from the Shade Study final report:

> "For those sites monitored in this study, shade was general[ly] lower on large streams than on small and medium streams. For unharvested streams[8], shade was lower on large streams than on small and medium streams by an average of 5% and 9% in the Blue Mountain and Coast Range Georegions, respectively. However, the small sample size and wide range in shade on large streams limits the explanatory power of stream size on shade [Table 5 and Figure 6]. There was considerable overlap between shade values over small and medium size streams for both harvested and unharvested streams in both georegions. Two extreme points are displayed in the box plots [Figure 6] for the harvested Blue Mountain and Coast Range streams. While the low shade value in the Coast Range may be explained by blowdown, there is no readily apparent reason for the extreme point in the Blue Mountains. . ."
>
> "Average stream shade in harvested stands was 15% and 11% less than unharvested stands in the Blue Mountain and Coast Range Georegions, respectively. In the Blue Mountain Georegion, the average shade was 58% and 73% for harvested and unharvested streams, respectively. In the Coast Range Georegion, the average shade was 73% and 84% for harvested and unharvested streams, respectively. Differences in shade between harvested and unharvested reaches ranged from 44% lower to 6% greater and 38% lower to no difference in the Blue Mountain and Coast Range Georegions, respectively. Harvested stands also had greater variability than unharvested stands for both georegions. While the upper ranges of shade are comparable to unharvested stands, shade over streams adjacent to harvested stands had much lower minimum shade levels (-21%)."(ODF 2001b)

Cold-Water Refugia

Oregon forested watersheds exhibit a high degree of variability in water temperature. The existence of 'cold-water refugia' is an important component of salmonid habitat because they provide holding (resting) and rearing habitat for juveniles and adult fish. Types of cold-water refugia include, but are not limited to: tributary mouths; lateral seeps; pool bottom seeps; and groundwater-to-surface interaction zones (Bilby, 1984).

Bilby (1984) determined the mouths of tributaries in a western Washington stream (Thrash Creek) averaged 8.5°F lower than the average stream temperatures of the receiving waters fed by the tributaries. Cool water pockets located at tributary mouths of western Washington streams constituted less than 1.5 percent of the overall flow volume of the watershed, while cool water areas of all types accounted for approximately 2.9 percent of the total water volume (Bilby, 1984).

[8] "Unharvested" streams are defined in this study as having not been disturbed for at least 25 years and a maximum of 160 years. Fire may have been excluded from some of these stands, especially in the Blue Mountain region.

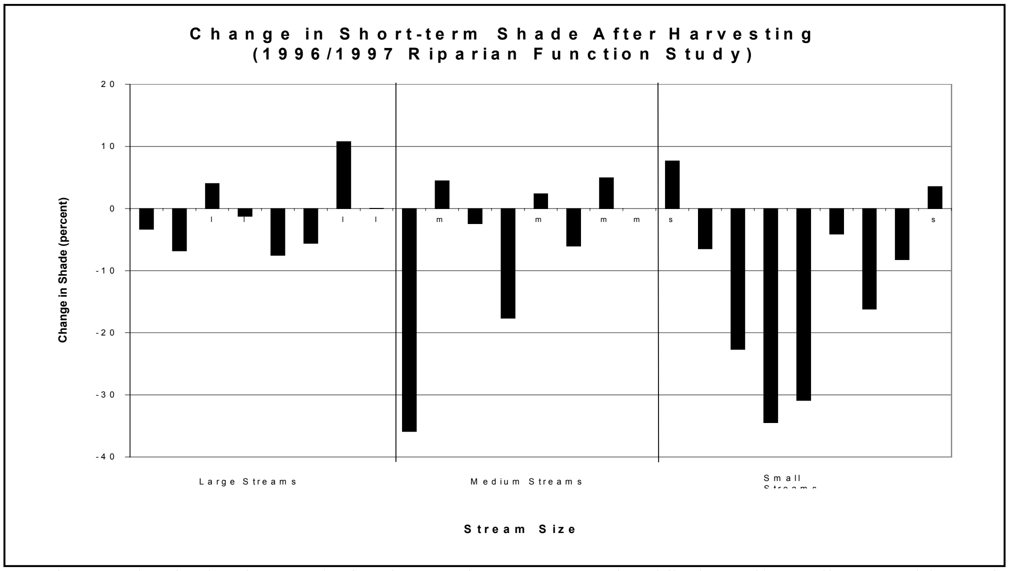

Figure 3. Changes in shade observed after harvesting on ODF-classified small, medium, and large forested streams in western Oregon. The range of measurement error is approximately ±10%. (ODF 2001a)

Table 5 (ODF 2001b). Shade and bankfull widths of harvested and unharvested sites in the Blue Mountain and Coast Range Georegions.

Blue Mountain Stand Type	Shade and Bankfull Width by ODF Stream Size											
	Small (n)			Medium (n)			Large (n)			Total (n)		
	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.
Harvested	12			7			2			21		
Shade (%)	40	60	80	29	55	69	28	55	83	28	58	83
Bnkfl. Width (ft)	6	14	21	17	24	32	23	32	41	6	19	41
Unharvested	2			6			4			12		
Shade (%)	63	73	84	63	74	83	72	80	88	63	73	88
Bnkfl. Width (ft)	10	12	15	20	26	36	21	29	37	10	25	37
Coast Range Stand Type	Shade and Bankfull Width by ODF Stream Size											
	Small (n)			Medium (n)			Large (n)			Total (n)		
	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.
Harvested	12			6			1			19		
Shade (%)	51	72	83	61	77	89	NA	55	NA	51	73	89
Bnkfl. Width (ft)	5	10	17	17	20	27		32		5	14	32
Unharvested	2			3			2			7		
Shade (%)	83	89	95	85	89	93	66	69	72	66	85	95
Bnkfl. Width (ft)	6	7	8	7	19	26	30	33	37	6	14	37

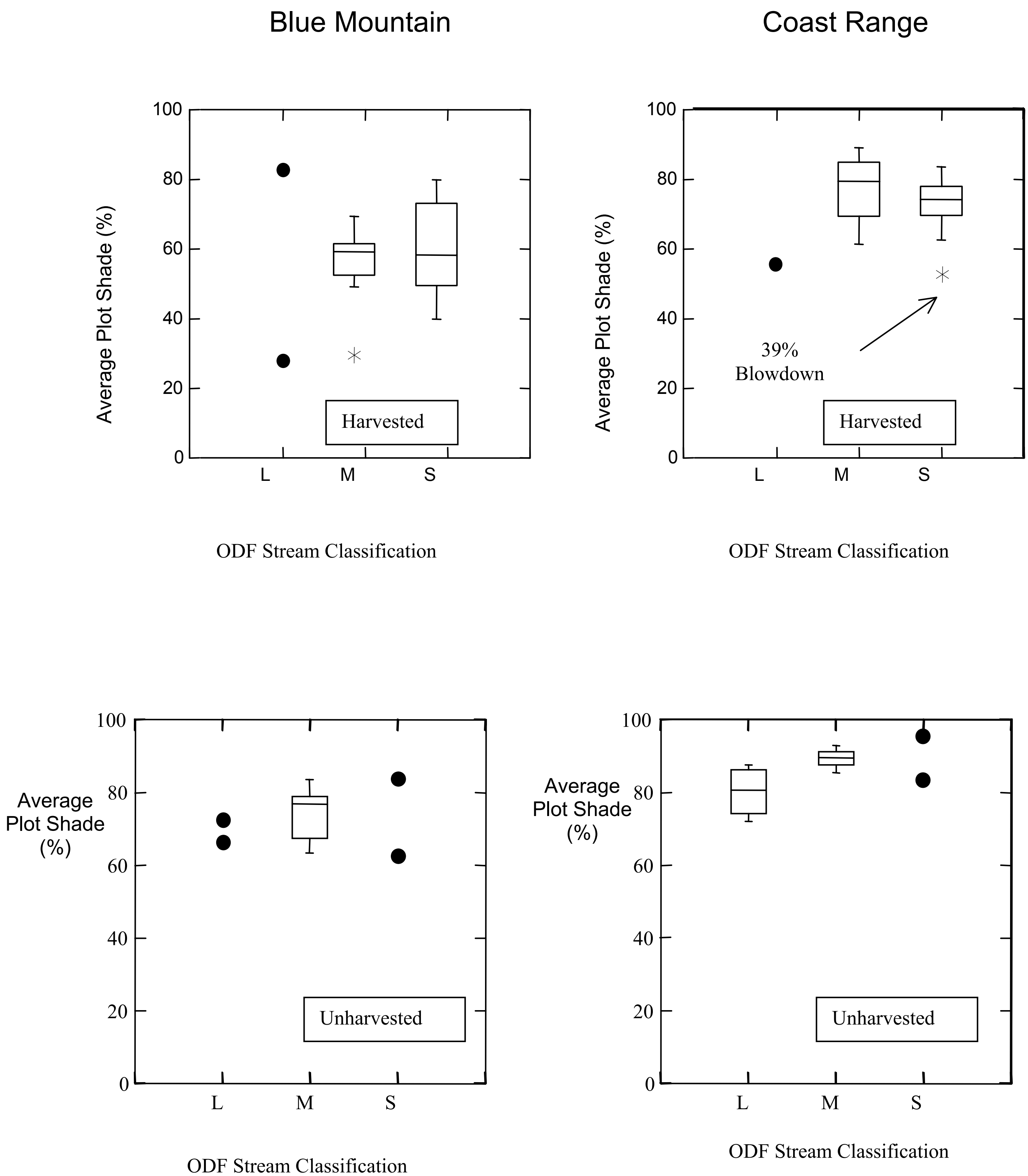

Figure 6 (ODF 2001b). Range in shade by ODF stream size class, for harvested and unharvested fish-bearing streams in each georegion (L = large, M = medium, S = small).

Cold-water refugia are addressed in water protection rule OAR 340-041-0205 (2)(b)(A) ". . . no measurable surface water temperature increase resulting from anthropogenic activities is allowed: (v) In waters determined by the department to be ecologically significant cold-water refugia;"

By definition [OAR 340-041-0006 (57)], "Ecologically Significant Cold-Water Refuge" exists when all or a portion of a waterbody supports stenotypic cold-water species (flora or fauna) not otherwise widely supported within the subbasin, and either: (a) Maintains cold-water temperatures throughout the year relative to other segments in the subbasin, providing summertime cold-water holding or rearing habitat that is limited in supply, or;
(b) Supplies cold water to a receiving stream or downstream reach that supports cold-water biota.

A specific delineation of what constitutes cold-water refugia (i.e. spatial extent and operational definition) and guidance on how to identify these areas has not been completed by DEQ. Until this is done, evaluating the FPA in terms of protecting cold-water refugia is not possible. There are many potential areas that might be considered in the evaluation cold-water refugia and the adequacy of the FPA. Given all of these factors, rule adequacy, as it pertains to this issue, may still need to be addressed at some point in the future.

Landscape-Scale Perspective

The effect of current practices, as well as past practices, can also be examined on a landscape-scale relative to historical conditions. For example, consider the historical distribution of forest age classes in the Coast Range, as compared to the current distribution on non-federal forestlands (Figure 4).

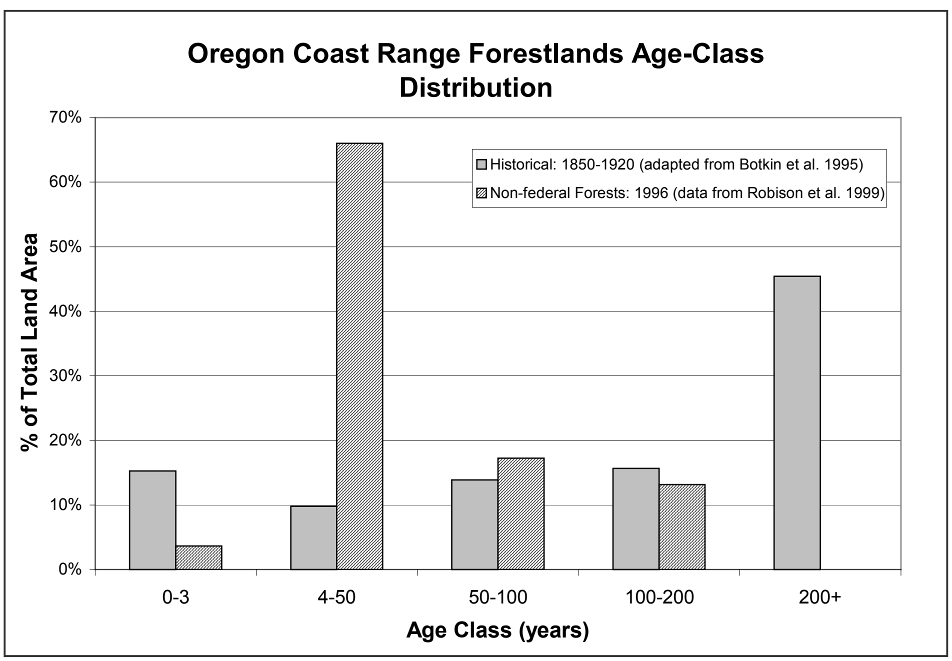

Figure 4. Comparison of historical forest age class distribution to current forest age class distribution on non-federal forestlands for the Coast Range.

Referencing the discussion in Appendix A on patterns of disturbance and natural variability, it is important to keep in mind that there is some variation in the historical distribution of stand ages that is not depicted in Figure 20. It is apparent, however, that on a landscape-scale there has been a shift in the distribution of age classes, where a reduction is observed in both the 0-3 and 200+ categories and an increase is observed in the 4-50 year category. The land area occurring in the 50-100 and 100-200 categories has generally remained unchanged when considering temporal variability. Consider Table 4 and the associated relative shade levels of different age classes, based on the earlier discussion of forest succession and stand dynamics. It appears that a shift in age class distribution has occurred on state and private forestlands on the Coast Range. There has been a decrease in land area occupied by age classes with 'moderately high' to 'very low' shade levels (0-3 & 200+), and an increase in the land area occupied by an age class with 'moderate' to 'very high' shade levels (4-50). If it is assumed the age class distribution across the entire landscape of the Coast Range approximates the age class distribution for riparian forests, there is a reasonable probability that current shade levels on state and private forestlands are higher on average than what occurred historically. To the extent that the difference in shade levels may be influencing stream temperature, there is the possibility that temperature conditions have shifted as well.

Effective fire suppression over the past century is another factor likely to have contributed to producing higher shade levels than what occurred historically. A U.S. Forest Service fire sciences laboratory analysis created a Geographic Information System (GIS) map of the historical fire regimes in the state of Oregon, as well as the current fires condition classes (see Appendix J). It is evident that in all georegions, except for the Coast Range and highest elevations of the Cascade Range, the fire regimes have been moderately or significantly altered. In many cases, the alteration of the fire regime translates into more densely stocked forests that are at a greater risk for catastrophic fire. Very dense forests provide relatively high levels of shade, precluding understory development.

Table 4. Summary of historical distribution of forest types and associated shade.

	Age of Riparian Forest (years)				
	0-3 (Stand Type 1)	4-50 (ST 2)	50-100 (ST 2-3)	100-200 (ST 3-4)	200+ (ST 4-5)
Portion of the Landscape Historically in this Age Class (adapted from Botkin et al., 1995)	**5-15%**	**10-15%**	**15-20%**	**15-20%**	**40-50%**
Portion of the Landscape Currently in this Age Class (data source: Robison et al., 1999)	**4%**	**66%**	**17%**	**13%**	**0%**
Relative shade levels[9]	**Very Low to Moderate**	**Moderate to Very High**	**High to Very High**	**Moderately High to High**	**Moderately High**

Sedimentation and Turbidity

As described in the introduction of this report, the water quality standards and criteria for sedimentation include general narrative standards consistent with FPA goals and objectives for water quality protection relative to sedimentation. Turbidity, on the other hand, does have a 'relative' numeric standard (10 percent above background turbidity) based on an upstream-downstream comparison (Table 1, p. 5). Data, however, is not currently available to evaluate this standard relative to specific forest activities conducted under current practices. Thus, the effectiveness of current practices in meeting water quality standards for both sedimentation and turbidity will be evaluated relative to the goals of the FPA intended to provide protection for these parameters. The evaluation of current rules is based, in large part, on the results of ODF monitoring, since practices used outside of Oregon may be very different and because road management practices have changed significantly over time.

How effective are the current BMPs at minimizing the delivery of sediment and turbidity to channels? ODF monitoring data shows that about one-third (29 to 39 percent) of active and inactive roads on state and private lands can deliver sediment to streams by ditch delivery (ODF, 1996). There is the potential for significant amounts of turbidity to be created from these sources, especially during hauling operations in the wet season. For the portions of the road network where sediment delivery is occurring, a number of issues have been identified that are contributing to the problem:

- A lack of rules that specifically address minimizing turbidity caused by wet-weather hauling.
- Monitoring has shown a general lack of filtering of drainage waters near streams.
- Cross drainage structures are often not in place to filter road runoff before reaching stream crossings.

[9] The relative shade levels described here are based on best professional judgement considering the information on forest succession dynamics (Appendix A) and data on shade conditions along streams with forests of varying ages (Appendix B).

- Steep-gradient roads tend to have cross drainage structures at wider spacing than lower-gradient roads. Under the current rules, road design and maintenance practices should result in steep-gradient roads having cross drainage structures with narrower spacing relative to lower-gradient roads.
- There are inconsistencies in drainage practices between georegions, with special concerns in the Siskiyou Georegion.
- In some areas, road maintenance and repair is inadequate, according to the rules.

Forest Road-Related Landslides: The following are conclusions from Robison et al. (1999). These findings include the most current information addressing the adequacy of the forest practice rules related to landslides and forest roads:

- Landslides associated with forest roads made up a smaller percentage of the total landslides in the ODF study, than in most previous studies.
- Road-associated landslides identified during the ODF study were smaller, on average, than road-associated landslides in past studies. However, these road-associated landslides were four-times larger, on average, than those landslides not associated with roads.
- Landslides that delivered sediment to stream channels rarely occurred on roads crossing slopes of less than 50 percent, especially when those roads had well spaced drainage systems and fills of minimal depth.
- Road fill placed on steep slopes created an increased landslide hazard, even where no drainage water is directed to those fills.
- Road-drainage waters directed onto very steep slopes created an increased landslide hazard, even when there was no road fill placed on those very steep slopes.
- In the ODF study, washouts were a significant problem in Tillamook, and to a lesser extent in Vida study areas. Washouts were often related to undersized culverts (installed prior to current rule requirements).
- Based on the lower numbers of road-associated landslides surveyed in the ODF study and on the smaller sizes of these landslides (as compared with previous studies), current road management practices are likely reducing the size of road-associated landslides and the number of landslides.

In addition to the conclusions from Robison et al. (1999), there are three other studies that examined current road construction standards. A road damage inventory conducted in Washington found that roads constructed in the last 15 years survived a landslide-inducing storm with minimal damage, while roads constructed earlier had very high damage rates (Toth, 1991). Department of Forestry landslide monitoring has made similar findings in Oregon (Mills, 1991). Although most surface erosion tends to occur in the first few years after construction, or during periods of heavy traffic use, landslides can occur many decades after original construction. Roads built using current construction practices (steep grades, full-bench design, and end haul construction) have been found to reduce landslide frequency and size compared to roads constructed using pre-1984 practices (Sessions, 1987).

Harvesting-Related Landslides and Forest Stand Condition: The following are conclusions from Robison et al. (1999). These findings include the most current information addressing the adequacy of the forest practice rules related to landslides and debris flows.

- Timber harvesting can initiate landslides in areas with moderate to high landslide risk. In three out of four ODF storm monitoring study areas, higher landslide densities and erosion volumes were found in stands that had been harvested in the previous nine years, as compared to forests older than one hundred years. Forested areas between the ages of 10 and 100 years typically had lower landslide densities and erosion volumes than those found in mature forest stands (Robison et al., 1999).
- There is significant landslide risk on very steep slope regardless of the age of vegetation, especially in certain geologic formations, where major storms and landslide processes are the dominant means by which the landscape is shaped.
- Landslides from recently harvested and older forests can have similar dimensions, including depth, initial volume and debris flow volume (Robison et al., 1999).
- Variability in both storm and site characteristics can be a dominant influence on landslide occurrence.
- Any disturbance that removes vegetation on steep, landslide-prone locations results in increased landslide occurrence. Both the length of time these locations experience periods of reduced forest cover and the extent of lands with reduced vegetative cover can affect landslide density and erosion rate.
- Landscape-level disturbances can result in large, contiguous areas in a condition susceptible to landslides.
- Alternative management strategies for high-risk sites should be carefully monitored. This will take considerable time, since landslides are a geologic process (variable in both time and space). The effectiveness of specific practices, therefore, will be difficult to evaluate until the landscape has experienced major storms and/or prolonged exposure to geologic processes.

Landslide-Related Stream Channel Impacts: The following are conclusions from Robison et al. (1999). These findings include the most current information addressing landslide-related stream channel impacts on forestlands in Oregon.

- In the ODF study, stream channel impacts varied greatly by study area and were not directly related to the number of landslides. Large, up-slope landslides originating above small channel junction angles ($<70^o$) and steep channel gradient slopes resulted in the greatest stream channel impacts.
- Debris torrents reduce stream shading, especially when they travel through younger stands.
- Debris torrents have only a minor effect on active channel width.
- The Benda-Cundy model provides a reliable tool for determining maximum potential travel distances of "typical" debris flows and torrents from forested slopes. Less than 10 percent of the total landslides in the ODF study traveled farther than predicted by the Benda-Cundy model (Benda and Cundy, 1990). The debris torrents that traveled farther than predicted were, on average, larger and had younger riparian vegetation near their terminus. Thus, when determining landslide run-out distance, channel junction angles and channel gradient are the primary factors, while landslide volume and composition of the riparian area along debris torrent-prone channels may also be important secondary factors.

- In the ODF study, slash in the channel was different by stand age class for the Elk Creek and Scottsburg areas. However, whether these differences in slash resulted in increased travel distances by debris torrents could not be determined.

Habitat Modification and Bio-criteria

As described in the introduction of this report, the water quality standards and criteria for habitat modification and bio-criteria are general narrative standards consistent with FPA goals and objectives for water quality protection relative to these parameters. Thus, the effectiveness of current practices in meeting water quality standards for these parameters will be evaluated relative to the goals of the FPA referred to in Table 1 (p. 5).

<u>Large Wood</u>

Since the Water Protection Rules were enacted in 1994, there has not been adequate time to observe significant changes in riparian characteristics on the ground. Given this fact, how can it be determined under these rules if large wood levels are, in fact, increasing towards those found in mature conifer forests? Initial monitoring results can help evaluate the validity of some of the assumptions built into the rules, and, in turn, allow for an evaluation of the potential effectiveness of the current rules.

Before examining these assumptions, it is helpful to consider available data on stocking levels of mature and late seral conifer forests in riparian areas across Oregon. Figure 5 summarizes this data and compares it to assumed stocking levels under the current rules for large Type F streams mid-way through the next harvest rotation (from ODF 2001a).

It is evident from Figure 5 that for those regions represented, the West Cascade/Interior region is the only region where the stocking assumed to represent mature forest conditions is substantially lower than the average value for unmanaged riparian areas in this region. The assumed stocking for a 120-year stand is, in fact, near the lowest end of the entire range of stocking levels for unmanaged stands in the West Cascade/Interior region.

Under the current water protection rules, are the RMAs "likely to develop characteristics of mature forest stands in a timely manner?" Two issues must be addressed in answering this question. The first is the adequacy of the RMA widths, and the second is the adequacy of the RMA management prescriptions.

Adequacy of RMA Widths

Historically, periodic disturbance occurred across the forested landscape. While it is likely that many riparian areas had mature or old-growth conifer stands, there were other recently disturbed areas with very young stands, grass, or brush. A 100-foot (30-meter) buffer width will generally capture 70-90 percent of the large wood input potential from riparian forests (this does not consider upslope sources) (Bilby and Bisson, 1998). While this represents an average value at a landscape level, it should be noted that different size streams provide different degrees of riparian functions. On the one hand, while the largest streams have the capacity to move very large pieces of large wood, the smallest streams do not normally move the larger wood during high flows. The smallest streams may be dominantly used by resident fish species, in which relatively small wood can function in a step-pool formation. In considering on-site effects of large wood, smaller trees can provide both stable and functional-size wood for small streams. For example, a small stream with an active channel width of 2 or 3 feet will interact well with a 20- or 30-foot long piece of wood that is 6 to 10 inches in diameter.

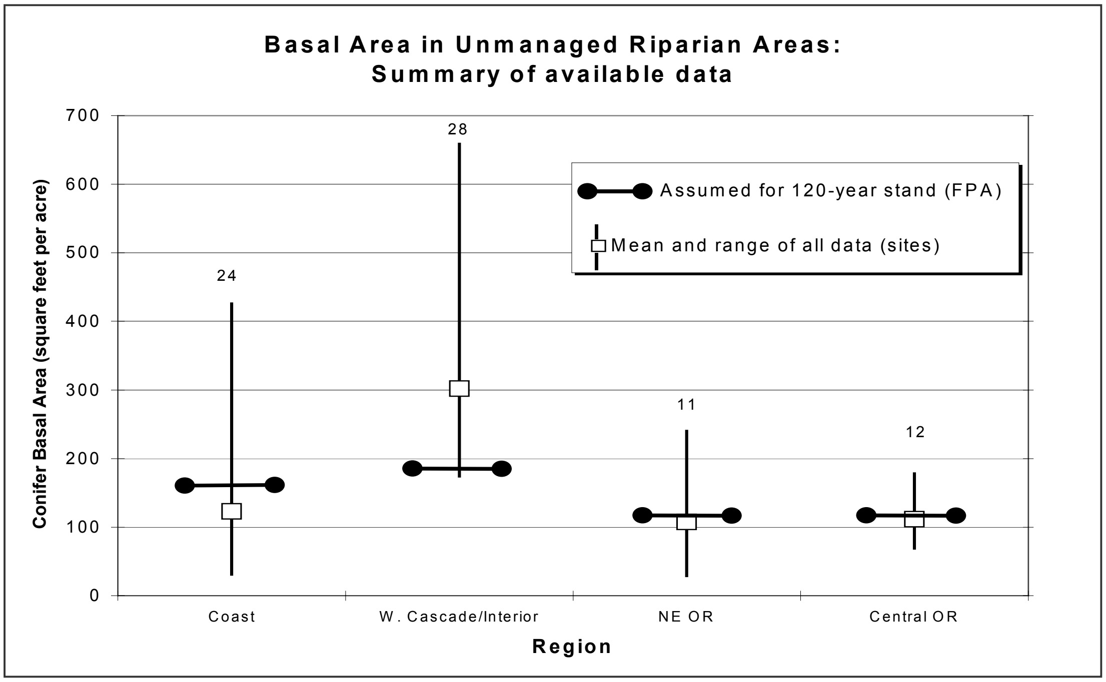

Figure 5. Mean and range of available data on unmanaged riparian areas and conifer stocking for different regions in Oregon. The dumbbell symbol represents the stocking level that is assumed for "mature forest conditions" (approximately 120 years old) under the 1994 Water Protection Rules for large Type F streams (From ODF, 2001). The basal areas represented by the dumbbells are those levels that are assumed to occur mid-way through a 50-year harvest rotation, and are thus higher than the standard targets required by the rules.

Historically, however, large diameter trees were present along all stream sizes to a greater or lesser degree. Large diameter trees, therefore, have been a component of the wood supply and aquatic structure in small streams. These larger pieces of wood, while being relatively immobile as compared to smaller large wood, provide for some functions that may not be supported by small diameter wood. These functions include storing large volumes of sediment and mitigating steep channel gradients by creating large steps in the channel profile (Montgomery et al., 1996). During high flow events, the larger pieces are also more stable than the smaller pieces. If the stream is in an area where debris flows occur, there is the potential for larger pieces to be transported some distance downstream from where the wood was first deposited (Robison et al., 1999).

A review of the studies referenced in Appendix B that examine buffer width versus potential large wood inputs shows that, in general, nearly all of the potential large wood from *stream-*

adjacent sources originates from within 60 to 130 feet of the stream. The majority of this potential large wood comes from relatively close to the stream, and the potential inputs rapidly diminish at distances beyond 60 to 130 feet. Greater than 90 percent of the potential large wood originates from within this distance from the stream. To achieve the entire 100 percent of potential large wood, the buffer would need to extend an additional 100 to 150+ feet, or to approximately one site-potential tree height.

For riparian areas managed to achieve mature forest conditions (all Type F streams), a 50- to 100-foot RMA is applied. Within the RMA, trees must be maintained with conifer basal area adequate to achieve mature forest conditions mid-way through the next harvest rotation (in 25 years). This range of RMA widths is believed to supply between approximately 65 percent and 95 percent of the potential conifer large wood of a mature forest, assuming the zones contain conifer stocking of a mature forest (McDade et al., 1990).[10]

In light of the discussion on forest ecosystem dynamics in Appendix B, it is reasonable to assume that, historically, all streams did not maintain 100 percent of large wood potential at all times. For Oregon west of the Cascades, estimates of the historical percentage of old growth occurring at any given time range from as little as 35 to 40 percent, to as high as 70 to 80 percent (see Appendix A). It is possible that providing approximately 65 to 95 percent of the potential conifer large wood of a mature forest is consistent with the historical levels of large wood potential given this variability of old growth conditions. Thus, it is possible that for those streams where 50- to 100-foot RMAs of mature conifer forests are maintained, the potential large wood supply from *stream-adjacent* riparian stands will be similar to what would exist over time under mature forest conditions historically. However, additional research would be needed to evaluate this definitively. This is not the case for large wood delivery from small Type D and N streams where RMAs are 20 feet or less.

Murphy (1995) analyzed the effectiveness of current forest practice rules in a number of western states in protecting and restoring riparian aquatic habitat. Murphy performs two analyses to quantitatively evaluate and rank large wood input protection among different states. Based on the RMA width alone (and assuming an unharvested, fully stocked mature conifer forest within the buffer), Murphy assigns Oregon an initial 92 percent potential large wood delivery score for large Type F streams in the Oregon Coast Range. Though not stated by Murphy, the same analysis for other size streams would result in estimates of potential large wood delivery of approximately 80 percent for medium and 70 percent for small fish-bearing streams. These estimates were based on the Oregon RMA widths and the McDade et al. (1990) study of large wood delivery. In addressing the adequacy of the Oregon stream rules, Murphy states the following:

[10] The range in large wood potential will also vary within each of the stream size classes defined under the FPA. Based on information presented in Appendix B, 50-foot RMAs on 'small' streams could provide 65-90% of the potential large wood, 70-foot RMAs on 'medium' streams 70-95%, and 100-foot RMAs on 'large' streams 85%-99%.

"Oregon's rules are based on the expectation that basal area will increase by 59 percent within 25 years, thereby achieving the level of large wood sources in a mature Douglas-fir streamside forest [at mid-rotation of the second rotation over the entire watershed/landscape]. Assuming a similar growth rate (59 percent per 0.5 rotation period) in the other states, the resulting large wood sources at mid-rotation [from adjacent riparian stands only along large Type F streams] would exceed 90 percent of the level in mature forests in Alaska and Oregon, but would still be far below that level in California and Washington."

Murphy (1995) further estimated potential large wood sources (conifer volume) present *immediately after* timber harvest, assuming the retention of the minimum basal area only, conforming to the forest practices requirements of the different western states. Based upon his analysis, Murphy estimated that approximately 58 percent of potential conifer large wood sources of mature forest stands would be present on large Type F streams in the Oregon Coast Range following timber harvest. Though not completed by Murphy, expanding the analysis to Medium and Small Type F streams in this region results in estimates of approximately 38 percent and 15 percent potential conifer large wood sources after harvest in medium and small stream RMAs, respectively (Table 6). Where stream enhancement activities and harvest to the "active management target" occurs, the potential conifer large wood retained in these RMAs immediately following harvest is less.

Table 6. Potential conifer large wood sources[1] following clearcut harvest to current FPA basal area retention standards (standard target) on Type F streams.

Georegion	Potential Large Wood Sources After Clearcut Harvest[2] (% of mature forest potential)								
	Large			Medium			Small		
	0 yrs	+25 yrs	+50 yrs	0 yrs	+25 yrs	+50 yrs	0 yrs	+25 yrs	+50 yrs
Coast	**58 (46)**	**92 (73)**	**126 (100)**	**38 (30)**	**60 (48)**	**82 (65)**	**15 (12)**	**24 (19)**	**33 (26)**
South Coast	**57 (45)**	**91 (72)**	**124 (98)**	**37 (29)**	**59 (47)**	**81 (64)**	**15 (12)**	**24 (19)**	**33 (26)**
West Cascades	**59 (47)**	**94 (75)**	**129 (103)**	**38 (30)**	**60 (48)**	**83 (66)**	**13 (10)**	**21 (17)**	**28 (22)**
Interior	**58 (46)**	**92 (73)**	**126 (100)**	**37 (29)**	**59 (47)**	**81 (64)**	**13 (10)**	**21 (17)**	**28 (22)**
Siskiyou	**58 (46)**	**92 (73)**	**126 (100)**	**37 (29)**	**59 (47)**	**81 (64)**	**16 (13)**	**25 (20)**	**35 (28)**

[1]Potential conifer large wood source estimates follow the analysis procedure described by Murphy (1995). Numbers in parenthesis are revised figures using Murphy's corrected calculations.

[2] For example, for a clearcut harvest along a large Type F stream in the Coast Georegion, 58 percent of the total potential large wood will be left after the RMA is managed to the standard target. At mid rotation (25 years in the future), 92 percent of the total potential large wood will be present (assuming a 59 percent increase in basal area every 25 years). At the end of the next rotation (in 50 years), 124 percent of the total potential large wood will be present. Medium and small streams have lower levels of potential large wood due, in part, to narrower RMAs. This is also due, in part, to the fact that additional large wood from ingrowth and adjacent second-growth assumed to contribute 25 percent and 75 percent of the total potential along medium and small streams, respectively, is not accounted for here.

Since the publishing of Murphy (1995), Murphy has corrected calculations of the percent of large wood sources at mid-rotation in mature forests for Type F streams in Oregon. Instead of the 92 percent quoted above, Murphy estimates the percent of large wood sources present along a large Type F stream in the Coast Range at mid-rotation to be only 73 percent of the adjusted normal yield of mature forest, as assumed under the Water Protection Rules (Mike Murphy, personal communication, 1998).

Adequacy of the RMA Management Prescriptions

The adequacy of the RMA management prescriptions is the second issue to address in examining whether RMAs are "likely to develop characteristics of mature forest stands in a timely manner." During the development of the Water Protection Rules, it was necessary to make a number of assumptions where data was lacking. Through effectiveness and implementation monitoring, the following assumptions need to be tested and revised, as warranted:

(1) Basal area targets were developed for the seven different georegions, and it was believed these targets would be reasonably accurate in describing the potential of a given riparian stand in a given georegion.
(2) Hardwood species would dominate the first 20 feet of the RMA across the landscape on small, medium, and large streams.
(3) The hardwood conversion option would provide an adequate incentive for landowners to convert riparian stands currently dominated by hardwoods back to conifer, where it is very likely that conifer existed historically.
(4) The basal area targets would provide an incentive for landowners to grow trees in excess of what must be retained, so the excess may be harvested.
(5) 25 percent and 75 percent of the large wood recruitment needs on medium and small Type F streams, respectively, would originate from ingrowth and newly established stands following harvest (this assumption has not been evaluated/examined by monitoring).

Monitoring data collected by the ODF provides some preliminary results pertaining to the validity of the first four of these five assumptions. As for assumption (1), there are indications that the high degree of variability in site potential within a given georegion makes the use of an average basal area target problematic. In theory, if unrealistic basal area targets are used, a very low productivity site will not allow for active management and will, thus, take longer to realize a 'mature stand' condition. A high productivity site, on the other hand, may never reach its potential (in terms of basal area and growth), because using a basal area target that is too low will result in harvesting that reduces the potential below what can actually be achieved.

It also appears that assumption (2) may not be valid, particularly for small, confined channels. Monitoring data indicates , variability is prevalent across all sizes of streams, and , this assumption appears to hold true for the large streams. For many of the medium and small streams, however, there are indications that a higher percent of conifer trees exists in the first 20 feet of the RMA than was anticipated. This has resulted in the potential for the total basal area requirement to be met in the first 20 feet of the RMA. Where this is the case, the actual retention will be significantly less than assumed, and it may not support the expected range of functions (including shade and large wood) at the level that was assumed. (ODF 2001a)

Assumption (3) also may not be valid. The hardwood conversion option does not appear to be used very often by the landowner (Liz Dent, personal communication, 1999). This may be because some hardwood-dominated riparian areas do not have enough merchantable timber to make the operation profitable and/or there are unfavorable market conditions. Also, landowners might be wary to exercise this option out of a concern they may inadvertently commit a violation in trying to implement this option.

Finally, assumption (4) may not be valid as well. About 60 percent of the 52 RMA sites surveyed by ODF monitoring crews were not entered, and, thus, not harvested down to the basal area target (Liz Dent, personal communication, 1999). Hairston-Strang and Adams (1997) found similar results in their survey of private landowners managing within the RMAs, where only 21 percent actively managed within the RMA to the basal area standard targets. These findings also show the estimates made by Murphy (1995) discussed above do not apply to the majority of RMAs sampled, since more basal area was retained than the minimum. It should be noted that data was not available to understand why landowners did not enter the RMA. Possible reasons include the stocking levels were too low for harvesting within the RMA to be an option, or the landowner chose not to manage for other reasons. If the lack of management within the majority of RMAs is the result of inadequate incentives for landowners, the rules may not be adequate in achieving the goal of developing characteristics of mature forest stands in a timely manner. Additional information is needed, however, before the reasons for the lack of active management can be determined.

Small Type N Streams, Opportunity for Large Wood Delivery, and Eastern Oregon Riparian Areas

For small Type N streams, vegetation retention is required on a portion of the perennial streams in all georegions, except the Coast Range and the Cascades. In eastern Oregon, some vegetation retention is required on all perennial streams. Where required, vegetation retention on these streams consists of a 10-foot understory vegetation and nonmerchantable conifer buffer requirement. All other small Type N streams do not require an RMA or vegetation retention under the current rules, other than what is necessary to protect the bed and banks. Small Type N streams can only provide for structural inputs to salmonid habitat if debris flows occur that move larger material downslope to Type F streams. Under the current rules that do not require an RMA, these streams are not contributing large wood inputs in this manner. The current rules assume the newly regenerated stand will likely provide some level of smaller large wood inputs over time, but this assumption has not been validated. The significance of a lack of larger large wood in these streams is uncertain, but nonetheless a reduction from this potential source does exist.

Potential large wood input from sources other than near-stream areas is related to vegetation retention along Type N streams. By its very definition, upstream riparian sources are maintained where RMAs are established above a given stream reach. Upslope sources of large wood are currently not maintained where a harvest operation occurs in the potential source area. The potential for delivery of upslope large wood only exists, however, in areas with steep slopes prone to landslides and/or debris flows that enter the channel. Exactly what proportion of large wood originates from each of the three source areas for a given stream reach depends on the make-up of the channel network and the extent of the RMAs. Because of the scientific uncertainty, determining the adequacy of the current rules relative to large wood supply from these three sources must be determined qualitatively using professional judgement.

Another concern is the opportunity for large wood originating from the RMA to fall into the stream. Currently, outside of the first 20 feet of the RMA, a landowner is able to harvest the largest trees within an RMA where management is an option, and harvest rotations can be as short as 50 years (so long as the basal area and minimum tree number requirements are met). This creates the possibility the large wood with the highest potential and value in terms of fish habitat might be harvested before enough time has elapsed for it to fall into the stream. The current rules provide no assurances trees retained beyond the first 20 feet of the RMA will have the opportunity to fall into the stream, or that a certain minimum number of the trees will fall into the stream. It is likely, however, some level of large wood inputs will occur, even if it cannot be quantified.

Finally, information on eastern Oregon riparian areas indicates that a single basal area target for all of eastern Oregon may be inappropriate. Stocking level recommendations provided by Fred C. Hall (Senior Plant Ecologist, USDA Forest Service, Pacific Northwest Region) show eastern Oregon forestlands have a very wide range of different site productivity classes. The lowest site class is for a typical juniper site (<20 cubic feet/acre/year), and the highest is for a relatively highly productive, mixed-conifer, site comparable to westside forests (120-164 cubic feet/acre/year). Using a single basal area target will result in the more productive sites being understocked and less productive sites being overstocked, potentially contributing to forest health problems prior to the next harvest entry. Having basal area targets for eastern Oregon that are tied to narrower site class ranges may be a more appropriate approach for managing the RMAs towards a mature forest condition. (see Appendix H for a more detailed discussion.)

Other Riparian Functions

Other riparian functions, besides providing large wood and maintaining stream temperatures, include microclimate, streambank stability, litterfall, sediment filtration, and floodplain processes. It is generally assumed these other functions will be provided, to some degree, by the current rules. This assumption is based on qualitative information and has not been evaluated through monitoring.

For streams that require an RMA, the understory and overstory vegetation within the 20-foot no-harvest zone, plus any additional overstory trees beyond the first 20 feet left for basal area requirements, will provide some level of protection for microclimate, litterfall, streambank stability, and sediment filtration. Floodplain processes will also be considered where the effective width of the RMA is equal to, or greater than, the floodplain. Rules that are currently designed to protect wetlands can also provide floodplain protection when these wetlands are adjacent to streams. When braided channels and islands occur within the annual high water mark or within the effective RMA, the current rules provide some level of protection as well.

In some cases, other riparian functions may receive less than optimal protections under the current rules. For example, on small Type N streams that generally do not require any retention of overstory vegetation, there is a relatively higher level of risk that other riparian functions will not be provided for immediately following harvesting, where those functions depend on the presence of overstory vegetation. Also, where the floodplain extends well beyond the effective RMA width, only a portion of those floodplain functions that depend on overstory vegetation will be provided for. Evaluating the performance of the rules providing these other riparian functions will require continued effectiveness monitoring.

Other Habitat Modification

Fish Passage Blockages

Under the current rules, fish passage is required for stream crossings constructed or reconstructed after September 1994. Culverts installed between 1972 and 1994, while providing adult passage, may not be providing juvenile passage. As older culverts are replaced, they will be required to meet the current standard. If a Type F stream extends up to, but not beyond the culvert outlet, that culvert would have to be designed to pass fish when it is eventually replaced under regular road maintenance. Currently, if it is determined the upstream reach has the capacity to be a fish-bearing stream, but is currently a non-fish-bearing stream because of a culvert that cannot pass fish, that upstream reach will remain classified as a non-fish-bearing stream until the culvert is replaced and fish access is provided.

The following basic steps to restoring fish passage at road/stream crossings (ODF survey protocol) are in place for a large portion of forestland and for state and county highways in conjunction with the Oregon Plan:

1. Find and prioritize problem road/stream crossings.
2. Get information about the stream and other conditions at the crossings to be restored.
3. Decide if the installation can be repaired or improved, or whether it must be replaced.
4. Decide on a design strategy based on information collected at the site.
5. Prepare a design.
6. Install new road/stream crossing structure.
7. Monitor and maintain the road/stream crossing structure.

The ODF survey protocol is being used on forestlands. A substantial portion of the survey effort has been completed on industrial and state-owned forestlands. The factor limiting passage restoration objectives is the actual completion of the fish passage restoration projects once the surveys are complete. However, on forestlands, substantial progress is being made.

How successful these voluntary activities will be in restoring fish passage is uncertain at this time. Nonetheless, road issues, especially fish passage restoration, are being emphasized statewide, and substantial accomplishments have been made. Success must be evaluated over time through continued implementation and effectiveness monitoring. These evaluation mechanisms are in place for forestland restoration actions.

Under the FPA rules, fish use surveys have been completed on approximately 20-30 percent of all forested streams. In addition to determining the presence of fish, the surveys have provided useful information about: (1) barriers to fish passage, (2) unmapped stream channels, and (3) baseline fish distribution. Where surveys have not been completed, an interim classification system for fish presence is providing a reasonable proxy for actual classification. Classification system issues include concerns about classifying streams as non-fish use, when the absence of fish could be caused by a human-caused passage barrier, and classifying streams when the channel has been recently torrented (especially after the 1996 storms). There is also a desire to get fish presence data available on a GIS-based system to enhance the ability to update and distribute maps.

The ODF fish passage guidance for implementing the fish passage requirements was first released in June 1995 and is updated as new information becomes available (last updated May 2002). While this guidance is based on the most current science available, effectiveness and implementation monitoring must be conducted to verify that these guidelines are achieving the goal of restoring fish passage. The ODF monitoring program recently completed a stream crossing compliance study evaluating the 1997 version of the guidance (previous to the current 2002 version) and a final report on the study has been released.

Changes to the guidance since the 1997 version were relatively minor, and the results from the compliance study provided valuable information applicable to the current guidance. Findings from this study did not indicate the Forest Practices policies need to be significantly changed. With the exception of alternatives one and six ('flat' and baffled culverts) described in the current guidance, it appears that when the guidelines are implemented correctly, the success rate for creating conditions that are believed to provide a high likelihood of fish passage is high. Alternatives one and six should be examined further and possibly revised to improve their effectiveness (see the "*Compliance with fish passage and peak flow requirements at stream crossings final study results*" (ODF, 2002) for more specifics on results from this study). The ODF guidance has recently been updated (ODF Technical Notes 4 and 5), incorporating findings from this study.

Summary of Water Quality Standards Evaluation

The water quality standards below are evaluated consistent with ORS 468B.015(2), 468B.110 (2), 527.765, and 527.770, to "insure that to the maximum extent practicable nonpoint source discharges of pollutants resulting from forest operations on forestlands do not impair the achievement and maintenance of water quality standards established by the Environmental Quality Commission for the waters of the state."(See p.6)

Though the following discussion evaluates the sufficiency of the FPA in meeting the specific water quality standards for the parameters addressed in this report, the parameters are first evaluated together in a broader context. Also included is a specific description of each water quality standard and how it is applied to evaluate forest practice rules. The information presented in preceding sections of this report and the appendices were used to develop the summary below:

Summary of Sufficiency Conclusions

The following conclusions apply to all applicable standards (temperature, sedimentation, turbidity, aquatic habitat modification, and bio-criteria):

Site-Specific Evaluation

Current protection requirements may be inadequate in the following areas:

- Standards for some medium and small Type F streams in western Oregon may result in short-term temperature increases at the site level. However, the significance and scope of this increase is uncertain and it may be offset at the landscape scale by other factors. Relevant to the habitat modification standard and criteria, large wood potential for some of these streams are less than what was assumed under the 1994 rules.

- Standards for some small Type N streams may result in short-term temperature increases at the site level that may be transferred downstream (this may impact water temperature and cold-water refugia) to fish-bearing streams. The significance and scale of this change is uncertain, and it may be offset at the landscape scale. Relevant to the habitat modification standard and criteria, large wood potential delivered by debris torrents along these streams (typically in areas of very steep topography) may be less than optimal.

For large Type F streams, shade levels appear to be adequate, and large wood outputs for these streams is consistent with that assumed under the 1994 rules.

With the exception of the issue of wet-weather hauling and steep-slope ground skidding and those areas noted above, the FPA appears to be adequate when implemented successfully.

Holistic Evaluation

Over time and space the forested landscape changes. Disturbance is an important process for maintaining productivity and resetting the environment, but it can also have a number of impacts to water quality parameters. Human activities can alter the frequency and magnitude of disturbance relative to historical patterns. While some human activities, like timber harvesting, may be more frequent than historical rates of disturbance, harvesting may also be less intense of a disturbance as compared to, for example, historical wildfire. Other impacts, like fire suppression, may reduce the frequency of disturbance, but result in somewhat more intense disturbances when fires do occur. The frequency and intensity of the event can influence vegetative and other disturbance recovery. Human activities to reduce adverse effects, therefore, need to be evaluated against historical patterns of disturbance.

The current distribution of forest stand age classes, the levels of tree stocking in managed plantations, and fire suppression have resulted in well-stocked, dense, closed canopy conifer stands across a larger portion of the forested landscape than has historically occurred. Thus the current rules and practices likely result in an increased level of shade at a landscape scale. At a site-specific scale, however, some level of risk exists along some streams, as noted in the next section. The significance of this risk in terms of influencing stream temperatures at a watershed (or sub-basin) scale is uncertain.

More arguably, higher conifer stocking levels across the landscape in upland and riparian areas may result in an increased potential for large wood delivery. The likelihood of such additional stocking resulting in increased large wood production is dependent upon the harvest levels, retained trees, natural mortality and other disturbance events. Until the sizes of riparian trees increase through normal growth volume may be limited, even though the number of trees may be relatively high. Nonetheless, current practices are likely sufficient at a landscape scale.

Temperature

An evaluation of the temperature standard includes considering of all aspects of the antidegradation narrative standard and numeric criteria. The standard also includes conditions for cold-water refugia, dissolved oxygen, and natural lakes. These are not addressed in this analysis because either there was a lack of information available to evaluate such conditions or there was a lack of applicability to forest management activities. The DEQ has yet to develop the specific guidance necessary to identify cold-water refugia on the ground so it can be evaluated against the standard. Until that guidance is developed, the evaluation of FPA sufficiency in meeting the antidegradation standard relative to cold-water refugia is not possible. Water quality impairment related to dissolved oxygen is "generally not attributable to forest management practices as regulated by the EPA."(April 1998) Temperature impairment related to natural lakes is also generally not attributable to forest management practices. A detailed description of the standard is included in Appendix F.

The following is an evaluation of the temperature standard by specific stream types and sizes:

Medium and small Type F streams: Current research and monitoring results show that current RMA prescriptions for western Oregon may result in short-term temperature increases on some Type F streams; however the significance of the potential temperature increases at a watershed (or sub-basin) scale is uncertain.

Small Type N streams: Current research and monitoring results show current practices may result in short-term (two to three years) temperature increases on some Type N streams. The significance of potential temperature increases on Type N streams to downstream fish-bearing streams and at a watershed (or sub-basin) scale is uncertain.

All other streams: Influences on stream temperatures from shade levels resulting from specific BMP prescriptions for the other stream category types have not been assessed due to a lack of relevant data. However, in light of the data and findings specific to medium and small Type F streams, and given the higher level of vegetation retention on large Type F streams, it is likely that the standard is being met on large Type F streams.

Remaining Issues:

- Under current practices, what is the significance of potential site-specific temperature effects (either increases or decreases) at a watershed scale along some small Type N streams? Monitoring of watershed-scale effects relative to these streams should be a priority to help narrow the current level of uncertainty.

- Is the occurrence of blowdown having an effect on meeting the goal of achieving "over time, average conditions across the landscape become similar to those of mature forest conditions" in RMAs?

- Are current forest practices meeting the water quality standard with respect to cold-water refugia? (This analysis will not be possible until specific guidance is developed to identify cold-water refugia on the ground so it can be evaluated against the standard.)

<u>Sedimentation Standard</u>

The narrative standard for sedimentation is the following:

> "The formation of appreciable bottom or sludge deposits or the formation of any organic or inorganic deposits deleterious to fish or other aquatic life or injurious to public health, recreation, or industry shall not be allowed."

The intent of the sedimentation standard, as it applies to the FPA, is to minimize soil and debris entering waters of the state. (OAR 629-30-000(3)) With the exception of wet-weather road use, complying with the road construction and maintenance rules currently in place is likely to result in meeting water quality standards. The rule and guidance recommendations described in the next section of this report will work towards ensuring the goals of the FPA and water quality standards are being met.

Remaining Issues:

- What effect, if any, are current practices along small non-fish-bearing streams having on downstream sediment regimes?

<u>Turbidity Standard</u>

The numeric standard for turbidity is the following:

> "No more than ten percent cumulative increase in natural stream turbidities shall be allowed, as measured relative to a control point immediately upstream of the turbidity causing activities."

Given the lack of quantitative data to specifically address the turbidity numeric standard, the turbidity standard is evaluated qualitatively. The intent of the turbidity standard, as it applies to the FPA, is to minimize soil and debris entering waters of the state. (OAR 629-30-000(3)).

When unfiltered surface runoff from road construction is entering applicable waters of the state, and there is a visible difference in the turbidity of the stream above and below the point of delivery of the runoff for less than a two- or four-hour duration (depending on the stream grade and with all practicable erosion controls in place), both the FPA and water quality standards are being met. When unfiltered surface runoff from general road use is minimized, and/or if all applicable BMPs have been applied, both the FPA and water quality standards are being met as well.

With the exception of wet-weather road use, complying with the road construction and maintenance rules and guidance currently in place is likely to result in meeting water quality standards. The recommendations relative to these rules and guidance described in the next section of this report will work towards improved compliance and implementation of the FPA to ensure the goals of the FPA and water quality standards are being met. Specific to the issue of wet-weather hauling, construction and maintenance standards should be developed for roads determined to be at risk for sediment delivery and associated turbidity. Prohibiting hauling during periods of wet weather on road systems that have not been constructed with specific standards for surface materials, drainage systems, or other alternatives (paving, increased numbers of cross drains, sediment barriers, settling basins, etc.) Given the lack of quantitative data to specifically address the turbidity numeric standard, the turbidity standard is evaluated qualitatively. The intent of the turbidity standard, as it applies to the FPA, is to minimize soil and debris entering waters of the state. (OAR 629-30-000(3)). Both the FPA and water quality standards are being met when unfiltered surface runoff from road construction is entering applicable waters of the state and there is a visible difference in the turbidity of the stream above and below the point of delivery of the runoff for less than a two- or four-hour duration (depending on the stream grade and with all practicable erosion controls in place). When unfiltered surface runoff from general road use is minimized, and/or if all applicable BMPs have been applied, both the FPA and water quality standards are being met as well.

With the exception of wet-weather road use, complying with the road construction and maintenance rules and guidance currently in place is likely to result in meeting water quality standards. The rule recommendations will help improve compliance and implementation of the FPA to ensure the goals of the FPA and thus water quality standards are being met. Specific to wet-weather hauling, construction and maintenance standards should be developed for roads at risk for sediment delivery. Prohibiting hauling during periods of wet weather on road systems that have not been constructed with specific standards for surface materials, drainage systems, or other alternatives (paving, increased numbers of cross drains, sediment barriers, settling basins, etc.) will also minimize delivery of sediment streams.

<u>Habitat Modification Standard</u>

The habitat modification standard, consistent with ORS 468B.015(2), 468B.110 (2), 527.765, and 527.770, is to "insure that to the maximum extent practicable nonpoint source discharges of pollutants resulting from forest operations on forestlands do not impair the achievement and maintenance of water quality standards established by the Environmental Quality Commission for the waters of the state."(see p.6) The narrative standard for habitat modification is the following:

> “The creation of tastes or odors or toxic or other conditions that are deleterious to fish or other aquatic life or affect the potability of drinking water or the palatability of fish or shellfish shall not be allowed;” or “waters of the state shall be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.”

The FPA standard as it relates to habitat modification is “to grow and retain vegetation [along fish-bearing streams] so that, over time, average conditions across the landscape become similar to those of mature streamside stands;” and “to have sufficient streamside vegetation [along non fish-bearing streams] to support functions and processes that are important to downstream fish use waters and domestic water use.”(OAR 629-640-0000)

The following is an evaluation of the habitat modification standard described above by specific stream types and sizes:

Medium and small Type F streams: Monitoring data indicates the assumptions used to determine basal area targets for small and medium streams in western Oregon may not be consistent with what the RMAs are capable of growing along these streams. The data also shows that 60 percent of harvest operations occurring along fish-bearing streams do not result in management within the RMAs. There is a reasonable possibility that, under the current rules, some of these streams are not likely to result in the “desired future condition” in a timely manner, as described in the goals of the FPA.

Small Type N streams: There is increasing scientific evidence that small non-fish-bearing streams prone to debris flows provide an important source of large wood for downstream fish habitat. While these streams are providing some level of functional large wood inputs and shade production under the current rules, the rules were not specifically designed to retain significant sources of large wood and shade in these areas. There is a reasonable possibility that, under the current rules, some of these streams are not likely to adequately support functions and processes important to downstream fish use waters, as described in the goals of the FPA.

All other streams: Influences on habitat modification resulting from specific best management practices for the other stream category types have not been assessed since they were considered a lower priority. However, given the higher level of vegetation retention on large Type F streams, and in light of the data and findings specific to medium and small Type F streams, it is likely the standard is being met on these streams.

Fish passage blockages: Since 1994, the FPA has required juvenile fish passage be provided on all fish-bearing streams. Current monitoring information does not indicate Forest Practices policies need to be significantly changed on how to install fish-passable stream crossings. With few exceptions, it appears when the guidelines are implemented correctly, the success rate is high for creating conditions believed to provide a high likelihood of fish passage.

Biocriteria Standard

The narrative standard for biocriteria is the following:

> “Waters of the state shall be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.”

This standard is consistent with multiple FPA purposes and goals that refer to the sound management of soil, air, water, fish and wildlife resources, while at the same time ensuring the continuous growing and harvesting of forest tree species. Given the general nature of this standard and the lack of specific criteria to use in evaluating this standard, biocriteria cannot be explicitly evaluated at this time. It is reasonable to assume that, given the inter-related nature of the temperature, sediment, turbidity and habitat modification parameters relative to biocriteria, to the extent these other parameters are being met, the biocriteria standard is likely to be met as well.

Table 7. This table links the recommendations in the up-coming section to specific water quality standards and WQS/FPA pathways (Figure 1, p. 8). The basis of the recommendations is also summarized. Unless specifically noted, each rule sufficiency/recommendation applies statewide.

Water Temperature Standard (OAR 340-41-(basin)(2)(b))				
Pathways Evaluated (From Figure 1)	Stream Size and Type	*Sufficiency of BMP Rule to Protect Water Quality:* Water Protection Rules (OAR 629-640); Harvesting Rules (OAR 629-630); & Road Construction & Maintenance Rules (OAR 629-625).	*Basis: Data/Information Referenced*	*Recommend-ation*
A1, B2, B3, C4, C5, & C6	Small and Medium Type F (fish bearing)	**Water Protection & Harvesting Rules:** Current research and monitoring results show that the current RMA prescriptions may result in short-term temperature increases on some type F streams, however the significance of the potential temperature increases at a watershed (or sub-basin) scale is uncertain. Applicability: Western Oregon.	ODF 2001; ODF 2001b; Dent & Walsh 1997	#1
A1, B2, B3, C4, C5, & C6	Small Type N (non-fish bearing)	**Water Protection & Harvesting Rules:** Current research and monitoring results show current practices may result in short-term (two to three years) temperature increases on some Type N streams. The significance of potential temperature increases on Type N streams to downstream fish-bearing streams and at a watershed (or sub-basin) scale is uncertain.	Robison et al., 1995; Caldwell et al., 1991	#2
A1	All other stream types and sizes.	**Water Protection & Harvesting Rules:** Influences on stream temperatures from shade levels resulting from specific BMP prescriptions for the other stream category types have not been assessed due to a lack of relevant data. However, in light of the data and findings specific to medium and small Type F streams, and given the higher level of vegetation retention on large Type F streams, it is likely that the standard is being met on large Type F streams.		N/A
B2	All streams	**Water Protection & Harvesting Rules:** The effects of current practices on potential large wood recruitment for small, medium, and large sized streams and its effect on stream temperature could not be evaluated relative to temperature standards due to a lack of information.		N/A
C4, D4, E4	All streams	**Other Water Protection Rules, Harvesting Rules, & Road Construction & Maintenance Rules not addressed here:** An evaluation of the temperature standards relative to other practices could not be specifically evaluated due to a lack of information.		N/A

Sedimentation [OAR 340-41(basin)(2)(j)] and **Turbidity** [OAR 340-41(basin)(2)(c)]

Pathways Evaluated (From Figure 1)	Stream Size and Type	*Sufficiency of BMP Rule to Protect Water Quality:* Water Protection Rules (OAR 629-640); Harvesting Rules (OAR 629-630); & Road Construction & Maintenance Rules (OAR 629-625).	*Basis: Data/Information Referenced*	*Recommend-ation*
E4 & E5	All streams	**Road Construction & Maintenance Rules:** Recent monitoring studies have found that many existing roads have drainage systems that are not designed to filter sediment. Steep roads (>12 percent grade) often have inadequate spacing of cross drainage structures (excessive distance between cross drains). These conditions exist on both older and more recently constructed roads. This issue could be addressed by minimizing the risk of sediment delivery by ensuring adequate cross drainage design and construction occurs on new roads. (Cross drains should not be confused with stream crossing culverts. Cross drains take water from the inboard side of the road and route it under/across the road and discharge the water downslope from the road.)	ODF 1996; others (see references)	#4
E4 & E5	All streams	**Road Construction & Maintenance Rules:** One area not directly addressed by the rules is sediment and turbidity problems related to road use. There are currently no rules that specifically address minimizing turbidity attributable to wet-season hauling. Specific construction and maintenance standards should be developed for wet-weather hauling roads and require these standards for roads at risk for sediment delivery. Durable rocking of roads during winter use in locations where there is a higher likelihood of sediment entering waters of the state will minimize sources of sedimentation to waters of the state. Prohibiting hauling during periods of wet weather on road systems that have not been constructed with specific standards for surface materials, drainage systems, or other alternatives (paving, increased numbers of cross drains, sediment barriers, settling basins, etc.), will also minimize delivery of sediment to waters of the state.	NA (Clarification of existing protection standards.)	#5
E4 & E5	All streams	**Road Construction & Maintenance Rules:** Roads built on some steep slopes above streams, or that directly fill or excavate in streams, floodplains, lakes, or wetlands, can have much greater impacts on water quality and aquatic resources than roads elsewhere across the landscape. If these roads are constructed, the risks they pose to aquatic resources should be minimized to the maximum extent practicable. The potential of sediment delivery, or other undesirable effects, to streams from new roads located where there is a high risk of landslides, surface erosion, or of direct physical alteration to streams, riparian areas, lakes, or wetlands should be minimized. This may include drafting more specific guidance that outlines criteria for deciding when a new road or road reconstruction would not be allowed.	Robison et al., 1999; N/A (issue of clarifying existing rule).	#6

Sedimentation [OAR 340-41(basin)(2)(j)] and **Turbidity** [OAR 340-41(basin)(2)(c)]

Pathways Evaluated (From Figure 1)	Stream Size and Type	*Sufficiency of BMP Rule to Protect Water Quality:* Water Protection Rules (OAR 629-640); Harvesting Rules (OAR 629-630); & Road Construction & Maintenance Rules (OAR 629-625).	*Basis: Data/Information Referenced*	*Recommend-ation*
D4 & D5	All streams	**Harvesting Rules:** Ground-based harvesting on steep slopes has a relatively higher risk of sediment delivery to streams, and has direct impacts to aquatic habitat compared to ground skidding on less-steep slopes or cable yarding. The current rule for ground-based harvesting on steeper slopes is neither clear nor specific. Action should be taken to reduce the potential of sediment delivery or other undesirable effects to streams from skid roads constructed on steep slopes.	N/A (issue of clarifying existing rule).	#8
D4 & D5	All streams	**Harvesting Rules:** Current rules require specific harvesting practices be employed on locations most prone to landslides ("high-risk sites"). These practices are designed primarily to limit ground disturbance so landslide risk will not be increased. High-risk sites should be managed with techniques that minimize impacts to soil and water resources. To achieve this objective, the best management practices used to protect high-risk sites that are currently in guidance should be incorporated into the forest practice rules, and a better case history should be developed to evaluate the effectiveness of those practices.	IMST 1999; N/A (issue of clarifying existing rule).	#9
C5	All streams	**Water Protection Rules, and Harvesting Rules & Road Construction & Maintenance Rules not addressed here:** An evaluation of the sedimentation and turbidity standards relative to other practices could not be specifically evaluated due to a lack of information.		N/A

Habitat Modification Standard [OAR 340-41(basin)(2)(i)]

Pathways Evaluated (From Figure 1)	Stream Size and Type	*Sufficiency of BMP Rule to Protect Water Quality:* Water Protection Rules (OAR 629-640); Harvesting Rules (OAR 629-630); & Road Construction & Maintenance Rules (OAR 629-625).	*Basis: Data/Information Referenced*	*Recommend-ation*
A1, B2, B3, C4, C5, & C6	Small and Medium Type F (fish bearing)	**Water Protection Rules:** Preliminary monitoring data indicates the assumptions for determining basal area targets for small and medium streams may not be consistent with what the RMAs are capable of growing along these streams. The data also shows that 60 percent of harvest operations are not managing within the RMAs. Action should be taken to ensure the level of large wood inputs being provided by the RMAs is consistent with the goals of the rules, which includes achieving the desired future condition (average conditions across the landscape similar to mature forests) in a timely manner. Applicability: Western Oregon.	ODF 2001; ODF 2001b; Dent & Walsh 1997	#1
A1, B2, B3, C4, C5, C6, & D6	Small Type N (non-fish bearing)	**Water Protection & Harvesting Rules:** There is increasing scientific evidence that small non-fish-bearing streams prone to debris flows provide an important source of large wood for downstream fish habitat. While these streams are providing some level of functional large wood inputs and shade production under the current rules, the rules were not specifically designed to retain significant sources of large wood and shade in these areas. Action should be taken to increase large wood inputs along small perennial Type N streams prone to landslides and debris flows that have the potential to impact downstream Type F waters.	Robison et al., 1995; Caldwell et al., 1991	#2
B2, B3, C4, C5, & C6	All streams	**Water Protection Rules:** It is widely believed current levels of large wood in many streams are significantly lower than what occurred historically, and recent stream habitat surveys by the Oregon Department on Fish and Wildlife confirm that relatively large pieces of large wood (>20-inch DBH) are currently lacking on private forestlands. Where specific stream reaches are identified as lacking large diameter trees, the active placement of key pieces of large wood can be an important tool for the creation of habitat functions in the short-term. To accelerate the rate of large wood inputs occurring under the current rules and measures, additional large wood should be actively placed in the appropriate streams.	Thom et al., 1998; Thom et al., 1999.	#3

Habitat Modification Standard [OAR 340-41(basin)(2)(i)]

Pathways Evaluated (From Figure 1)	Stream Size and Type	*Sufficiency of BMP Rule to Protect Water Quality:* Water Protection Rules (OAR 629-640); Harvesting Rules (OAR 629-630); & Road Construction & Maintenance Rules (OAR 629-625).	*Basis: Data/Information Referenced*	*Recommend-ation*
E6	All streams	**Road Construction & Maintenance Rules:** There is an increasing body of scientific evidence that supports the idea that the movement of large wood downstream is an important function that provides for, and maintains, fish habitat. A broader range of engineering options for stream crossing designs that will pass large wood and sediment when debris flows occur, both during high flows and for steep channels, should be provided. Stream crossings should be constructed to pass large wood and gravel downstream, and other means should be provided for passage of large wood and sediment at those crossings that restrict this passage. The transport mechanisms for large wood and gravel to be accommodated include both stream storm flows and channelized debris flows. This would also reduce the risk of debris backing up behind the structure and subsequent catastrophic sediment delivery caused by washouts.	Robison et al., 1999; Reeves et al., 1995; Reeves at al. 1997; others (see references).	#7
F7	All streams	**Water Protection Rules:** Provide for riparian functions along stream reaches above impassable stream crossing structures that have a high probability of recolonization by salmonids once the structure is replaced/improved.	N/A.	#10
F7	All streams	**Road Construction & Maintenance Rules:** Facilitate the identification, prioritization, and restoration of existing culverts that currently do not pass fish. Culvert replacement should be accelerated above what is currently being done, especially for family forestland owners who often do not have adequate resources to address this issue in a timely manner.	N/A. (issue of improved implementation of existing rule).	#11
F7	All streams	**Road Construction & Maintenance Rules:** The current water classification scheme is based on the presence or absence of fish. The survey process used to determine presence/absence is time-consuming, limited to a short season, and requires significant funding (though costs are relatively low compared to the resources that may or may not be retained based upon the results). Fish presence surveys are becoming more restricted due to the listing of fish under the federal Endangered Species Act (ESA). A more effective and efficient means of classifying streams for "fish use" should be provided, and the forest practice rule definition of Type F and Type N streams should be revised, based upon a physical habitat approach to classify fish use and nonuse streams.	N/A. (issue of improved implementation of existing rule).	#12
C6	All streams	**Other Water Protection Rules, Harvesting Rules, & Road Construction & Maintenance Rules not addressed here:** An evaluation of the habitat modification standard relative to other practices could not be specifically evaluated due to a lack of information.		N/A

Biological Criteria Standard [OAR 340-41-027]				
Pathways Evaluated (From Figure ABC)	Stream Size and Type	*Sufficiency of BMP Rule to Protect Water Quality:* Water Protection Rules (OAR 629-640); Harvesting Rules (OAR 629-630); & Road Construction & Maintenance Rules (OAR 629-625).	*Basis: Data/Information Referenced*	*Recommend-ation*
Interrelated (see Table 2)	All streams	**Water Protection Rules, Harvesting Rules, & Road Construction & Maintenance Rules:** Current practices that influence water quality with respect to temperature, sedimentation, turbidity, and habitat modification that may also affect biological criteria, are addressed elsewhere. The biological criteria standard was not specifically evaluated due to a lack of information.		N/A

Table 8 summarizes the 12 recommendations and their relationship to the WQS/FPA pathways illustrated in Figure 1 (p.8) and described in Table 2 (p.9).

Table 8. Summary of the WQS/FPA Pathways that the various recommendations address.

WQS/FPA Pathways	Recommendations											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
A1	x	x										
B2	x	x	x									
B3	x	x	x									
C4	x	x	x									
C5	x	x	x									
C6	x	x	x									
D4								x	x			
D5								x	x			
D6		x										
E4				x	x	x						
E5				x	x	x						
E6							x					
F7										x	x	x

RECOMMENDATIONS

This sufficiency analysis has considered the adequacy of administrative rules in achieving FPA and state water quality goals and objectives. The recommendations that follow have been developed by reviewing available research and monitoring data relevant to current forest practices included in the preceding sections and appendices of this report. The purpose of these recommendations is to help ensure FPA goals and objectives and water quality standards are being met.

The FPA goals and objectives, as well as most of the state water quality standards and criteria being evaluated in this analysis (temperature and turbidity being the exceptions), are qualitative in nature. Thus, conclusions regarding the effectiveness of the rules in meeting the goals and objectives are qualitative as well. Available data relevant to those quantitative water quality standards (i.e. temperature and turbidity) is inadequate to draw specific and comprehensive conclusions about the adequacy of current practices; therefore, the evaluation of these criteria is also qualitative.

Data in many areas is lacking and, in many cases, not comprehensive. In light of this, any policy decisions made when this report is completed will depend upon professional judgement consistent with available scientific information. As the Board of Forestry considers these recommendations, social and economic factors, along with the scientific evidence on the adequacy of current practices presented here, will be considered as well.

The following recommendations are offered to highlight general areas where current practices could be improved upon to better meet the FPA goals and objectives and, in turn, provide added assurance of meeting water quality standards. Below each recommendation are the applicable FPA/WQS functions pathways from Figure 1 (p. 8) that connect the recommendation to the specific water quality standard(s) the recommendation addresses (summarized in Table 8, p. 56). Also provided is the applicable monitoring/research used to develop the recommendation, followed by a summary of the basis of the recommendation.

Large Wood and Temperature

Recommendation #1: The RMA basal area retention standards should be revised, where appropriate, to be consistent with achieving characteristics of mature forest conditions in a timely manner; and to ensure that RMAs are providing desirable amounts of large wood and shade over space and time.

FPA/WQS Pathway: A1, B2, B3, C4, C5, & C6.
Monitoring/Research: ODF 2001a, Dent & Walsh 1997.

Basis: The Water Protection Rules were originally designed to provide a level of large wood inputs based on some assumptions about the capabilities of riparian areas to grow wood. Monitoring data indicate the assumptions for determining basal area targets for small and medium streams may not be consistent with what the RMAs are capable of growing along these streams, and also shows that 60 percent of harvest operations are not actively managing within the RMAs. Current research and monitoring results also show the current RMA prescriptions may result in short-term temperature increases on some Type F streams, however the significance of the potential temperature increases at a watershed (or sub-basin) scale is uncertain. If current practices are, in fact, resulting in an increased level of shade on a landscape scale, and if stream temperatures are reduced as a result, there may be opportunities to provide greater incentives for landowners to actively manage riparian areas in order to accelerate the growth of large wood along streams.

Recommendation #2: Revise current practices so desirable amounts of large wood is available along small stream channels that can deliver debris torrents to Type F streams. Ensure that adequate shade is maintained or rapidly recovered for riparian areas along small perennial Type N streams with the potential to impact downstream Type F waters.

FPA/WQS Pathway: A1, B2, B3, C4, C5, & C6.
Monitoring/Research: Caldwell et al., 1991; Robison et al., 1995; Robison et al., 1999.

Basis: There is increasing scientific evidence that small non-fish-bearing streams prone to debris flows provide an important source of large wood for downstream fish habitat. It is also known that the removal of shade-producing vegetation along small perennial Type N streams temporarily increases stream temperatures, until regeneration occurs. While these streams are providing some level of functional large wood inputs and shade production under the current rules, the rules were not specifically designed to retain significant sources of large wood and shade in these areas. Current research and monitoring results show the current practices may result in short-term temperature increases in some Type N streams that feed into fish-bearing streams, however, the significance of the potential temperature increases at a watershed (or sub-basin) scale is uncertain.

Recommendation #3: Provide additional large wood to streams by actively placing the wood in areas where it will provide the greatest benefits to salmonids.

FPA/WQS Pathway: B2, B3, C4, C5, & C6.
Monitoring/Research: Thom et al., 1998; Thom et al., 1999.

Basis: It is widely believed that current levels of large wood in many streams are significantly lower than what occurred historically, and recent stream habitat surveys by the Oregon Department on Fish and Wildlife (ODFW) confirm that relatively large pieces of large wood (>20-inch DBH) are currently lacking on private forestlands. Where specific stream reaches are identified as lacking in large diameter trees, the active placement of key pieces of large wood can be an important tool for the creation and/or enhancement of fish habitat in the short-term. If current practices are, in fact, resulting in an increased level of shade on a landscape scale, and if stream temperatures are reduced as a result, there may be opportunities to provide greater incentives for landowners to place large wood from riparian areas in streams where large wood is lacking.

Roads

Recommendation #4: Reduce the delivery of fine sediment to streams by installing cross drains to keep drainage waters from eroding slopes. This will allow filtering of sediments and infiltration of drainage water into undisturbed forest soils. Cross drains should not be confused with stream crossing culverts. Cross drains take water from the road surface and ditch and route it under/across the road, discharging the water downslope from the road.

FPA/WQS Pathway(s): E4 & E5.
Monitoring/Research: ODF 1996; others (see references).

Basis: Cross drain structures are installed to protect road surfaces from erosion and retaining water, to reduce erosion of roadside ditches, to prevent ditch water from discharging onto unstable slopes, and to reduce the amount of ditch water (and associated ditch water sediment) discharging directly into a stream. An insufficient drainage design can result in unfiltered surface runoff entering streams. This may have adverse effects on the maintenance and recovery of salmonids. Currently, a large network of active roads exist across forested lands that were not built to current FPA design standards. While old roads[11] may be functioning adequately, it is believed a significant portion of these roads pose an increased risk of fill failure and/or washouts that can adversely affect water quality and the maintenance and recovery of salmonids. Recent monitoring studies have found many existing roads have drainage systems that are not designed to filter sediment. A secondary finding was that steep roads (>12 percent grade) often have inadequate spacing of cross drainage structures (excessive distance between cross drains). These conditions exist mostly on older and, to a lesser extent, on more recently constructed roads.

Recommendation #5: Develop specific standards for roads that will be actively used during the wet season. This would include a requirement for durable surfacing of roads in locations where fine sediment can enter streams. This would also include ceasing to haul if roads have not been constructed with effective surface materials, drainage systems, or other alternatives (paving, increased numbers of cross drains, sediment barriers, settling basins, etc.) that minimizes delivery of sediment into streams.

FPA/WQS Pathway: E4 & E5.
Monitoring/Research: N/A (issue of clarifying existing rule).

[11] "Old" roads are those built prior to the 1983 rule changes (i.e., roads built before end-hauling of material excavated from the road prism on steep slopes).

Basis: One area not directly addressed by the rules is sediment and turbidity problems related to road use during the wet season. Currently, road maintenance rules and guidance directs operators to stop hauling when high levels of turbidity associated with the hauling are observed downstream stream. However, there are currently no rules that specifically address minimizing turbidity attributable to wet-season hauling.

Recommendation #6: Develop specific guidance describing how roads in critical locations would be reviewed to reduce road length, and determining when, despite the relocation, the road location would pose unacceptable risk to resources and not be approved.

FPA/WQS Pathway: E4 & E5.
Monitoring/Research: Robison et al., 1999; N/A (issue of clarifying existing rule).

Basis: Roads that are built on some steep slopes above streams, or that directly fill or excavate in streams, floodplains, lakes, or wetlands can have much greater impacts on water quality and aquatic resources than roads elsewhere across the landscape. If these roads are constructed, the risks they pose to aquatic resources should be minimized to the maximum extent practicable. There are also cases where roads should not be constructed. Current rules require that operators "avoid locating roads on steep slopes, slide areas, high-risk sites, and in wetlands, riparian management areas, channels, or floodplains where viable alternatives exist." Prior approval by the State Forester is required before roads can be constructed or reconstructed in such locations. Current rule language allows ODF to require written plans and not approve construction or reconstruction when the risk of such action is too high.

Recommendation #7: Construct stream crossings that adequately pass large wood and gravel downstream, and provide other means for passage of large wood and sediment at those crossings that restrict passage. The transport mechanisms for large wood and gravel should include both stream storm flows and channelized debris flows. This would reduce the risk of debris backing up behind the structure, potentially resulting in catastrophic sediment delivery caused by washouts.

FPA/WQS Pathway: E6.
Monitoring/Research: Robison et al., 1999; Reeves et al., 1995; Reeves at al. 1997; others (see references).

Basis: Most stream crossing culverts restrict or prevent the passage of large wood to a greater or lesser degree. Historically, stream crossing structures have been designed primarily to pass water. In recent years, there has been an increased effort to design stream crossings so they effectively pass fish as well. New culverts in Type F streams designed to simulate streambeds pass gravel and other bedload material, but their ability to pass large wood is limited. There is an increasing body of scientific evidence supporting the movement of large wood downstream to create and maintain fish habitat. A broader range of engineering options for stream crossing designs should be developed to help pass large wood and sediment, including debris flows on steeper channels.

Recommendation #8: Develop specific steep-slope ground-based yarding practices, or add a prior approval requirement for ground skidding in high-erosion hazard locations.

FPA/WQS Pathway: D4 & D5.
Monitoring/Research: N/A (issue of clarifying existing rule).

Basis: Ground-based harvesting on steep slopes has a relatively higher risk of sediment delivery to streams and direct impacts to aquatic habitat compared to ground skidding on less-steep slopes or cable yarding. The current rule for ground-based harvesting on steeper slopes is neither clear, nor specific. Action should be taken to reduce the potential of sediment delivery or other undesirable effects to streams from skid roads constructed on steep slopes.

Landslides

Recommendation #9: Manage locations most prone to landslides (high-risk sites) with techniques that minimize impacts to soil and water resources. To achieve this objective, best management practices to protect landslide-prone terrain currently in guidance should be incorporated into the forest practice rules, while developing a better case history for evaluating the effectiveness of those practices. These standard practices are designed to minimize ground alteration/disturbance on high-risk sites from logging practices.

FPA/WQS Pathway: D4 & D5.
Monitoring/Research: N/A (issue of clarifying existing rule).

Basis: Current rules require specific harvesting practices be employed on landslide-prone terrain. These practices are designed primarily to limit ground disturbance so landslide risk will not be increased. The rules and/or guidance do not require that merchantable trees be left on the site to possibly play a role in stabilizing the slope, either through a mechanical (root reinforcement) or hydrological (water routing) mechanisms. Since hazards and risks are variable, it is logical to develop practices consistent with the potential for landslide delivery to streams. A hazard is also related to the percent of the watershed that is subject to debris flows, as well as reduced forest cover.

Fish Passage

Recommendation #10: Provide for riparian functions along stream reaches above impassable stream crossing structures that have a high probability of recolonization by salmonids once the structure is replaced/improved. If an upstream reach has the capacity to be a fish-bearing stream, but is currently a non-fish-bearing stream because a stream crossing structure cannot pass fish, the forest practices rules should be amended so the upstream reach is classified as a fish-bearing stream.

FPA/WQS Pathway: E6.
Monitoring/Research: NA (policy choice)

Basis: Providing for riparian functions along these stream reaches will facilitate reoccupation by fish once a culvert is replaced, and will help maintain and restore good fish habitat over time. The potential disincentive of replacing a culvert in a timely manner would also be removed. The same level of riparian vegetation retention will be necessary, regardless of when the culvert is replaced. It may also remove the incentive to harvest a reach above the culvert before culvert replacement. An unbalanced dichotomy in how streams are classified will also be eliminated. Currently, if fish presence surveys have not been conducted above a culvert, the interim guidelines are applied and the appropriate reach above the culvert is treated as a Type F stream. If fish presence surveys have confirmed the absence of fish above a culvert, then the entire stream above the culvert is treated as a Type N stream. Implementing this recommendation would provide the same level of riparian protection, regardless of the status of stream surveys above the culvert.

Recommendation #11: Facilitate the identification, prioritization, and restoration of existing culverts that currently do not pass fish. Culvert replacement should be accelerated, specifically for family forestland owners who often do not have adequate resources to address this issue in a timely manner.

FPA/WQS Pathway: E6.
Monitoring/Research: N/A. (issue of improved implementation of existing rule).

Basis: A large number of stream crossings in Oregon currently do not pass juvenile and adult fish up and downstream. However, on forestland, a protocol for road assessments has been developed, as have criteria for fish passage. Many watershed councils are helping landowners establish restoration priorities and facilitating grant writing. Recent training efforts are helping to improve landowners' technical understanding of design criteria.

Recommendation #12: Provide a more effective and efficient means of classifying streams for "fish use." Revise the forest practice rule definition of Type F and Type N streams using a physical habitat approach to classify fish-use and non-use streams.

FPA/WQS Pathway: E6.
Monitoring/Research: N/A. (issue of improved implementation of existing rule).

Basis: The current water classification scheme is based on the presence or absence of fish. The survey process to determine presence/absence is time-consuming, limited to a short season, and requires significant funding (though costs are relatively low compared to the resources that may or may not be retained based upon the results). Fish presence surveys are becoming more restricted due to the listing of fish under the federal Endangered Species Act (ESA). The surveys do provide useful information to identify barriers to fish passage, identify unmapped stream channels, and create a baseline of fish distribution information. However, surveys can produce unreliable results when fish populations are depressed or there are other influential environmental factors such as drought or extreme flows. This survey-based approach potentially reduces the amount of mature forest riparian habitat maintained over time. This occurs where older forest structure along a given stream reach may not be maintained as well as it might under a Type F classification over time, as fish were not present at the time the fish survey was conducted.

COMPLIANCE AND EFFECTIVENESS MONITORING

Current Monitoring

The goal of the ODF forest practices monitoring program is to evaluate the effectiveness of the forest practice rules. Monitoring results are used to guide future management practices through the rule revision process. The goal includes a commitment to address specific Oregon Plan issues.

The specific objectives of the program are to:

1. **Evaluate the effectiveness of the Act and rules to encourage economically efficient forest practices, while protecting forest productivity, water and air quality, and fish and wildlife at a variety of scales and over time.** Effectiveness monitoring information is used to assess whether forest practice regulations are having the desired effect on forest resources at multiple scales—site, watershed, basin, and landscape—and over long periods of time.

2. **Assess the implementation of the Act and rules.** Implementation monitoring evaluates whether the rules were carried out as intended.

3. **Validate the assumptions built into the Act and rules.** Validation monitoring assesses whether the assumptions underlying the design of the Forest Practices Act or specific rule objectives are correct.

4. **Provide timely feedback on the effectiveness of the rules.** While monitoring is a long-term process, the program strives to report its progress and make recommendations for administrative changes or rule refinement to the Board of Forestry.

5. **Facilitate coordination and cooperation on monitoring efforts.** The program works with other agencies, forest landowners, and other interested parties to coordinate monitoring approaches and to pursue cooperative studies, particularly in conjunction with the Oregon Plan.

6. **Coordinate monitoring projects to address Oregon Plan monitoring objectives.** The program specifically addresses the Oregon Plan objectives for determining forest practices effects on coastal salmon habitat.

7. **Encourage, synthesize and report other relevant information and research on the effects of forest practices.**

The forest practices monitoring program is in the final phases of completing current effectiveness and compliance monitoring projects. The following discussion focuses on stream temperature-related effectiveness studies. A complete list of available ODF Technical Reports is provided in Table 9.

Final reports are available from two earlier stream temperature studies that monitored effects of harvesting on stream temperature for small Type N (ODF Technical Report #2) and medium and large Type F streams (ODF Technical Report #3). More recently, ODF has been monitoring stream temperature at a sub-basin scale at four sites and at a reach-level scale at seven sites. Pre- and post-harvest data were collected. A preliminary report will be available in 2003.

Table 9. Oregon Department of Forestry Monitoring Reports

ODF Technical Report Number	Report Title
1	OFPA Water Protection Rules: Policy And Scientific Considerations
2	Cooperative Stream Temperature Monitoring Project Completion Report For 1994 – 1995 (Small Type N Streams)
3	Effectiveness Of Riparian Management Areas And Hardwood Conversions In Maintaining Stream Temperature
4	ODF Storm Impacts And Landslides Of 1996
5	ODF Forest Practices Compliance Monitoring Project: 1998 Pilot Study Results
6	ODF Compliance With Fish Passage And Peak Flow Requirements At Stream Crossings: Pilot Study Results
7	ODF Aerial Pesticide Application Project Final Report
8	Evaluation of the Effectiveness of Forest Road Best Management Practices to Minimize Stream Sediment Impacts
9	Forest Roads, Drainage, and Sediment Delivery in the Kilchis River Watershed
10	Forest Road Sediment and Drainage Monitoring Project Report for Private and State Lands in Western Oregon
12	Harvest Effects on Riparian Function And Structure Under Current Oregon Forest Practice Rules
13	Shade Conditions Over Forested Streams in the Blue Mountain and Coast Range Georegions of Oregon

Current projects include fish presence surveys, fish passage and stream crossing compliance (ODF Technical Report #6), effectiveness of chemical application rules (ODF Technical Report #7), and Best Management Practices Compliance monitoring (ODF Technical Report #5).   Pilot study results from the BMP Compliance project indicate high compliance levels (98 percent) at a rule level and low compliance at a harvest unit level (50 percent of the sites had some form of non-compliance).

The forest practices monitoring strategy is currently being revised. The key areas identified for improvement include:

- Building understanding, acceptance and support for the monitoring strategy.
- Using random sample design to select all sites. This has been used for two current projects.
- Combining monitoring efforts at each site to increase efficiency (i.e. compliance monitoring and riparian function at the same site)
- Increasing coordination with other Oregon Plan monitoring efforts, most notably DEQ and ODF&W.
- Addressing issues at a watershed scale.

- Improving communication of project status and results, both internally and externally using newsletters and project publications.

The monitoring strategy outlines key questions in the areas of forest productivity, fish and wildlife, water quality, and air quality. These categories and the prioritization of questions will be revisited.

Recommended Future Monitoring

The Sufficiency Analysis evaluation resulted in the following specific recommendations for future monitoring. Each recommendation is followed by a summary of the basis of the recommendation.

Monitoring Recommendations:

1. Maintain a riparian monitoring program that continues to monitor the effectiveness of riparian prescriptions and riparian functions to ensure water quality goals are achieved in the future.

   Basis: Continued monitoring of the rules protecting riparian functions must occur to understand how the rules are being implemented and to evaluate whether or not they are achieving their objectives. Currently, as part of the BMP Compliance Audit Project, the ODF is monitoring compliance with the water protection rules. This project is a three-year effort to monitor compliance with the forest practice rules in general. The ODF also has an on-going stream temperature-monitoring project. Resources should be provided to enable the ODF to do effectiveness monitoring related to the large wood objectives of the Oregon Plan and water quality standards, as well as continued compliance monitoring.

2. Monitor improvement of forest roads at a landscape level, looking specifically at implementation of the road hazard and risk reduction project.

   Basis: Currently a large network of active roads that were not built to current FPA design standards exits across forestlands. While old roads[12] may be functioning adequately, it is believed that a significant portion of these roads pose an increased risk of fill failure and/or washouts that can adversely affect water quality and the maintenance and recovery of salmonids. It is important to monitor, over time, the effectiveness of the road hazard risk reduction project in addressing resource protection issues specific to these old roads.

3. Evaluate the need for further road compliance and effectiveness monitoring following the completion of the BMP compliance monitoring project relating to road BMPs. Also evaluate the progress and effectiveness of current voluntary efforts under the Oregon Plan to upgrade existing culverts that do not pass fish.

[12] "Old" roads are those built prior to the 1983 rule changes (i.e. roads built before end-hauling of material excavated from the road prism on steep slopes).

Basis: Roads are generally considered the single greatest chronic source of fine sediment associated with forest practices. However, available information also confirms that when properly implemented, current BMPs are effective at reducing delivery of sediment from roads. Road BMP compliance and effectiveness monitoring was recently completed as part of the Oregon Forest Practices BMP compliance monitoring project. The BMP pilot study has already identified a need to more specifically monitor BMP effectiveness during rainy-season hauling.

4. Monitoring of watershed-scale effects relative to current practices along small Type N streams should be a priority to help narrow the current level of uncertainty.

   Basis: In many cases, the alteration of the fire regime described earlier in this report translates into more densely stocked forests that are at a greater risk for catastrophic fire. Very dense forests provide relatively high levels of shade, precluding understory development. Considering this information, as well as the discussion of stand development dynamics, there is a reasonable probability that current shade levels on state and private forestlands are higher, on average, than what occurred historically. Where the difference in shade levels influence stream temperature, there is the possibility at the landscape scale temperature conditions have shifted as well (i.e. are lower). However, at the site-specific level, current research and monitoring results show current practices may result in short-term (two to three years) temperature increases on some small Type N streams transferred downstream to fish-bearing streams. The significance of potential site-specific temperature increases at a watershed (or sub-basin) scale is uncertain, given the landscape-scale condition. Additional monitoring at a watershed scale can provide information to better describe the interactions between the landscape and site-specific conditions.

The following are remaining issues identified in this report that may warrant future examination as additional information is available:

- Is the occurrence of blowdown having an effect on meeting the goal of achieving “over time, average conditions across the landscape become similar to those of mature forest conditions” in RMAs?

- Are current forest practices meeting the water quality standard with respect to cold-water refugia? (This analysis will not be possible until the DEQ develops the specific guidance necessary to identify cold-water refugia on the ground that can be evaluated against the standard.)

- What effect, if any, are current practices along small non-fish-bearing streams having on downstream sediment regimes?

The Board of Forestry is currently deliberating the recommendations introduced by the Forest Practices Advisory Committee (FPAC) in September 2000. The process of implementing changes to current BMPs will occur over the next few years and is likely to consist of both regulatory and non-regulatory measures. The ODF monitoring program is also beginning a new series of effectiveness monitoring projects to evaluate BMP sufficiency in protecting riparian functions and water quality. There may also be some issues with water quality parameters that are not specifically addressed in this report that could have an unknown potential for current practices to cause changes in water quality conditions. In these cases, the DEQ will coordinate with the ODF and its monitoring program to address these parameters as concerns are identified and documented. Specific details of future monitoring efforts will be determined once the FPAC recommendations are developed further and implemented. ODF's monitoring strategy will continue to be developed at that time.

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APPENDIX A: SOCIAL, ECONOMIC, AND ENVIRONMENTAL FRAMEWORK

Social Setting: Legal and Policy Framework

Forest Practices Act

The Board of Forestry (Board) is charged by ORS 526.016 to "supervise all matters of forest policy and management under jurisdiction of this state." To assist in carrying out this responsibility, the Board has developed a strategic plan, the "Forestry Program for Oregon" (FPFO). This plan includes a number of key broad policy objectives. These objectives are as follows (Table 1):

Table 1. FPFO Objectives

Objective	Description
1-- Forestland Base	Preserve the forestland base of Oregon
2-- Research and Monitoring	Use research and monitoring of the forest condition to understand the effectiveness of forest management strategies, and incorporate the knowledge gained into policies and programs.
3-- Ecosystem Health and Sustainability	Promote cooperative land management strategies among the public and private forest landowners, on a larger geographic scale and over a longer timeframe, to maintain the health and integrity of Oregon's diverse forested ecosystems.
4-- Timber Growth and Harvest	Promote healthy and productive forests to provide maximum, sustainable supply of timber.
5-- Stewardship Through Regulation of Forest Practices	Through regulations, assure practical and appropriate forest practices that conserve and protect soil productivity, fish and wildlife habitat, air quality, and water quality and quantity.
6-- Voluntary Stewardship of Forest Values and Resources	Develop incentives and foster the collection and sharing of information to spur voluntary management initiatives beyond regulatory standards; to assist in recovery of threatened and endangered species and prevent further listings; and to encourage appropriate opportunities for activities, such as fish and wildlife enhancement, fishing, hunting, wildlife observation, grazing, recreation and scenic values.
7-- Forest Protection	Devise and use environmentally responsible and economically efficient strategies to protect Oregon's forests from unacceptable effects from wildfire, insects and disease.
8-- Public Education and Involvement	Assure increased understanding and informed decision-making by Oregonians about the role and function of Oregon forests, and the connection between Oregon's forests and people's choices.

In establishing programs and adopting rules, the Board attempts to balance their actions to avoid creating unintended negative consequences that undermine the achievement of their strategic objectives. The Forest Practices Program is one of the Board's regulatory components. However, other programs, including the Forest Practices Program, include non-regulatory components designed to further support or enhance the regulations.

The Oregon Forest Practices Act, passed in 1971, was the first of its kind in the nation to require resource protection during logging operations. Nine other states have since adopted forest practice regulations.

ORS 527.765 requires the Board, in consultation with the Environmental Quality Commission (EQC), to establish Best Management Practices (BMPs) and other rules applying to forest practices to ensure that to the maximum extent practicable non-point source discharges of pollutants resulting from forest operations do not impair the achievement and maintenance of water quality standards established by the EQC. The ODF is the Designated Management Agency by the Department of Environmental Quality (DEQ) for regulation of water quality on nonfederal forestlands. The EQC, DEQ, the Board and the ODF have determined that pollution control measures required as BMPs will be relied upon to result in achievement of water quality standards. In meeting the charge of ORS 527.765, factors to be considered by the board in establishing best management practices shall include, where applicable, but not be limited to:

(a) Beneficial uses of waters potentially impacted;
(b) The effects of past forest practices on beneficial uses of water;
(c) Appropriate practices employed by other forest managers;
(d) Technical, economic and institutional feasibility; and
(e) Natural variations in geomorphology and hydrology.

In addition, ORS 527.714 establishes specific standards for rulemaking by the Board for rules adopted to implement the provisions of ORS 527.710 (2), (3), (6), (8), (9), (10) and (11) that grant broad discretion to the board and that set standards for forest practices not specifically addressed in statute. These standards require that the Board adopt such rules only after determining that the following facts exist and standards are met:

(a) If forest practices continue to be conducted under existing regulations, there is monitoring or research evidence that documents that degradation of resources maintained under ORS 527.710 (2) or (3) is likely, or in the case of rules proposed under ORS 527.710 (11), that there is a substantial risk of serious bodily injury or death;
(b) If the resource to be protected is a wildlife species, the scientific or biological status of a species or resource site to be protected by the proposed rule has been documented using best available information;
(c) The proposed rule reflects available scientific information, the results of relevant monitoring and, as appropriate, adequate field evaluation at representative locations in Oregon;
(d) The objectives of the proposed rule are clearly defined, and the restrictions placed on forest practices as a result of adoption of the proposed rule:
    (A) Are to prevent harm or provide benefits to the resource or resource site for which protection is sought, or in the case of rules proposed under ORS 527.710 (11), to reduce risk of serious bodily injury or death; and

(B) Are directly related to the objective of the proposed rule and substantially advance its purpose;

(e) The availability, effectiveness and feasibility of alternatives to the proposed rule, including nonregulatory alternatives, were considered, and the alternative chosen is the least burdensome to landowners and timber owners, in the aggregate, while still achieving the desired level of protection; and

(f) The benefits to the resource, or in the case of rules proposed under ORS 527.710 (11), the benefits in reduction of risk of serious bodily injury or death, that would be achieved by adopting the rule are in proportion to the degree that existing practices of the landowners and timber owners, in the aggregate, are contributing to the overall resource concern that the proposed rule is intended to address.

Economic Setting: Oregon's Forest Landbase

Oregon's total land area is 61.4 million acres. Almost half of this, 27.5 million acres, is forested. Oregon's forests are divided into two major geographic regions: eastern Oregon and western Oregon, which are separated by the Cascade Range. Douglas-fir and western hemlock are the primary conifer species in western Oregon. In eastern Oregon, ponderosa pine and lodgepole pine are the primary conifers. Several species of true fir and larch also grow east of the Cascades. Non-commercial forests are found along the crest of the Cascade Range and in the high-desert country of eastern Oregon. Species in these forests include alpine fir, mountain hemlock and western juniper. The area occupied by non-commercial juniper forests is increasing.

Sixty-one percent of Oregon's forests are publicly owned, and almost 57 percent of Oregon's forests are in federal ownership. Fifty-nine percent of the forestland, or 16.2 million acres, is capable of producing timber for commercial harvest (and has not been administratively withdrawn from harvest consideration); more than 23 percent, or 6.3 million acres, is capable of producing commercial timber, but is withdrawn from commercial production; 18 percent, or 4.9 million acres, contains less suitable non-commercial forest.

Forestland available for commercial timber management has decreased significantly. For example, 9 billion board feet were harvested from Oregon forestlands in 1971. By 1997, this figure had declined to 4.1 billion board feet. Much of this decline is due to dramatic decreases in timber harvesting from federal land, which plummeted from 5.5 billion board feet harvested in 1972 to 659 million board feet in 1997. Timber harvesting on privately owned commercial forestlands has declined as well, but not as dramatically, dropping from 3.1 billion board feet in 1971 to 2.6 billion board feet in 1997. The only increase in timber harvesting by land ownership occurred among private nonindustrial forest landowners. In 1981, private nonindustrial landowners harvested 180 million board feet; in 1997, this same group harvested 592 million board feet of commercial timber.

According to the Oregon State of the Environment Report "… instances of good or excellent water quality occur most often in the forested uplands of Oregon. Both forest practices rules on public and private forests and lack of development help explain the result. …On the other hand, instances of poor or very poor water quality occur most often in the non-forested lowlands where intensive land uses and land conversion have occurred. Riparian practices are controlled to a much greater degree on forestlands than on urban, agricultural or range lands." The following sections summarize the economic setting of private and public forests in which this general evaluation of water quality occurred.

<u>Private Forestlands</u>

Private forestlands represent a larger portion of Oregon's timber supply due to harvest limitations placed on federal forestland. Timber harvest levels on non-industrial forestlands (ownerships typically smaller than 5,000 acres and owned by individuals, not corporations) have more than doubled since 1981, and harvest levels on industry-owned forestlands have remained stable throughout this same period. Nearly all of the timber harvested from private forestlands is second growth. Since private forestlands are generally being reforested, they will continue to play a major role in sustaining Oregon's long-term timber supply.

<u>Federal Forestlands</u>

The United States Department of the Interior (USDI) Bureau of Land Management (BLM) and the United States Department of Agriculture Forest Service (Oregon's largest federal forestry agencies) are in the process of changing their overall management strategies for federal lands. Ecosystem management, where all planned actions are considered and made in a large-scale geographic context, is the preferred approach.

A major emphasis for federal agencies involves providing for the habitat for threatened or endangered species. Species currently listed are the northern spotted owl, the marbled murrelet, and various populations, stocks and species of anadromous fish (four species of salmon and one of steelhead trout).

These listings have a profound effect on the management of all forestlands, but particularly public lands managed by the federal government. Federal land management actions cannot be taken without intense consultation and planning. The agencies must prove that proposed actions either have no adverse effect on a listed species or its habitats, or that expected actions having positive effects elsewhere will offset the locally negative ones.

Federal timber harvest levels have declined as timber sales have been appealed and forest set-asides for habitat protection have increased. Reduced revenues have affected local services and infrastructure (where a percentage of harvest tax dollars are reinvested) and the overall structure and funding of federal agencies.

<u>State Forestlands</u>

The Department of Forestry manages about 789,000 acres of forestland that are held and managed for the benefit of counties, schools and local taxing districts. Nearly 657,000 acres are Board of Forestry lands, which are managed by the department for the counties in which they are located. More than 132,000 acres of Common School Lands are managed by the department for the State Land Board. These state forestlands are not managed with the same strategy as are federal forests. According to statute, state forestlands are managed for sound environmental protection and to produce sustainable revenue for counties, schools and local taxing districts.

Despite the fact that these state forestlands make up only 3 percent of Oregon's commercial forest landbase, the state has become an important supplier of timber due to restrictions placed on harvest activity in federal forests.

Oregon has five major state forests (Clatsop, Elliott, Santiam, Sun Pass and Tillamook) together with a number of small tracts scattered across the state. State forests generally contain younger trees (<150 years old). For example, the Tillamook State Forest was burned in a series of disastrous fires in the 1930s, 1940s and 1950s, and much of the Elliott State Forest burned in 1868.

Environmental Setting: Forest Ecosystem Dynamics

The diversity inherent in forested landscapes results from variation in such things as climate, soils, and topography and from disturbances such as fire, windstorms, and human activities. Vegetation diversity across the landscape and over time is an important consideration in evaluating the sufficiency of forest practices rules in providing for water quality protection. The historic condition of vegetation patterns that characterized the riparian forests in which salmonids evolved and thrived was significantly influenced by natural disturbances such as fire, insects, disease, windthrow, landslides, and floods. A high degree of spatial and temporal variability was present at both small and large scales. Fire disturbance has received increased attention in recent years, perhaps because it is arguably the disturbance type that has been most influenced by human activities across the landscape (Agee, 1998). More recently, increased attention has been given to the effects of landslides and flooding in how they influence the physical and biological characteristics of riparian areas and associated aquatic species.

Forest Succession

Pacific Northwest forests generally follow a typical progression of stand structures over time following a major stand-replacement disturbance. One model of forest succession following disturbance has been clearly defined by Oliver and Larson (1996). Their model includes stand initiation, stem exclusion, and understory reinitiation. The final stage of stand progression identified by Oliver and Larson is older forest structure. This definition is based upon natural stand progressions that could take 200 to 1,000 years or more in the western hemlock/Douglas-fir forests.

Forest stands develop along continuums. The continuum described in the boxes below is characteristic of Coast Range forests after a stand-replacement disturbance.

Stand Type Definitions

The forest stand types are briefly defined here and are explained in more detail in the next several pages.

Regeneration (REG) — This stand type occurs when a disturbance such as timber harvest, fire, or wind has killed or removed most or all of the larger trees, or when brush fields are cleared for planting.

Closed single canopy (CSC) — This stand type occurs when new trees, shrubs, and herbs no longer appear in the stand, and some existing ones begin to die from shading and competition, in a process called stem exclusion.

Understory (UDS) — This stand type occurs after the stem exclusion process has created small openings in the canopy, when enough light and nutrients become available to allow herbs, shrubs, and new trees to grow again in the understory.

Layered (LYR) — This stand type occurs as the process of understory reinitiation progresses where openings in the canopy persist. Shrub and herb communities are more diverse and vigorous, and two or more distinct layers of tree canopy appear.

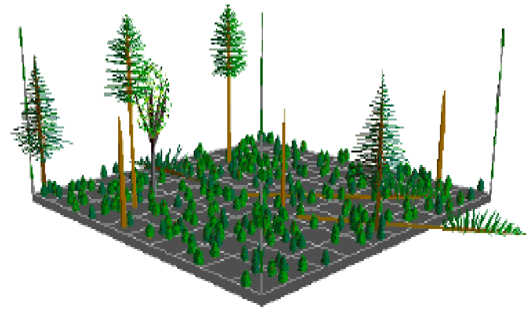
Older forest structure (OFS) — This stand type occurs when forest stands attain structural characteristics such as numerous large trees, multi-layered canopy, substantial number of large, down logs, and large snags.

Table 2. Relationships between Stand Type Definitions and Stand Development Processes

Stand Type		Stand Development Process
Regeneration (REG)	———	Stand Initiation (SI)
Closed Single Canopy (CSC)	———	Stem Exclusion (SE)
Understory (UDS) Layered (LYR) Older Forest Structure (OFS)	}	Understory Reinitiation (UR)

Stand Type 1 — Regeneration

Stand Development Process — Stand Initiation (SI)

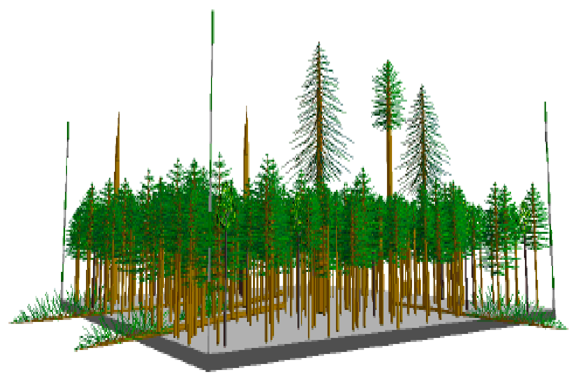


The site is occupied primarily by tree seedlings or saplings, and herbs or shrubs. The trees can be conifers or hardwoods. Herbs, shrubs, and/or grasses are widespread and vigorous, covering 20 to 80 percent of the ground. This type includes first-year regenerated stands, and continues to the stage when the trees approach crown closure.

A REG stand develops through the stand initiation process, which begins when a disturbance such as timber harvest, fire, or wind has killed or removed most or all of the larger trees, or when undesirable vegetation is cleared for planting. Herbs, shrubs, and some live trees will remain from the previous stand, as well as snags and down wood. New plants (trees, shrubs, and herbs) begin growing from seed, sprouts, artificial regeneration, or other means in the early years of this stage. In the later years of this stage, increasing crown closure shades the ground, and herbs, shrubs, and grasses begin to die out or lose vigor.

Stand Type 2 — Closed Single Canopy

Stem Exclusion (SE)

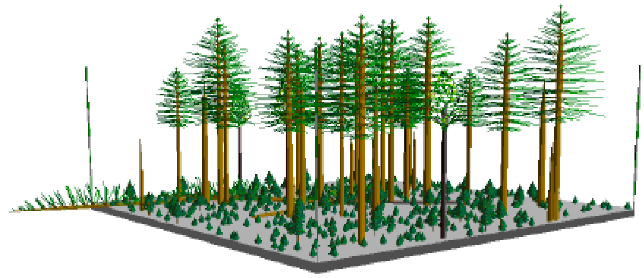


Trees fully occupy the site and form a single, main canopy layer. There is little or no understory development. Where understory vegetation exists, there is low shrub and herb diversity. The shrub and herb layers may be completely absent or may be short and dominated by one or two shade-tolerant species, such as sword fern, Oregon grape, oxalis, or salal. CSC stands may include sapling stands, unthinned stands, or thinned stands where the overstory still occupies most of the stand.

This stand type develops when the trees in a regeneration stand grow larger and begin to compete for moisture, light, and nutrients. The stem exclusion process begins when new trees, shrubs, and herbs no longer appear and existing ones begin to die, due to competition. Later in the stage, shrubs and herbs may essentially die out of the stand altogether. The trees begin to show decreasing limb sizes, diameter growth rate, and crown length. Later, less competitive trees die. Root diseases may kill additional trees. As some trees die, snags and down wood begin to appear in the stand. The surviving trees grow bigger and have more variation in height and diameter. Near the end of the stage, enough trees have died and the living trees have enough variation that small gaps form and understory trees, shrubs, and herbs begin to reappear.

Stand Type 3 — Understory

Understory Reinitiation (UR)



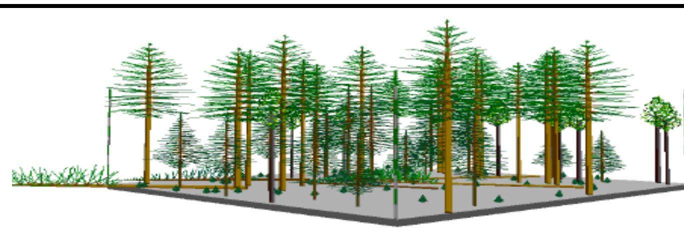
These stands have developed more diverse herb or shrub layers than CSC stands and have trees larger than sapling size. Tree canopies may range from a single-species, single-layered, main canopy with associated dominant, codominant, and suppressed trees, to multiple species canopies. However, significant layering of tree crowns has not yet developed.

The least developed stands in this category consist of a single-species, single-layered, main tree canopy with a diversified understory of shrubs and herbs. Adequate light reaches the ground to allow shade-tolerant and intolerant herb and shrub species (e.g., Oregon grape, sword fern, blackberry, huckleberry, twinflower) to flourish. This category also includes stands where the herbs, shrubs, and understory trees are vigorous and beginning to diversify. Vertical layering may be developing, but is not yet extensive.

The understory reinitiation process occurs after stem exclusion, when enough light and nutrients become available to allow forest floor herbs, shrubs, and tree regeneration to again appear in the understory. The amount of brush and herbaceous species is minimal at the beginning, but increases to a substantial part of the stand by the end of the stage. In all UDS stands, the shrub and herb layers are likely to continue to diversify and maintain or improve their vigor. These stands offer good potential to develop into highly diversified vegetative communities. Depending on the intensity and timing of density management activities, stands could shift back and forth between the CSC and UDS stand types over time.

Stand Type 4 — Layered

Understory Reinitiation (UR)



LYR stands have extensive layering of herbs, shrubs, and tree crowns; vertical structure is more complex than in UDS stands. Shrubs or herbs are present and tree canopies have two or more levels. Trees of 18 inches or larger dbh and 100 feet or more in height are predominant in the overstory.

More complex LYR stands have a mixture of shade tolerant (e.g., western redcedar, western hemlock) and intolerant tree species (e.g., Douglas-fir, noble fir); and shrub and herb species (vine maple, huckleberry, rhododendron, Indian plum, prince's pine). The younger cohort of trees should be at least 30 feet tall. Tree crowns show significant layering from the tallest trees to the forest floor. Shrub and herb layers are diverse, in terms of species and in vertical arrangement. The plant community provides a wide range of habitat niches from the forest floor through the canopy.

The understory reinitiation process occurs after the stem exclusion process, when enough light and nutrients become available to allow herbs, shrubs, and tree regeneration to appear again in the understory. The new understory may grow very slowly at higher stand densities. Understory brush and herbaceous species increase to a substantial component of the stand by the end of the stage.

Stand Type 5 — Older Forest Structure

Understory Reinitiation

This stand type occurs when a layered stand develops the structural characteristics typically linked with older forests or old growth. In addition to the variety of trees typically found in a layered stand, these stands have all of the following four characteristics.

- Numerous live trees that are 24 to 32 inches in diameter at breast height or greater.
- Two or more tree canopy layers. Often one layer is a shade-tolerant species.
- Numerous large snags.
- Sound down logs.

In addition, the following characteristics are normally associated with older forest conditions, and may also be present to varying degrees.

- At least 1 large remnant tree per 5 acres (over 32" DBH).
- Multiple tree species.
- Some trees within the stand contain defect or indicators of decadence.
- Diverse understory vegetation including herbs and tall shrubs.

The understory reinitiation process described for understory and layered stand types is also the developmental process occurring in these stands, which are essentially layered stands that have achieved the structural characteristics defined above.

Partial disturbances, caused by natural agents such as low intensity fires and windstorms, can result in patchy openings in stands and may not affect all sizes of trees in the stand. Such disturbances can result in stands with numerous variations in structure, often with remnant patches or individual trees larger or smaller than the rest of the stand. In some instances, the residual trees grow fast enough to prevent the establishment of another age class. In other instances, new trees, shrubs, and herbs regenerate in the larger openings. The patches of new regeneration will generally follow the same sequence of development that occurs in stands that regenerate following a major disturbance. Partial disturbances may thus result in stands with a variety of age classes and vegetation development (McComb et al., 1993). The pattern of natural succession may well have been more dynamic in lowland areas, where hardwood species were likely more dominant historically in the riparian forests and beavers likely modified both channel and vegetation patterns in significant ways.

An investigation of forest succession following a high intensity fire is presented by Tappeiner et al. (1997). In this study, the diameters and diameter growth rates for the first 100 years of old-growth stands on the Oregon Coast were compared to 50-70 year-old second-growth stands. It was observed that the regeneration of old-growth forests do not necessarily follow the scenario of a stand replacement disturbance followed by an even-aged forest. The ten old-growth study sites that were examined showed that the development of these forests occurred over a prolonged period where the trees grew at a low density with little self-thinning. It is suggested that where the management objective is to speed development of old-growth characteristics, thinning may be needed in dense young stands. As few as 40-49 trees per acre were observed in the early stages of some old-growth stands that were examined:

> Density of young-growth stands in this study was greater than that of old stands [when the stand was younger than 100 years], and diameter growth rates of individual trees were much less, even in the thinned stands. Our stand simulations also indicated that young stands with even as few as 250 trees/ha [about 100 trees/ac] will develop along a different pathway than the old stands. (Tappeiner et al., 1997)

In addition to natural disturbances, forest succession dynamics have been greatly influenced by extensive logging of old growth forests, intensive forest management, and recent decades of fire suppression.

Plantation forestry began as early as 1915 in the Coast Range. Past management in western Oregon emphasized reforestation with Douglas-fir. In more recent years, reforestation efforts have shifted more towards a diverse mix of native conifers and hardwoods. Specific sites are more closely evaluated for the appropriate species to plant, favoring those that occur there naturally. This has resulted in forest succession patterns that are shifting away from Douglas-fir as the predominant reforestation species, to greater use of species like western hemlock, western redcedar, Sitka spruce and red alder. In addition, thinning prescriptions in recent years have tended to favor opening stands up more, encouraging more diverse understory development.

Harvesting practices have also increased the percent of the forest landscape in the stem exclusion stage of development. This is particularly true in western Oregon where clear-cut harvesting is the preferred method for the growing and harvesting of Douglas-fir forests. Harvest rotations are on average about 50 years, and other than the period immediately following harvesting and thinning operations, these forests are generally in the stem exclusion stage of development.

Fire suppression has generally resulted in stands of increased density, particularly in eastern Oregon. Where fire has not been allowed to thin out the small trees and fire sensitive tree species, tree densities have increased and resulted in competition for water and nutrients. Trees that are under stress are more vulnerable to insect attack and disease outbreaks. Drought conditions will increase some of the stress factors, all of which result in a higher risk of more intense disturbance events (Oester et al., 1992). In recent decades, harvesting methods that involve the thinning of over-stocked stands has become a preferred approach in many areas in order to improve forest health and minimize some of the negative effects of fire suppression.

Historic Disturbance

The following is from the recent Independent Multidisciplinary Science Team[13] (IMST) report on the recovery of wild salmonids in western Oregon forests:

> "Periodic disturbance plays an important role in maintaining the integrity and variability of salmonid habitat, since the extent, magnitude, and frequency of disturbance are key components in shaping landscape structure and functions. For example, within the Oregon Coast Range, historic patterns of disturbance are dominated by climatic events that result in heavy precipitation, windstorms, and lightning-caused fire (Benda et al., 1998; Agee, 1993). The frequency, intensity, and magnitude of the response to these disturbances vary widely, depending on the structural components of the landscape (i.e., topography, channel networks). These structural components ultimately determine the impact of disturbances and their effect on habitat integrity. For example, input of large wood into streams involves an interaction between disturbances that kill trees (e.g., fire) and floods that are of sufficient magnitude to transport them. Variation in the frequency of fires affects the rate of wood input to streams, as well as its potential size. Along the northern Coast Range, for instance, the fire frequency exceeds 400 years (Agee, 1993), allowing time for forests to produce very large trees.
>
> "Although fire is not the only cause of tree mortality, the synergy created when a catastrophic fire is followed by intense storms leads to massive inputs of sediment, rock, and wood into aquatic systems (Benda et al., 1998). The variability in the amount of wood and sediment added to streams over time and space is just one part of landscape dynamics that should be considered when developing management strategies to protect salmonid habitat. Although we may never be able to recreate the historic patterns of landscape disturbance, they can be used as a guide to choosing management options which may ultimately maintain habitat integrity and function across the current landscape."(IMST 1999, p.15)

Natural disturbance is a normal process in ecosystems. Climate cycles, forest fires, windstorms, landslides, floods, and insect and disease outbreaks have always been normal events in the dynamic landscape of the Pacific Northwest. Over the centuries, small and large disturbances created a diverse forest. The landscape was never homogeneous, and only part of the forest was old growth at any one time (Agee, 1993). For Oregon west of the Cascades, estimates of the historical percentage of old growth at a given times range from as little as 35 to 40 percent, to as high as 70 to 80 percent.

Disturbances range from very large to very small. In forests, large-scale disturbances generally favor colonizing species such as Douglas-fir. Small-scale disturbances can create gaps where shade-tolerant understory species and herbaceous plants flourish, and also increase the supply of snags and large woody material in the forest.

[13] The Independent Multidisciplinary Science Team was established under Oregon Senate Bill 924 (1997 Or. Laws, ch. 7) to provide independent scientific oversight of the Oregon Plan.

Species depend on habitats created by disturbances, and on the pattern of habitats across the landscape (Pickett and White 1985). For example, trees that topple in a windstorm become, as they rot, homes to fungi, voles, mice, nitrogen-fixing bacteria, and amphibians. Big game like deer and elk need open areas of meadows or young forest to graze, but also need forest cover during winter storms or to hide from predators. Hundreds of species find homes in Pacific Northwest forests, and each species has a different set of habitat needs.

In summary, disturbance plays an important role in the ecology of both upland and riparian forests. Management prescriptions that do not consider the role of disturbance and historical patterns of forest succession may result in riparian forests that differ significantly from what occurred in the past.

Fire

Fire is a significant force in the development of the Pacific Northwest forests. A number of factors affect fire return intervals, including rainfall patterns, frequency of lightning, and frequency of fires started by people. In the north and central Coast Range, large forest fires occurred infrequently, about once every 300-to-350 years in any particular spot, but were usually high-intensity, stand-replacement fires. Smaller fires were more frequent, occurring about every 50-to-100 years. In the Cascades, more lightning led to moderate fire frequencies, with the return interval ranging from 25-to-100 years. In eastern Oregon and southern Oregon, fire return intervals range from 10-to-100 years. Fire effects covered a wide range, including severe, stand-replacement fires; patchy fires; and understory burns. (USDA Forest Service et al., 1994a)

In the Pacific Northwest, forest fire ignition historically came from two primary sources: lightning and Native American fires. Although fire was already part of the western Oregon landscape when European-American settlers arrived, the evidence indicates that the frequency of large fires increased in the 1840s, with the growing number of European-American settlers (Pyne 1982). Between 1846 and 1853, a series of large fires burned over 800,000 acres between the Siuslaw and Siletz Rivers in the central Oregon Coast Range. The largest fire, known as the Yaquina Burn, covered 480,000 acres. The Nestucca Fire burned over 300,000 acres. It is not known whether the fires were caused by lightning, Native Americans, or settlers. There were a number of large fires throughout the Pacific Northwest in 1868, with the largest fire in northwestern Oregon burning around Yaquina Bay.

By the early 1900s, people had begun to form fire control organizations in order to fight fires. The growing and harvesting of forest tree species was not practicable until forest fires could be more effectively controlled. From the 1920s to the 1960s, the annual area burned by forest fires declined steadily. But the annual area burned began to increase in the 1960s, possibly due to more logging and more prescribed burning, with some prescribed fires escaping control.

Because there were long intervals between fires in western Oregon, very old forests with large trees persisted in many areas. When major fires did occur, they generally killed most trees and covered large areas. These often dramatic fire events, which usually were associated with drought years and warm, dry winds, left large amounts of woody debris and snags in the forest (Agee, 1990).

After large fires, natural regeneration depended on the fire intensity, weather patterns, source of seed, and numerous other factors. As a result many different types and compositions of stands developed. Fire intensity and fire return intervals influenced what tree species were present in a forest. The coastal mountains and western hemlock/Douglas-fir forests were characterized by infrequent crown fires or severe surface fires that usually killed all trees in the stand. After the fire, western hemlock seedlings often outnumbered Douglas-fir. But Douglas-fir were usually more robust and dominated the site for 250-to-1,000 years, when the species began to disappear from the stand. Western hemlock became more common until eventually it dominated the stand.

In the Cascades, more frequent but more moderate fires often left a mosaic composed of patches of dead and surviving trees. Stands often consisted of two or more age classes, with the various age classes originating after different fires.

In eastern and parts of southern Oregon, historic fire recurrence was relatively frequent. Low-intensity burns occurred every 8-to-20 years in lower elevation ponderosa pine and every 20-to-40 years in mixed conifer forests (Oester et al., 1992). The fire-tolerant ponderosa pine and western larch would be left after these periodic fires, and the fire-sensitive fir species would be eliminated. This resulted in relatively open stands across the landscape with minimal build up of brush in the understory and low tree densities.

In all forest types, exposed soils were more likely to erode or collapse in slope failures in the years after a large fire. Slope failures deposited trees, other vegetation, boulders, and sediment in streams. These slides or debris flows damaged fish habitat in the short term, but over the long term helped to create more complex habitat. The logs and boulders created pools, gravel formed spawning beds, and structural complexity created complex habitats (Reeves et al., 1995).

Fire interacted with other disturbances such as heavy rains and windstorms. Severe fires created large open areas, which in turn increased the amount of runoff. Fires reduced the amount of fine root biomass and altered the routing of precipitation through the soil profile, increasing the probability of mass soil movements on slopes. Also, the trees on the edges of fire openings were more susceptible to windthrow during storms. Finally, a variety of insects and diseases attacked injured and dead trees. In general, fire is now less prevalent on the landscape than it was before the Twentieth Century. When large fires do occur, fire effects can be severe because fire suppression has created more uniform stands and allowed fuel loading to increase.

Decades of fire suppression has increased the frequency and intensity of insect and disease disturbance in eastern Oregon, where relatively dense stands of pine and mixed conifer forests have become stressed due to increased competition for limited resources. As a result, these forests can be more susceptible to high-severity fire and insect and disease outbreaks than was historically the case. For low-severity fire regimes, Agee (1998) suggests that a combination of underburning and thinning to modify the fuel loads in the system can result in a forest that more closely resembles a natural pattern. In areas where moderate-severity fire regimes were historically present, harvesting techniques that utilize partial cuts, small patch cuts with snag retention, and a system of reserves will result in a forest structure that more closely resembles the historic pattern than either even-aged management or a no-harvest reserve system that does not recognize natural disturbance processes (Agee, 1998). Management options that influence fire behavior in forests adapted to high-severity fire regimes are relatively limited. Severe weather appears to be the controlling factor in these forest-types, thus large stand-replacement fires are probably going to occur regardless of the fire suppression activities or harvesting methods that are employed (Agee, 1998).

Wind

Severe windstorms can blow down or snap off most trees in a stand, but usually storms blow down scattered trees over a large area. Although severe storms have dramatic effects, ultimately small-scale events have more impact on the forests because they are more common. A number of factors make trees more susceptible to wind. Root disease and stem decay are the most common biological factors contributing to blowdown. Poorly anchored trees are more likely to be uprooted by wind; trees may have shallow rooting as a result of shallow soil, bedrock, or a high water table.

In northwest Oregon, periodic severe windstorms typically occur between October and March. The Columbus Day storm on October 12, 1962, blew down an estimated 17 billion board feet of timber in western Oregon and Washington. Other major windstorms occurred on January 9, 1880, in northern Oregon; December 4, 1951, in western Oregon; and the winter of 1995-96 in western Oregon. The winters of 1949-52 and 1955-56 also had heavy winds.

As is typical of most disturbances, windstorms interact with other events in many ways. Douglas-fir bark beetles killed over 2 billion board feet of live trees between 1951 and 1959, after getting started in blowdown from the winters of 1949-52 and 1955-56. After the Columbus Day storm in 1962, beetle damage killed an additional 2.6 billion board feet of timber by 1965.

Floods and Landslides

Western Oregon, especially the Coast Range, has frequent, intense winter rainstorms. Heavy rain periodically results in flooding. The most severe floods, such as the flood of February 1996, are usually rain-on-snow events, when heavy rain falls on snow, swelling the streams with melted snow and rain. Heavy rains also saturate soils, particularly where other disturbances such as fires have exposed the ground. The saturated soils can give way and start landslides and debris flows.

Floods are more common in the cool, wet periods of climate cycles. Over the past 150 years, major floods occurred in western Oregon in 1861, 1890, 1948, 1964, and 1996.

Floods have different effects on complex, resilient streams and simplified streams. Complex streams have a much better ability to absorb impacts from flooding, and the impacts are more likely to be positive. Simplified streams are more likely to be scoured and damaged by the same event (Rapp 1997). Major floods can scour streambeds, move sediment and logs, and carve new channels. Scouring will damage streams, but floods can bring in wood and gravel that creates new and more complex habitats.

Floods interact with fire in shaping landscapes. In a comparison of streams in the Coast Range (Reeves et al., 1995), scientists found that the stream habitat most complex and favorable to coho salmon was where catastrophic fire and landslides had occurred 160 to 180 years ago. Historically, western Oregon streams would have represented a mosaic of habitat conditions, with some streams accumulating sediment and others losing sediment (aggradation and degradation), in cycles lasting decades or centuries.

Insects and Disease

Insects and diseases are also significant disturbances in forests. Periodic insect outbreaks have impacted extensive areas of forestland. The Douglas-fir bark beetle has probably killed more Douglas-fir in Oregon than any other insect. This insect builds huge populations in windthrown, fire-killed, or weakened timber. Bark beetles have killed trees comprising over two billion board feet of timber after major windstorms, at least twice in the last fifty years in western Oregon.

The hemlock looper, a pest of old growth hemlock stands, has had several major outbreaks in western Oregon this century. The looper-killed trees consisted of approximately 50 million board feet of timber in Tillamook County between 1919 and 1921. Other looper outbreaks occurred east of Seaside in 1944 and in the Coast Range from 1961 to 1963. The spruce aphid and hemlock sawfly can also kill significant numbers of trees in outbreaks. With the exception of the Douglas-fir beetle, most of these insects rarely cause significant damage in present-day forests.

Diseases were also common in the original forests of northwest Oregon. Stem decays were more abundant in older forests than in younger ones, largely because decay increases as trees get older. Root diseases were also common, but kept in balance by the natural processes of windthrow and colonization of disease patches by resistant or immune tree species. Hemlock dwarf mistletoe was abundant, but periodic large fires diminished local populations.

Disease and insects combine with wind damage to create patchy stands. The interactions of wind, root disease, and bark beetles create canopy gaps, mix soils during tree uprooting, and increase structural and biological diversity in stands.

APPENDIX B: CURRENT SCIENTIFIC KNOWLEDGE

Stream Temperature

Stream temperature is an important component of fish habitat and has a direct effect on the growth and survival of salmonids. The effect of changes in stream temperature on fish varies between species and within the life cycle of a given species (DEQ, 1995). Critical life stages that occur during the warmest months in the summer are of particular concern. For the chinook salmon, juvenile rearing, adult holding and adult migrations all occur during the summer months. Juvenile rearing also occurs in the summer for the coho salmon, and migration occurs in the late summer and early fall. Spawning and within-stream migration occurs in the summer and fall for the bull trout. Preferred temperature ranges for these species and particular life stages are shown in Table 1.

Table 1. Optimum and lethal limit temperature ranges for coho, chinook and bull trout (from DEQ 1995).

Fish Species	Coho	Chinook	Bull Trout
Preferred juvenile temperature range	54-57°F	50-60°F	39-50°F
Adult migration, holding, or spawning	45-60°F	46-55°F	39-54°F
Lethal limit	77°F	77°F	NA
State water quality standard[14]	64°F	64°F	50°F

The various physiological and ecological processes of salmonids that are affected by temperature are well documented. Listed below are some of the more important processes (from Spence et al., 1996).

- Decomposition rate of organic materials
- Metabolism of aquatic organisms, including fishes
- Food requirements, appetite, and digestion rates of fish
- Growth rates of fish
- Developmental rates of embryos and alevins
- Timing of life-history events including migrations, fry emergence, and smoltification
- Competitor and predator-prey interactions
- Disease-host and parasite-host relationships
- Development rate and life history of aquatic invertebrates

Exposure to temperatures above optimum levels has the potential to negatively affect salmonid survival and recovery. As stream temperature increases, the ability of water to hold dissolved oxygen decreases (MacDonald et al., 1991). Increases in stream temperature also raise the metabolic rate of salmonids, which can enlarge demands on the available food supply. Primary productivity can be augmented as a result of increases in light reaching the stream where nutrients are limiting, which can add to the available food supply for salmonids (MacDonald et al., 1991; Murphy and Meehan, 1991). However, decreased levels of dissolved oxygen may also lead to appetite suppression in salmonids (Jobling, 1993; in Spence et al., 1996).

[14] See Appendix F for more information on state water quality standards and criteria.

The presence of cool-water refugia can help salmonids avoid areas with adverse stream temperatures and help sustain a population of sensitive species (Bilby, 1984; Sedell et al., 1990). When ambient stream temperatures are too warm, sensitive aquatic species can inhabit these patches of cool water habitat. Deep pools, cool springs, hyporheic flow, and the junction of cooler tributary streams are all examples of cool-water refugia. Matthews et al. (1994) and Nielsen et al. (1994) found that stream temperatures are stratified in deep pools (3 to 9 feet), in pools with large gravel bars at the upstream end, and in shallow pools (1.5 feet) with subsurface seepage. Differences in temperature ranged from 7.0 to 8.0°F between the stream surface and stream bottom in these areas.

There are several factors that make up the heat balance of water, which determine how the temperature of a stream will change as it flows downstream. Net radiation, evaporation, convection, conduction, and advection all contribute to the net rate of gain or loss in stream temperature as it moves through a forest (Brown 1983). Stream temperatures also can fluctuate significantly over both space and time. Seasonal and daily cycles produce a high degree of variability in stream temperatures. Spatial variables such as latitude, proximity to the ocean, stream order, and distance from watershed divide can all affect differences in stream temperatures as well (Beschta et al., 1987; Sullivan et al., 1990). Heat inputs result from solar radiation, conserved solar radiation in the form of channel substrate heat loading (conduction), and air temperature that is greater than the water temperature (convection). Heat losses occur from evaporation, air temperature that is less than the water temperature (convection), channel bed conduction if the bed is cooler than the water column, and surface water/ground water interactions. Over any stream length, heat will be retained as it flows downstream in the water column only if the heat inputs are greater than the heat losses.

During the summer months, when stream temperatures are at their highest, the combination of direct solar radiation, a decrease in discharge, and the relative number of tributaries contributing flow have the greatest effect on stream temperatures changes in the downstream direction (Beschta et al., 1987). Of these three factors, forest management can have the greatest effect on direct solar radiation. Solar energy is also the largest component of energy available to warm stream water (Chamberlin et al., 1991). The more forest canopy that is removed that reduces shade, the more energy reaches the stream translating into a potential increase in stream temperature. While shade cannot physically cool the stream down, it can prevent further heating of the stream. In the case where significant groundwater inputs or tributaries are contributing relatively cool water, shading can have the appearance of cooling. In fact what is occurring is that shade is preventing further heating so that other processes (e.g., evaporation; groundwater mixing; convection) have a chance to cool the stream.

Many studies have documented increases in stream temperature due to timber harvesting. The degree of impact varies with particular practices and stream characteristics. Harvesting to the edge of the stream without leave trees or riparian buffer strips is consistently shown to increase mean, maximum, and diurnal fluctuation of stream temperature (Levno and Rothacher, 1967; Meehan, 1970; Feller, 1981; Hewlett and Fortson, 1982; Holtby, 1988). Maintaining riparian vegetation has been shown to be successful in minimizing or eliminating increases in stream temperature associated with harvesting (Brazier and Brown, 1973; Kappel and DeWalle, 1975; Lynch et al., 1985; Amaranthus et al., 1989). When examining the potential influence of harvesting near streams on stream temperatures, it is important to account for 'natural' heating in the downstream direction that is commonly observed (Sullivan et al., 1990; Zwieniecki and Newton, 1999). Increases in stream temperatures that might occur in the downstream direction whether or not vegetation is removed can be difficult to separate out from potential harvesting effects on stream temperatures (Dent and Walsh, 1997).

The width of the riparian vegetation alone, however, does not dictate the amount of shade provided to a given stream reach. Canopy density, canopy height, stream width, and stream discharge are all interrelated and determine the effectiveness of the riparian buffer width (Brazier and Brown, 1973). For example, a stand of dense vine maple and salmonberry over a small stream might provide close to 100 percent shading for that stream in the middle of summer. It would not matter how much riparian vegetation was retained beyond the width occupied by these two species in terms of increased shade. For a medium or large stream in eastern Oregon, on the other hand, that has a widely-spaced stand of Ponderosa Pine it may not be possible to obtain 100 percent shade no matter how wide of a buffer is retained. Because of the complex interactions between all of the factors that determine effective shade about a stream, buffer width alone is not always a reliable determinant of effective shade.

Angular canopy density (ACD) is an effective means of providing a direct estimate of the shading effects of riparian vegetation (NCASI, 1999). ACD is a measurement of the canopy density at an angle coincident with the sun when the most significant solar heating occurs. ACD is expressed as a percentage, where 100 percent represents no sunlight reaching the stream or forest floor. Considering 'small' streams only (under the FPA stream classification some of the streams in this study are considered medium and large in size), Figure 1 demonstrates the relatively high variability of buffer width as a determinant of effective shade. For example, 75-90 percent shading can be achieved with a buffer width of anywhere from 30 to 145 feet. Looking at it a different way, a 50-foot buffer width might provide anywhere from 18-80 percent shading.

Natural disturbance regimes historically played a significant role in the temporal and spatial distribution of forest-types across the landscape (Swanston, 1991). The historic distribution of forest-types is important in understanding the temporal and spatial distribution of effective shade along riparian areas across the landscape. While significant areas of 'old growth' are likely to have occurred along riparian areas historically, variability in the intensity, timing, and location of disturbance events created a diverse mosaic of riparian vegetation characteristics. Wildfire, windthrow, debris torrents, and major floods periodically reset riparian forests and changed the characteristics of riparian vegetation.

The result of the natural disturbance events in terms of effective shade is that while relatively high levels of shade may have been present in some areas or at one moment in time, lower shade levels are likely to have occurred in other areas or at another moment in time. Understanding the natural or climactic variability in stream temperatures brought about by natural disturbance regimes is an important first step in understanding how forest management may be altering stream temperatures and thus influencing salmonid populations. If harvesting near a stream results in temperature changes that are consistent with the range of natural variability, both spatially and temporally, of the temperature regime, then such effects may be unimportant

(Beschta et al., 1987). However where the opposite is true, harvesting effects on the maintenance and recovery of salmonids may be significant.

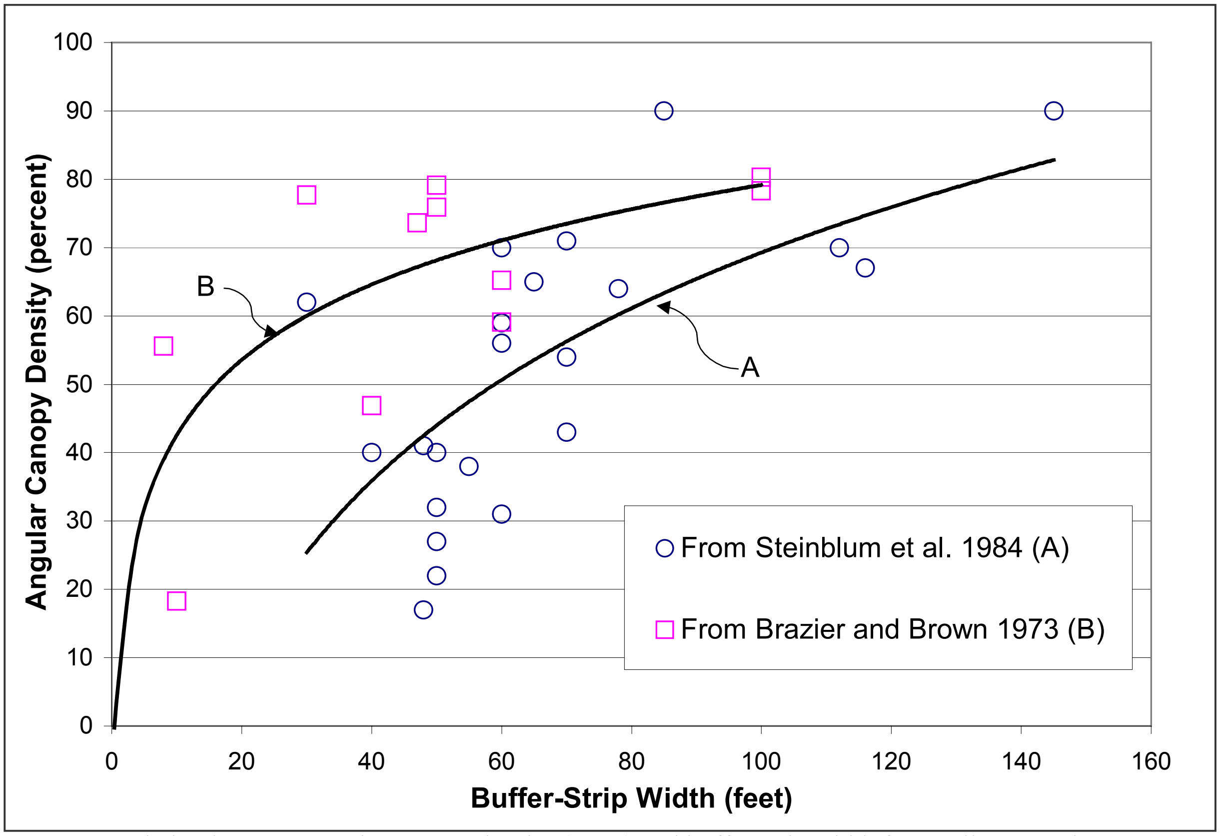


Figure 1. Relation between angular canopy density (ACD) and buffer-strip width for small streams in western Oregon (from Beschta et al., 1987).

Data is available from a number of sources that describe the shade conditions provided under different forest types of different ages. Figure 2 is taken from the Draft Tillamook TMDL (DEQ, 1998), and can be used to help understand what type of shade levels are possible along streams under different forests types and ages. The highest levels of shade occur in hardwood forests, regardless of age. The next highest shade levels are observed in the "seedling/young" category of conifer forests, followed by the "established/mature" confers where less shade was observed. The least amount of shade was observed for "annuals."

Similar observations can be made for data collected in the Upper Grande Ronde basin (Figure 3). The highest mean levels of shade are observed in the younger forests (12-20 inch diameter and breast height). The next highest shade levels are observed in the 6-12 inch diameter-at-breast-height (DBH) category, followed by the 20-35 inch DBH category. The lowest shade levels were observed in the categories of less than six-inch DBH and annuals.

Similar results were also observed in sites monitored as part of the 1996 ODF Flood Study (Figure 4). The vast majority of the streams surveyed were relatively small (bankfull width <15 feet). The highest average cover of 94 percent was observed in the 31-70 year category, followed by 86 percent in the 11-30 year age category. The 2-10, 71-100, and 101-151 year categories had the lowest average cover levels of 80 percent, 79 percent and 78 percent, respectively (data source: Robison et al., 1999).

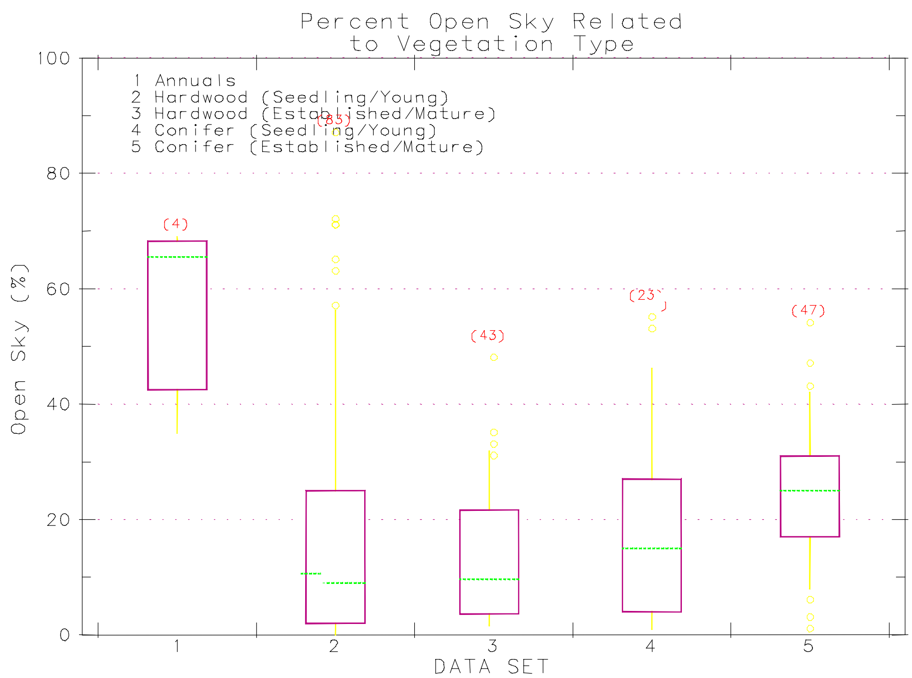


Figure 2. Percent Open Sky Related to Various Riparian Vegetation Types (using only *Survey 2* riparian vegetation observations and open sky data). (DEQ, 1998--Draft Tillamook TMDL, 12/98)

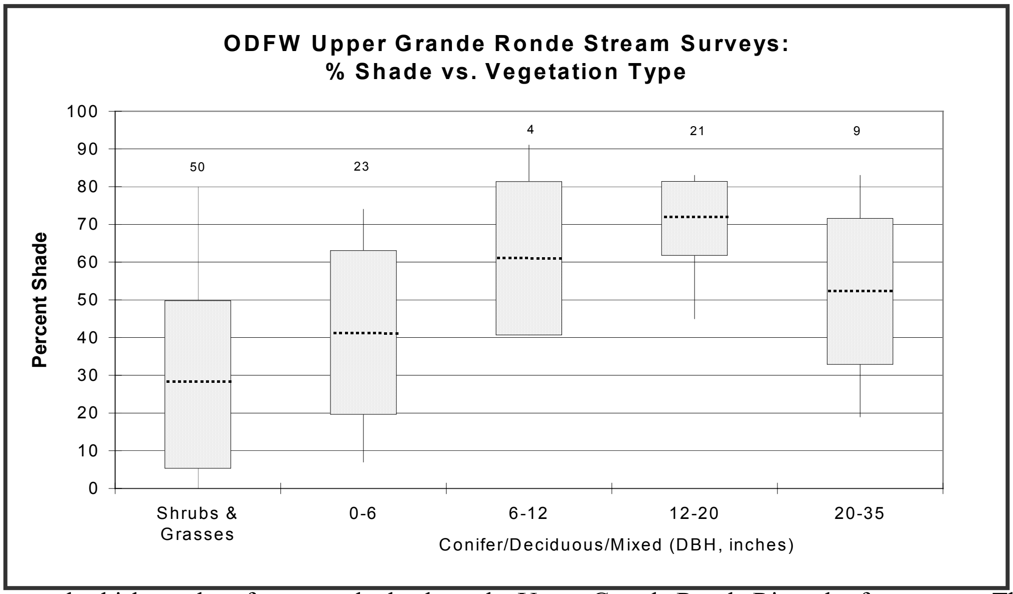


Figure 3. Box-and-whiskers plot of percent shade along the Upper Grande Ronde River, by forest type. The number of reaches sampled is at the top of each plot. The vertical line represent the range of values and the box represent plus and minus one standard deviation. The dashed horizontal line is the average. (Data source: Moore et al., 1997)

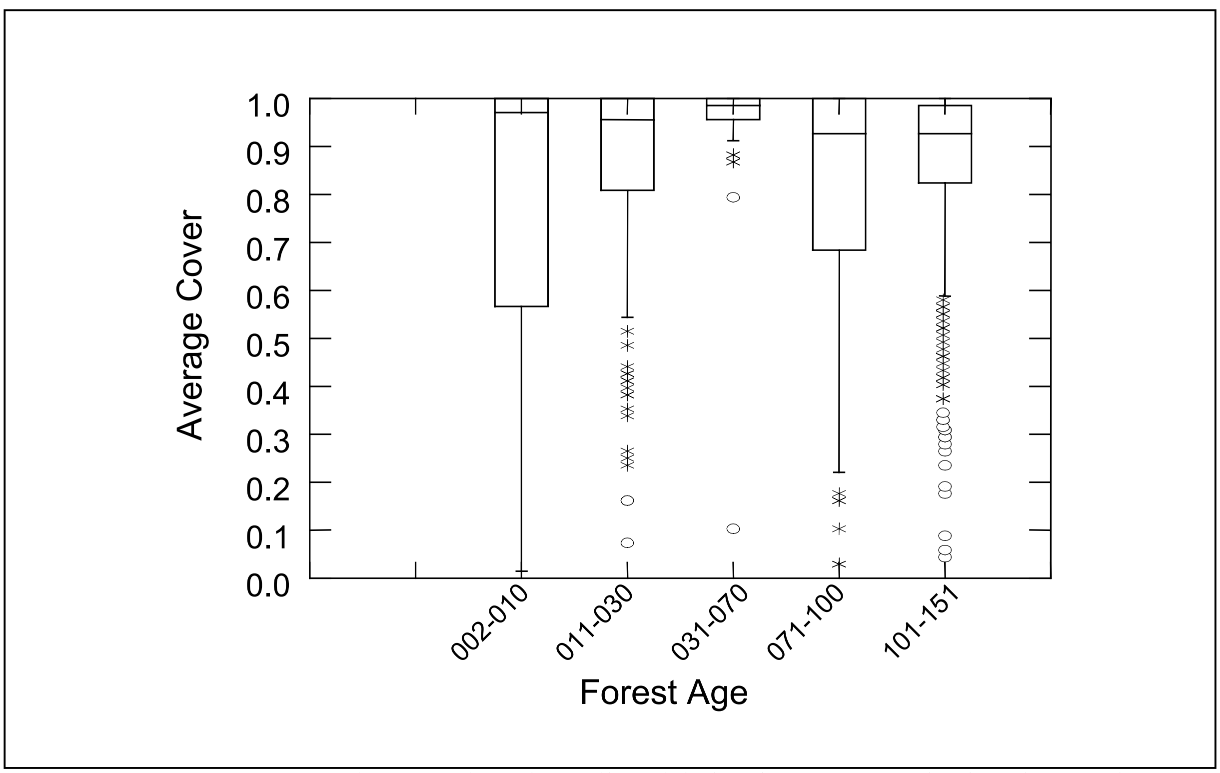


Figure 4. Average cover versus forest age from data collected during the ODF 1996 Flood Study. Densiometer measurements were taken while standing in the middle of the stream. Nearly 900 total data points are represented here, only for those streams that did not experience a debris torrent (medium and low impacts). "0.0" is open sky, and "1.0" is 100 percent closed sky. The upper and lower ends of the boxes represent the 25th and 75th percentiles, and the line through the boxes is the median (data source: Robison et al., 1999).

Since riparian shade reduces or eliminates solar radiation inputs to the stream, retaining riparian buffers is a widely accepted method of minimizing or eliminating harvesting effects on stream temperature. Some studies, however, have demonstrated that increased sunlight in clearcut areas can increase salmonid production and/or growth in unbuffered streams in the short-term (Holtby, 1988; Tschaplinski, 1999). This is related to increases in primary production, and ultimately salmonid food sources, that can occur when a stream is exposed to increased levels of sunlight. This response can only occur, however, where food production is a limiting factor in salmonid growth and survival. Increased stream temperature also increases the metabolic demands of salmonids. When this occurs, an increased food supply is needed to support the increased metabolic demands or else increases in growth and survival may not be realized. There must also be adequate physical habitat available to support the increased salmonid production and/or growth that may be stimulated by an increased food supply.

The complex interactions between primary production, salmonid metabolic demands, and stream temperature results in a highly variable response to increased levels of sunlight to the stream. Research has shown, however, that in some locations a closed dense conifer stand typical of second-growth is not very productive for fish due to a substantial reduction in sunlight reaching channels as compared to either old-growth or clearcut streams (Sedell and Swanson, 1984). The various results have led some to argue that buffers designed to maintain physical habitat over the long-term, but that also increases the level of sunlight above that provided by closed-canopy forests, may be more productive overall than either mature forest or clearcut reaches (Koski et al., 1984; Murphy et al., 1986; Murphy and Meehan, 1991; Sedell and Swanson, 1984).

Large Wood (Habitat Modification, Bio-Criteria)

Large wood (a.k.a. large woody debris; coarse woody debris; large organic debris) is an important component of salmonid habitat (Bisson et al., 1987; Bilby and Bisson, 1998). Large wood is a key factor in the development of channel form, including off-channel rearing backwaters, side channels, and pools and riffles, that are important for salmon. The National Research Council (1996) states that "[p]erhaps no other structural component of the environment is as important to salmon habitat as large woody debris, particularly in coastal watersheds."(p. 194)

> Physical processes associated with [large woody] debris in streams include the formation of pools and other important rearing areas, control of sediment and organic matter storage, and modification of water quality. Biological properties of [woody] debris-created structures can include blockages to fish migration, provision of cover from predators and from high streamflow, and maintenance of organic matter . . . The locations and principle roles of woody debris change throughout the river system. In steep headwater streams where logs span the channel, debris creates a stepped longitudinal profile that governs the storage and release of sediment and detritus, a function that facilitates the biological processing of organic inputs from the surrounding forest. When the stream channel becomes too wide for spanning by large logs, debris is deposited along the channel margins, where it often forms the most productive fish habitat in main-stem rivers. (Bisson et al., 1987)

Large wood loading of streams has been correlated to winter survival of juvenile salmonids (Bisson et al., 1987; Murphy et al., 1986) and can increase fish numbers within a given watershed. Reeves et al., (1997) found that adding large wood to Fish Creek resulted in a 27 percent increase in the mean number of fish in during the period following wood placement compared to the prior five-year period[15]. Steelhead age 1+ and smolts were also significantly larger ($P<0.05$), 12.5 percent and 4.1 percent, respectively, following wood placement compared to the period before.

Reductions in large wood will often result in habitat simplification which has been shown to reduce the diversity of fish species. Habitat simplification, however, does not necessarily result in a decline in total fish populations. Certain species and age classes may increase in numbers to occupy space vacated by other species or age classes that found the habitat simplification undesirable (Schwartz, 1990). It is also possible for habitat simplification to favor no species or age classes and all groups experience a decline in productivity (House and Boehne, 1987).

Currently, there is no accepted minimum criteria for what large wood levels (i.e., pieces per 1000 feet) are necessary for maintaining and recovering salmonids. Despite this lack of prescriptive information, a better understanding of possible historic stream conditions relative to current conditions can be useful. The Oregon Department of Fish and Wildlife (ODFW) Aquatic Inventory project has attempted to describe both the possible historic conditions (which would include the entire range of successional and disturbance conditions), and desired future conditions for streams in western Oregon, in terms of various aquatic habitat characteristics (Thom et al., 1998). Information about the reference sites surveyed for this project were not intended to portray what stream conditions should be like for all western Oregon watersheds, but rather give a range of values from which to compare current habitat conditions in a general way. Fifty-seven reference reaches were inventoried covering 93 km of streams, most of which occurred in the Oregon Cascade Range with a few in the Coastal Range. The reference sites were described as follows:

- 4.5 percent average stream gradient
- 11 meter (36 feet) average active channel width
- Located in unmanaged watersheds and wilderness areas
- Primarily in upper portions of watersheds and federally owned
- Fire suppression may have reduced the influence of disturbance relative to historic conditions
- Stream cleaning projects may have occurred in the past along some reaches

In the summer of 1998, the ODFW selected stream reaches across western Oregon using a random and unbiased methodology and the habitat conditions of those reaches were summarized (Thom et al., 1999). Each area of the state had 50 sample sites, with the exception of the “Southwest Washington” area that had only 35 sites. Large wood (number of pieces, number of key pieces, and volume) was one of the habitat variables inventoried and randomly selected reaches were compared to the reference sites. The ODFW inventory defines large wood as any

[15] This difference was not statistically significant, $P>0.05$. Due to the many different factors that influence fish populations and the variability from one year to the next, a 27% increase over five years was not statistically significant in this study.

piece greater than six inches in diameter and 10 feet in length (15 cm x 3 m). Key pieces are defined as greater than two feet in diameter and 33 feet in length (60 cm x 10 m):

> The reference values observed for the distribution of the number of pieces of wood in the stream channel falls within the range observed in the streams used for current conditions analysis [i.e. reference sites] . . . The number of key pieces of wood differs more markedly than the number of wood pieces. These large pieces were low in all of the areas with 50 percent of the stream length surveyed in each basin having less than 1.0 piece per 100 m of stream channel. The median value for the reference reaches is 1.8 key pieces per 100 m of stream channel. Again, the North Coast and Willamette areas had higher levels of key pieces of woody debris than any other area. The Mid-Coast, South Coast, and Lower Columbia areas had the lowest number of key wood pieces with over 75 percent of the stream length in those areas having less than 1.0 key piece per 100 m of stream channel. . . . Wood volume density showed a wide range of distributions between the different areas surveyed. The general pattern was similar to the density of wood pieces, but the distributions had a much wider range. (Thom et al., 1999)

The density of large riparian conifers was also examined to understand current conditions in terms of future large wood recruitment. The number of conifers greater than 20 inches in diameter and within 100 feet of the stream on the random sites was compared to the reference sites.

> The number of conifers observed differs markedly from the reference reaches. All of the [randomly selected] areas show low conifer numbers with over 30 percent of the stream lengths surveyed having no large conifers in the riparian zone. The 75th percentile occurs at less than 120 conifers per 305 m of stream length for all of the areas, while the reference reaches had a 75th quartile of 240 conifers. (Thom et al., 1999)

While the frequency and distribution of total pieces of large wood across western Oregon appears similar to that of the reference sites, there is a marked difference when it comes to total key pieces and large riparian conifers. For the largest large wood, there appears to be a shortage of potential key pieces of large wood currently in riparian areas. Long-term supplies may or may not be at risk, depending on whether or not adequate numbers of current small conifers are retained and grow into potential key pieces of large wood in the future.

A number of different factors are responsible for the lower levels of key pieces of large wood and large riparian conifers in the sampled streams. In the 1800s and up through the turn of the century, splash damming was an accepted practice that resulted in extensive scouring of long stretches of some steam channels. It’s estimated that close to 25 percent of the streams in Oregon were impacted by splash damming (Dave Hibbs, personal communication, 1999). Extensive dam building and an acceleration of road building into forestland during most of this century have also reduced levels of large wood in the system. As large wood moved into reservoirs or backed up behind stream crossing structures, it would be removed either for safety reasons or to utilize the wood, thereby preventing that large wood from continuing downstream and being utilized by the stream system. Stream cleaning also occurred in the 1970s and early

1980s because it was believed large wood was a barrier to fish passage. During this period, there was an effort to remove large accumulations of large wood from selected streams. A significant amount of this stream cleaning occurred immediately after large storm events such as the 1964 and 1977-78 floods. Previous to any forest practice rules that require the retention of trees along streams, harvesting operations were also removing the large trees that were potential future sources of key pieces of large wood. Historical harvesting practices that did not retain riparian buffers have also resulted in fewer large conifers being grown in riparian forests and upslope areas (forestlands susceptible to landslides that result in large wood being transported to fish-bearing streams), reducing the future supply of key pieces of large wood.

There are essentially three ways in which large wood can end up in streams. It can fall directly in from the riparian area, it can be delivered via a landslide or debris flow from upslope areas, or it can be manually placed in the stream. Considering riparian areas first, potential large wood inputs can be expressed as a function of distance from the stream. A review of the literature shows that anywhere from 70 percent to 99 percent of the large wood input potential *from adjacent riparian stands* originates from within the first 30 meters, or about 100 feet, of the riparian forest (Murphy and Koski, 1989; Van Sickle and Gregory, 1990; McDade et al., 1990; Bilby and Bisson, 1998). It is also possible, however, for 70-99 percent of the large wood input potential from riparian stands to originate from within the first 50 feet of the riparian forest (Murphy and Koski, 1989). It should be emphasized that these studies did not intend to examine upslope source areas. They analyze potential large wood inputs in terms of the total large wood potential from riparian areas only. Large wood is defined in most of these studies as pieces with a minimum diameter of 10 centimeters (4 inches) and a minimum length of 1-1.5 meters (3.25-5 feet). The majority of larger pieces of large wood, such as key pieces, originate from within a distance less than 100 feet (Robison and Beschta, 1990). The bulk of the potential *riparian area* inputs of large wood comes from vegetation in close proximity to the channel, with diminishing amounts coming from distances farther from the stream (Figure 5).

The incidence of windthrow affects the frequency and distribution of large wood inputs from riparian areas. An increase in windthrow can occur where riparian buffers are retained. It is generally believed that the potential for windthrow is higher for narrow buffers and decreases for wider buffers, however there is a wide range of scientific opinion on how wide a buffer needs to be before the risk of windthrow is significantly reduced. Windthrow associated with riparian buffers is also highly variable depending on vegetation, local topographic relief, and an area's susceptibility to windstorms. It could be argued that an increase in the incidence of windthrow due to narrow buffers could have a positive short-term effect on salmonid habitat by delivering large wood to the stream (Spence et al., 1996). Potential negative effects of windthrow include an increase in stream temperatures due to additional solar radiation reaching the stream, increased bank erosion due to the displacement of soil by root wads, upslope erosion of fine sediments where oversteepened slopes are exposed by displaced trees, and reduced large wood input potential until a future stand of large trees becomes established.

There are many factors that must be considered in determining what types of buffers are effective or ideal in maintaining or enhancing salmonid production. Botkin et al., (1995) points out that mature forests (forests older than 100 years of age) covered 50-70 percent of the Coast Range between 1850 and 1940. It is estimated that historically 15-25 percent of the forest in the

Central Oregon Coast Range was in early successional stages because of disturbance by wildfire (Benda, 1994; Reeves et al., 1995). Wildfire, floods and windstorms were all important disturbance events that had a significant effect on forest characteristics. These types of disturbance also tend to leave behind significant amounts of structure in the form of snags and large wood on the ground, as compared to timber harvesting where this is not always the case. Data presented by Dave Hibbs (MOA Riparian Habitat Workshop) illustrated how the percentage of forestland in conifer versus hardwoods changed dramatically over 1000-year time periods, sometimes by a factor of 50 percent. At least for coastal forests, it appears that hardwood tree species may have been much more pervasive at certain times than was previously assumed to be the case. While the notion of mature forest conditions everywhere on the Coast Range (and the Cascades) is not consistent with what is known about historic disturbance patterns, the current disturbance pattern due to fire suppression and forest management is not consistent with historic disturbance patterns either.

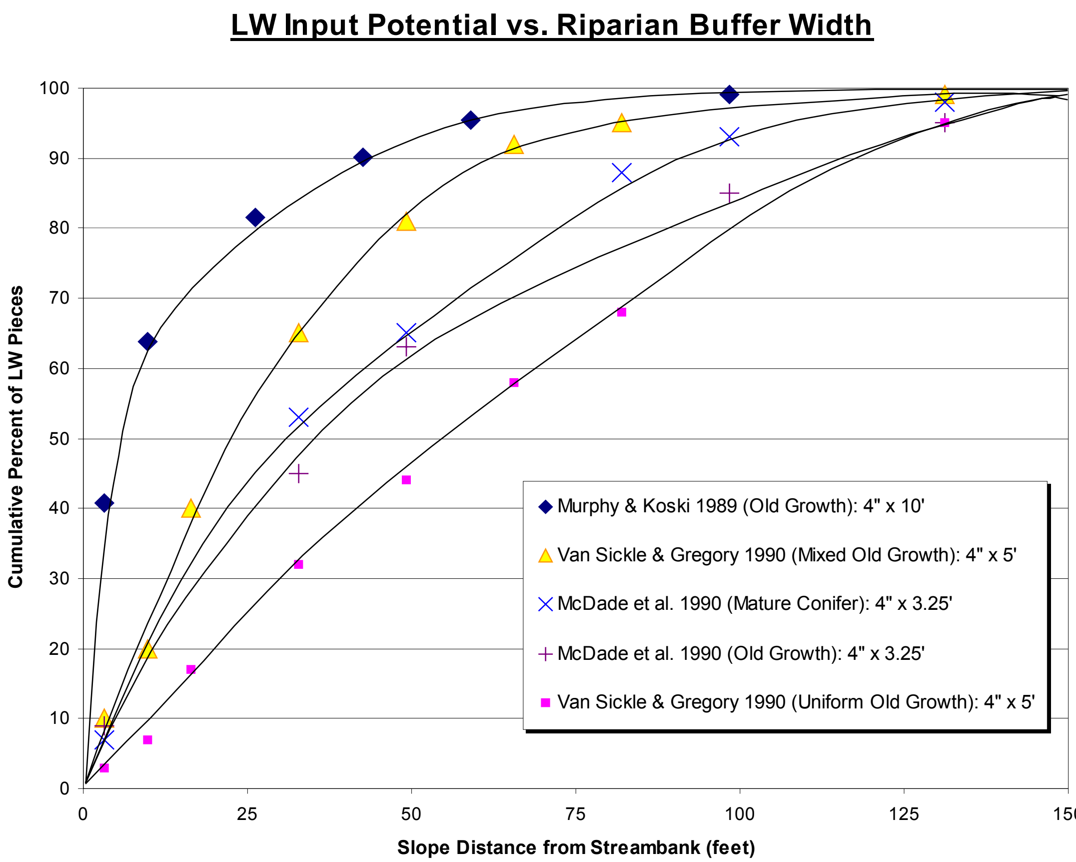


Figure 5. Compilation of current studies relating buffer width to large wood input potential. Murphy and Koski (1989) conducted their study in Alaska, the McDade et al. (1990) data is from the Oregon Cascades, Van Sickle and Gregory "mixed old growth" data is from the Oregon Cascades, and the Van Sickle and Gregory "uniform old growth" is modeled data from a hypothetical (modeled) stand.

Historically, most streams, wetlands, and lakes had some riparian overstory vegetation composed of conifer and/or hardwood trees. The processes for plant succession in riparian areas are debated and it is likely that succession follows a number of potential paths. Beavers and elk may have maintained some riparian areas, particularly along lower gradient reaches, in early (more open) seral stages. Large conifer, now often absent in some riparian areas, may have played an important role in conifer regeneration on some sites through nurse trees (Hibbs and Giordano, 1996). This role may have been relatively more important on wet coastal sites. Vegetation succession paths are likely to vary for different streams. More frequent disturbance events, including beaver activity and floods, may create more diverse conditions and a greater hardwood component on larger and lower gradient streams. Small streams in steeper terrain, however, are more likely to be more dominated by conifer due to different types of disturbance (more frequent fire) and site conditions. Since large wood originates from many different sources on the landscape, these patterns also likely influenced large wood inputs and habitat conditions.

In terms of source areas for large wood, potential inputs are not limited to stream-adjacent locations. Upstream or upslope areas can also be a source of large wood for fish-bearing streams (Keller and Swanson, 1979; McGarry, 1994; Benda and Sias, 1998). In steep landscapes, where the occurrence of debris flows is a normal part of the disturbance regime, relatively large pieces of large wood in small streams can play an important role in maintaining salmonid habitat (Swanson et al., 1987). High stream flows and debris flows are both mechanisms by which large wood can be transported from relatively small stream channels downstream to larger channels.

Debris flows can periodically move very large pieces of wood from a hillslope or hollow downslope to fish-bearing streams where the large wood can interact with the channel and form fish habitat. In these cases, small stream channels can play a significant role in contributing key pieces of large wood to downstream riparian functions. These sources of large wood have been referred to as both “upslope” and “upstream” sources. For the sake of clarity, the following terminology will be used to define large wood sources for this discussion.

Near-stream riparian:

Areas directly adjacent to the stream. large wood is delivered simply by the tree falling directly into the stream from the adjacent streambank or hillslope.

Upstream riparian:

Near-stream riparian sources that are upstream of the reach of concern. High water and/or a debris flow transport the large wood to its current location after initially falling into the stream from the riparian area.

Upslope:

Zero-order channels (zero-order channels are small unbranched draws), hollows, or hillslopes. Areas outside of the riparian area. large wood is delivered by a landslide or landslide-debris flow combination that moves the wood into the stream channel from these areas.

Currently, there is limited scientific information on the relative inputs from these three sources. McGarry (1994) is one of the few studies that have attempted to quantify the relative contribution from each large wood source. He found that the large wood inputs in Cummins Creek, Oregon were split about 50/50 between near-stream riparian and other source areas, or what was termed “transported” and “nontransported.” McGarry (1994) did not attempt to quantify what percent of the transported large wood originated from upstream versus upslope areas. McDade et al., (1990) also identified about 50 percent of the large wood as originating from near-stream areas, but did not attempt to classify the origin of the other 50 percent either. Unless the debris flow and/or landslide delivering the material is inventoried before high stream flows are able to transform the deposits and relocate the large wood downstream, it is difficult to determine what pieces of transported large wood originated from upslope versus upstream areas. Both of these studies (MacGarry, 1994; McDade, 1990) utilized a single-season data collection method, representative of conditions for a snap-shot in time.

Despite the limitations of the data, some qualitative statements can be made in regards to large wood sources. In terms of upslope sources, the relative importance of potential large wood from zero-order channels and hillslopes to a given stream reach becomes less and less the larger the channel network is above that reach. The larger the channel is along a given reach, the greater the percentage of potential large wood originates from near-stream and upstream riparian sources. This will vary, however, depending on the topographic characteristics and landslide/debris flow potential. An area where debris flows rarely occur and where the slopes are relatively mild will have virtually all of the large wood originating from near-stream and upstream riparian sources. An area that has frequent landslide/debris flow activity and relatively steep slopes, on the other hand, may have a significant portion of the large wood potential in upslope sources originating from the zero-order channels and hillslopes. Benda and Sias (1998) conducted a modeling exercise where they estimated that the overall contribution of large wood by debris flows is limited to about 10-15 percent of the overall wood budget. While this may imply that mass wasting plays a relatively minor role in the long-term wood budget of a given watershed, "wood from debris flows can overwhelm all other sources to a channel or valley floor locally in time and space, and therefore dominate in the shorter-term (decadal – human lifespan)."(Benda and Sias, 1998)

Where shallow rapid landslides are rare or do not occur, the dominant available mechanism for transporting large wood downstream is stream flow. For this population of streams, the hydrologic regime will determine what sizes of large wood will be stable and hydrologically functional in the channel. Bilby (1985) found that length and diameter of stable large wood in a stream is in part a function of channel width, where smaller pieces of large wood can be stable in smaller streams. Other research has found that the amount and distribution of large wood will vary with channel size. Smaller channels contain more abundant amounts of randomly distributed large wood, while larger streams more easily transport large wood, resulting in fewer pieces and reduced aggregation of large wood (Bilby and Bisson, 1998). On very large, main-stem channels, large wood tends to form accumulations at the head of gravel bars and along the edge of the channels. These accumulations are important for maintaining spawning areas and creating off-channel habitats (Sedell et al., 1982).

Forest Roads and Landslides (Sedimentation and Turbidity, Habitat Modification, Bio-Criteria)

Landscape-scale processes that can be affected by forest road systems can include chronic turbidity during wet periods from repeated truck use (Bilby et al., 1989); changes in channel morphology and substrate composition; changes in peak flows in small basins; addition of certain pollutants (petroleum products, accidental spills); and the prevention of downstream movement of large wood and/or sediment.

Sedimentation impacts occurring over space and time from timber harvesting and other forest management activities are often overshadowed by those of roads (Reid, 1993).
The dominant road-related sources for these direct impacts include road runoff delivery to stream channels (chronic erosion and potential peak flow changes in small watersheds); landslides (which tend to have larger volumes than nonroad landslides) (Robison et al, 1999); washouts related to stream crossings; and streams adjacent to roads.

Forest roads can also have indirect effects, depending in large measure on control of access to recreational and unauthorized road users and are considered uncommon on many private lands where access is controlled. These indirect effects can include increased fishing pressure (legal and illegal); access for fish stocking or illegal introduction of non-native species; traffic damage to the surface and drainage system; garbage dumping; and accidental petroleum and chemical spills.

Other examples of both direct and indirect effects include landslides that become larger debris torrents that scour long lengths of stream channel; road fills failing when impacted by up-slope landslides increasing the volume of debris flows; debris flows stopping at road fills and plugging drainage structures; stream crossing structures that do not pass large wood to fish-bearing streams downslope; traffic-turbidity sources related to multiple forest operations; cascading washouts (where one culvert becomes plugged, sending the stream down the road, and exceeding culvert capacity at every culvert encountered along the road); and synchronous connection of ditches to waterways.

Attempts to use road density to evaluate potential landscape-scale effects can be problematic. Roads can have very different effects on water resources, depending on road size, design, location, construction and maintenance techniques. Road-related landslides that enter stream channels are uncommon if hillslope steepness is less than 50 percent (Robison et al., 1999). Chronic delivery of sediment to stream channels is rare on ridge top roads, while most stream adjacent roads have a high potential for chronic sediment delivery (ODF, 1996). Washouts are more common on roads with undersized drainage structures, high fills and long steady grades (Weaver and Hagans, 1994; ODF, 1997). All of these factors can be independent of road density. For example, the greatest road densities identified in the “Storm Impacts of 1996” study was found in the Vernonia and Estacada study areas (4.6 and 3.3 miles per square mile). Nevertheless, these areas had the fewest road washouts, and the lowest volume of road-associated sediment delivery to streams as compared to the other six study areas (Robison et al., 1999). Therefore, the road area disturbed in “critical locations” is probably a much better indicator of cumulative effects than is road density. The IMST report concludes, “The reported relationships between road density and sedimentation provide only qualitative guidance for landscape-level planning and management. Monitoring and more case history analyses will provide a stronger basis for policy."

Landscape-scale effects depend on the length and characteristics of roads in critical locations, and on the timing of both the disturbance and subsequent effects of the disturbance. Historical practices further complicate the assessment of forest road effects over both space and time. Logging railroads required the construction of high fills, often using logs for drainage structures. These structures are very susceptible to major washouts that resemble dam-break floods. Roads next to streams were a common practice in the past and have resulted in the loss of side-channel habitat. Stream relocation to reduce the number of road crossings was also a common historical practice (for example, the East Fork of the Millicoma River and the Luckiamute River).

Sedimentation and Turbidity Related to Roads

All streams under natural conditions have sediment inputs at varying levels from terrestrial sources (background levels) depending upon soil, topography, vegetation and rainfall. Sediment enters water through various processes that include soil surface erosion, channel erosion and mass movements (landslides, debris flows), and these inputs can be either chronic or episodic. Studies have indicated that high sediment levels can affect fish by increasing mortality, reducing growth rates, causing physiological stress, impairing homing instincts, and reducing feeding rates.

Efforts to relate sediment concentration to fish response had mixed results (Everest et al., 1987). Some studies have found that increased sedimentation reduces egg and alevin survival. However, not all sediment increases have detrimental effects and there are cases where fish have maintained large and viable populations in streams with high chronic loads of fine sediment (Everest et al., 1987). Fish appear to react most negatively when fine sediment concentrations are both high and persistent (Newcombe & MacDonald 1991). Whether effects of increased sediment are adverse depends upon the nature and timing of the delivery, the type of material delivered, and the prior condition of the stream.

Massive levels of fine sediment delivery can produce changes in channel habitat by reducing pool frequency, depth and volume (Coats et al., 1985, Megahan et al., 1980). Streams that have a limited supply of coarse sediments, or minimal ability to retain these materials, can experience reductions in habitat quality through channel degradation, sometimes resulting in channels scoured to bedrock in mountain streams. Habitat can potentially be enhanced if mass erosion delivers material to streams where coarse sediment is limited (Botkin 1995, Everest, et al., 1987). Fine sediment can also affect the production of aquatic insects (fish food organisms) (Hicks et al., 1991)

The effects of increased sediment delivery from roads depend upon numerous factors. Most fine sediment from surface erosion processes is delivered during common rainfall events and is relatively chronic. Road-related landslides and stream crossing failures can result in significant sediment impacts from the volume of material in the failed fill and also by scouring headwater channels for some distance. These types of sediment inputs tend to be episodic and are often the result of large rainfall events. The IMST report also includes similar findings on the differences between chronic and episodic sources of road sediment (p. 23-26).

It is roads rather than timber harvesting that historically have been the primary source of sediment from forest management activities in the western United States (Megahan & Ketcheson, 1996). High-risk factors for forest roads include road surface erosion, road fill failure, and the proximity and hydrologic connection of road segments to streams. Roads can also directly alter stream channels and fish habitat, especially when roads are constructed parallel to streams and within the floodplain. The effects of roads on fish passage are covered in another issue paper.

Research has shown newly constructed or reconstructed roads may have ten times more surface erosion the first winter after construction as compared to subsequent years (Megahan and Kidd, 1972; Megahan, 1974; Luce and Black, 1999). This results from increased erodibility because of soil disturbance during construction, and the lack of erosion pavement and vegetation to protect the soil surface, which can in large part be mitigated by applying Best Management Practices (BMPs) to protect the soils immediately after construction.

During periods of wet weather, road surfaces that are not constructed with adequate surface materials and spacing of drainage structures are a potential source of fine sediment delivery by allowing sediment laden waters to enter stream channels directly. Hauling operations conducted on roads with poor drainage can further increase the risk of sediment delivery (Bilby, et al., 1989; Reid & Dunne, 1984). Fill failure is also a risk, especially for those roads not constructed to current standards. Sidecast roads, roads built on old railroad crossings with relatively deep fills, and stream crossings with inadequately designed and sited culverts are examples of forest road features with increased fill failure risk. Road segments that are close to streams and stream crossings also have an increased risk of sediment delivery. The likelihood of road surface runoff, fill failure, and washouts delivering sediment to the stream channel increases the closer a road segment is located to a stream.

Roads create a contiguous linear physical alteration to hillslopes, as shown in Figure 6. To create the running surface, or tread, it is necessary to excavate into the natural hillslope. On less steep slopes, this excavated material can be used as fill to make a portion of the running surface. Prior to the mid-1980s, excavated soil and rock from full-bench road construction were generally sidecast onto very steep slopes immediately below the road prism. These steeply sloped sidecast fills were often associated with landslides. Both cut and fillslopes are steeper than the natural slopes, and, at least for some period of time after construction, are not vegetated. Thus, cut- and fillslopes have a higher landslide potential than the native hillslopes. Roads also alter the flow of water. Road cuts may intercept shallow groundwater, and the road surface normally collects surface water. This water is routed along the road to a location where it is discharged downslope of the road. Roads must also periodically cross streams. While most forest stream crossing structures are culverts, other designs include fords and bridges. During high flows, stream flows and/or road runoff can exceed culvert capacity, bedload and floating debris may reduce or block the flow of water through the culvert. When drainage system capacity is exceeded, fill washouts, gullies or landslides may occur in or below the fill, or further down the road.

Stream-crossing culverts and bridges are subject to plugging by woody debris and sediment and/or their capacity being exceeded by high flows. If water backs up and flows over the surface, a washout-type failure similar to a dam breaching may occur. When a road grade climbs through the stream crossing, there may be a high potential for channel diversion down the road (Weaver and Hagans, 1994). Such diversions can cause large gullies running long distances down the road and can cause additional landslide and washouts as well. The concentration of road drainage can also be associated with interactions between road systems and channels in steep terrain, causing gullies or increasing the risk of landslide occurrence at culvert outfalls (Montgomery, 1994).

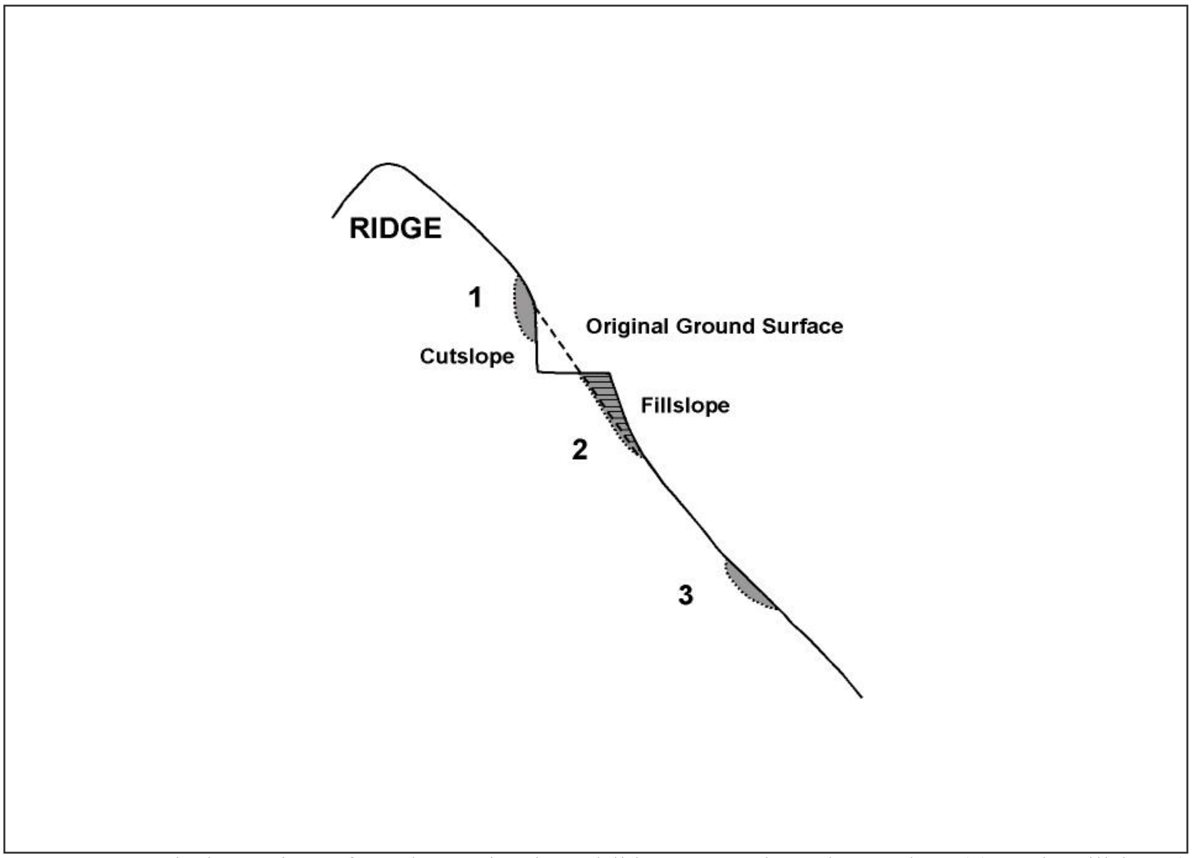


Figure 6. Typical Locations of Road Associated Landslides Surveyed: In the Cutslope (1), In the Fillslope (2), and Associated with Drainage Discharge and Below the Fill (3). Note: The road construction depicted in this figure is not allowed under current FPA road construction rules. New roads built on steep slopes require full-bench and end-haul construction.

Landslides are typically the dominant erosion mechanism in areas with steep slopes. Landslide frequency can be greatly accelerated by road management practices (Sidle, et al., 1985). For example, Megahan and Kidd (1972) found that 70 percent of accelerated sediment production in an Idaho batholith study site was associated with road-related landslides. Piehl, et al., (1988) found only two landslides at culvert outlets, yet they comprised 72 percent of the total outlet erosion associated with 515 cross-drainage culverts.

The location of landslide initiation in relation to the road prism has a significant influence on potential sediment delivery to streams. Landslides affecting the cutslope portion of the road are typically deposited in the road. While road surface runoff may erode the deposits of cutslope landslides, the landslide deposit may also divert surface waters away from designed drainage structures or divert water onto fillslopes. Fillslope failures are more likely to become debris flows, increasing in size and then entering intermittent and perennial channels.

For slopes that are considered at high-risk for landslide potential, a technique known as end hauling can be used to transport excess excavated materials to more stable waste area locations (this is required in Oregon). Using steeper grades to keep roads on ridgetops can be a significantly less expensive road system design as compared to having to end haul for steep slopes. Relocating roads in lower risk areas is also an effective means of landslide prevention. However, where these practices are not possible, end hauling may be an effective, albeit expensive, technique for reducing landslides (Sessions, et al., 1987).

Sedimentation and Turbidity Not Related to Roads

Landslides are the dominant erosional processes on steep forested slopes in western Oregon and throughout the Pacific Northwest (Swanson et al., 1987). A landslide is the movement of a mass of soil, rock or debris down slope. The typical landslide on steep forestlands begins as a relatively small and shallow feature, with typical dimensions of 3 feet in depth, 30 feet in width, and 40 feet in length, and a relatively planar failure surface (same shape as the ground surface). These small landslides can initiate debris flows (a semi-fluid mass scouring or partially scouring soils on the slope along its path). Upon entering stream channels, debris flows often carry large amounts of wood and are referred to as debris torrents. These features are described in more detail in the "Landslides and Stream-Channel Modifications" section.

Ancient or relict deep-seated landslides are perhaps more prevalent in the mountainous areas of western Oregon than previously thought. Many of these relict slide landforms cover tens to hundreds of acres. Relict landslides are often believed to have developed under different geomorphic or climatic conditions (Cruden and Varnes, 1996). A few of these deep-seated landslides have occurred over the past decade. Whether they were seismically induced as a result of high magnitude subduction zone earthquakes, wetter climatic periods (there is geomorphic evidence that the Pleistocene-Holocene epoch transition was a period of high rates of landsliding, possibly due to a wetter climate (Personius et. al., 1993), or simply occur over long periods of time is unknown.

The vast majority of landslide studies have focused on the relationship of tree removal and road construction to debris slides (also referred to as shallow rapid landslides) and not deep-seated landslides. Koler (1992) notes a handful of studies on deep-seated landslides, only one of which was designed to examine the effects of timber harvesting on an active earthflow in southwest Oregon. Swanston et al. (1988) found that in the years immediately after logging, the displacement rate of an active earthflow increased to one inch per year. After three years, the displacement rate returned to the pre-logging rate of a tenth of an inch per year. Because of the limited information and lack of applicable knowledge available on deep-seated landslides, this discussion will focus on shallow rapid landslides.

Subsurface water and associated pore-water pressure is the most important factor associated with the occurrence of most landslides. Pore water pressure affects the inter-grain forces within the soil. The higher the pore water pressure, the lower the effective strength. Landslides may occur if there is either an increase in shear stress and/or a reduction in shear strength along the failure surface; or they may fail as a result of soil liquefaction (where the slope, or a portion of the soils on the slope behave more like a liquid, usually due to a sudden rise in pore pressure, or a rapid loss of cohesion or cementation (Terzaghi and Peck, 1967; Andersen and Sitar, 1995).

Forest practices may alter both physical and biological (vegetative) slope properties that influence slope stability and the occurrence of shallow rapid landslides. Physical alterations can include slope steepening, slope-water effects, and changes in soil strength. Most physical alterations are the result of roads and skid roads. On a unit-area basis, roads have the greatest effect on slope stability of all activities on forestlands (Sidle et al., 1985). Changes in vegetation can also have both hydrological and mechanical effects on the stability of slopes (Greenway, 1987).

Since most landslide inventories have found a relationship between timber harvesting and an increased frequency of shallow rapid landslides for some time period after logging, many researchers have assumed that the increase in landslides is due to a decrease in root strength (Sidle and others, 1985). There is direct evidence that root-reinforced soil is stronger than the same soil without roots (Ziemer, 1981). Sidle et al. (1985) describes the relevancy of root reinforcement:

> "The importance of roots to the stability of shallow soils on steep lands under intact coniferous forests and after the removal of forests in western North America has been elucidated by Swanston (1970, 1974), O'Loughlin (1974); Ziemer and Swanston (1977), Burroughs and Thomas (1977), Wu et al. (1979), Ziemer (1981), and Gray and Megahan (1981). These studies generally indicate that the continued stability of soils on many steep, forested slopes depend partly on reinforcement from tree roots, especially when soils are partly or completely saturated. After forest removal, the gradual decay of tree roots often predisposes forest soils to failure. Similar conclusions have been reached in Japan (Kitamura and Namba 1976, Endo and Tsuruta, 1969, Nakano 1971) and in New Zealand (O'Loughlin and Pearce 1976, Selby, 1981, O'Loughlin et al., 1982)."

Most research on the effects of vegetation on slope stability has focused on root tensile strength. (Burroughs and Thomas, 1977). A very large body of scientific evidence concludes root strength is an important stabilizing mechanism on steep slopes. (Sidle and others, 1985). Much of the earlier scientific evidence is based on modeling and has not been hypothesis-tested using ground-based data applied to actual landslides (and areas that did not have landslides). Schmidt (1999) measured root characteristics at 41 sites in the Oregon Coast Range. He found the highest root strength in three test pits in natural forest settings. The lowest root strength values were found in three test pits in clearcuts where herbicides had been applied. Average rooting depth was constrained to the upper 0.5 meters of regolith (1.5 feet of soil).

Strength values cited in the technical literature and attributed to root reinforcement can, in some cases, lead to the conclusion that forested sites can't fail and all high-risk sites that are harvested must fail (Skaugset, 1997), especially when analysis is based on basal root reinforcement. It is well documented from extensive ground-based landslide surveys that forested sites can and do fail (Hughes and Edwards, 1978; Ketcheson and Froehlich, 1978; Swanson and others, 1977; Robison and others, 1999). Dietrich (2001) points out that, even with high root strength, landslides can happen in forests according to those models if soil depths are sufficiently great over a wide enough area and also because gaps in root density occur in "forests" because of death and shading that can create local root strength gaps. After forests are cut, residual strength can be enough to withstand pore pressures from normal storms. Although in the past most models have considered basal root reinforcement, lateral root reinforcement is the likely important factor in the stability of steep forested slopes in the Pacific Northwest

It can be argued that increased landslide occurrence after timber harvesting may be due to changes in microsite hydrology. Although there is no direct research on this issue, it is possible that a forest canopy may affect the delivery of "rainfall spikes" to the ground, thus affecting the potential for slope liquefaction. Forest canopy is usually measured in terms of the leaf area index, or the average surface area of all leaves, needles, branches and bole above any point on the ground. During periods of rainfall, the forest canopy probably stores moisture in proportion to the leaf area index. Even when canopy is saturated, water is stored for a short period of time. Megahan (1983) documents many subsurface hydrology changes and shows an average increase of 47 percent in maximum groundwater levels after vegetation removal (following clearcutting by helicopter and subsequent wildfire on granitic slopes) in Idaho.

In addition, while vegetation is generally thought to have a stabilizing effect on slopes, there are situations where it can have the opposite effect (Greenway, 1987). Wind loading on trees can result in dynamic loading on slopes, especially when trees blow down. Rogers and McHale 1999) measured increased pore-water pressure under stumps as they were rocked back and forth in the same manner that wind rocks a tree back and forth. Slopes can also become locally oversteepened as the overturning root wad displaces soil around the root wad. Often, blow-down occurs during very wet periods, so the local disturbance and dynamic forces may lead to liquefaction. The distribution of trees in any forest is far from uniform, so there are always openings where forest canopy and root density are lower. Slope failure should occur preferentially in locations where material strength is lower or water levels are higher.

There is strong, ground-based scientific evidence that removal of vegetation typically results in increased landslide occurrence on steep slopes in western Oregon (Hughes and Edwards, 1978; Ketcheson and Froehlich, 1978; Swanson and others, 1977; Robison and others, 1999). At the present time, there is limited scientific information on the relative importance of roots versus changes in microsite hydrology; nor is there specific information on how to precisely model either root effects or canopy-related hydrologic effects. The role of roots versus changes in hydrology is important because forest management activities may have a different effect on roots as compared to canopy growth. Attempting to maintain roots and not canopy might not effectively mitigate the increase in landslide occurrence after timber harvesting if it is canopy that has the biggest influence on landslide occurrence. On the other hand, canopy and root growth patterns may be similar. In that case, it may not matter which mechanism is most important.

Landslides and Stream-Channel Modifications

The principal landslide-related effects of major storms, such as those that occurred in Oregon in February and November 1996, are both off-site and in-channel. Scour and deposition from landslides, debris flows, and torrents significantly modified stream channels (Robison et al., 1999). A potential concern with landslides is their effect on forest productivity. However, past studies in the Pacific Northwest have shown that even in areas with high landslide densities, generally less than two percent of the land area is directly impacted by landslides (Ketcheson and Froehlich, 1978; Ice, 1985).

In steep terrain, small shallow landslides can quickly transform into debris flows. A debris flow occurs if the landslide moves down slope as a semi-fluid mass, scouring or partially scouring soils on the slope along its path. A debris flow is any movement below the initial landslide and upslope of a stream channel. Upon entering and continuing down a stream channel, debris flows are sometimes called debris torrents (Van Dine, 1985; Robison et al., 1999). In western Oregon, landslides initiate most debris flows and torrents (Swanson and Lienkaemper, 1978). Debris torrents in the Pacific Northwest typically contain significant amounts of large wood. Debris flows and debris torrents travel varying distances and result in variable degrees of impact depending on channel slope, confinement, layout of the channel network, and other characteristics (Fannin and Rollerson, 1993).

Upon entering stream channels, debris flows have probably increased greatly in both momentum and volume. In the stream channel, there may be a much larger source of water to affect debris flow movement. Debris (wood, boulders) in the channel can also be incorporated into the debris torrent. Confinement is critical for debris torrent movement in channels. Typical Oregon debris torrents travel long distances (thousands of feet) down relatively gentle channel gradients and away from steep hillslopes.

May (1998) looked at debris torrents that reached fish-bearing stream channels (moved long distances) in the Siuslaw River watershed. These long running debris flows often included road-associated landslides that were much larger than the other landslides. Long running debris flows disproportionately came from recent clearcuts (46 percent of the initiating landslides). Multiple initiating landslides, debris left in channels and younger riparian forests may all be factors that increase potential debris torrent movement distances (May, 1998; Robison and others, 1999).

When channels become wide, debris flows typically spread out laterally and quickly lose momentum and behave more as a flood (leaving the large boulders behind). Channel junctions can also affect debris flow momentum and cause them to cease movement (Benda and Cundy, 1990). Channel junctions tend to stop debris torrents because of decreased channel gradients and the loss of momentum due to the change in direction.

While landslide features may constitute a very small percentage of the total land area, they can have varying degrees of impacts on a significant portion of the channel network (Swanson et al., 1987). Robison et al. (1999) found that anywhere from 40 to 80 percent of the entire channel network experienced severe impacts (defined in this study as major scour or deposition from debris torrents or dam break floods) in areas that experienced the most severe storm impacts (the five "red zone" areas). However, in non-red zone areas very little, if any, of the stream channel network had noticeable impacts.

Small streams in steep terrain supply wood, sediment, and relatively cool water to larger fish-bearing streams. In addition, small streams often provide habitat for critical life stages of fish and other aquatic organisms. Landslides and debris flows provide most of the sediment input into small streams in steep forested watersheds (Benda and Dunne, 1987). Past studies have documented channel changes for small and large streams resulting from high water and landslide activity including channel scour and fill, channel widening, changes in channel longitudinal profile, and decreases in ecological stability (Lyons and Beschta, 1983; Kaufmann , 1987; Lamberti et al., 1991; Reeves et al., 1995). Reeves et al. (1995) suggests that the input of spawning gravel, large wood, and floodplain sediment from naturally occurring landslides is an important factor for maintaining productive fish habitat. It is hypothesized by Reeves and others that in many cases, the short-term disturbance caused by a landslide may be necessary to improve long-term aquatic habitat conditions.

Debris flows and torrents commonly transport many times more sediment than the initiating landslide through scour of hillslopes and channels. In some cases, an initiating landslide of 10 cubic yards or less may become a debris torrent moving thousands of yards of material into and through portions of the channel network. Debris flows and torrents tend to deposit sediment when channel gradients drop to less than six percent (Benda and Cundy, 1990). They also tend to stop in the form of a debris jam at tributary junctions where the junction angle is greater than 70 degrees (Benda and Cundy, 1990).

While woody debris carried in debris flows torrents may have long-term benefits for aquatic habitat, it may also create a public safety hazard in some cases. Harvey and Squier (1998) found that "slash piles in the channel, or abundant slash, which can form temporary debris jams in the channel, can increase the severity of debris flows." Wood is also associated with "migrating organic dams" that can move long distances down relatively gentle stream channels (Coho and Burges, 1994).

Potential landscape-scale effects of forest management may influence both the quantity and quality of landslides. If a relatively high percentage of the high-risk areas in a given watershed is in a very young age class, the risk of landslide occurrence is increased. The quality of landslides can also be influenced at a landscape-scale if a relatively large portion of the land area in the upper reaches of a watershed is in a young age class. Younger forests will not provide as many of the larger key pieces of wood to areas where landslides and debris flows occur as compared to what an older forest would provide. Leaving trees and/or large down wood (in key areas) from the previous stand at the time of harvest may mitigate these effects.

The IMST report (1999) includes the following summary information about managing slope failures and the movement of material into streams:

> "Slope failure is a natural process and it can have both positive and negative effects on fish habitat. The technical basis for managing roads to reduce or minimize slope failure

is well developed. The technical basis for managing non-road-related slope failure is much less well developed, except under extremes of site conditions. Although speculative, we believe maintenance of functional riparian zones along channels where debris torrents may occur can mitigate their destructive force, and increase the positive effects they may have."

Fish Passage (Habitat Modification, Bio-Criteria)

Over time and space, “natural” fish passage varies due to a range of disturbance and geological factors. Streams are complicated systems conveying and storing large amounts of water, energy, wood, sediment, and bedload material. The combination of these elements result in an elaborate pattern of flow, water temperature and channel forms (i.e., riffles, pools, runs, glides, and side channels) over both space and time. The natural forces that created these patterns also produce barriers and delays to fish passage at waterfalls, landslides, debris jams, and channel constrictions, and during times of extreme flows and temperatures. Native fish have evolved with these patterns, resulting in behavior and swimming capabilities adapted to the range of natural conditions. Many natural barriers are transitory (e.g., debris dams), and fish can soon reoccupy lost territory or reconnect genetically after a barrier is modified or eliminated.

Human-made barriers such as dams and impassable stream crossings have increased the delays and barriers to fish passage well above natural levels. In some cases, human-made barriers may be in place for periods much longer than a similarly occurring natural barrier. In particular, human-caused barriers may pose the most significant landscape-scale impact to fish with migratory life histories and specialized habitat needs such as bull trout. For the species with various life histories such as bull trout or cutthroat trout, fish passage problems may negatively impact some life history forms while not others.

The management of forests has resulted in an overlay of roads across the landscape. Where stream crossings are inadequately designed and maintained, they may prevent fish from meeting their basic requirements for reproduction, habitat, and refuge. Crossings may also produce broader ecosystem effects due to impacts on large wood routing, nutrient cycling, delays to movement, and genetic health of fish populations.

Other forest management activities such as timber harvesting may have altered stream temperatures or caused channel changes that may delay or prevent fish passage. Timber harvesting can increase summer and fall flows, possibly improving some fish passage opportunities. While the extent of fish passage problems related to stream crossing structures has been quantified to some degree, other forest management effects related to fish passage at a landscape-scale level have not been well documented. As described later, systems are in place for forestlands to address many of the fish passage problems over time.

Movement of fish throughout a watershed is necessary for a number of life history needs. Upstream and downstream migration of juveniles during low summer flow is often needed so they can find suitable habitat (e.g., to seek cool water refugia). During winter, juveniles may move upstream or into side tributaries and off-channel habitats to escape flood flows. Upstream migration of juveniles has been observed related to the presence and availability of beaver ponds and other fish-rearing habitat. Upstream migration of adults is important for access to spawning grounds.

The Botkin Report (1995) and other studies have identified "impediment construction" as a major factor leading to the decline of salmonids in western Oregon. Loss of fish passage at road crossings and other human-caused barriers has many potential effects, including:

- Loss of access to spawning, rearing, and winter habitat;
- Loss of genetic diversity in an upstream reach for resident fish, as fish can go downstream but not back upstream;
- Loss of range for juvenile fish that may migrate upstream at certain times of the year;
- Loss of nutrients (from the carcasses of anadromous spawning adults) to reaches upstream of passage problems;
- Changes in fish genetics or community assemblages upstream of fish passage impediments (stronger swimming fish species, more hearty gene pools, or only certain life stages can pass upstream, while other fish cannot); and
- Loss of resident fish populations in small streams after extreme flood or drought events that evacuate the fish from the reach and prevent their return.

Some of the primary motives fish have to move or migrate are to satisfy basic requirements for reproduction, habitat (i.e., food, cover, thermal regime), and refuge. On an annual basis, upstream migration of adult salmon occurs in many Oregon streams and rivers. Spawning salmon, however, do not arrange themselves haphazardly in a watershed, but instead seek particular habitats according to stream size, substrate and water velocity. For example, pink and chum salmon do not stray far from the estuary, while steelhead and cutthroat trout can be found in small headwater streams. Selecting certain niches in the freshwater network for spawning is beneficial to the resultant juveniles by reducing competition for limited resources.

While upstream movement of reproducing adults and young salmon heading down river to reach ocean feeding grounds are familiar phenomena, other types of fish migration or movement occur but are less obvious. Both juvenile salmon and resident trout have been observed to move both up and downstream in response to various environmental factors. This includes seeking refuge from elevated stream temperatures, extreme flow conditions and predation, or seeking less densely populated areas with better opportunities for food and cover (Bustard and Narver, 1975; Cederholm and Scarlett, 1981; Everest, 1973; Fausch and Young, 1995; Gowan et al., 1994; Hartman and Brown, 1987; Reiser and Bjornn, 1979; Shirvell, 1994). For some juvenile fish, upstream migration can be an important part of their life cycle, such as sockeye salmon fry swimming upstream to reach a rearing lake. Coho juveniles have also been noted in several studies to migrate upstream in the fall into sidewater channels and tributaries (Bustard and Narver, 1975; Cederholm and Scarlett, 1981; Skeesick, 1970). While the exact reason for this migration strategy is unknown, there is growing evidence that coho juveniles overwintering in these areas have significantly higher survival rates (Bustard and Narver, 1975).

From this discussion, it is apparent that barriers to movement caused by road crossings can prevent fish from meeting their basic requirements for reproduction, habitat, and refuge. Delays and barriers due to stream crossings can be divided into three different categories (Dane, 1978), each with different potential impacts to fish (Table 2).

Table 2. Barriers to Fish Passage and Their Potential Impacts.

Barrier Category	Definition	Potential Impacts
Total	Impassable to all fish at all times.	1) Exclusion of fish entirely or from portions of a watershed. 2) Isolation of fish populations upstream of barrier.
Partial	Impassable to some fish at all times.	1) Exclusion of certain fish species or ages entirely or from portions of a watershed. 2) Isolation of certain fish species or ages upstream of barrier.
Temporary	Impassable to all fish some of the time.	1) Delay of movement beyond the barrier for some period of time.

The problem of human-caused barriers to fish passage in the Pacific Northwest appears to be very significant. In the Skagit River basin in Washington State, impassable culverts are responsible for 13 percent of the total decrease in summer rearing habitat on all ownerships (Beechie et al., 1994). This decrease in summer rearing habitat was considered greater than the sum total effects of all other forest management activities combined. Another study reported that as many as 75 percent of culverts in forested watersheds are either outright blockages or impediments to fish passage based upon field surveys done in Washington State (Conroy, 1997).

Of the 532 fish presence surveys conducted on forestlands in Oregon coastal basins during the 1995 survey season, 15 percent (n=79) of the confirmed end of fish use were due to human barriers. Road culverts make up the largest percentage of the barriers (96 percent), with various types of dams comprising the balance. An additional 3 percent of the surveys identified culverts with an upstream population of resident trout, but they were impassable to anadromous fish.

Surveys of county and state highways conducted by the Oregon Department of Fish and Wildlife (ODFW) for the Oregon Department of Transportation (ODOT) have found hundreds of culverts that were assumed to at least partially block fish passage (Al Mirati, personal communication, 1999). The roads surveyed were frequently located low in a drainage system and thus may be impacting passage for a large array of fish species.[16] The state and county road survey found the following number of problem culverts in Oregon:

Coastal Basins – 1,140 crossings
Lower Willamette – 167 crossings
Upper Willamette – 771 crossings
Grande Ronde & Imnaha – 83 crossings
John Day Basin – 260 crossings

[16] The criteria used in the ODFW-ODOT survey included: (1) a slope greater than 1%, and (2) an outlet jump greater than one foot if only adult passage was considered and six inches if juvenile passage was also considered. If a jump occurred, the pool needed to be 1.5 – 2.0 times deeper than the height of the jump. Another condition that put culverts into the problem category were inlet deposits and drops at the inlet which was termed “diving flow.”

The ODFW and ODF have jointly developed fish passage guidelines to help ensure that any artificial obstructions placed across a stream will not pose a barrier to the movement of adult and juvenile salmonids, both resident and anadromous.

Table 3 provides a general summary of the criteria found in the ODFW fish passage guidelines and the related biological factors. To simplify the complexity of the guidance criteria, ODF has taken a more conservative approach to fish passage by requiring that in all cases, road crossings must be designed to pass juvenile fish. Since these smaller fish are less capable swimmers, providing conditions that meet their passage needs will also assure that the needs of the adult fish are also met. The design alternatives in the ODF guidelines also eliminate the need for trying to design for specific water velocities in the pipe barrel. Thus, while the alternatives in the ODF guidelines do not explicitly contain the criteria contained in Table 3, their design is based on consideration of these criteria.

In western Oregon forestlands, passage conditions are most commonly designed to meet the needs of juvenile or adult coho, chinook, steelhead, and rainbow and cutthroat trout. In central and eastern Oregon, structures are most commonly designed to pass juvenile or adult chinook, steelhead, rainbow, cutthroat or bull trout. Obviously, predicting when and where fish will need access is challenging, and coordination with a fisheries biologist is essential for identifying the proper species, age, and time of year to account for in designing the drainage feature. While the ODFW guidelines provide criteria for designing crossings for the adults of different salmonid species, in most cases the crossing will be designed for the passage of all juvenile fish.[17]

Table 3. Biological Factors Related to Fish Passage Criteria.

FISH PASSAGE CRITERIA AND RELATED BIOLOGICAL FACTORS	
General Regulatory Criteria	Biological Factors
Water velocity in culvert	Swimming speed
Water depth in culvert	Submergence (sufficient depth for swimming)
Design flow criteria	Delays, dispersion
Height between culvert outlet and water surface	Jumping ability
Timing of in-stream work	Emergence (silting in of redds) Migration - delays or reduction of adult spawners

The most problematic characteristics of culverts that are often readily identifiable in the field include:

- High velocities or sudden changes in velocity at the culvert inlet, outlet, or within the barrel;
- Excessive jumps at the culvert inlet or outlet;
- Shallow water depths within the structure; and
- A lack of resting pools at the culvert inlet, outlet, or within the barrel.

[17] The ODFW guidelines advise that the culvert should be designed to pass fish for at least 90% of the streamflow for a given season when fish are likely to pass. In other words, the culvert should pose a fish passage problem only 10% of the time. ODF guidelines are designed to pass all juvenile fish, and a site-specific plan would be required where this may not be possible.

Design considerations for minimizing these adverse effects should include managing water velocities in and around the culvert, preventing drops in and around the culvert, and providing adequate water depth within the culvert.

In terms of fish passage restoration activities on a landscape scale, there are seven basic steps that should be considered:

1. Find and prioritize problem road/stream crossings.
2. Get information about the stream and other conditions at the crossings to be restored.
3. Decide if the installation can be repaired, improved, or whether it must be replaced.
4. Decide on a design strategy based on information collected at the site.
5. Prepare a design.
6. Install new road/stream crossing structure.
7. Monitor and maintain the road/stream crossing structure.

There are several methods being used to survey culvert conditions in Oregon. Two prominent methods are the ODFW culvert survey form and the ODF Road Hazard Survey Protocol (ODF, 1998). The ODFW survey form was used to evaluate culverts on state and county roads. The ODF survey protocol has been used on forest roads. Key measurements from the culvert assessments used in passage evaluations are the culvert slope, outlet drop, and outlet pool dimensions. The information from these key measurements can be used to estimate if a culvert is partially or totally blocking fish passage, or poses a moderate to high risk of catastrophic crossing failure.

Partial fish passage blockage refers to stream crossings that are not allowing juvenile salmonid fish passage because of their design, maintenance, or condition. Generally, juvenile salmon passage requires two feet per second or less velocity, outlet perching less than 6 inches, and little to no inlet constriction or drop. In addition, the culvert should be free from debris that may concentrate flow and increase velocities. Flow depths should be 12 inches or more in the culvert, or the culvert should have a simulated natural streambed similar to conditions in the natural channel.

Total fish passage blockage refers to instances in which the design, maintenance, or condition of the stream crossing is such that most (if not all) adult and juvenile salmonids cannot move upstream through the crossing structure. Blockage results where conditions exceed most adult anadromous salmonid swimming capabilities. Generally, this occurs where culvert water velocities exceed 10 feet per second, outlet drops are over 4 feet or over 1 foot without adequate jump pools, or extreme inlet drops or material in the culvert causes barriers. Water depths should be 8 inches or more in the culvert at higher flows or the culvert should have a simulated natural streambed similar to conditions in the natural channel.

There are primarily five ways to improve fish passage at existing crossings without replacing the structure. These methods include adding baffles to the structure, adding sediment or sediment catching devices inside a culvert, backwatering through the crossing by installing downstream weir(s), removing debris, or modifying the inlet or inlet approach to remove an inlet constriction. Adding baffles to an existing crossing will decrease the peak flow capacity, so this option should only be used for culverts that have excess capacity. Baffles should only be added when other factors such as outlet drop or inlet constriction are dealt with as well. Materials to use for baffles on existing culverts can be concrete or metal. However, retrofitting metal baffles using bolts may cause the baffle to rip the culvert barrel if the culvert is made of corrugated metal pipe. Probably the most common use of baffle retrofits is for large properly sized concrete culverts that have little slope and no inlet or outlet problems. Baffle maintenance must also be considered, especially in streams where the transport of large substrate or wood occurs. These materials can damage baffles and require future replacement or maintenance.

Recruiting and retaining stream substrate in culverts can also improve passage conditions. Clancy and Reichmuth (1990) introduced a detachable fishway design for a sediment catcher in culverts. This particular type of sediment catcher employs angle iron and attaches to the inlet end of the culvert by a hook or T-bar, so it requires no bolting inside the culvert. Like baffles, sediment-catching devices should only be used for culverts that have adequate capacity and do not have other fish passage problems that cannot be easily mitigated. Sediment catchers along with placed and naturally deposited streambed material can allow for the creation of a simulated natural channel in the culvert. This option should only be used for culverts that have a width of span similar to that of the natural active channel (Clancy and Reichmuth, 1990).

Backwatering through the culvert by using a series of weirs downstream of the culvert can be an effective way of mitigating fish passage at some crossings. However, in a published field survey, almost all installations that used this strategy had problems with fish passage (Browning, 1990). If this strategy is used, the weirs downstream of the culvert should have a drop between the weir top and the downstream residual pool of no more than 6 inches. The first weir downstream of the culvert should also be a channel width or 20 feet downstream to avoid damage from the force at culvert outlets. Subsequent weirs should be placed downstream at an interval of approximately one channel width, with each weir designed to take up no more than 6 inches of drop from the residual pool to the top of the weir. As with baffles, the long-term maintenance of weirs must be considered before selecting this strategy.

APPENDIX C: DESCRIPTION OF POLLUTION CONTROL MECHANISMS

Large Wood and Stream Temperature

Voluntary Measures

The Oregon Plan contains several voluntary measures to supplement the conifer stocking within riparian areas and the recovery rate for large wood to streams. This is accomplished during harvest operations by (1) placing appropriate-sized large wood within streams that meet parameters of gradient, width, and existing wood in the channel; and (2) relocating in-unit leave trees in priority areas[18] to maximize their benefit to salmonids while recognizing operational constraints, other wildlife needs, and specific landowner concerns.

The measures include the following:

ODF 3.2 - Conifer Restoration (ODF 8S)

Forest practice rules have been developed to allow and provide incentives for the restoration of conifer forests along hardwood-dominated RMAs where conifers historically were present. This process enables sites capable of growing conifers to contribute conifer large wood in a timelier manner. Conifer restorations within priority areas are subject to additional review and require a site-specific plan to be submitted and reviewed by the department.

ODF 3.3 - Additional Conifer Retention along Fish-Bearing Streams in Priority Areas (ODF 19S)

This measure retains more conifers in RMAs by voluntarily limiting harvest activities to 25 percent of the conifer basal area above the standard target. This measure is only applied to RMAs containing a conifer basal area that is greater than the standard target.

ODF 3.4 - Limited RMA for Small Type N Streams in Priority Areas (ODF 20S)

This measure provides limited 20-foot RMAs along all perennial or intermittent small Type N streams for the purpose of retaining snags and downed wood.

ODF 3.5 - Active Placement of large wood during Forest Operations (ODF 21S)

This measure provides a more aggressive and comprehensive program for placing large wood in streams currently deficient of large wood. Placement of large wood is accomplished following existing ODF/ODFW placement guidelines and determining the need for large wood placement is based upon a site-specific stream survey.

ODF 3.6 - 25 Percent In-unit Leave Tree Placement and Additional Voluntary Retention (ODF 22S)

This measure has one regulatory component and two voluntary components:

[18] The Executive Order replaced the concept of "core areas" with "priority areas". See (1)(f) of the Executive Order (p.5).

1) The State Forester, under statutory authority, will direct operators to place 25 percent of in-unit leave trees in or adjacent to riparian management areas on Type F and D streams.
2) The operator voluntarily locates the additional 75 percent in-unit leave trees along Type N, D or F streams, and
3) The State Forester requests the conifer component be increased from 50 percent to 75 percent.

ODF 3.7 - Voluntary No-Harvest Riparian Management Areas (ODF 62S):
Establishes a system to report and track, on a site-specific basis, when landowners voluntarily take the opportunity to retain no-harvest RMAs.

DEQ measures include the following:

DEQ2S - Development of 303(D) List and Identification of Priorities for Total Maximum Daily Loads (TMDL) Development

- Summary of Measure: Under Section 303(d) of the Clean Water Act, Department of Environmental Quality (DEQ) recently revised its list of water quality limited water bodies and has developed a priority list for TMDL development over the next two years. DEQ prioritized its 1994/96 list of water quality limited waters to address limiting factors for salmonid recovery. The presence of threatened or endangered species within a given watershed is a criterion for Priority 1 ranking of water bodies for TMDL action. DEQ will update the 303(d) list and TMDL priority list again in April 1998 and every two years thereafter (or at an alternative frequency identified by EPA). The updates to the list include an analysis of all water quality data available to the department, and over time should provide a comprehensive list of all watersheds in Oregon where water quality standards are not being met.
- Goal: To have all waters of the state achieve water quality standards within a reasonable time frame.
- Objective: Identify waters that do not meet water quality standards, prioritize and target water bodies and address water quality concerns through the development and implementation of Total Maximum Daily Loads and Management Plans.

DEQ6S - Implement Antidegradation Water Quality Standard

- Summary of Measure: DEQ will implement its antidegradation water quality standard in steelhead ESUs to address degradation of water quality that is currently cleaner than parameter specific water quality standards would allow. DEQ will ensure that point source discharges are subjected to antidegradation review as permits are issued for new or increased discharges, and will work with ODF, ODA and other state and federal natural resource agencies to ensure the antidegradation standard is implemented for nonpoint sources.
- Goal: Ensure that water quality and beneficial uses are protected on agricultural lands and forestlands, and that high-quality waters are protected from degradation.
- Objective: The development of water quality management plans for the steelhead ESUs that meet the requirements of the Coastal Nonpoint Pollution Control Program and the State's water quality antidegradation policy. DEQ's objective is to provide

ODA, ODF, USFS, BLM and local management agencies the technical assistance they need to successfully complete water quality management plans and to ensure that these plans contain the appropriate water quality objectives and are likely to achieve those objectives.

The ODF voluntary management measures are implemented within priority areas. Several of the measures utilize in-unit leave trees and are applied in a "menu" approach to the extent that in-unit leave trees are available to maximize their value to the restoration of salmonid habitat. The choice of menu measures is at the discretion of the landowner, but one or more of the measures may be selected.

The measures can be described as either active restoration measures, or passive restoration measures that provide long-term large wood recruitment. Voluntary measures ODF 3.2 and 3.5 are active restoration activities. ODF 3.2 restores hardwood-dominated riparian areas back to a conifer-dominated condition, where appropriate, using a site-specific plan. Site-specific plans require additional consultation with the ODFW to minimize potential damage to the resource. They often result in conditions that are more protective of the resources than would occur without the site-specific plan. ODF 3.5 addresses large wood placement if stream surveys determine there is a need. Measures ODF 3.3, 3.4, 3.6, and 3.7 provide future large wood recruitment through additional riparian protection. This additional protection is accomplished by retaining in-unit leave trees, snags, and downed wood within and along RMAs, and by changing the ratio of in-unit leave trees to 75 percent conifer.

The following application priority has been developed for harvest units containing more than one stream type. The list establishes the general priority for placement of in-unit leave trees.

- Small and medium Type F streams.
- Nonfish-bearing streams (Type D or Type N), especially small low-order headwater stream channels, that may affect downstream water temperatures and the supply of large wood in priority area streams.
- Streams identified as having a water temperature problem in the DEQ 303(d) list of water quality limited water bodies, or as evidenced by other available water temperature data; especially reaches where the additional trees would increase the level of aquatic shade.
- Potentially unstable slopes where slope failure could deliver large wood.
- Large Type F streams, especially where low gradient, wide floodplains exist with multiple, braided, meandering channels.
- Significant wetlands and stream-associated wetlands, especially estuaries and beaver pond complexes, associated with a salmon core area stream.

FPA Rules

The Water Protection Rules identify seven geographic regions and distinguishes among streams, lakes, and wetlands. The rules further distinguish each by size and type. Stream size is distinguished as small, medium, or large, based on average annual flow. Stream type is distinguished as fish use, domestic use, or neither. Table 1 lists the required RMA widths based on stream size and type.

Table 1. Riparian Management Area widths for streams of various sizes and beneficial uses (OAR 629-635-310).

	Type F	Type D	*Type N*
LARGE	100 feet	70 feet	70 feet
MEDIUM	70 feet	50 feet	50 feet
SMALL	50 feet	20 feet	Apply specified water quality protection measures, and see OAR 629-640-200

Generally, no tree harvesting is allowed within 20 feet of fish bearing, domestic use, and all other medium and large streams unless stand restoration is needed. In addition, all snags and downed wood must be retained in every riparian management area. Provisions governing vegetation retention are designed to encourage conifer restoration on riparian forestland that is not currently in the desired conifer condition. Future supplies of conifer on these sites are deemed desirable to support stream functions and to provide fish and wildlife habitat. The rules provide incentives for landowners to place large wood in streams to immediately enhance fish habitat. Other alternatives are provided to address site-specific conditions and large-scale catastrophic events.

The goal for managing riparian forests along fish-use streams is to grow and retain vegetation so that, over time, average conditions across the riparian landscape become similar to those of mature, unmanaged riparian stands. This goal is based on the following considerations (Lorensen et al., 1994):

(1) Mature riparian stands can supply large, persistent woody debris necessary to maintain adequate fish habitat. A shortage of large wood currently exists in streams on nonfederal forestlands due to historic practices and a wide distribution of young, second-growth forests. For most streams, mature riparian stands are able to provide more of the functions and inputs of large wood than are provided by young second-growth trees.

(2) Historically, riparian forests were periodically disturbed by wildfire, windstorms, floods, and disease. These forests were also impacted by wildlife such as beaver, deer, and elk. These disturbances maintained a forest landscape comprised of riparian stands of all ages ranging from early successional to old growth. At any given time, however, it is likely that a significant proportion of the riparian areas supported forests of mature age classes. This distribution of mature riparian forests supported a supply of large, persistent woody debris that was important in maintaining quality fish habitat.

The overall goals of the riparian vegetation retention rules along Type N and Type D streams are the following:

- Grow and retain vegetation sufficient to support the functions and processes that are important to downstream waters that have fish;
- Maintain the quality of domestic water; and

- Supplement wildlife habitat across the landscape.

These streams have reduced buffer widths and reduced basal area retention requirements as compared to similar sized Type F streams. In the design of the rules, this was judged appropriate based on two assumptions. First, it was assumed that the amount of large wood entering Type N and D channels over time was not as important for maintaining fish populations in downstream reaches. Second, it was assumed that the future stand could provide some level of "functional" wood input over time to support nutrient and sediment storage processes. The validity of these assumptions needs to be evaluated over time through monitoring.

With the exception of small Type D and N streams, basal area targets are established and used for any type of management within the RMA[19]. These targets were determined based on the data that was available at the time, with the expectation that these targets could be achieved on the ground. There is also a minimum tree number requirement of 40 trees per 1000 feet along large Type F streams, and 30 trees per 1000 feet along medium Type F streams[20]. The specific levels of large wood inputs that the rules are designed to achieve vary by stream size and type. Given the potential large wood that is functional for a given stream, a combination of basal area targets, minimum tree retention, buffer widths, and future regenerated stands and ingrowth are used to achieve the appropriate large wood inputs for a given stream.

The expectation is that the 20-foot no-harvest area on all but small Type N streams, combined with the shade provided by trees left outside of the first 20 feet for basal area requirements when an RMA is managed to the standard target, will be sufficient towards maintaining stream temperatures consistent with 'natural' conditions. In the design of the Water Protection Rules, shade data was gathered for 40 small nonfish-bearing streams to determine the shade recovery rates after harvesting. One to two years after harvest, 55 percent of these streams were at or above pre-harvest shade levels due to understory vegetation re-growth. Most of these streams had a bankfull width averaging less than six feet, and most shade was provided by shrubs and grasses within 10 feet of the bank. Since 1991, there has also been a 120-acre limit on a single clearcut size, which is assumed to result in a scattering of harvested area across a watershed over time. In the development of the rules, it was assumed that this, combined with the relative rapid shade recovery along smaller nonfish-bearing streams, would be adequate in protecting stream temperatures and reduce possible cumulative effects. The monitoring program is collecting data to test these assumptions, evaluate the effectiveness of the rules, and evaluate whether or not water quality standards for temperature are being achieved.

Forest Roads

Voluntary Measures

The Oregon Plan Road Erosion and Risk Projects (measures ODF 3.1 and ODF 5.1) are currently being implemented. Many forest roads built prior to the Oregon Forest Practices Act, or prior to the current BMPs, continue to pose increased risk to fish habitat. Industrial forest

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[19] Small Type D streams require a 20-foot no-harvest RMA. Type N streams do not require an RMA.
[20] The leave tree requirements for Type D and N streams are 30 live conifers per 1000 feet for large streams and 10 for medium streams.

landowners and state forestlands are currently implementing a voluntary program to identify risks to salmon from roads and address those risks. The purposes of this project are:

1. Implement a systematic process to identify road-related risks to salmon and steelhead recovery.
2. Establish priorities for problem solution.
3. Implement actions to reduce road-related risks.

The Road Erosion and Risk Project is a major element of the Oregon Plan. The two major field elements of this project are (1) surveying roads using the Forest Road Hazard Inventory Protocol, and (2) repairing problem sites identified through the protocol. Road repairs conducted as a result of this project include improving fish passage, reducing washout potential, reducing landslide potential, and reducing the delivery of surface erosion to streams.

Roads assessed by this project include all roads on Oregon Forest Industry Council (OFIC) member forestland, plus some other industrial and nonindustrial forestland, regardless of when they were constructed. Industrial forest landowners have estimated spending approximately $13 million a year, or $130 million over the next 10 years, on this project for the coastal ESUs alone. However, the effort is not limited to, nor bound by, this funding estimate. Funding for the implementation of this measure within the other ESUs will be reflective of road problems found.

Under ODF 5.1, the State Forests program has spent over $2.5 million during the last biennium (1997-1999) for the restoration of roads, replacement of culverts and other stream crossing structures damaged by the 1996 storm. State Forests program is also proposing to spend an additional $2.5 million dollars in each of the next two biennia to improve roads, including stream crossing structures. This effort will upgrade approximately 130 miles of road in each biennium. The State Forests program has completed all of their road inventories done as part of ODF 5.1.

In addition to ODF 3.1 and 5.1, there are additional measures under the Oregon Plan that address road management concerns:

ODF 1.8 - Evaluation of the Adequacy of Fish Passage Criteria: Establish that the criteria and guidelines used for the design of stream crossing structures pass fish as intended under the goal.

ODF 4.9 - Improve Fish Passage BMPs on Stream Crossing Structures: Ensure that all new stream crossing structures on forestland installed, or replaced, after the fall of 1994 will pass both adult and juvenile fish upstream and downstream.

FPA Rules

For the purposes of this report, the following definitions will apply. A “road” normally refers to truck (sometimes called “haul”) roads. Skid roads or trails (used by tracked or wheeled skidding machines to move logs from the stump to the landing) are only addressed in relation to ground-based harvesting on steep slopes in this issue report. The Forest Practices Rules recognize three types of roads:

Active: Roads used for removing commercial forest products (regardless of the year constructed).
Inactive: Roads used for forest management purposes other than log hauling (regardless of the year constructed).
Vacated: Roads that have been purposely “put to bed,” stabilized, and are impassible.

Current road maintenance rules require maintenance of both “active” and “inactive” roads. The term “legacy” road is not defined in the administrative rules. It is widely used in the public dialogue regarding forest road issues and has a different meaning depending on when and where it is used. ODF considers “legacy” roads to be synonymous with “abandoned” roads. Regardless of when a road was built, if it has been used for hauling logs or forest management since 1972, it is subject to regulation under the Forest Practices Act. The term “older” road is also used sometimes. The administrative rules continually evolve in response to changes in scientific knowledge; since the creation of the 1973 administrative rules, major revisions to the road rules occurred in 1978, 1983, and 1994. ODF considers “old” roads to be those built prior to the 1983 rule changes (i.e., roads built before end-hauling of material excavated from the road prism on steep slopes).

On nonfederal forestlands, BMPs within the Forest Practices Act regulate road design, construction, and maintenance. The bulk of the BMPs are directed at minimizing sediment delivery to channels. The primary goals of the road rules are to protect (1) the water quality of streams, lakes, and wetlands; (2) fish and wildlife habitat; and (3) forest productivity.

The Board of Forestry revised several BMPs related to road design when the new Water Protection Rules were adopted in the fall of 1994. Significant changes made to the road construction rules include the following:

- The requirement for operators not to locate roads in riparian management areas, flood plains, or wetlands unless all alternative locations would result in greater resource damage.
- The requirement for operators to design stream crossings to both minimize fill size **and** minimize excavation of slopes near the channel. A mandatory written plan is required for stream crossing fills over 15 feet deep.
- The requirement to design stream crossing structures for the 50-year flow with no ponding, rather than the 25-year storm with no specification of allowable ponding.
- The requirement that stream crossing structures be passable by juvenile fish as well as adult fish.
- The requirement that fish must be able to access side channels.
- The requirement that stream structures constructed under these rules must be maintained for fish passage.

In determining the location of a new road, operators are required to avoid steep slopes, slides, and areas next to channels or in wetlands to the extent possible. Existing roads should be used when possible, and stream crossings should be used only when essential. The design of the road grade must vary to fit the local terrain and the road width must be minimized. The operator must also follow specific guidelines for stream-crossing structures (listed above). Cross drainage structures must be designed to divert water away from channels so that runoff intercepted by the road is dispersed onto the hillslope before reaching a channel. The specific method used is up to the operator, but the end result should be the dispersal of water running off of the road and the filtering of fine sediment before the water reaches waters of the state.

Construction and maintenance activities should be done during low water periods and when soils are relatively dry. Excavated materials must be placed where there is minimal risk of those materials entering waters of the state, and erodible surfaces must be stabilized. Landings must be built away from streams, wetlands, and steep slopes.

Road maintenance is required on all active and inactive roads. Regardless of when a road was constructed, if the road has been used as part of an active operation after 1972, it is subject to all maintenance requirements within the current rules. Culverts must be kept open, and surface road drainage and adequate filtering of fine sediment must be maintained. If the road surface becomes unstable or if there is a significant risk of sediment running off of the road surface and entering the stream, road activity must be halted and the erodible area must be stabilized. Abandoned roads constructed prior to 1972 <u>and</u> not used for forest management since that time are not subject to Forest Practices regulatory authority.

All roads in use since 1972 must either be maintained or vacated by the operator. Vacated roads must be effectively barricaded and self-maintaining, in terms of diverting water away from streams and off of the former road surface, where erosion will remain unlikely. Methods for vacating roads include pulling stream crossing fills, pulling steep side cast fills, and cross ditching. It is up to the landowner to choose between vacating a road and maintaining a road. If a road is not vacated, the operator is required to maintain the road under the current rules whether it is active or inactive, however they are not required to bring the design up to current standards outside of the normal maintenance and repair schedule.

Many active and inactive roads were constructed prior to current BMPs. The design standards of these older roads pose a higher sediment delivery risk than roads constructed under current design standards. Roads built under older standards are not required to be brought up to current design standards until either a segment needs to be reconstructed or the road shows immediate signs of failure that would damage waters of the state (i.e., collapsing culverts, actively moving hillslopes, drainage waters causing gullying, etc.). For example, design standards for stream crossings were recently changed. This change did not immediately require that operators replace all older culverts with new larger culverts. However, as the older culverts are replaced as part of the overall road maintenance required under the rules, they must be replaced with culverts that meet the new standards.

The department estimates that the majority of existing forest roads were constructed prior to 1983 (in other words, prior to rule changes which improved construction practices on steep slopes).

One area not directly addressed by the rules is sediment problems related to road use. Increased turbidity can be associated with the use of roads during rainy or thawing periods (Bilby et al., 1989; Reid and Dunne, 1984). Currently, within the guidance for the road maintenance rules, operators are directed to stop hauling when FPFs observe high levels of turbidity entering streams. However, there are currently no rules that address the specific level of turbidity that is considered acceptable during wet season hauling.

Landslides

Voluntary Measures

The Oregon Plan does not include any specific measures for the management of landslide and/or debris flow occurrence. However, ODF 3.4 can be applied to influence the quality of landslides when they occur. This measure provides limited 20-foot RMAs along all perennial or intermittent small Type N streams for the purpose of retaining snags and downed wood. Under this measure, there will be a greater potential for large wood to be delivered to downstream fish-bearing streams when applied in landslide-prone areas.

FPA Rules

OAR 629-600-100 - Definitions

(27) "High-risk areas" are lands determined by the State Forester to have a significant potential for destructive mass soil movement or stream damage because of topography, geology, biology, soils, or intensive rainfall periods.

(28) "High-risk sites" are specific locations determined by the State Forester within high-risk areas. A high-risk site may include, but is not limited to: slopes greater than 65 percent, steep headwalls, highly dissected land formations, areas exhibiting frequent high intensity rainfall periods, faulting, slumps, slides, or debris avalanches.

OAR 629-630-100 Skidding and Yarding Practices

(3) Operators shall locate skid trails where sidecasting is kept to a minimum.

(4) Operators shall locate skid trails on stable areas so as to minimize the risk of material entering waters of the state.

(5) Operators shall avoid excavating skid trails on slumps or slides.

(6) Operators shall limit cable logging to uphill yarding whenever practical. When yarding across high-risk sites in the Northwest Oregon Region or Southwest Oregon Region, or when downhill cable yarding in any region is necessary, operators shall use a layout and system which minimizes soil displacement.

OAR 629-630-500 Harvesting on High-risk sites in Western Oregon

(1) In the Northwest Oregon and Southwest Oregon regions, operators shall obtain prior approval from the State Forester before conducting harvesting operations on high-risk sites.

(2) Written plans, where required for harvesting on high-risk sites, will describe how harvesting operations will be conducted to minimize impact upon soil and water resources.

OAR 629-630-600 Felling; Removal of Slash

(2)(b) On steep slopes, use felling practices such as jacking, line pulling, high stumps, whole tree yarding, or stage-cutting as necessary and feasible to prevent damage to vegetation retained in riparian management areas, soils, streams, lakes and significant wetlands.

(3) Operators shall minimize the effects of slash that may enter waters of the state during felling, bucking, limbing or yarding by:
(b) Not allowing slash to accumulate in Type N streams, lakes or wetlands in quantities that threaten water quality or increase the potential for mass debris movement.

High-risk sites are designations used by ODF for locations that are vulnerable to landslides capable of causing damage to natural resources (specifically, water quality and fish habitat). Evaluating the accuracy of these high-risk site determinations is critical, since there are specific rules and administrative procedures that apply only after high-risk sites are identified. High-risk sites have been designated as having the following landform characteristics:

- Actively moving landslides;
- Any slope steeper than 80 percent;
- Concave slopes steeper than 70 percent;
- Slope breaks where the lower slope exceeds 70 percent;
- Inner gorges with slopes steeper than 60 percent; and
- Other sites determined to be of marginal stability by ODF personnel.

The Oregon Board of Forestry adopted most of the current landslide prevention rules in June 1983. Rules for harvesting on high-risk sites were adopted in 1985. The forest practice rules for harvest operations are intended to minimize both surface and mass (landslide) erosion. Harvest practices are subject to added regulation if they affect high-risk sites.

Standard practices for the protection of high-risk sites during forest harvesting and stand management activities on private lands in Oregon include:

- Felling timber to minimize ground disturbance and slash accumulations on high-risk sites;
- Not building skid trails on high-risk sites;
- When yarding across high-risk sites, providing at least one end suspension and ensuring that logs do not gouge soils;
- Not building landings on high-risk sites, and avoiding placement of landing debris or landing drainage on high-risk sites; and
- Replanting as soon as possible after logging.

The following additional practices have at times been used to protect high-risk sites, but are not considered standard practices or requirements in most cases:

- Leaving nonmerchantable trees and understory vegetation relatively undisturbed;
- Avoiding prescribed burning;
- Avoiding use of herbicides;

- Leaving a buffer area around headwalls (headwall-leave areas);
- Thinning the stand instead of clearcut harvesting to retain some root strength; and
- Not harvesting the area.

Fish Passage

The ODFW by statute is the lead state agency for all types of fish passage concerns in Oregon. In keeping with this role, ODFW has produced guidelines regarding fish passage. The statutes require that fish passage be provided where anadromous, food or game fish species are present. On state and private lands, the ODF and Division of State Lands (DSL) also regulate fish passage in a manner compatible with ODFW. A Memorandum of Agreement among the agencies has been developed to guide the consistent application of technical requirements to achieve fish passage. On federal lands, the Forest Service and other federal landholders are to comply with ODFW rules and statutes. In areas with endangered fish species listings, fish passage authority is also given to National Marine Fisheries Service and U.S. Fish and Wildlife Service.

The ODFW guidelines specify maximum velocities, entrance drops, and minimum water depth criteria for culverts. The ODFW guidelines specify a preference for using bridges but also allow for culverts that simulate natural streambed conditions, nonembedded culverts placed essentially flat, and culverts using baffles or weirs in order of decreasing preference.

ODF has also produced regulatory guidance designed for landowners and operators regarding fish passage that describes crossing alternatives that will likely pass fish under different situations (Robison et al., 1999). The differing situations include stream gradient, stream valley fill present, and specific type of strategy involved. These guidelines (both old and new) require that culverts designed to have no sediment in them be placed essentially flat (less than or equal to 0.5 percent gradient), and that culverts designed to simulate natural bed conditions be designed for stream widths similar to the natural stream width and be placed at a gradient similar to or somewhat below natural stream gradient. A training document designed to guide fish passage on state and private forestlands has been developed.

DSL regulates the standards for fish passage for structures requiring removal/fill permits. Permits are required for fills in excess of 50 cubic yards of material or for any amount of fill in stream segments designated as “Essential Indigenous Anadromous Salmonid Habitat.” The expedited general authorization approval process, as well as fill and removal permit information for road construction on nonforestlands, is available on the World Wide Web at [http://statelands/dsl.or.us/roadinfo.htm].

There are several other nonregulatory programs regarding fish passage in Oregon. Within the Oregon Plan for Salmon and Watersheds, there are two primary forestry measures that relate to fish passage (ODF 1.5 and ODF 5.1). These two voluntary measures target the identification and correction of road-related problems on private industrial forestlands and State Forestlands over the next ten years. OFIC members provide funding for these projects, which are reported using the Oregon Watershed Enhancement Board (OWEB) Watershed Restoration Inventory.

The Watershed Restoration Inventory reports that between 1995 and 1999, $32 million have been spent by private industrial forestland owners. The funding for the projects is provided by OFIC members, while the funding for data collection and distribution is funded by OWEB. Some private non-industrial forest landowners obtain funding through OWEB and other sources to complete their projects. As part of ODF 3.1, approximately $4 million has also been spent by other landowners, the majority of which are private non-industrial owners that are members of the Oregon Small Woodlands Association (OSWA).

<u>Voluntary Measures</u>

The Oregon Plan contains several voluntary measures with the goal of identifying and correcting obstructions and impediments to fish passage. The following is a brief description of these measures that have a direct impact on fish passage:

ODF 3.1: *Road Erosion and Risk Project* –
Many forest roads built prior to the development of the Oregon Forest Practices Act or prior to the current BMPs pose increased sediment risk to fish habitat. Industrial forest landowners have agreed to implement a voluntary program to identify risks from roads and to address those risks. This action is making improvements to road elements such as road fills, stream crossings, and drainage and surface problems to improve fish passage and habitat. As part of this measure, a road management guidebook has been developed that includes alternatives for solving identified problems.

ODF 5.1: *State Forestlands Road Erosion and Risk Project* –
This measure, similar to ODF 5.1, will identify risks from roads on state-owned lands. This effort will upgrade at least 130 miles of road in each of the next three biennia. Surveys to identify needed work have been completed on all State Forestlands.

ODF 1.8: *Evaluation of Adequacy of Fish Passage Criteria* –
Technical criteria and guidelines for fish passage have been recently established. These criteria and guidelines will be followed by all state agencies when designing or approving projects. However, the criteria and guidelines, while developed using the best available science, have not been validated by monitoring. The objective of this measure is to verify that the criteria and guidelines used for the design of stream crossing structures will allow for the passage of both adult and juvenile fish.

ODF 3.8: *Fish Passage Surveys (Weyerhaeuser)* –
The Coos Watershed Association and Weyerhaeuser have completed an analysis of all "major" anadromous fish culverts in the Coos River Watershed. Weyerhaeuser will contract with ODFW to evaluate stream conditions above culverts that are fish passage-limiting to establish priority for enhancement.

Measures contained within the Oregon Plan which have some effect on fish passage through monitoring, surveys, and restoration projects include the following:

ODF 3.8 - North Coast Salmonid Habitat Restoration Project (ODF 5S)

ODF 3.8 - Mid-Coast Restoration Project (ODF 6S)
ODF 1.2 - Forest Practices Monitoring Program (ODF 10S)
ODF 1.5 - Storms of 1996 Monitoring Project (ODF 13S)
ODF 1.9 - BMP Compliance Audit Program (ODF 23S)
ODF 2.1 - Fish Presence/Absence Surveys and Fish Population Surveys (ODF 25S)
ODF 4.7 - Fish Presence Survey (ODF 32S)
ODF 3.8 - South Coast Technical Advisory Team (ODF 52S)

<u>FPA Rules</u>

The forest practice rules since their inception in 1972 have required "adequate" fish passage. Prior to 1994, this was interpreted to mean passage of adult fish upstream at "Class I" stream crossing. Thus, culverts installed between 1972 and 1994 to provide adult passage may not be providing juvenile passage. During this time, there was also no requirement that passage conditions be maintained following culvert installation. The current standard of protection adopted in 1994 under the forest practice rules for fish passage is to design, construct, and maintain stream crossing structures to allow migration of adult and juvenile fish upstream and downstream during conditions when fish movement normally occurs. Guidance describing structural designs to meet this standard has been developed.

Stream Crossing Structures OAR 629-625-320(2)

"Operators shall design and construct stream crossings (culverts, bridges and fords) to:

(a) Pass a peak flow that at least corresponds to the 50-year return interval. When determining the size of culvert needed to pass a peak flow corresponding to the 50-year return interval, operators shall select a size that is adequate to preclude ponding of water higher than the top of the culvert; and
(b) Allow migration of adult and juvenile fish upstream and downstream during conditions when fish movement in that stream normally occurs."

Road Maintenance OAR 629-625-600(8)

"In order to maintain fish passage through water crossing structures, operators shall:

(a) Maintain conditions at the structures so that passage of adult and juvenile fish is not impaired when fish movement normally occurs. This standard is required only for roads constructed or reconstructed after September 1994, but is encouraged for all other roads; and
(b) As reasonably practical, keep structures cleared of woody debris and deposits of sediment that would impair fish passage.

Other fish passage requirements under the authority of ORS 498.268 and 509.605 that are administered by other state agencies may be applicable to water crossing structures, including those constructed before September 1, 1994."

APPENDIX D: ODF/DEQ MOU

MEMORANDUM OF UNDERSTANDING BETWEEN THE OREGON STATE DEPARTMENT OF ENVIRONMENTAL QUALITY AND THE OREGON STATE DEPARTMENT OF FORESTRY

I. Introduction and Statement of Purpose

A. Introduction

1. The Environmental Quality Commission (EQC) and the Oregon Department of Environmental Quality (DEQ) are responsible for implementing the Federal Clean Water Act in Oregon, ORS 468B.035, including adoption of water quality standards. The DEQ has adopted and the U.S. Environmental Protection Agency (EPA) has approved Oregon's water quality standards and its 1994/1996 303(d) list. DEQ intends to update and resubmit its 303(d) list to EPA in 1998 and subsequent years as required by federal regulations. DEQ is setting priorities for TMDL preparation.

2. Subsection 303(d) of the Federal Clean Water Act (the Act), 33 U.S.C. §1313(d), requires states to identify waters for which effluent limitations or other pollution control requirements required by local, State, or Federal authority are not stringent enough to implement applicable water quality standards, 40 C.F.R. §130.7 (b). These water bodies are referred to as "water quality limited." For each water on the 303(d) list that is not removed from the list by findings of water quality impairment due to natural conditions or best management practice (BMP) effectiveness, the state must establish a total maximum daily load (TMDL) allocation at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality. A TMDL is the sum of the individual wasteload allocations for point sources and load allocations for non-point sources and natural background, 40 C.F.R. §130.2(i).

3. TMDLs must be incorporated into the continuing planning process required by Section 303(e) of the Act and the continuing planning process must be included in the state's water quality management plan. Sections 208 and 319 of the Act, 33 U.S.C. §1288 and §1329, require the state to prepare non-point source management plans.

4. ORS 527.765 requires the Oregon Board of Forestry (the Board), in consultation with the EQC, to establish Best Management Practices (BMPs) and other rules applying to forest practices to ensure that to the maximum extent practicable non-point source discharges of pollutants resulting from forest operations do not impair the achievement and maintenance of water quality standards established by the EQC. The Oregon Department of Forestry (ODF) is the Designated Management Agency (DMA) by DEQ for regulation of water

quality on nonfederal forestlands. Forest operators conducting operations in accordance with ODF BMPs are considered to be in compliance with Oregon's water quality standards.

5. The Board in consultation and with the participation and support of DEQ, has adopted water protection rules in the form of BMPs for forest operations, including, but not limited to, OAR Chapter 629, Divisions 635-660. These rules are implemented and enforced by ODF and monitored to assure their effectiveness. DEQ participates in the design and implementation of these monitoring efforts. The EQC, DEQ, the Board and ODF determined that pollution control measures required as BMPs under ORS 527.765 will be relied upon to result in achievement of state water quality standards.

6. The EQC, DEQ, the Board, and ODF are all committed to restoring salmon and meeting water quality through the Healthy Streams Partnership and Oregon Plan for Salmon and Watersheds, 1997 Oregon Laws, Ch. 7.

B. Purposes of MOU

The purposes of this memorandum of understanding:

1. To further define the respective roles and responsibilities of the EQC, the DEQ, the Board, and ODF in preventing, controlling and reducing non-point source discharges to achieve and maintain water quality standards;

2. To explain the process for determining whether (a) forest practices contribute to identified water quality problems in listed water quality limited streams; (b) if so, to determine whether existing forest practice rules provide sufficient control to assure that water quality standards will be met so that waters can be removed from the 303(d) list;

3. To describe the process for interagency coordination in revising forest practice rules, if necessary, to assure the achievement of water quality standards; and

4. To encourage the use of voluntary and incentive-based regulatory solutions to achieve and maintain water quality.

II. Forest Practice BMPs and Water Quality Standards

Since ODF is the DMA for water quality management on nonfederal forestlands and ODF's BMP's are designed to protect water quality, ODF and DEQ will jointly demonstrate how the Forest Practices Act (FPA), forest practice rules (including the rule amendment process), and BMP's are adequate protection pursuant to ORS 527.765. This demonstration of the ODF BMP program adequacy will be done at the statewide scale with due consideration to regional and local variation in effects including non-anthropogenic factors that can lead to water quality standard violations.

Water quality impairment related to aquatic weeds, bacteria, chlorophyll a, dissolved oxygen, flow modification, many nutrients, total dissolved gas, or toxins are generally not attributable to forest management practices as regulated by the EPA. However, it is generally accepted that forest management practices have in some cases caused documented changes in temperature, habitat modification, sedimentation, turbidity, and bio-criteria. Therefore, this statewide demonstration of FPA effectiveness in protection of water quality will address these specific parameters and will be conducted in the following order:

a. temperature (draft report target completion date Spring, 1999),
b. sedimentation and turbidity (draft report target completion date Summer, 1999),
c. aquatic habitat modification (draft report target completion date fall 1999),
e. bio-criteria (draft report target completion date end 1999), and
f. other parameters (draft report target completion date spring 2000).

The analyses will be presented in a format compatible with EPA region 10 guidance (pages 4-6, dated November 1995) regarding BMP effectiveness determinations, and will include:

a. "Data analysis of the effectiveness of controls relative to the problem": analyze relevant data and studies on the parameter and known control methods,
b. "Mechanisms requiring implementation of pollution controls": give a clear exposition of the rules/programs that are designed to provide for protection,
c. "Reasonable time frame for attaining water quality standards": discuss expected recovery times which may be long for some parameters because the ecological processes that bring recovery are long-term, and
d. "Monitoring to track implementation and effectiveness of controls": describe the scope and extent the effectiveness and implementation monitoring program and how they tie back to program changes for adaptive management.

In addition, these analyses will address attainment of state anti-degradation policy. These demonstrations will be reviewed by peers and other interested parties prior to final release. While analysis is being conducted and unless or until changes are made in accordance with ORS527.765, the EPA and implementing rules will constitute the water quality BMP program for forestlands. These sufficiency analyses will be designed to provide background information and techniques for watershed based assessments of BMP effectiveness and water quality assessments for watersheds with forest and mixed land uses.

III. ODF and DEQ coordination for listed waterbodies (i.e., 303(d) list)

A. Waterbody Specific Coordination

The following coordination will occur between ODF and DEQ regarding the TMDL process and water quality management plans:

1. For basins where agreement is reached that water quality impairment is not attributable to forest management practices (Figure 1), the forest practice rules will constitute the water quality compliance mechanism for forest management practices on nonfederal forestland. ODF will not participate in the development of the TMDL or water quality management plan except as requested to assist DEQ as ODF budgeted resources permit. If the basin associated with a listed waterbody is entirely or almost entirely on federal land or non-forestland ODF will have little or no involvement (Figure 1).

2. For basins where water quality impairment is attributed to the long-term legacy of historic forest management and/or other practices, but ODF and DEQ jointly agree that the forest practice BMP's are now adequately regulating forest management activities and not adding to further degradation of water quality, the forest practice rules will be designated in the water quality management plan as the mechanism to achieve water quality compliance for forest operations. ODF will participate with the other DMAs in developing the water quality management plan as necessary.

3. For basins where water quality impairment may be attributable to forest management practices and ODF and DEQ cannot agree that the current BMPs are adequately regulating forest management activities (Figure 1), the current forest practice rules will be designated in the water quality management plan as the mechanism to achieve water quality compliance for forest operations. However, ODF will design and implement a specific monitoring program as part of the basin plan to document the adequacy of the best management practices. The schedule and scope of the monitoring program will be jointly agreed to by DEQ and ODF. During the interim, while monitoring is being conducted, the current rules will constitute the water quality compliance mechanism. If the monitoring results indicate that changes in practices are needed in a basin, the DEQ and the Board will use OAR 629-635-120 to create watershed specific protection rules or use other existing authority to ensure that forest management activities do not impair water quality.

4. For basins where both ODF and DEQ agree that there are water quality impairments due to forest management activities even with FPA rules and BMP's, the DEQ and the BOF will use OAR 629-635-120 to create watershed specific protection rules or use other existing authority to ensure that forest management activities do not impair water quality.

In deciding between conditions (a)-(d) above, the statewide rule sufficiency analysis (described in II) will be critical in determining which situation exists. If the practices and impairments are found by DEQ and ODF to be regional or statewide in nature the BOF will create or modify statewide or regional rules or design other effective measures to address the impairment.

B. Removal or Reclassification of Waterbodies

DEQ will propose removal of waterbodies (Figure 1) on the 303(d) list when:

1. additional data indicates that the waterbody is not in violation,

2. water quality parameters are found to be in violation for reasons other than human activities,

3. TMDL's, or water quality management plans or their equivalents, have been established in compliance with the Clean Water Act §303, or

4. the FPA, forest practice rules and BMP's are found to be adequate for a given water quality parameter in a given basin via the statewide demonstration or watershed based demonstration (see section n above) and all land affecting the listed waterbody is deemed forestland that is regulated under the FPA. Forest basins that have water quality impairment due to legacy conditions that will not be corrected by the current BMPs alone, remain listed with their present status until voluntary or incentive based actions are implemented that are intended to restore watershed conditions such that water quality standards can be met.

IV. Voluntary and Incentive-Based Approaches

DEQ and ODF will work jointly with landowners and watershed councils, as resources permit, to use innovative approaches to resolving water quality problems. DEQ and ODF will use other pollution control requirements when appropriate to restore watershed conditions such that water quality standards can be met in waterbodies listed under Section 303(d) of the Clean Water Act. These pollution programs include but are not limited to the following:

1. Oregon Laws 1997, ch. 553, The Green Permits Act,;

2. Oregon Laws 1995, ch. 413, The Forest Stewardship Act,;

3. Oregon Laws 1997, ch. 7, Healthy Streams Partnership and the Oregon Plan for Salmon and Watersheds;

4. DEQ's Environmental Management Systems Incentives Project;

5. Habitat Conservation Plans adopted and approved under the Endangered Species Act;

6. Project XL agreements with the EPA; and

7. Pollution Prevention Partnership agreements with the EPA Some of these alternative approaches will become critical and complementary to the forest practices program when attempting to restore water quality in streams with significant legacy conditions caused by past actions such as channel simplification from splash damming and stream cleaning.

V. Other key coordination points for DEQ and ODF

There are two other issues that will require special coordination between DEQ and ODF. These coordination issues regard:

1. Outstanding Resource Water designations and management measures, and
2. Coordination between the two agencies when there is a land use conversion.

Both agencies agree to open discussion on how to coordinate on these issues but they are separate issues that are not covered by this particular MOU.

VI. Signatures

Signed:____________________________
James E. Brown, State Forester
Oregon Department of Forestry

Signed:____________________________
Langdon Marsh, Director
Oregon Department of
Environmental Quality

Date:______________________________

Date:______________________________

APPENDIX E: WATER QUALITY STANDARDS SUMMARY, ANTIDEGRADATION AND HIGH QUALITY WATERS POLICY, 303(D) LIST, AND TMDLS.

This appendix provides a general discussion of water quality standards, anti-degradation and high quality water policy, 303(d) water quality limited streams, total maximum daily loads (TMDL), and a more specific descriptions of water quality standards for parameters being evaluated in this Sufficiency Analysis. These include temperature, sedimentation/turbidity, habitat modification, and biological criteria.

Water Quality Standards Summary

Water quality standards are benchmarks established to assess whether the quality of Oregon's streams, rivers, and lakes is adequate for fish and other aquatic life, recreation, drinking, agriculture, industry and other beneficial uses. Water quality standards are also regulatory tools used by the State Department of Environmental Quality (DEQ) and the federal Environmental Protection Agency (EPA), to prevent pollution of our waters. Oregon is delegated the responsibility to implement the federal Clean Water Act. This requires that Oregon adopt water quality standards and submit them to EPA for approval.

Water quality standards are comprised of two elements. The first element is the identification of existing or potential beneficial uses. The second element identifies specific benchmarks that describe the level of water quality needed to achieve those uses. When a waterbody supports several uses, such as industrial water supply, recreation, salmonid fish rearing, and livestock watering, federal law requires the DEQ to protect the most sensitive of those uses.

Narrative guidelines describe what Oregon waters will be "free from," like oil and scum or color and odor. Numeric criteria assign numbers that represent limits and/or ranges of chemical concentrations, like pH or dissolved oxygen, or physical conditions like water temperature.

Antidegradation and High Quality Waters Policy

340-04l-0026
Policy and Guidelines Generally Applicable to All Basins

(1) In order to maintain the quality of waters in the State of Oregon, the following is the general policy of the EQC:

(a) Antidegradation Policy for Surface Waters. The purpose of the Antidegradation Policy is to guide decisions that affect water quality such that unnecessary degradation from point and nonpoint sources of pollution is prevented, and to protect, maintain, and enhance existing surface water quality to protect all existing beneficial uses. The standards and policies set forth in OAR 340-041-0120 through 340-041-0962 are intended to implement the Antidegradation Policy;

(A) High Quality Waters Policy: Where existing water quality meets or exceeds those levels necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water, and other designated beneficial uses, that level of water quality shall be maintained and protected. The Environmental Quality Commission, after full satisfaction of the intergovernmental coordination and public participation provisions of the continuing planning process, and with full consideration of sections (2), (3) and (5) of this rule, however, may allow a lowering of water quality in these high quality waters if they find:

(i) No other reasonable alternatives exist except to lower water quality; and

(ii) The action is necessary and justifiable for economic or social development benefits and outweighs the environmental costs of lowered water quality; and

(iii) All water quality standards will be met and beneficial uses protected.

The "Antidegradation Policy" is designed to help protect beneficial uses in the state's 19 watershed basins with regard to all of the water quality standards discussed below, and is also applicable to 'high quality waters'.

303(d) Listing Information

Section 303(d) of the 1972 Federal Clean Water Act (CWA) in Section 303(d) requires each state to identify those waters for which existing required pollution controls are not adequate to achieve that state's water quality standards.

The state must establish criteria and compare all existing and readily available water quality data against that criteria in order to prepare the list of water quality limited water bodies. At a minimum, the following sources of information should be considered: waters identified as partially or not meeting water quality standards in the 305(b) report; waters for which dilution calculations or predictive models indicate nonattainment of standards; waters for which problems have been reported by other agencies, institutions and the public; and waters identified as impaired or threatened in the state's nonpoint assessments submitted to EPA under Section 319 of the CWA.

The quality of Oregon's streams, lakes, estuaries and groundwater is monitored by the Oregon Department of Environmental Quality (DEQ). This information, in part, is used to determine whether water quality standards are being violated and, consequently, whether the beneficial uses of the waters are impaired.

Listings can be based on: evidence of a numeric standard exceedence; evidence of a narrative standard exceedence; evidence of a beneficial use impairment; or a declining trend in water quality such that it would exceed a standard prior to the next listing period. 303(d) listing criterion are found in Appendix F. Current information on the 303(d) list can be found on the web at http://www.deq.state.or.us/wq/303dlist/303dpage.htm.

Total Maximum Daily Load (TMDL)

Under requirements of the Clean Water Act, the DEQ establishes basin or subbasin TMDLs for 303(d) listed waterbodies. DEQ coordinates with ODF, the DMA for state and private forestlands, in achieving water quality standards.

With a few exceptions, such as in cases where violations are due to natural causes, the state must establish a TMDL for any waterbody designated as water quality limited. A TMDL is the total amount of a pollutant (from all sources) that can enter a specific waterbody without violating the water quality standards.

The loading capacity is the total permissible pollutant load is allocated to point, non-point, background, and future sources of pollution. Wasteload Allocations are portions of the total load that are allotted to point sources of pollution, such as sewage treatment plants or industries. The Wasteload Allocations are used to establish effluent limits in discharge permits. Load Allocations are portions of the loading capacity that are attributed to either natural background sources or from non-point sources, such as urban, agriculture or forestry activities. Allocations can also be reserved for future uses. Simply stated, allocations are quantified measures that assure water quality standard compliance while distributing the allowable pollutant loads between nonpoint and point sources. The TMDL is the integration of all these developed Wasteload and Load Allocations.

The U. S. Environmental Protection Agency (EPA) has the authority under the Clean Water Act to approve or disapprove TMDLs that states submit. When a TMDL is officially submitted by a state to EPA, EPA has 30 days to take action on the TMDL. In the case where EPA disapproves a TMDL, EPA would need to establish the TMDL within 30 days.

The required elements of a TMDL that must be submitted to EPA include:

1. A description of the geographic area to which the TMDL applies;
2. Specification of the applicable water quality standards;
3. An assessment of the problem, including the extent of deviation of ambient conditions from water quality standards;
4. Evaluation of seasonal variations
5. Identification of point sources and non-point sources;
6. Development of a loading capacity including those based on surrogate measures and including flow assumptions used in developing the TMDL;
7. Development of Waste Load Allocations for point sources and Load Allocations for non-point sources;
8. Development of a margin of safety.

The DEQ takes a comprehensive watershed approach for developing TMDLs. This takes into account pollution from all sources, including point source industrial and municipal discharges, as well as non-point source discharges from farms, forests, and urban areas.

Water Quality Standards/Criterion

Temperature

Oregon's water temperature standards include specific numeric criteria, as well as the narrative water quality standard. The numeric criteria are "seven-day moving averages" of daily maximum temperature based on general and special habitat considerations, along with development requirements of the most sensitive species (salmonids). The narrative standard of 'no measurable temperature increase' is triggered by any one of the numeric criteria, depending on water quality and/or aquatic habitat conditions (see below).

Table 1. State water quality temperature numeric criteria.

	Bull Trout Habitat Criteria	Cold Water Spawning, Egg Incubation, and Fry Emergence Habitat Criteria	Standard Criteria	Willamette & Columbia Rivers Criteria
°F	50	55	64	68*
°C	10.0	12.8	17.8	20.0

* With the exception of the 68° C temperature standard for the Willamette River, EPA has reviewed and approved these standards as of July 1999.

For an extensive analysis of the water temperature standard as it relates to aquatic life refer to the *1992-1994 Water Quality Standards Review Final Issue Papers* (ODEQ, 1995).

<u>Narrative standard</u>: No measurable surface water temperature increases resulting from anthropogenic activities are allowed under specified water quality conditions or at specified locations as described in the following rule [A measurable temperature increase means an increase in stream temperature of more than 0.25°F [OAR 340-041-0006(55)]]:

> OAR 340-041-(Basin)-
> Water Quality Standards Not to be Exceeded (To be Adopted Pursuant to ORS 468.735 and Enforceable Pursuant to ORS 468.720, 468.990, and 468.992)
>
> (2)(b) Temperature: The changes adopted by the Commission on January 11, 1996, become effective July 1, 1996. Until that time, the requirements of this rule that were in effect on January 10, 1996, apply. The method for measuring the numeric temperature criteria specified in this rule is defined in OAR 340-041-0006(54):
>
> To accomplish the goals identified in OAR 340-041-0120(11), unless specifically allowed under a department-approved surface water temperature management plan as required under OAR 340-041-0026(3)(a)(D), no measurable surface water temperature increase resulting from anthropogenic activities is allowed:
>
> (i) In a basin for which salmonid fish rearing is a designated beneficial use, and in which surface water temperatures exceed 64.0°F (17.8°C);
> (ii) In the Columbia River or its associated sloughs and channels from the mouth to river mile 309 when surface water temperatures exceed 68.0°F (20.0°C);
> (iii) In waters and periods of the year determined by the department to support native salmonid spawning, egg incubation, and fry emergence from the egg and from the gravels in a basin which exceeds 55.0°F (12.8°C);
> (iv) In waters determined by the department to support or to be necessary to maintain the viability of native Oregon bull trout, when surface water temperatures exceed 50.0°F (10.0°C);

(v) In waters determined by the department to be ecologically significant cold-water refugia;
(vi) In stream segments containing federally listed Threatened and Endangered species if the increase would impair the biological integrity of the Threatened and Endangered population;
(vii) In Oregon waters when the dissolved oxygen (DO) levels are within 0.5 mg/l or 10 percent saturation of the water column or intergravel DO criterion for a given stream reach or subbasin;
(viii) In natural lakes.

The corresponding rule OAR 629-635-0100 (7) describes in general terms the achievement and maintenance of water quality standards with respect to forestry operations:

> OAR 629-635-0100 (7) The overall goal of the water protection rules is to provide resource protection during operations adjacent to and within streams, lakes, wetlands and riparian management areas so that, while continuing to grow and harvest trees, the protection goals for fish, wildlife, and water quality are met.
>
> (a) The protection goal for water quality (as prescribed in ORS 527.765) is to ensure through the described forest practices that, to the maximum extent practicable, non-point source discharges of pollutants resulting from forest operations do not impair the achievement and maintenance of the water quality standards.
>
> (b) The protection goal for fish is to establish and retain vegetation consistent with the vegetation retention objectives described in OAR 629-640-0000 (streams), OAR 629-645-0000 (significant wetlands), and OAR 629-650-0000 (lakes) that will maintain water quality and provide aquatic habitat components and functions such as shade, large woody debris, and nutrients.

Exceptions to applying the narrative temperature standard [OAR 340-041-(Basin)(2)(A)] may occur under different scenarios. One scenario: if the department approves a surface water temperature management plan as required under OAR 340-041-0026(3)(a)(D):

> OAR 340-041-0026(3)(a)(D) Effective July 1, 1996, in any waterbody identified by the Department as exceeding the relevant numeric temperature criteria specified for each individual water quality management basin identified in OAR 340-041-0205, OAR-340-041-0245, OAR-340-041-0285, OAR-340-041-0325, OAR-340-041-0365, OAR-340-041-0445, OAR-340-041-0485, OAR-340-041-0525, OAR-340-041-0565, OAR-340-041-0605, OAR-340-041-0645, OAR-340-041-0685, OAR-340-041-0725, OAR-340-041-0765, OAR-340-041-0805, OAR-340-041-0845, OAR-340-041-0885, OAR-340-041-0925, OAR-340-041-0965, and designated as water quality limited under Section 303(d) of the Clean Water Act, the following requirements shall apply to appropriate watersheds or stream segments in accordance with priorities established by the Department. The Department may determine that a plan is not necessary for a particular stream segment or segments within a water-quality limited basin based on the contribution of the segment(s) to the temperature problem:
>
> (i)Anthropogenic sources are required to develop and implement a surface water temperature management plan which describes the best management practices, measures,

and/or control technologies which will be used to reverse the warming trend of the basin, watershed, or stream segment identified as water quality limited for temperature;

(iii) Sources shall continue to maintain and improve, if necessary, the surface water temperature management plan in order to maintain the cooling trend until the numeric criterion is achieved or until the Department, in consultation with the Designated Management Agencies (DMAs), has determined that all feasible steps have been taken to meet the criterion and that the designated beneficial uses are not being adversely impacted. In this latter situation, the temperature achieved after all feasible steps have been taken will be the temperature criterion for the surface waters covered by the applicable management plan. The determination that all feasible steps have been taken will be based on, but not limited to, a site-specific balance of the following criteria: protection of beneficial uses; appropriateness to local conditions; use of best treatment technologies or management practices or measures; and cost of compliance;

(iii) Once the numeric criterion is achieved or the Department has determined that all feasible steps have been taken, sources shall continue to implement the practices or measures described in the surface water temperature management plan in order to continually achieve the temperature criterion;
(iv) For point sources, the surface water temperature management plan will be part of their National Pollutant Discharge Elimination System Permit (NPDES);

(v) For nonpoint sources, the surface water temperature management plan will be developed by designated management agencies (DMAs) which will identify the appropriate BMPs or measures;

(vi) A source (including but not limited to permitted point sources, individual landowners and land managers) in compliance with the Department or DMA (as appropriate) approved surface water temperature management plan shall not be deemed to be causing or contributing to a violation of the numeric criterion if the surface water temperature exceeds the criterion;

(vii) In waters the Department determines to be critical for bull trout recovery, the goal of a bull trout surface water temperature management plan is to specifically protect those habitat ranges necessary to maintain the viability of existing stocks by restoring stream and riparian conditions or allowing them to revert to conditions attaining the coolest surface water temperatures possible under natural background conditions;

The process for developing watershed specific practices for water quality limited watersheds under the Forest Practices Act, which could serve as a surface water temperature management plan, is described in OAR 629-635-0120.

629-635-0120 Watershed Specific Practices for Water Quality Limited Watersheds and Threatened or Endangered Aquatic Species

(1) The objective of this rule is to describe a process for determining whether additional watershed specific protection rules are needed for watersheds that have been designated as water quality limited or for watersheds containing threatened or endangered aquatic species.

(2) The Board of Forestry shall appoint an interdisciplinary task force, including representatives of forest landowners within the watershed and appropriate state agencies, to evaluate a watershed, if the board has determined based on evidence presented to it that forest practices in a watershed are measurably limiting to water quality achievement or species maintenance, and either:

(a) The watershed is designated by the Environmental Quality Commission as water quality limited; or

(b) The watershed contains threatened or endangered aquatic species identified on lists that are adopted by rule by the State Fish and Wildlife Commission, or are federally listed under the Endangered Species Act of 1973 as amended.

(3) The board shall direct the task force to analyze conditions within the watershed and recommend watershed-specific practices to ensure water quality achievement or species maintenance.

(4) The board shall consider the report of the task force and take appropriate action.

(5) Nothing in this rule shall be interpreted to limit the Board's ability to study and address concerns for other species on a watershed basis.

Stat. Auth.: ORS 527.710 & ORS 527.765

Stats. Implemented: ORS 527.710

Hist.: FB 3-1994, f. 6-15-94, cert. ef. 9-1-94, Renumbered from 629-057-2020

Another scenario for obtaining an exception to applying the narrative temperature standard is stated in OAR 340-041-(Basin)- (2)(b) (C):

> OAR 340-041-(Basin)-(2)(b) (C) Any source may petition the Commission for an exception to subparagraphs (A)(i) through (vii) of this subsection for discharge above the identified criteria if:
>
> (i)The source provides the necessary scientific information to describe how the designated beneficial uses would not be adversely impacted; or
>
> (ii) A source is implementing all reasonable management practices or measures; its activity will not significantly affect the beneficial uses; and the environmental cost of

treating the parameter to the level necessary to assure full protection would outweigh the risk to the resource.

Sedimentation, Turbidity, Habitat Modification, and Biological Criteria

A brief summary of information regarding these standards is provided below. Appendix F lays out more detailed descriptions of these parameters (including temperature) with respect to 303(d) listing criteria.

Sedimentation Standard:

The sedimentation standard can be applied to forestry operations with respect to on-site monitoring of BMPs used in vegetation removal, road construction and use, skid trails, and removal/fill activities (such as culvert replacement):

> OAR 340-41-(basin)(2) (applicable to all basins) No wastes shall be discharged and no activities shall be conducted which either alone or in combination with other wastes or activities will cause violation of the following standards in the waters of the (applicable) Basin:
>
> (j) The formation of appreciable bottom or sludge deposits or the formation of any organic or inorganic deposits deleterious to fish or other aquatic life or injurious to public health, recreation, or industry shall not be allowed;

The sedimentation standard, which is narrative, does not assign a threshold level for anthropogenic activities. In basins where sedimentation or turbidity listings occur, loads are in mg/L of total suspended solids (TSS). Loads have been calculated using best professional judgement based on levels of Nephelometric Turbidity Units (NTUs) (which correlate with basin suspended sediment loads) determined to be protective of aquatic species and not detrimental to residential biological communities.

Turbidity

The turbidity standard can be applied to forestry operations with respect to on-site monitoring of BMPs used in vegetation removal, road construction and use, skid trails, and removal/fill activities (such as culvert replacement):

> OAR 340-41-(basin)(2) (applicable to all basins) No wastes shall be discharged and no activities shall be conducted which either alone or in combination with other wastes or activities will cause violation of the following standards in the waters of the (applicable) Basin:
>
> (c) Turbidity (Nephelometric Turbidity Units, NTU): No more than a ten percent cumulative increase in natural stream turbidities shall be allowed, as measured relative to a control point immediately upstream of the turbidity causing activity. However, limited

duration activities necessary to address an emergency or to accommodate essential dredging, construction or other legitimate activities and which cause the standard to be exceeded may be authorized provided all practicable turbidity control techniques have been applied and one of the following has been granted:

(A) Emergency activities: Approval coordinated by DEQ with the Department of Fish and Wildlife under conditions they may prescribe to accommodate response to emergencies or to protect public health and welfare;

(B) Dredging, Construction or other Legitimate Activities: Permit or certification authorized under terms of Section 401 or 404 (Permits and Licenses, Federal Water Pollution Control Act) or OAR 14l-085-0100 et seq. (Removal and Fill Permits, Division of State Lands), with limitations and conditions governing the activity set forth in the permit or certificate.

To better understand compliance with the turbidity standard, the Department of Environmental Quality includes the following language for projects reviewed through its 401 certification program:

Turbidity/Erosion Control—The authorized work shall not cause turbidity of affected waters to exceed 10 percent over natural background turbidity 100 feet downstream from the fill point. For projects proposed in areas with no discernible gradient break (a gradient less than 2 percent), monitoring shall take place at 4 hour intervals and the turbidity standard may be exceeded for a maximum of one monitoring interval per 24 hour work period provided all practicable control measures have been implemented. This standard applies only to coastal lowlands and floodplains, valley bottoms and other low-lying and/or relatively flat land. For projects in hilly or mountainous areas, the turbidity standard can only be exceeded for a maximum of 2 hours (limited duration) provided all practicable erosion control measures have been implemented. These projects may also be subject to additional reporting requirements.

Turbidity shall be monitored during active in-water work periods. Monitoring points shall be 100 feet upstream from the fill point at an undisturbed site (background), 100 feet downstream, from the fill point and at the point of fill. A turbidimeter is recommended, however, visual gauging is acceptable. Turbidity that is visible over background is considered an exceedence of the standard.

All practicable erosion control measures shall be implemented, as appropriate, including but not limited to the following:

a. Prevent all construction debris from entering waterway;
b. Use filter bags, sediment fences, sediment traps or catch basins, silt curtains, leave strips or berms, or other measures sufficient to prevent movement of soil;
c. Use impervious materials to cover stockpiles when unattended or during rain event;
d. Erosion control measures shall be inspected and maintained periodically to ensure their continued effectiveness;

e. Limit the number and size of entry points or access roads into the work area to the minimum number necessary to accomplish project goals.
f. All access points and staging areas shall have a gravel cover underlain with geotextile.
g. Protect planted areas from disturbance and/or erosion; and
h. Flag or fence off wetlands, riparian areas, and other environmentally sensitive areas adjacent to the construction area.
i. Place fill in the water using methods that avoid disturbance to the maximum practicable extent (e.g. place fill with a machine rather than end-dumping from a truck).

Turbidity shall be measured (or visually assessed) and recorded at the designated monitoring interval prescribed above during periods of active construction. The designated person attending the monitoring equipment shall be responsible for notifying the project foreman of any exceedence of the turbidity standard. If a 10 percent exceedence of the background level occurs at 100 feet below the project site, modify the activity causing the problem and continue to monitor at the proper interval. If exceedences occur with two consecutive measurements stop the activity causing the turbidity until the problem is resolved.

Habitat Modification and Biological Criteria

Habitat Modification Standard:

OAR 340-41-(basin)(2) (applicable to all basins): The creation of tastes or odors or toxic or other conditions that are deleterious to fish or other aquatic life or affect the potability of drinking water or the palatability of fish or shellfish shall not be allowed.

-or-

OAR 340-41-027 (applicable to all basins): Waters of the state shall be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.

Biological Criteria Standard

OAR 340-41-027 (Standards applicable to all basins) Waters of the state shall be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.

"*Aquatic species*" means any plants or animals which live at least part of their life cycle in waters of the State.
"*Biological Criteria*": means numerical values or narrative expressions that describe the biological integrity of aquatic communities inhabiting waters of a given designated aquatic life use.

"*Resident Biological Community*" means aquatic life expected to exist in a particular habitat where water quality standards for a specific ecoregion, basin, or water body are met. This shall be established by accepted biomonitoring techniques.
"*Without Detrimental Changes in the Resident Biological Community*" means no loss of ecological integrity when compared to natural conditions at an appropriate reference site or region.
"*Ecological Integrity*" means the summation of chemical, physical and biological integrity capable of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region.
"*Appropriate Reference Site or Region*" means a site on the same water body, or within the same basin or ecoregion that has similar habitat conditions, and represents the water quality and biological community attainable within the areas of concern.

Both the *habitat modification* and *biological criteria* standards can be applicable to forestry activities at the reach or watershed level. TMDLs are not currently being developed for the habitat modification or biological criteria since these parameters are not considered by EPA to be discrete 'pollutants'; but are rather categorized as 'pollution'.

Habitat modification and biological criteria are important parameters for consideration for this evaluation because they focus directly on the presence of aquatic life, a 'beneficial use' of state waterways. Habitat modification 303(d) listings sometimes utilize watershed analyses that also take into account the biological criteria (or some indexing measurement of the biotic condition), as well as benchmark comparisons to the channel morphology or in-stream habitat conditions represented by such elements as large wood, pool frequency, or channel width to depth ratios. Since the recruitment and cycling of large wood through the watershed system plays an important role in the shaping and contouring of channels, not to mention the materials it provides for habitat complexity, this parameter is applicable to the evaluation of the FPA BMPs that retain or provide for the placement of large wood in streams.

APPENDIX F: SELECTED WATER QUALITY STANDARDS AND CRITERIA

The following descriptions of Oregon water quality standards reflect these standards as of the date this evaluation was completed, and are currently in draft form undergoing public review (until November 1, 2002). The Oregon Department of Environmental Quality is actively working on modifications to several of these standards. Therefore, the reader is advised to determine the currently effective standards by reviewing Oregon Administrative Rules (OAR) Chapter 340 Division 41. For a more complete listing of other water quality standards and criteria, go to http://www.deq.state.or.us/wq/303dlist/303dAssessmentMethod.pdf.

PARAMETER: **Temperature**

BENEFICIAL USES AFFECTED: Resident Fish & Aquatic Life, Salmonid Fish Spawning & Rearing

NARRATIVE CRITERIA: OAR 340-41-(basin)(2)(b)

Standards applicable to all basins (adopted 1/11/96, effective 7/1/96):

No measurable surface water increase from anthropogenic activities is allowed when surface water temperatures exceed:

- **64°F (17.8°C)** in basins for which salmonid rearing is a beneficial use;
- **55°F (12.8°C)** during times and in waters that support salmon spawning, egg incubation and fry emergence from the egg and from the gravels;
- **50°F (10°C)** in waters that support Oregon Bull Trout;
- **68°F (20°C)** in the Columbia River (mouth to river mile 309);
- **68°F (20°C)** in the Willamette River (mouth to river mile 50);

  [except when the air temperature during the warmest seven-day period of the year exceeds the 90th percentile of the 7-day average daily maximum air temperature calculated in a yearly series over the historic record]

The numeric criteria are measured as the seven (7) day moving average of the daily maximum temperatures. If there is insufficient data to establish a seven – day moving average of the daily maximum temperatures, the numeric criteria shall be applied as an instantaneous maximum (OAR 340-41-0006(54)).

The Department used the 1997 Bull Trout distribution maps contained in "Status of Oregon's Bull Trout", (Oregon Department of Fish and Wildlife, October 1997, Buchanan, David, M. Hanson and R. Hooton, Portland, OR) to determine where to apply the bull trout criterion. The criterion applies to the stream reaches which indicate the "Spawning, Rearing, or Resident Adult Bull Trout" populations are present. A solid green line shows these waters on the maps that are referenced (ODEQ memo to EPA, June 22, 1998).

Figure 8 describes the temperature data evaluation process.

WATER QUALITY LIMITED DETERMINATION (EPA CATEGORY 5): Moving seven (7) day average of the daily maximum exceeds the appropriate criterion listed above. Where grab data (non-continuous data) were collected, more than 25 percent (and a minimum of at least two exceedences) of the samples exceed the appropriate criterion based on multi-year monitoring programs that collect representative samples on separate days for the season of concern.

ATTAINING CRITERION (EPA CATEGORY 2): Where continuous data were collected the moving seven (7) day average of the daily maximum attains the appropriate criterion listed above. In locations where grab data were collected, a minimum of five samples must be available. Greater than 90% of the samples must meet the appropriate criterion.

INSUFFICIENT DATA (EPA CATEGORY 3): Where grab data were collected, less than 5 samples are available for the time period of interest. Where continuous data were collected, insufficient data was available to calculate the seven-day average of the daily maximums.

TIME PERIOD:
See Table 4.

DATA REQUIREMENTS:
Data collected since October 1990.

EXAMPLES OF DATA USED FOR 2002 "INTEGRATED REPORT":
Continuous temperature monitoring data collected by:

- Oregon Department of Environmental Quality
- U.S. Forest Service
- Bureau of Land Management

Grab temperature data collected by:

- Watershed councils

PARAMETER: **Sedimentation**

BENEFICIAL USES AFFECTED: Resident Fish & Aquatic Life, Salmonid Fish Spawning & Rearing

NUMERIC CRITERIA: None

NARRATIVE CRITERIA: OAR 340-41-(basin)(2)(j)

Standards applicable to all basins:

The formation of appreciable bottom or sludge deposits or the formation of any organic or inorganic deposits deleterious to fish or other aquatic life or injurious to public health, recreation, or industry shall not be allowed.

WATER QUALITY LIMITED DETERMINATION (EPA CATEGORY 5):
Documentation that sedimentation is a significant limitation to fish or other aquatic life as indicated by the following information:

> Beneficial uses are impaired. This documentation can consist of data on aquatic community status that shows aquatic communities (primarily macroinvertebrates) which are 60% or less of the expected reference community **for both** multimetric scores and multivariate model scores.
>
> or-
>
> Where monitoring methods determined a Biotic Condition Index, Index of Biotic Integrity, or similar metric rating of poor or a significant departure from reference conditions utilizing a suggested EPA biomonitoring protocol or other technique acceptable to DEQ.
>
> -or-
>
> Fishery data on escapement, redd counts, population survey, etc. that show fish species have declined due to water quality conditions; and documentation through a watershed analysis or other published report which summarizes the data and utilizes standard protocols, criteria and benchmarks (e.g. those currently used and accepted by Oregon Fish and Wildlife or Federal agencies (PACFISH)). Measurements of cobble embeddedness or percent fines are considered under sedimentation. Documentation should indicate that there are conditions that are deleterious to fish or other aquatic life.

ATTAINING CRITERION (EPA CATEGORY 2): Streams with aquatic communities greater than 75% of expected reference communities using either multimetric or multivariate models are considered unimpaired.

TIME PERIOD:
Annual

DATA REQUIREMENTS:
Data collected since October 1990 and included in the most recent watershed analysis or published report.

EXAMPLES OF DATA USED FOR 2002 "INTEGRATED REPORT":
U.S. Forest Service

PARAMETER: **Turbidity**

BENEFICIAL USES AFFECTED: Resident Fish and Aquatic Life, Water Supply,

Aesthetics

NARRATIVE CRITERION: OAR 340-41-(basin)(2)(c)

Standards applicable to all basins:

No more than ten percent cumulative increase in natural stream turbidities shall be allowed, as measured relative to a control point immediately upstream of the turbidity causing activities.

WATER QUALITY LIMITED CRITERIA: A systematic or persistent increase (of greater than 10%) in turbidity due to an operational activity that occurs on a persistent basis (e.g. dam release or irrigation return, etc).

TIME PERIOD:
Annual

DATA REQUIREMENTS:
Data collected since October 1990 on a frequent enough basis (e.g. daily) to establish a relationship between water quality and a turbidity causing activity.

EXAMPLES OF DATA USED FOR 2002 "INTEGRATED REPORT":
No new data was submitted for evaluation in 2002.

PARAMETER: **Habitat Modification**

BENEFICIAL USES AFFECTED: Resident Fish and Aquatic Life, Salmonid Fish Spawning, Salmonid Fish Rearing

NUMERIC CRITERION: None

NARRATIVE CRITERION: OAR 340-41-(basin)(2)(i)

Standards applicable to all basins:

The creation of tastes or odors or toxic or other **conditions that are deleterious to fish or other aquatic life** or affect the potability of drinking water or the palatability of fish or shellfish shall not be allowed.

-or-

OAR 340-41-027

Standards applicable to all basins:

Waters of the state shall be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.

WATER QUALITY LIMITED DETERMINATION (but does not require the development of a TMDL because the impairment is not caused by a pollutant) **(EPA CATEGORY 4c):**

Documentation that habitat conditions are a significant limitation to fish or other aquatic life as indicated by the following information:

> Beneficial uses are impaired. This documentation can consist of data on aquatic community status that shows aquatic communities (primarily macroinvertebrates) which are 60% or less of the expected reference community **for both** multimetric scores and multivariate model scores.
>
> -or-
>
> Where monitoring methods determined a Biotic Condition Index, Index of Biotic Integrity, or similar metric rating of poor or a significant departure from reference conditions utilizing a suggested EPA biomonitoring protocol or other technique acceptable to DEQ.
>
> -or-
>
> Fishery data on escapement, redd counts, population survey, etc. that show fish species have declined due to water quality conditions; and
>
> Habitat conditions that are a significant limitation to fish or other aquatic life as documented through a watershed analysis or other published report which summarizes the data and utilizes standard protocols, criteria and benchmarks (e.g. those currently used and accepted by Oregon Fish and Wildlife or Federal agencies (PACFISH)). Habitat conditions considered here are represented by data that relate to channel morphology or in-stream habitat such as Large Woody Material, Pool Frequency, Channel Width: Depth Ratio (other habitat factors are considered elsewhere - cobble embeddedness or percent fines would be considered under sedimentation, stream shading would be factored in under temperature, etc).

ATTAINING CRITERION (EPA CATEGORY 2): Streams with aquatic communities greater than 75% of expected reference communities using either multimetric or multivariate models are considered unimpaired.

TIME PERIOD:
Annual

DATA REQUIREMENTS:
Data collected since October 1990 and included in the most recent watershed analysis or published report. Earlier data will be considered on a case by case basis.

EXAMPLES OF DATA USED FOR 2002 "INTEGRATED REPORT":
No new data was submitted for evaluation in 2002. All water bodies that were on previous 303(d) lists under this category are now in the "water quality limited but not by a pollutant – a TMDL is not required" category.

NARRATIVE BIOLOGICAL CRITERION:
The narrative biological criterion is described in OAR 340-41-027:

> Standards applicable to all basins:
> Waters of the state shall be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.

In previous 303(d) lists, ODEQ evaluated biological data using multimetric scores and multivariate models. A water body was determined to be water quality limited by the following evaluation (ODEQ 1998 303(d) Listing Criteria):

> Aquatic communities (primarily macroinvertebrates) which are 60% or less of the expected reference community **for both** multimetric scores and multivariate model scores are considered impaired.

ODEQ is in the process of developing numeric biological criteria and is currently reanalyzing its data against the draft numeric criteria (Rick Hafele, ODEQ, personal communication, February, 2002). The numeric criteria will be different than the values used in previous 303(d) lists. Water bodies placed on the 1998 303(d) list based on interpretation of the narrative biological criterion will be maintained on the 2002 303(d) list unless a TMDL addressing the listing has been approved by EPA. Biological data collected during the 2002 303(d) list cycle will be evaluated during the next list cycle.

ODEQ will report the results of the biological monitoring in a format consistent with the EPA 2002 Guidance memo. Under the guidance, EPA recommends reporting the percentage of the target population that attains the criteria and the percentage that does not attain the criteria. The results will be accompanied by the precision of the estimates in the form of confidence intervals.

APPENDIX G: SELECTED STATUTES AND ADMINISTRATIVE RULES

The Water Protection Rules identify seven geographic regions and distinguishes among streams, lakes, and wetlands. The rules further distinguish each by size and type. Stream size is distinguished as small, medium, or large, based on average annual flow. Stream type is distinguished as fish use, domestic use, or neither (Table D-1).

Table 1. Riparian Management Area widths for streams of various sizes and beneficial uses (OAR 629-635-310).

	Type F	Type D	Type N
LARGE	100 feet	70 feet	70 feet
MEDIUM	70 feet	50 feet	50 feet
SMALL	50 feet	20 feet	Apply specified water quality protection measures, and see OAR 629-640-200

Generally, no tree harvesting is allowed within 20 feet of all fish bearing, all domestic-use, and all other medium and large streams unless stand restoration is needed. In addition, all snags and downed wood must be retained in every riparian management area. Provisions governing vegetation retention are designed to encourage conifer restoration on riparian forestland that is not currently in the desired conifer condition. Future supplies of conifer on these sites are deemed desirable to support stream functions and to provide fish and wildlife habitat. The rules provide incentives for landowners to place large wood in streams to immediately enhance fish habitat. Other alternatives are provided to address site-specific conditions and large-scale catastrophic events.

The goal for managing riparian forests along fish-use streams is to grow and retain vegetation so that, over time, average conditions across the riparian landscape become similar to those of mature unmanaged riparian stands. This goal is based on the following considerations (Lorensen et al., 1994):

(1) Mature riparian stands can supply large, persistent woody debris necessary to maintain adequate fish habitat. A shortage of large wood currently exists in streams on non-federal forestlands due to historic practices and a wide distribution of young, second growth forests. For most streams, mature riparian stands are able to provide more of the functions and inputs of large wood than are provided by young second-growth trees.

(2) Historically, riparian forests were periodically disturbed by wildfire, windstorms, floods, and disease. These forests were also impacted by wildlife such as beaver, deer, and elk. These disturbances maintained a forest landscape comprised of riparian stands of all ages ranging from early successional to old growth. At any given time, however, it is likely that a significant proportion of the riparian areas supported forests of mature age classes. This distribution of mature riparian forests supported a supply of large, persistent woody debris that was important in maintaining quality fish habitat.

The overall goals of the riparian vegetation retention rules along Type N and Type D streams are the following:

- Grow and retain vegetation sufficient to support the functions and processes that are important to downstream waters that have fish;
- Maintain the quality of domestic water; and
- Supplement wildlife habitat across the landscape.

These streams have reduced buffer widths and reduced basal area retention requirements as compared to similar sized Type F streams. In the design of the rules this was judged appropriate based on some assumptions. First, it was assumed that the amount of large wood entering Type N and D channels over time was not as important for maintaining fish populations within a given stream reach. And second, it was assumed that the future stand could provide some level of "functional" wood over time in terms of nutrient inputs and sediment storage. The following are additional underlying assumptions regarding temperature used in the development of the current BMP (Lorensen et al., 1994):

1) Shade is important in reducing heat loading to water bodies.

2) The achievement of a 'mature conifer stand' would emulate conditions that provide adequate shade to water bodies.

3) The twenty-foot no-cut zone and RMA basal area prescriptions would provide higher levels of shade compared to pre-94 rules (applicable to all but small Type-N streams).

4) The twenty-foot no-cut zone retains all trees closest to the stream where the greatest amount of effective shade is produced per unit of vegetation (applicable to all but small Type-N streams).

5) BMPs for small Type-N streams, for which the rules prescribe the retention of non-merchantable vegetation within 10 feet of the bankfull level, are considered adequate to protect stream temperature because:

    a) Given that most Type N streams have bankfull widths of less-than six feet, most shade is provided by shrubs and grasses within 10 feet of the bank;
    b) Fifty-five percent of small Type-N streams were at or above preharvest shade levels within 1 to 2 years after harvest due to understory vegetation re-growth;
    c) Based on the assumption that temperature increases would not exceed 10° F where vegetation had been removed, it was estimated that once the water reached fish-bearing channels it would not be more than 2° above pre-harvest levels; and
    d) Post 1991 clear-cut rules that prohibit adjacent 120-acre clearcuts for four years or until four feet of vegetative growth is achieved, in combination with shade recovery within two years of harvest, would reduce possible cumulative effects on fish-bearing streams due to harvesting along Type N streams.

The following are excerpts from the forest practices statutes and administrative rules relevant to stream temperatures and riparian functions:

ORS 527.765 Best management practices to maintain water quality.

(1) The State Board of Forestry shall establish best management practices and other rules applying to forest practices as necessary to insure that to the maximum extent practicable nonpoint source discharges of pollutants resulting from forest operations on forestlands do not impair the achievement and maintenance of water quality standards established by the Environmental Quality Commission for the waters of the state. Such best management practices shall consist of forest practices rules adopted to prevent or reduce pollution of waters of the state. Factors to be considered by the board in establishing best management practices shall include, where applicable, but not be limited to:

(a) Beneficial uses of waters potentially impacted;

(b) The effects of past forest practices on beneficial uses of water;

(c) Appropriate practices employed by other forest managers;

(d) Technical, economic and institutional feasibility; and

(e) Natural variations in geomorphology and hydrology.

ORS 527.770 Good faith compliance with best management practices not violation of water quality standards; subsequent enforcement of standards.

A forest operator conducting, or in good faith proposing to conduct, operations in accordance with best management practices currently in effect shall not be considered in violation of any water quality standards. When the State Board of Forestry adopts new best management practices and other rules applying to forest operations, such rules shall apply to all current or proposed forest operations upon their effective dates.

OAR 629-635-100 - Water Protection Rules; Purpose and Goals

(3) The purpose of the water protection rules is to protect, maintain and, where appropriate, improve the functions and values of streams, lakes, wetlands, and riparian management areas. These functions and values include water quality, hydrologic functions, the growing and harvesting of trees, and fish and wildlife resources.

(4) The water protection rules include general vegetation retention prescriptions for streams, lakes and wetlands that apply where current vegetation conditions within the riparian management area have or are likely to develop characteristics of mature forest stands in a "timely manner." Landowners are encouraged to manage stands within riparian management areas in order to grow trees in excess of what must be retained so that the excess may be harvested.

(5) The water protection rules also include alternative vegetation retention prescriptions for streams to allow incentives for operators to actively manage vegetation where existing vegetation conditions are not likely to develop characteristics of mature conifer forest stands in a "timely manner."

(6) OARs 629-640-400 and 629-645-020 allow an operator to propose site-specific prescriptions for sites where specific evaluation of vegetation within a riparian management area and/or the condition of the water of the state is used to identify the appropriate practices for achieving the vegetation and protection goals.

(7) The overall goal of the water protection rules is to provide resource protection during operations adjacent to and within streams, lakes, wetlands and riparian management areas so

that, while continuing to grow and harvest trees, the protection goals for fish, wildlife, and water quality are met.
(a) The protection goal for water quality (as prescribed in ORS 527.765) is to ensure through the described forest practices that, to the maximum extent practicable, non-point source discharges of pollutants resulting from forest operations do not impair the achievement and maintenance of the water quality standards.
(b) The protection goal for fish is to establish and retain vegetation consistent with the vegetation retention objectives described in OAR 629-640-000 (streams), OAR 629-645-000 (significant wetlands), and OAR 629-650-000 (lakes) that will maintain water quality and provide aquatic habitat components and functions such as shade, large woody debris, and nutrients.

OAR 629-640-000 - Vegetation Retention Goals for Streams; Desired Future Conditions
(1) The purpose of this rule is to describe how the vegetation retention measures for streams were determined, their purpose and how the measures are implemented. The vegetation retention requirements for streams described in OAR 629-640-100 through OAR 629-640-400 are designed to produced desired future conditions for the wide range of stand types, channel conditions, and disturbance regimes that exist throughout forestlands in Oregon.

(2) The desired future condition for streamside areas along fish use streams is to grow and retain vegetation so that, over time, average conditions across the landscape become similar to those of mature streamside stands. Oregon has a tremendous diversity of forest tree species growing along waters of the state and the age of mature streamside stands varies by species. Mature streamside stands are often dominated by conifer trees. For many conifer stands, mature stands occur between 80 and 200 years of stand age. Hardwood stands and some conifer stands may become mature at an earlier age. Mature stands provide ample shade over the channel, an abundance of large woody debris in the channel, channel-influencing root masses along the edge of the high water level, snags, and regular inputs of nutrients through litter fall.

(3) The rule standards for desired future conditions for fish use streams were developed by estimating the conifer basal area for average unmanaged mature streamside stands (at age 120) for each geographic region. This was done by using normal conifer yield tables for the average upland stand in the geographic region, and then adjusting the basal area for the effects of riparian influences on stocking, growth and mortality or by using available streamside stand data for mature stands.

(4) The desired future condition for streamside areas that do not have fish use is to have sufficient streamside vegetation to support the functions and processes that are important to downstream fish use waters and domestic water use and to supplement wildlife habitat across the landscape. Such functions and processes include: maintenance of cool water temperature and other water quality parameters; influences on sediment production and bank stability; additions of nutrients and large conifer organic debris; and provision of snags, cover, and trees for wildlife.

(5) The rule standards for desired future conditions for streams that do not have fish use were developed in a manner similar to fish use streams. In calculating the rule standards, other factors used in developing the desired future condition for large streams without fish use and all medium and small streams included the effects of trees regenerated in the riparian management area during the next rotation and desired levels of instream large woody debris.

(6) For streamside areas where the native tree community would be conifer dominated stands, mature streamside conditions are achieved by retaining a sufficient amount of conifers next to large and medium sized fish use streams at the time of harvest, so that halfway through the next rotation or period between harvest entries, the conifer basal area and density is similar to mature unmanaged conifer stands. In calculating the rule standards, a rotation age of 50 years was assumed for even-aged management and a period between entries of 25 years was assumed for uneven-aged management. The long-term maintenance of streamside conifer stands is likely to require incentives to landowners to manage streamside areas so that conifer reforestation occurs to replace older conifers over time.

(7) Conifer basal area and density targets to produce mature stand conditions over time are outlined in the general vegetation retention prescriptions. In order to ensure compliance with state water quality standards, these rules include requirements to retain all trees within 20 feet and understory vegetation within 10 feet of the high water level of specified channels to provide shade.

(8) For streamside areas where the native tree community would be hardwood dominated stands, mature streamside conditions are achieved by retaining sufficient hardwood trees. As early successional species, the long-term maintenance of hardwood streamside stands will in some cases require managed harvest using site specific vegetation retention prescriptions so that reforestation occurs to replace older trees. In order to ensure compliance with state water quality standards, these rules include requirements in the general vegetation retention prescription to retain all trees within 20 feet and understory vegetation within 10 feet of the high water level of specified channels to provide shade.

(9) In many cases the desired future condition for streams can be achieved by applying the general vegetation retention prescriptions, as described in OAR 629-640-100 and OAR 629-640-200. In other cases, the existing streamside vegetation may be incapable of developing into the future desired conditions in a "timely manner." In this case, the operator can apply an alternative vegetation retention prescription described in OAR 629-640-300 or develop a site specific vegetation retention prescription described in OAR 629-640-400. For the purposes of the water protection rules, "in a timely manner" means that the trees within the riparian management area will meet or exceed the applicable basal area target or vegetation retention goal during the period of the next harvest entry that would be normal for the site. This will be 50 years for many sites.

(10) Where the native tree community would be conifer dominant stands, but due to historical events the stand has become dominated by hardwoods, in particular, red alder, disturbance is allowed to produce conditions suitable for the re-establishment of conifer. In this and other situations where the existing streamside vegetation is incapable of developing characteristics of a mature streamside stand in a "timely manner," the desired action is to manipulate the streamside area and woody debris levels at the time of harvest (through an alternative vegetation retention prescription or site specific vegetation retention prescription) to attain such characteristics more quickly.

The following are additional excerpts from DEQ administrative rules relevant to stream temperatures and riparian functions:

340-041-0120: Implementation Program Applicable to All Basins

(11) EQC policy on surface water temperature (as regulated in the basin standards found in OAR 340-041-0205, OAR-340-041-0245, OAR-340-041-0285, OAR-340-041-0325, OAR-340-041-0365, OAR-340-041-0445, OAR-340-041-0485, OAR-340-041-0525, OAR-340-041-0565, OAR-340-041-0605, OAR-340-041-0645, OAR-340-041-0685, OAR-340-041-0725, OAR-340-041-0765, OAR-340-041-0805, OAR-340-041-0845, OAR-340-041-0885, OAR-340-041-0925, OAR-340-041-0965:

(a) It is the policy of the Environmental Quality Commission (EQC) to protect aquatic ecosystems from adverse surface water warming caused by anthropogenic activities. The intent of the EQC is to minimize the risk to cold-water aquatic ecosystems from anthropogenic warming of surface waters, to encourage the restoration of critical aquatic habitat, to reverse surface water warming trends, to cool the waters of the State, and to control extremes in temperature fluctuations due to anthropogenic activities:

(A) The first element of this policy is to encourage the proactive development and implementation of best management practices or other measures and available temperature control technologies for nonpoint and point source activities to prevent thermal pollution of surface waters;

(B) The second element of this policy is to require the development and implementation of surface water temperature management plans for those basins exceeding the numeric temperature criteria identified in the basin standards. The surface water temperature management plans will identify the best management practices (BMPs) or measures and approaches to be taken by nonpoint sources, and technologies to be implemented by point sources to limit or eliminate adverse anthropogenic warming of surface waters.

(e) Surface water temperature management plans will be required according to OAR 340-041-0026(3)(a)(D) when the relevant numeric temperature criteria are exceeded and the waterbody is designated as water-quality limited under Section 303(d) of the Clean Water Act. The plans will identify those steps, measures, technologies, and/or practices to be implemented by those sources determined by the Department to be contributing to the problem. The plan may be for an entire basin, a single watershed, a segment of a stream, single or multiple nonpoint source categories, single or multiple point sources or any combination of these, as deemed appropriate by the Department, to address the identified temperature problem:

(A) In the case of state and private forestlands, the practices identified in rules adopted pursuant to the State Forest Practices Act (FPA) will constitute the surface water temperature management plan for the activities covered by the act. Consequently, in those basins, watersheds or stream segments exceeding the relevant temperature criterion, and for those activities covered by the Forest Practices Act, the forestry component of the temperature management plan will be the practices required under the FPA. If the mandated practices need to be improved in specific basins, watersheds or stream segments to fully protect identified beneficial uses, the Departments of Forestry and Environmental Quality will follow the process described in ORS 527.765 to establish, implement, and improve practices in order to reduce thermal loads to achieve and maintain the surface water temperature criteria. Federal forest management agencies are required by the federal Clean Water Act to meet or exceed the substantive requirements of the state

forestry nonpoint source program. The Department currently has Memoranda of Understanding with the U.S. Forest Service and Bureau of Land Management to implement this aspect of the Clean Water Act. These memoranda will be used to identify the temperature management plan requirements for federal forestlands;
(g) Maintaining low stream temperatures to the maximum extent practicable in basins where surface water temperatures are below the specific criteria identified in this rule shall be accomplished by implementing technology based permits, best management practices or other measures. Any measurable increase in surface water temperature resulting from anthropogenic activities in these basins shall be in accordance with the antidegradation policy contained in OAR 340-041-0026.

340-04l-0026: Policy and Guidelines Generally Applicable to All Basins

In order to maintain the quality of waters in the State of Oregon, the following is the general policy of the EQC:
(a) Antidegradation Policy for Surface Waters. The purpose of the Antidegradation Policy is to guide decisions that affect water quality such that unnecessary degradation from point and nonpoint sources of pollution is prevented, and to protect, maintain, and enhance existing surface water quality to protect all existing beneficial uses. The standards and policies set forth in OAR 340-041-0120 through 340-041-0962 are intended to implement the Antidegradation Policy;
(A) High Quality Waters Policy: Where existing water quality meets or exceeds those levels necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water, and other designated beneficial uses, that level of water quality shall be maintained and protected. The Environmental Quality Commission, after full satisfaction of the intergovernmental coordination and public participation provisions of the continuing planning process, and with full consideration of sections (2), (3) and (5) of this rule, however, may allow a lowering of water quality in these high quality waters if they find:
(i) No other reasonable alternatives exist except to lower water quality; and
(ii) The action is necessary and justifiable for economic or social development benefits and outweighs the environmental costs of lowered water quality; and
(iii) All water quality standards will be met and beneficial uses protected.
(3)(a)(D) Effective July 1, 1996, in any waterbody identified by the Department as exceeding the relevant numeric temperature criteria specified for each individual water quality management basin identified in OAR 340-041-0205, OAR-340-041-0245, OAR-340-041-0285, OAR-340-041-0325, OAR-340-041-0365, OAR-340-041-0445, OAR-340-041-0485, OAR-340-041-0525, OAR-340-041-0565, OAR-340-041-0605, OAR-340-041-0645, OAR-340-041-0685, OAR-340-041-0725, OAR-340-041-0765, OAR-340-041-0805, OAR-340-041-0845, OAR-340-041-0885, OAR-340-041-0925, OAR-340-041-0965, and designated as water quality limited under Section 303(d) of the Clean Water Act, the following requirements shall apply to appropriate watersheds or stream segments in accordance with priorities established by the Department. The Department may determine that a plan is not necessary for a particular stream segment or segments within a water-quality limited basin based on the contribution of the segment(s) to the temperature problem:
(i) Anthropogenic sources are required to develop and implement a surface water temperature management plan which describes the best management practices, measures, and/or control

technologies which will be used to reverse the warming trend of the basin, watershed, or stream segment identified as water quality limited for temperature;

(ii) Sources shall continue to maintain and improve, if necessary, the surface water temperature management plan in order to maintain the cooling trend until the numeric criterion is achieved or until the Department, in consultation with the Designated Management Agencies (DMAs), has determined that all feasible steps have been taken to meet the criterion and that the designated beneficial uses are not being adversely impacted. In this latter situation, the temperature achieved after all feasible steps have been taken will be the temperature criterion for the surface waters covered by the applicable management plan. The determination that all feasible steps have been taken will be based on, but not limited to, a site-specific balance of the following criteria: protection of beneficial uses; appropriateness to local conditions; use of best treatment technologies or management practices or measures; and cost of compliance;

(iii) Once the numeric criterion is achieved or the Department has determined that all feasible steps have been taken, sources shall continue to implement the practices or measures described in the surface water temperature management plan in order to continually achieve the temperature criterion;

(iv) For point sources, the surface water temperature management plan will be part of their National Pollutant Discharge Elimination System Permit (NPDES);

(v) For nonpoint sources, the surface water temperature management plan will be developed by designated management agencies (DMAs) which will identify the appropriate BMPs or measures;

(vi) A source (including but not limited to permitted point sources, individual landowners and land managers) in compliance with the Department or DMA (as appropriate) approved surface water temperature management plan shall not be deemed to be causing or contributing to a violation of the numeric criterion if the surface water temperature exceeds the criterion;

340-041-0205: Water Quality Standards Not to be Exceeded [For N. Coast-Lower Columbia Basin, but generally applicable to all basins.]

(1) Notwithstanding the water quality standards contained below, the highest and best practicable treatment and/or control of wastes, activities, and flows shall in every case be provided so as to maintain dissolved oxygen and overall water quality at the highest possible levels and water temperatures, coliform bacteria concentrations, dissolved chemical substances, toxic materials, radioactivity, turbidities, color, odor, and other deleterious factors at the lowest possible levels.

(2)(b) Temperature: The changes adopted by the Commission on January 11, 1996, become effective July 1, 1996. Until that time, the requirements of this rule that were in effect on January 10, 1996, apply. The method for measuring the numeric temperature criteria specified in this rule is defined in OAR 340-041-0006(54):

(A) To accomplish the goals identified in OAR 340-041-0120(11), unless specifically allowed under a Department-approved surface water temperature management plan as required under OAR 340-041-0026(3)(a)(D), no measurable surface water temperature increase resulting from anthropogenic activities is allowed:

(i) In a basin for which salmonid fish rearing is a designated beneficial use, and in which surface water temperatures exceed 64.0°F (17.8°C);

(ii) In the Columbia River or its associated sloughs and channels from the mouth to river mile 309 when surface water temperatures exceed 68.0°F (20.0°C);
(iii) In waters and periods of the year determined by the Department to support native salmonid spawning, egg incubation, and fry emergence from the egg and from the gravels in a basin which exceeds 55.0°F (12.8°C);
(iv) In waters determined by the Department to support or to be necessary to maintain the viability of native Oregon bull trout, when surface water temperatures exceed 50.0°F (10.0°C);
(v) In waters determined by the Department to be ecologically significant cold-water refugia;
(vi) In stream segments containing federally listed Threatened and Endangered species if the increase would impair the biological integrity of the Threatened and Endangered population;
(vii) In Oregon waters when the dissolved oxygen (DO) levels are within 0.5 mg/l or 10 percent saturation of the water column or intergravel DO criterion for a given stream reach or subbasin;
(viii) In natural lakes.
(B) An exceedence of the numeric criteria identified in subparagraphs (A)(i) through (iv) of this subsection will not be deemed a temperature standard violation if it occurs when the air temperature during the warmest seven-day period of the year exceeds the 90th percentile of the seven-day average daily maximum air temperature calculated in a yearly series over the historic record. However, during such periods, the anthropogenic sources must still continue to comply with their surface water temperature management plans developed under OAR 340-041-0026(3)(a)(D);
(C) Any source may petition the Commission for an exception to subparagraphs (A)(i) through (viii) of this subsection for discharge above the identified criteria if:
(i) The source provides the necessary scientific information to describe how the designated beneficial uses would not be adversely impacted; or
(ii) A source is implementing all reasonable management practices or measures; its activity will not significantly affect the beneficial uses; and the environmental cost of treating the parameter to the level necessary to assure full protection would outweigh the risk to the resource.

APPENDIX H: EASTERN OREGON RMAS AND SITE PRODUCTIVITY

The following is a comparison of the eastern Oregon riparian area stocking level recommendations provided by Fred C. Hall (Senior Plant Ecologist, USDA Forest Service, Pacific Northwest Region) with the standard basal area targets for the two eastside georegions in the current forest practice rules.

Fred's recommendations should be interpreted as stocking maximums. To maintain viable stands, stocking reductions (such as through commercial harvest) should occur when these stocking levels are reached to reduce the susceptibility of the trees to insect damage. Stocking reduction needs to be enough that regrowth before the next planned entry does not increase stocking above these thresholds.

<u>Site Productivity Background:</u>

Site Class 1	> 225	cubic feet/acre/year at culmination of mean annual increment (best westside ground)
Site Class 2	165-224	(westside ground)
Site Class 3	120-164	(very high site on the eastside)
Site Class 4	85-119	(eastside mixed conifer)
Site Class 5	50-84	(eastside mixed conifer)
Site Class 6	20-49	(typical ponderosa pine site)
Site Class 7	< 20	(typical juniper site, reforestation not required under current rules)

<u>Fred Hall's Recommendations for Eastern Oregon Riparian Areas:</u>

Site Class 4 (95 cubic feet/acre/year: grand fir/white fir, subalpine fir, larch white pine sites)

160 square feet of basal area per acre (BA/Ac)

Site Class 5 (60 cubic feet/ac/yr: ponderosa pine, grand fir/white fir, Douglas-fir, incense cedar)

120 square feet BA/Ac

Site Class 6 (30 cubic feet/ac/yr: pure ponderosa pine, some incense cedar)

80 square feet BA/Ac

Site Class 7 (12 cubic feet/ac/yr: western juniper with some ponderosa pine)

40 square feet BA/Ac

Harvest Method	Current standard targets in rules converted to basal area/acre *FPA-Large Type F (100' RMA)*	*FPA-Med. Type F (70' RMA)*	*FPA--Small Type F (50' RMA)*
Harvest Type 2 or 3 (including clearcutting, seed tree methods, overstory removals, etc.)	**74**	**56**	**44**
Thinnings and other partial cutting	**96**	**75**	**44**

Important note: The rule targets are not directly comparable to Fred Hall's recommendations because they are stocking standards to be met immediately after harvest, and do not include regrowth that will occur prior to the next harvest entry. The rules assume a 50-year return interval for Harvest Type 2 and 3 units and a 25-year return interval for thinnings and other partial cutting. Based on data for mature eastern Oregon stands, a future stocking level target of 116 square feet/per acre across all eastside sites was assumed during development of the 1994 rules. This value is more directly comparable to Fred's recommendations.

Discussion: The rule targets apply to all eastern Oregon operations regardless of site productivity. A large amount of the "forestland" in eastern Oregon produces less than 20 cubic feet per acre per year (Site Class 7). These lands are generally considered to be "noncommercial" and typically support only western juniper. Occasionally, a commercial forest operation will take place on these low productivity sites and such operations are subject to the Forest Practices Act and the water protection rules. Through a study mandated by 1999 Senate Bill 1151, ODF in cooperation with DEQ, ODA, ODFW, and others will evaluate whether the forest practice rules should be modified with respect to commercial juniper harvests or whether such harvest should be considered agricultural activities associated with rangeland restoration and placed solely under ODA jurisdiction.

A majority of the eastern Oregon sites capable of growing 20 cubic feet per acre per year or more are in the Site Class 6 range. Based on Fred's recommendations, it appears the current eastern Oregon standard targets and future basal area targets may be requiring stocking levels that could leave residual stands, along at least large and medium Type F streams, susceptible to insect problems (primarily bark beetles) on these Site 6 areas. On Site 5 and better sites, the rule targets appear to result in stocking levels that are lower that the potential of the growing sites, according to Fred's information. Overall, the current rules may oversimplify the variable site conditions that exist in this part of the state and further analysis of the stocking targets may be needed.

APPENDIX I: DEQ ANALYSIS OF ODF SHADE STUDY DATA

A DEQ analyses of the ODF Shade Study data set (ODF 2001b) provides some additional information on riparian vegetation conditions that can influence stream temperature, and the inherent variability of riparian forest conditions. The Oregon Department of Forestry collected stream shade measurements using a densiometer and hemispherical canopy photography (fish-eye lens) at 31 sites in the Blue Mountain Georegion during the summer of 1999, and 30 sites in the Coast Range Georegion (see Figure 1). Shade was measured along stream reaches managed under Forest Practice Act (FPA) rules, identified as 'Harvested' sites, as well as along unmanaged stream reaches, identified as either 'Unharvested' or 'Late Seral' sites.

Along with shade measurements, extensive channel and riparian vegetation data were collected, including: channel measurements, tree species composition, tree height, canopy measurements, tree distance from stream, topographic shade angle, grazing effects, fire effects, and insects and disease effects.

Basal area-to-shade comparisons along with current FPA basal area prescription targets are depicted in Figures I-6, I-9, and I-12 for small, medium and large streams, respectively for the Blue Mountains, and Figures I-15, I-18, and I-21 for small, medium and large streams, respectively for the Coast Range. Basal area values (cross-sectional trunk area at breast height) used in the analysis below were summed for each site, and include all of the standing live trees at least 6-inches in diameter within the riparian widths indicated for the left and right sides of the stream for each reach sampled. This excludes snags and blowdown.

While the FPA basal area prescriptions were developed based primarily on potential conifer growth in riparian areas, basal area 'credits' may be applied to other conifers and some hardwoods. These study sites collectively present a unique assembly of conifers and hardwoods, and some mixed stands. The basal area versus percent shade comparisons presented in Tables I-1 – I-6 should be viewed as preliminary analysis, and are subject to change in the final shade study report.

Blue Mountain Small Streams (2 cfs and less):

Data was gathered on fourteen Small stream sites, each providing two sets of riparian vegetation and shade data, corresponding to the left and right side of the stream. Four of the five highest basal area values were associated with shade values equal to or greater than 90 percent, and six of the ten lowest basal area values were associated with shade values less than 70 percent. There is no apparent linear relationship between basal area and shade between sites (r^2 = 0.10 and 0.28 for riparian vegetation widths of 50 and 100 feet, respectively; see Figures I-7 and I-8). Evidently, a single basal area prescribed to a large range of sites may produce a wide range of shade. The between-site comparisons of the small stream data set reveal no formulaic predictor of shade versus basal area.

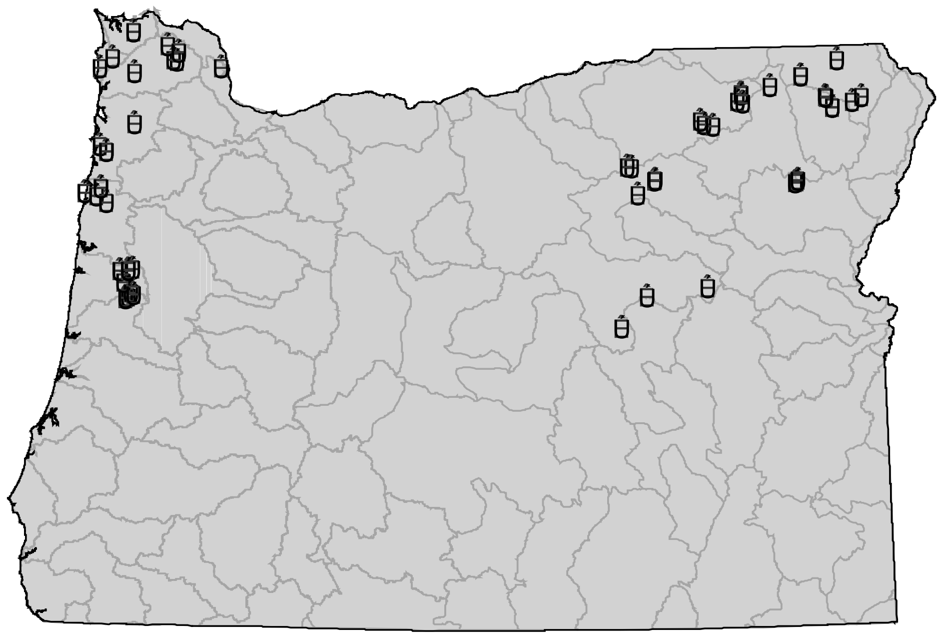


Figure I-1. Sample site locations (ODF 2001b)

Table 1 presents comparisons of the average basal areas for categories of sites above and below various shade-level thresholds for small streams. The majority of sites exhibiting densiometer shade values of less than 80 percent on average had lower RMA (Riparian Management Area) basal areas than those sites exhibiting shade values of equal to or greater than 80 percent. This difference was even greater between groups exhibiting less than 90 percent shade compared to those with greater than 90 percent shade. Differences for lower shade thresholds were less exaggerated.

Table I-1. Small Blue Mountain Georegion Stream Comparison: Basal Area versus Percent Shade.

Site Group	n	Average (stdev) BA: 50X1000ft (RMA)	Median	Average (stdev) BA : 100 X1000 ft	Median
Less than 50% shade	2	62 (22)	62	93(15)	93
50% shade or greater	26	72(32)	67	124(53)	102
Less than 60% shade	5	69(37)	68	91(36)	82
60% shade or greater	23	71(31)	65	128(53)	106
Less than 70% shade	10	64(29)	62	92(33)*	85
70% shade or greater	18	75(33)	67	138(54)*	126
Less than 80% shade	18	62 (24)*	57	103 (39)*	98
80% shade or greater	10	86 (38)*	97	155 (57)*	164
Less than 90% shade	21	61 (25)*	58	106 (40)*	98
90% shade or greater	7	100 (33)*	114	170 (58)*	203

* Asterisk indicates statistically significant difference between groups (95% confidence; t-test)

Blue Mountain Medium Streams (between 2 and 10 cfs):

Data was gathered on 13 medium stream sites, each providing two sets of riparian vegetation and shade data, corresponding to the left and right side of the stream. Three of the four highest basal area values were associated with shade values greater than or equal to 90 percent, and four of the seven lowest basal area values were associated with shade values less than 60 percent. As observed with the small streams, there is no apparent linear relationship between basal area and shade between sites ($r^2 = 0.11$ for both riparian vegetation widths of 70 and 100 feet; see Figures I-10 and I-11) again for reasons already described.

It should be noted that several other factors besides basal area can influence the amount of shade on a stream: tree species and distribution, topography, stand species composition and health, channel width and aspect, and land use history. Combinations of these factors combined with a dynamic landscape can account for why tree presence alone, represented by a single basal area number, is generally not a reliable predictor of shade levels, as is seen in the case of medium and small streams surveyed in this study.

Table 2 presents comparisons of the average basal areas for categories of sites above and below various shade-level thresholds for medium streams. Trends regarding shade versus basal area for medium streams were similar to that of small streams. The majority of sites exhibiting densiomenter shade values of less than 70 percent on average had lower RMA basal areas than those sites exhibiting shade values of equal to or greater than 70 percent. This difference was also observed between groups exhibiting less than 90 percent shade compared to those with greater than 90 percent shade. Substantial differences between average basal area values were also observed for shade thresholds of 50 percent and 60 percent.

Table I-2. Medium Blue Mountain Georegion Stream Comparison: Basal Area versus Percent Shade.

Site Group	n	Average (stdev) BA: 70X1000ft (RMA)	Median	Average (stdev) BA : 100 X1000 ft	Median
Less than 50% shade	3	76(23)	71	115(13)	115
50% shade or greater	23	116(59)	119	158(73)	146
Less than 60% shade	4	69(23)	63	104(24)	108
60% shade or greater	22	119(59)	121	162(72)	152
Less than 70% shade	5	64(23)*	56	96(27)*	102
70% shade or greater	21	123(58)*	123	166(70)*	159
Less than 80% shade	11	105 (58)	84	142 (61)	127
80% shade or greater	15	116 (59)	119	161(76)	146
Less than 90% shade	19	96 (55)*	84	136 (64)*	123
90% shade or greater	7	154(43)*	146	198 (69)*	183

* Asterisk indicates statistically significant difference between groups (95% confidence; t-test)

Blue Mountain Large Streams (10 cfs and greater):

Data was gathered on four large stream sites, each providing two sets of riparian vegetation and shade data, corresponding to the left and right side of the stream. The two highest basal area values were associated with shade values greater than or equal to 90 percent, and the two lowest basal area values were associated with shade values less than 40 percent. Contrary to what was observed on the small and medium-sized streams, there does appear to be a relatively strong linear relationship between basal area and shade between sites (r^2 = 0.73 and 0.74 for riparian vegetation widths of 50 and 100 feet, respectively; see Figures 9 and 10), although the sample size was relatively small.

Table 3 presents comparisons of the average basal areas for categories of sites above and below various shade-level thresholds for large streams. Similar trends regarding shade versus basal area observed for small and medium streams were observed for large streams. The majority of sites exhibiting densiomenter shade values of less than 40 percent on average had lower RMA basal areas than those sites exhibiting shade values of equal to or greater than 80 percent[21]. This difference was also observed between groups exhibiting less than 90 percent shade compared to those with equal to or greater than 90 percent shade. It is important to note that while most of the small and medium stream buffers were categorized as ‘conifers,’ at least four of the six large streams were categorized as ‘hardwoods’.

Table I-3. Large Blue Mountain Georegion Stream Comparison: Basal Area versus Percent Shade.

Site Group	n	Average (stdev) BA: 50X1000ft	Median	Average (stdev) BA : 100 X1000 ft (RMA)	Median
Less than 40% shade[1]	2	36(20)*	36	65 (48)*	65
80% shade or greater[1]	6	99(26)*	90	188(49)*	182
Less than 90% shade	4	56(26)*	63	107(57)*	118
90% shade or greater	4	110(24)*	110	207(49)*	220

* Asterisk indicates statistically significant difference between groups (95% confidence; t-test)

Coast Range Small Streams (2cfs and less):

Data was gathered on fourteen small stream sites, each providing two sets of riparian vegetation and shade data, corresponding to the left and right side of the stream. Four of the seven highest basal area values were associated with shade values of equal or greater than 95 percent for the 100-foot riparian width. There is no apparent linear relationship between basal area and shade between sites (r^2 = 0.08 and 0.17 for riparian vegetation widths of 50 and 100 feet, respectively; see Figures I-16 and I-17). Site 83L was considered an outlier and not included in the regression equation or in the statistical analysis. Excluding site 83L, all of the small stream sites exhibited densiometer shade levels of greater than 70 percent.

[21] There were no sites on large streams with shade measurements between 40 and 80 percent. Using the 80 percent threshold shade level created one population of sites with shade values less than 40 percent, and another with values of 80 percent and greater.

Table 4 presents comparisons of the average basal areas for categories of sites above and below various shade-level thresholds for small streams. The majority of sites exhibiting densiometer shade values of less than the 85, 90, and 95 percent thresholds on average had lower RMA (Riparian Management Area) basal areas than those sites exhibiting shade values of equal to or greater than the corresponding threshold. None of the differences were statistically significant.

Table I-4. Small Coast Range Georegion Stream Comparison: Basal Area versus Percent Shade.

Site Group	n	Average (stdev) BA: 50X1000ft (RMA)	Median	Average (stdev) BA : 100 X1000 ft	Median
Less than 85% shade	4	115 (47)	107	138(80)	113
85% shade or greater	23	142(52)	128	198(98)	190
Less than 90% shade	8	119(37)	118	156(78)	133
90% shade or greater	19	145(56)	139	203(103)	190
Less than 95% shade	14	136(55)	130	170(83)	142
95% shade or greater	13	140(51)	128	209(110)	190

* Asterisk indicates statistically significant difference between groups (95% confidence; t-test)

Coast Range Medium Streams (between 2 and 10 cfs):

Data was gathered on nine medium stream sites, each providing two sets of riparian vegetation and shade data, corresponding to the left and right side of the stream. Seven of the eight highest basal area values were associated with shade values greater than or equal to 95 percent for the RMA width (70 ft), and the eight highest basal area values were associated with shade values greater than or equal to 95 percent for the 100 ft buffer width (plot unit). The linear relationship between basal area and shade between sites was slightly greater for medium streams than was observed with the small streams ($r^2 = 0.3$ for both riparian vegetation widths of 70 and 100 feet; see Figures I-19 and I-20). Logarithmic equations exhibited r^2 values of 0.47 and 0.56 for the RMA buffer width and the 100 ft buffer plot width, respectively.

Table 5 presents comparisons of the average basal areas for categories of sites above and below various shade-level thresholds for medium streams. All of sites exhibiting densiometer shade values of less than the 85, and 95 percent thresholds on average had lower basal areas than those sites exhibiting shade values of equal to or greater than the corresponding threshold. The difference was statistically significant for both RMA width buffers and the 100-ft buffer plot area at the 95 percent threshold level.

Table I-5. Medium Coast Range Georegion Stream Comparison: Basal Area versus Percent Shade.

Site Group	n	Average (stdev) BA: 70X1000ft (RMA)	Median	Average (stdev) BA : 100 X1000 ft	Median
Less than 85% shade	4	117(49)	119	119(48)	123
85% shade or greater	14	257(152)	211	357(245)	271
Less than 95% shade	7	132(65)*	139	148(68)*	147
95% shade or greater	11	286(155)*	223	404(257)*	303

* Asterisk indicates statistically significant difference between groups (95% confidence; t-test)

Coast Range Large Streams (10 cfs and greater):

Data was gathered on seven large stream sites, each providing two sets of riparian vegetation and shade data, corresponding to the left and right side of the stream. The four highest basal area values for the RMA buffer width were associated with shade values of equal to or greater than 95 percent, and the three lowest basal area values for the RMA buffer width were associated with shade values of less than 80 percent. A relatively strong linear relationship between basal area and shade is evident for the RMA buffer width ($r^2 = 0.5$), and relatively weak linear relationship for the 50-foot plot area ($r^2 = 0.2$); see Figures I-22 and I-23 respectively.

Table 6 presents comparisons of the average basal areas for categories of sites above and below various shade-level thresholds for large streams. Similar trends regarding shade versus basal area observed for small and medium streams were observed for large streams. The sites exhibiting densiomenter shade values of less than 80 percent on average had lower basal areas than those sites exhibiting shade values of equal to or greater than 80 percent for RMA and 50-foot plot width buffers. This difference was also observed between groups exhibiting less than 95 percent shade compared to those with equal to or greater than 95 percent shade. Statistically significant differences in basal areas resulted at the 100-foot RMA buffer width at both the 80 percent and 95 percent cutoff thresholds.

Table I-6. Large Coast Range Georegion Stream Comparison: Basal Area versus Percent Shade.

Site Group	n	Average (stdev) BA: 50X1000ft	Median	Average (stdev) BA : 100 X1000 ft (RMA)	Median
Less than 80% shade	3	145(46)	124	164(76)*	125
80% shade or greater	11	257(92)	267	433(133)*	471
Less than 95% shade	6	192(77)	176	264(137)*	257
95% shade or greater	8	264(101)	296	458(140)*	520

* Asterisk indicates statistically significant difference between groups (95% confidence; t-test)

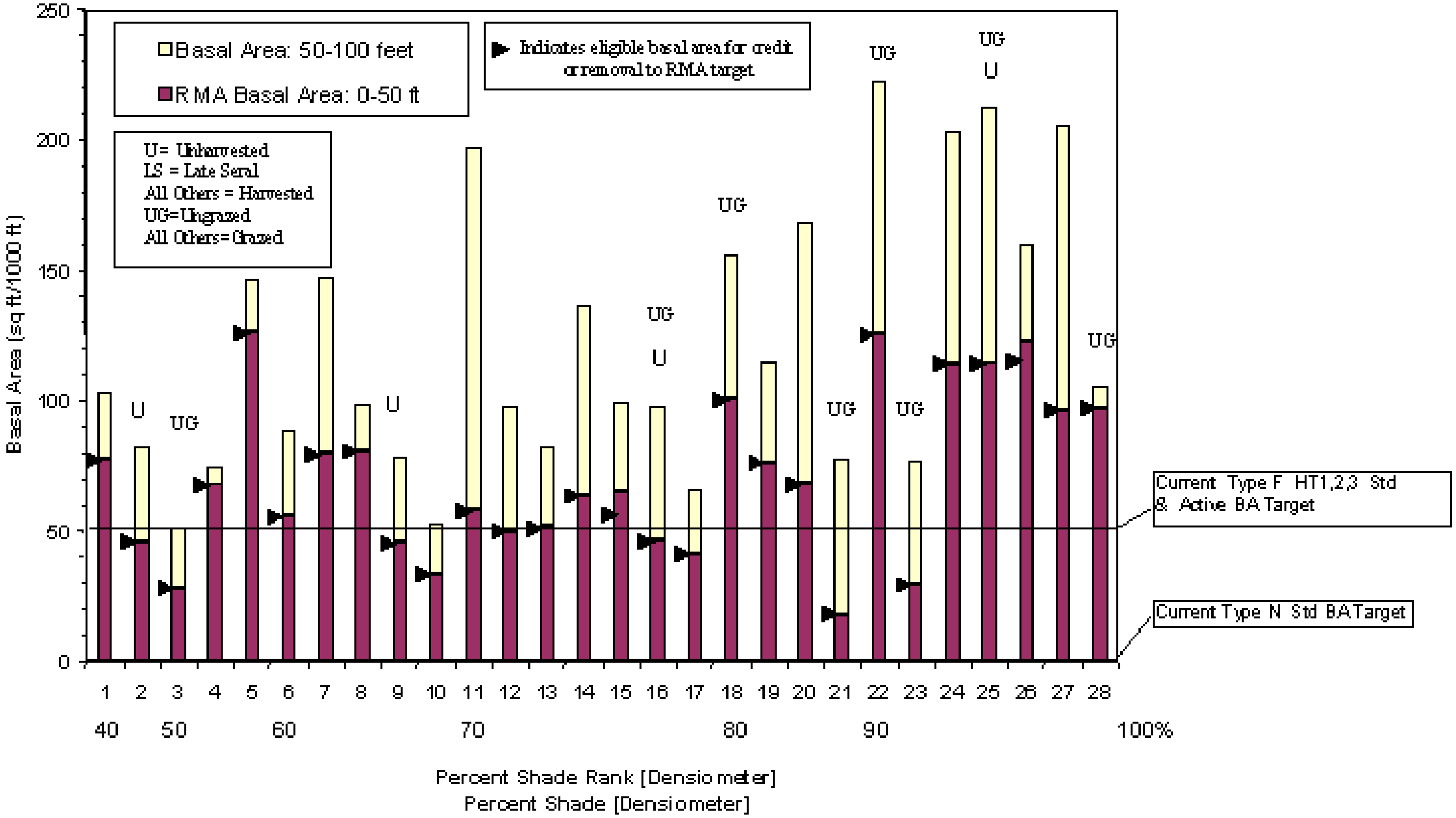
Basal Area versus Shade Summary:

Blue Mountains Georegion: All stream size classes exhibited substantial variability in shade with respect to their corresponding basal area values. Small and medium size streams surveyed in this study showed a relatively weak linear relationship between basal area and shade. The four large stream reaches surveyed in this study showed a relatively strong linear relationship between basal area and shade, however the sample size for the large streams was relatively small compared to small and medium sized streams. For each case tested, the average basal area for those sites above the various threshold shade levels (50, 60, 70, 80, and 90 percent) was greater than the basal area average for those sites below that level. Statistically significant differences between basal area groups occurred at the higher threshold shade levels (70, 80, and 90 percent, depending on the riparian width considered) for all stream sizes. Among all stream size classes surveyed in this study, the majority of the highest and lowest basal area/unit area values were associated with relatively high and low shade values, respectively. For mid-range shade values (60 percent – 90 percent) there was generally no correlation between and basal area and shade.

Coast Range Georegion: As with the Blue Mountain dataset, substantial variability in shade with respect to corresponding basal area values was evident. Overall, the Coast Range sites exhibited relatively high shade levels (higher than shade levels for the Blue Mountain sites). Linear relationships between shade and basal area were strongest with large streams, less strong for medium streams, and weak for small streams. For each case tested, the average basal area for those sites above the various threshold shade levels was greater than the basal area average for those sites below that level. Statistically significant differences between basal area groups occurred at the higher threshold shade levels, most notably at the 95 percent threshold level for medium and large streams. Among all stream size classes surveyed in this study, the majority of the highest and lowest basal area/unit area values were associated with relatively high and low shade values, respectively.

Many factors other than basal area can affect shade levels on streams, including but not limited to: bankfull width, topographic shade angle, understory vegetation and shrubs, and land uses other than tree harvesting. Further study of these various factors is warranted, particularly with regard to land use. A final report of this shade study with a comprehensive analysis of the multiple factors influencing shade is available from the Oregon Department of Forestry (ODF 2001b).

Figure I-6. E. OR Blue Mountains: Small Streams (Shade Study Data: 1999)



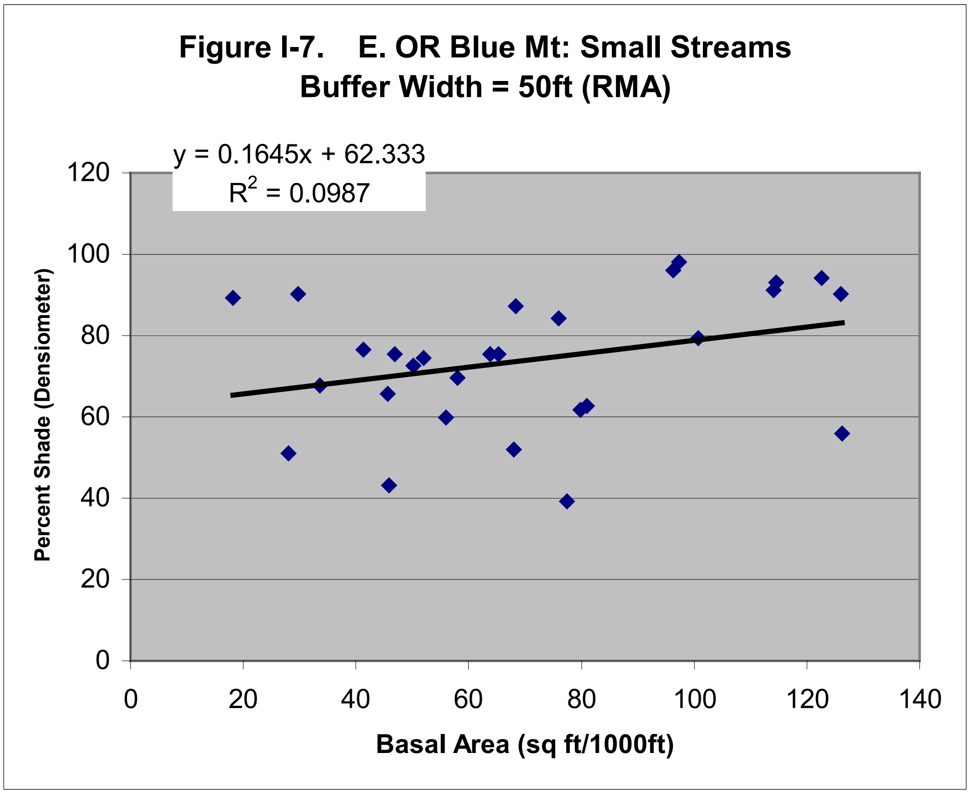


Figure I-7. E. OR Blue Mt: Small Streams
Buffer Width = 50ft (RMA)
y = 0.1645x + 62.333
R2 = 0.0987
Percent Shade (Densiometer)
Basal Area (sq ft/1000ft)
0
20
40
60
80
100
120
140

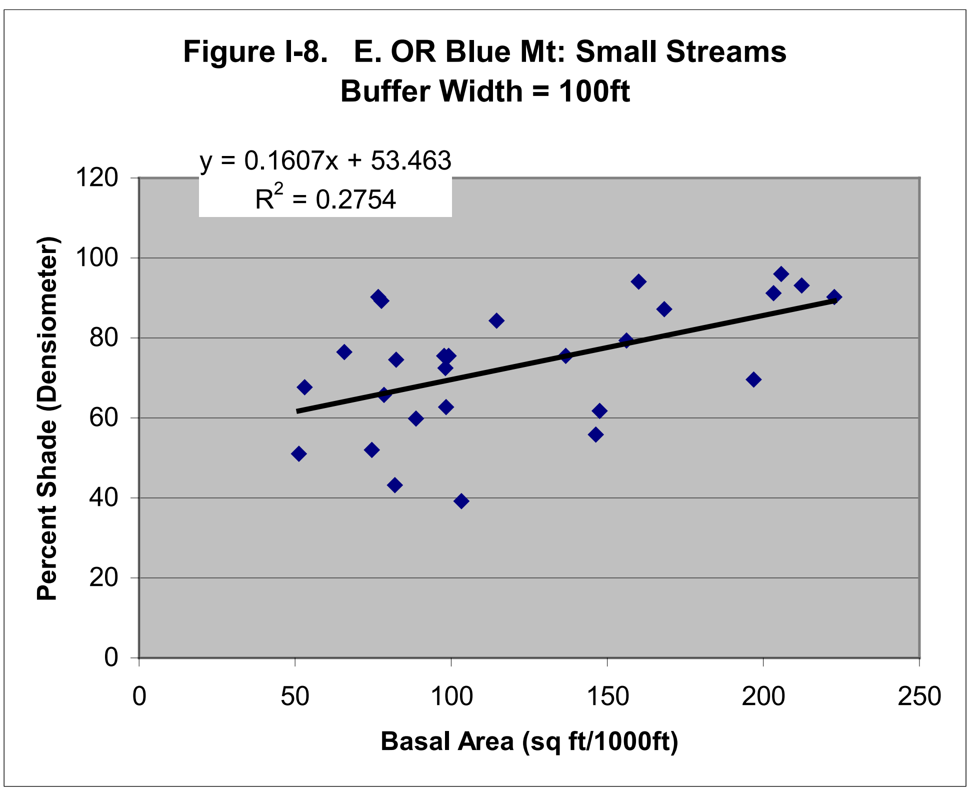
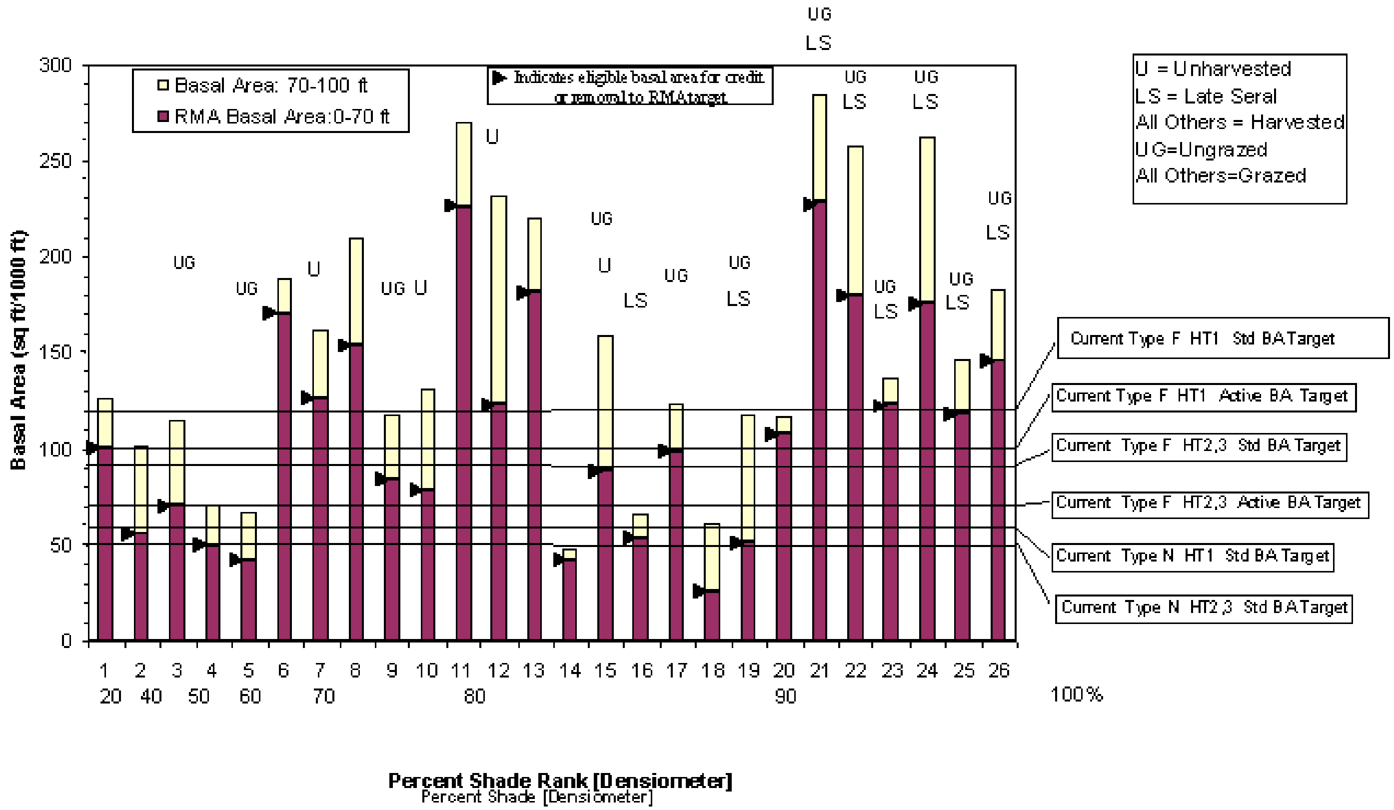


Figure I-8. E. OR Blue Mt: Small Streams
Buffer Width = 100ft
y = 0.1607x + 53.463
R2 = 0.2754
Percent Shade (Densiometer)
Basal Area (sq ft/1000ft)
0
50
100
150
200
250

Figure I-9. E. OR Blue Mountains: Medium Streams (Shade Study Data: 1999)



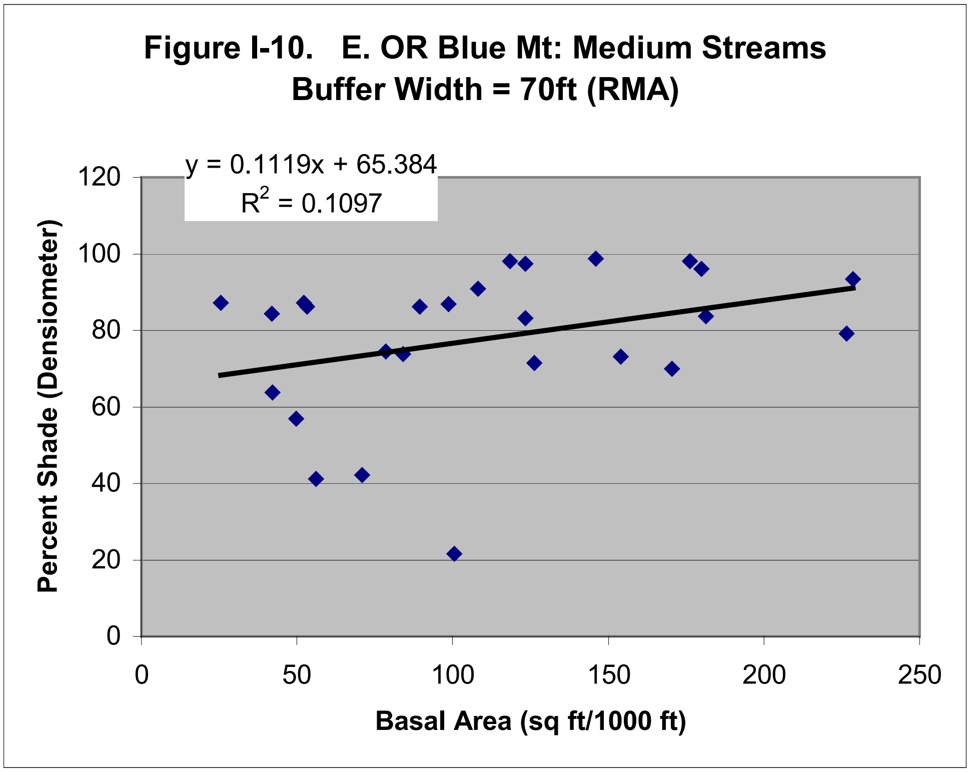


Figure I-10. E. OR Blue Mt: Medium Streams
Buffer Width = 70ft (RMA)
y = 0.1119x + 65.384
R2 = 0.1097
Percent Shade (Densiometer)
Basal Area (sq ft/1000 ft)
0
20
40
60
80
100
120
0
50
100
150
200
250

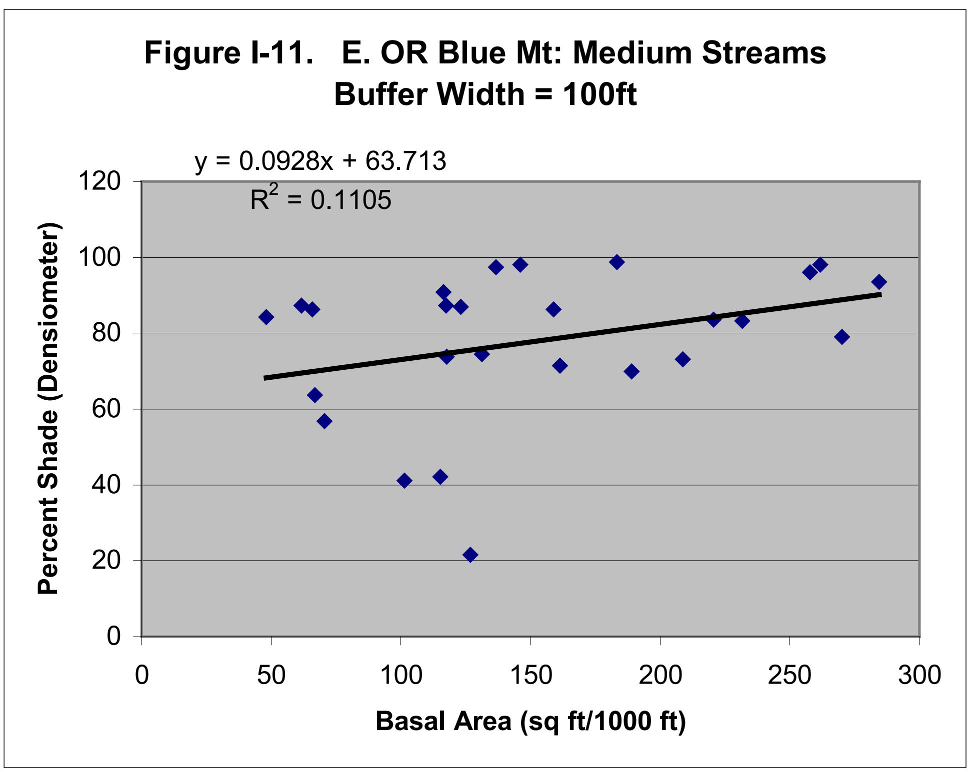
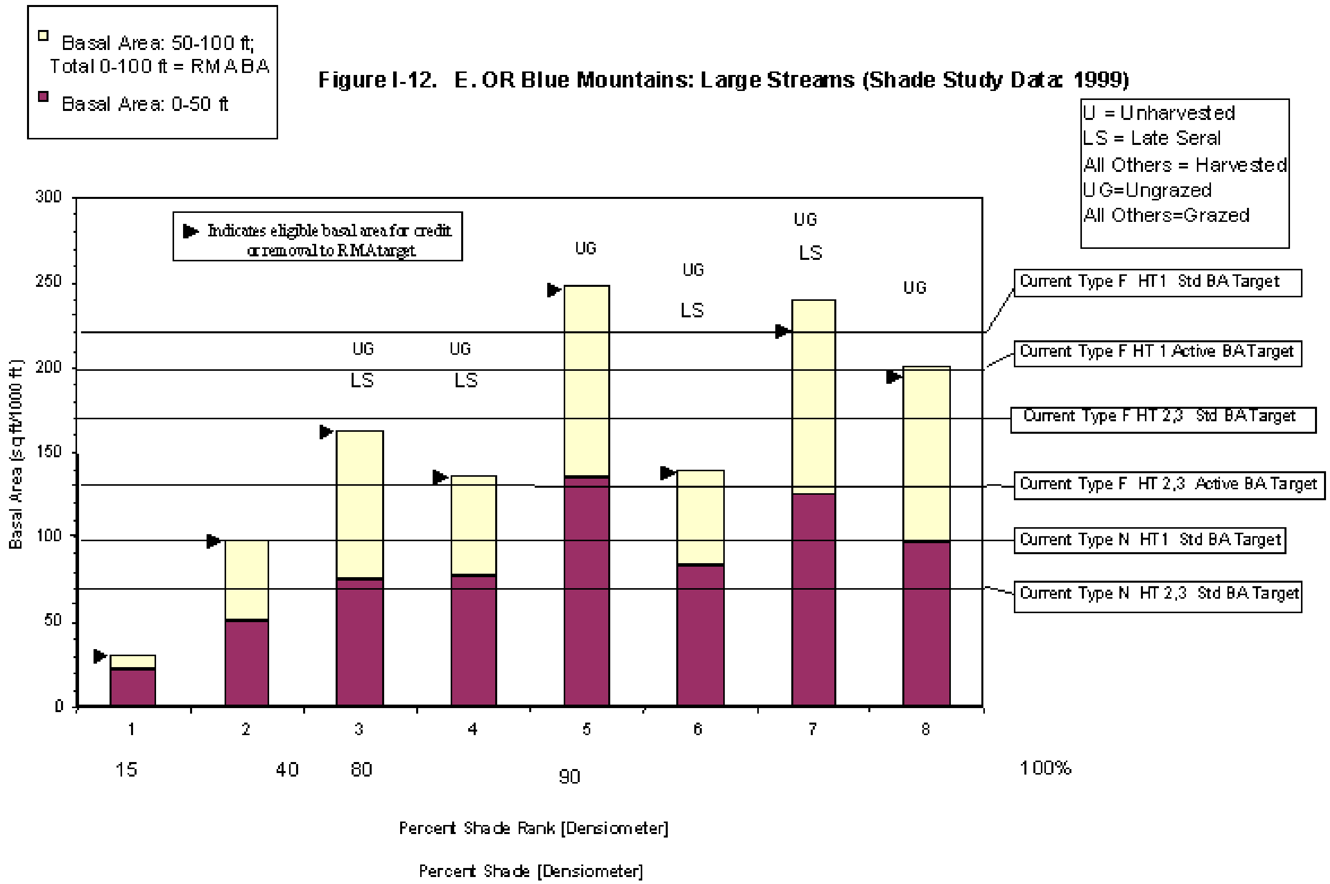


Figure I-11. E. OR Blue Mt: Medium Streams
Buffer Width = 100ft
y = 0.0928x + 63.713
R2 = 0.1105
Percent Shade (Densiometer)
Basal Area (sq ft/1000 ft)
0
20
40
60
80
100
120
0
50
100
150
200
250
300

Figure I-12. E. OR Blue Mountains: Large Streams (Shade Study Data: 1999)



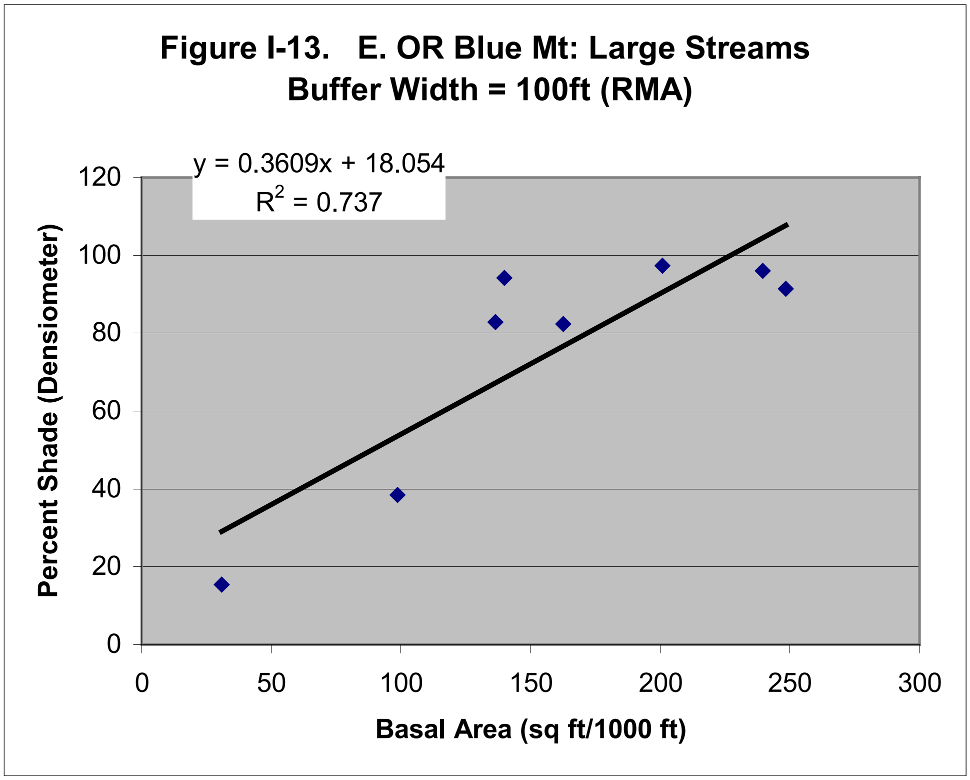


Figure I-13. E. OR Blue Mt: Large Streams
Buffer Width = 100ft (RMA)

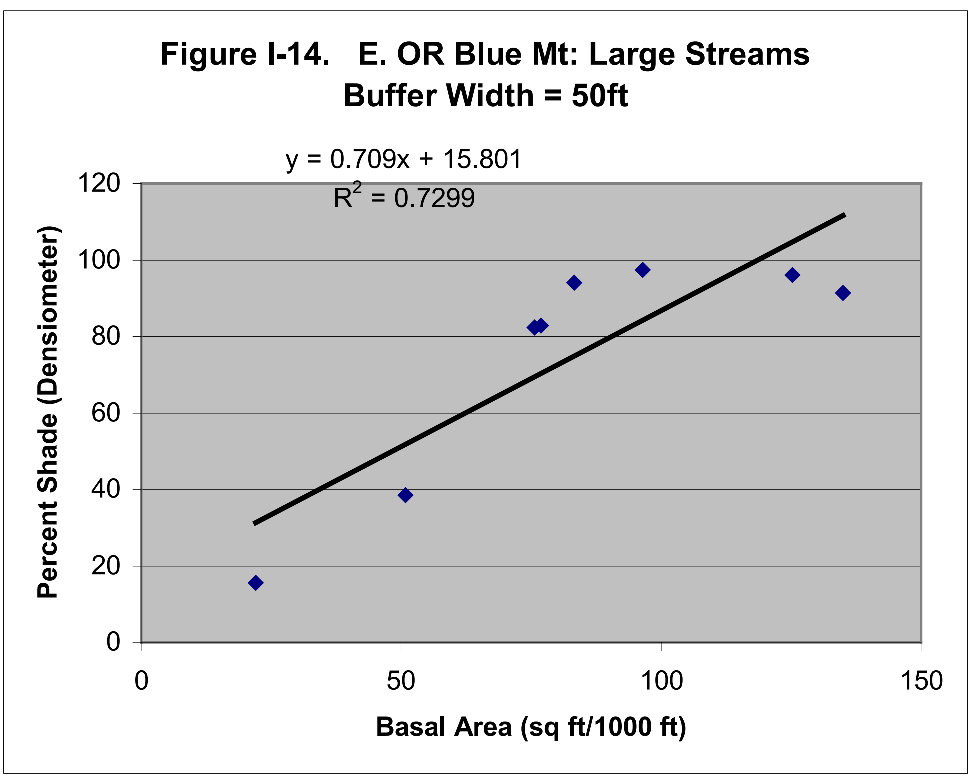
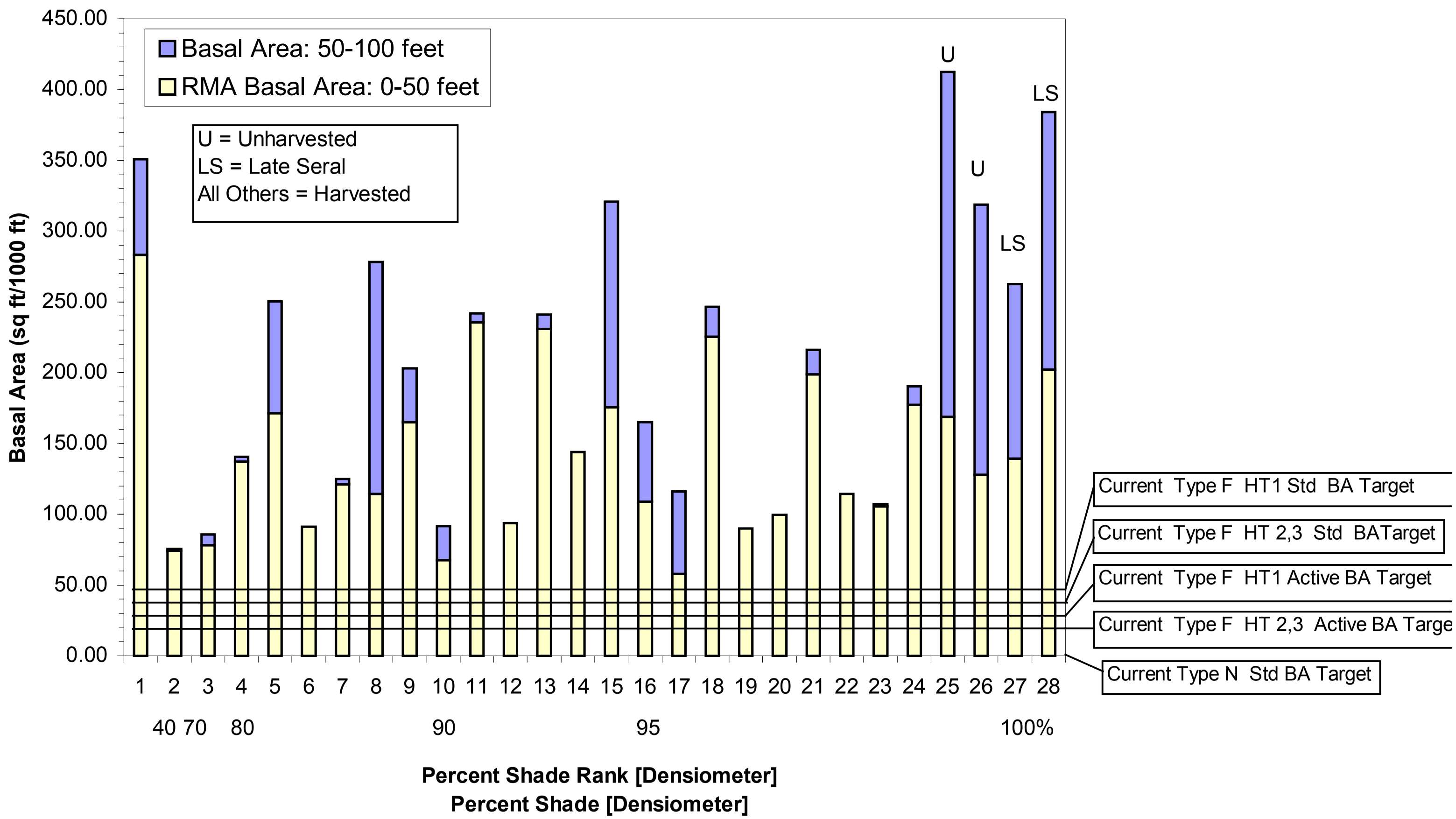


Figure I-14. E. OR Blue Mt: Large Streams
Buffer Width = 50ft

Figure I-15.   W. OR Coast Range Mountains: Small Streams (Shade Study Data: 1999)



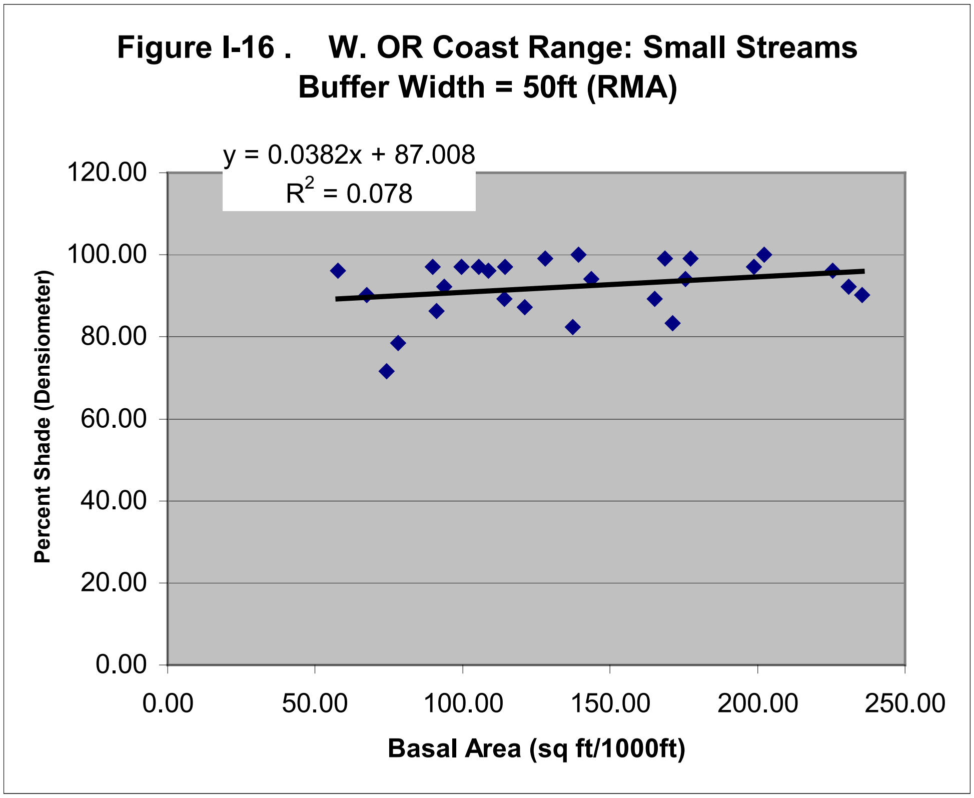


Figure I-16 . W. OR Coast Range: Small Streams
Buffer Width = 50ft (RMA)
y = 0.0382x + 87.008
R2 = 0.078
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Percent Shade (Densiometer)
0.00
50.00
100.00
150.00
200.00
250.00
Basal Area (sq ft/1000ft)

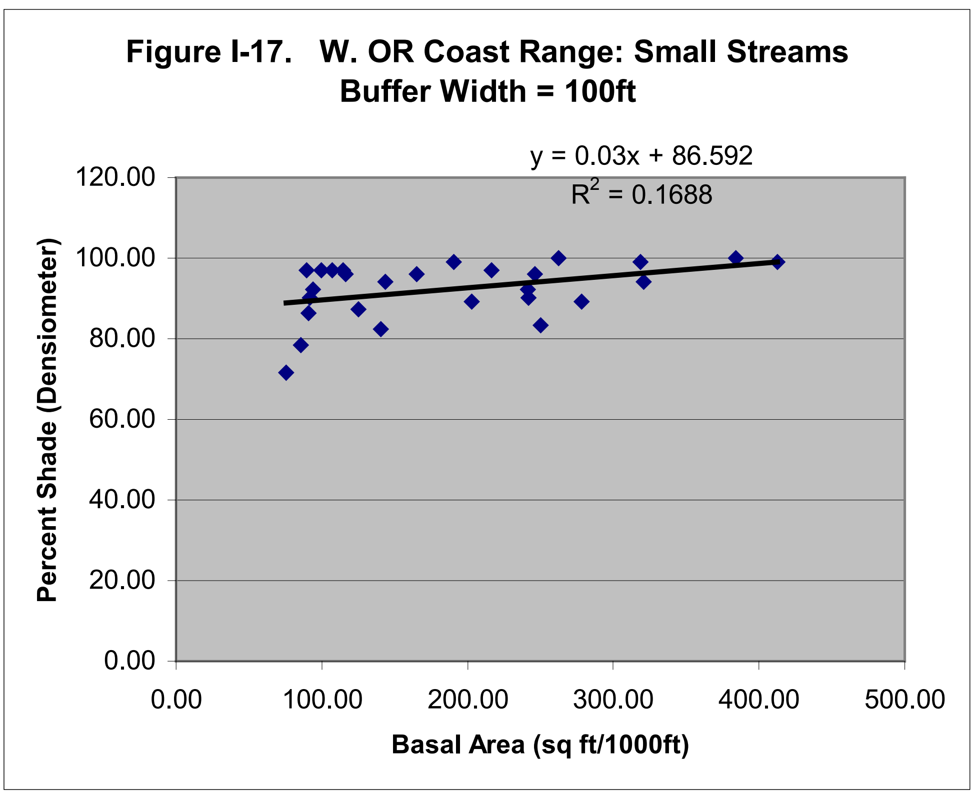


Figure I-17. W. OR Coast Range: Small Streams
Buffer Width = 100ft
y = 0.03x + 86.592
R2 = 0.1688
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Percent Shade (Densiometer)
0.00
100.00
200.00
300.00
400.00
500.00
Basal Area (sq ft/1000ft)

Figure I-18 W. OR Coast Range: Medium Streams (Shade Study Data: 1999)

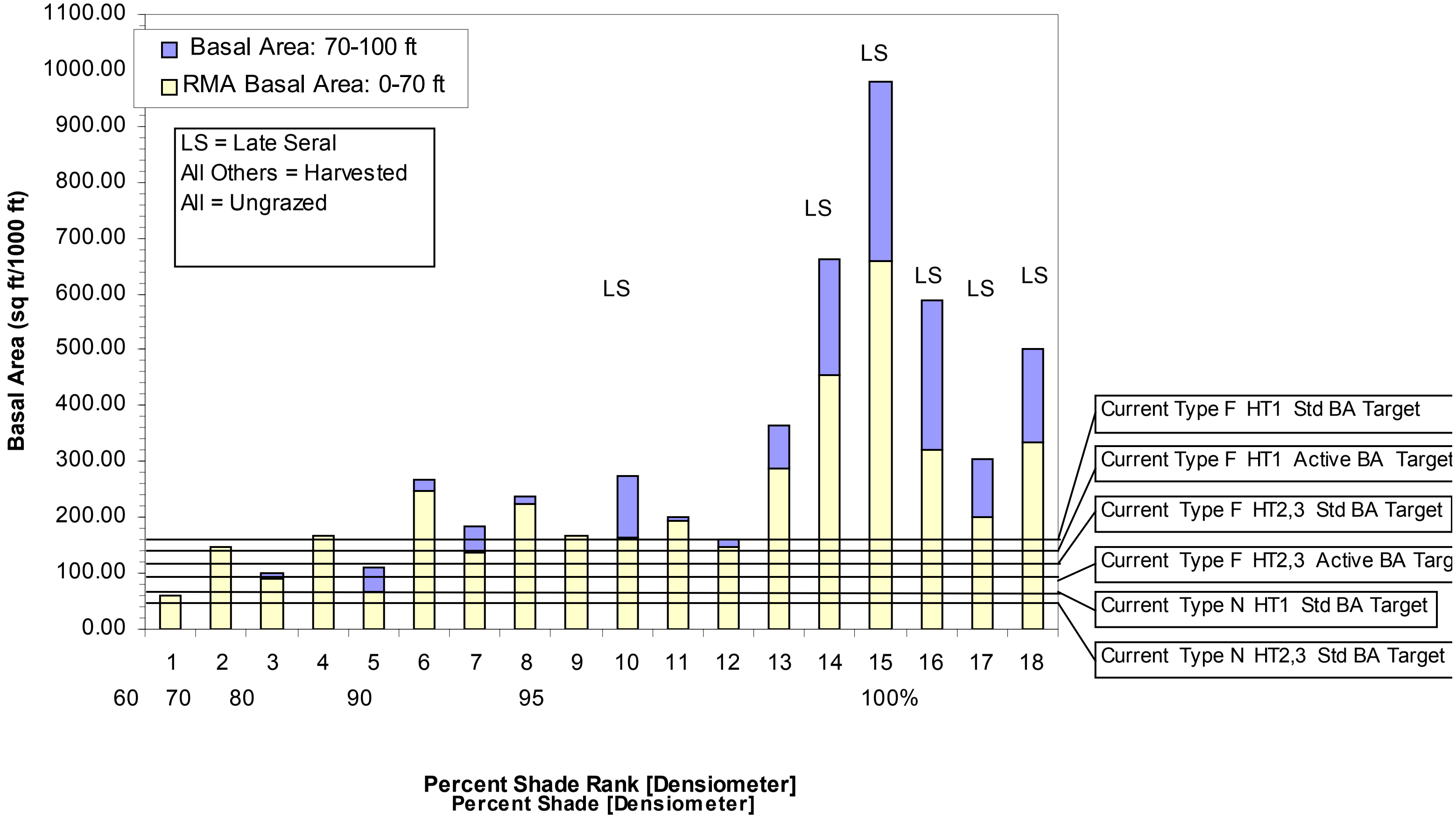


Figure I-19. W. OR Coast Range: Medium Streams Buffer Width = 70ft (RMA)

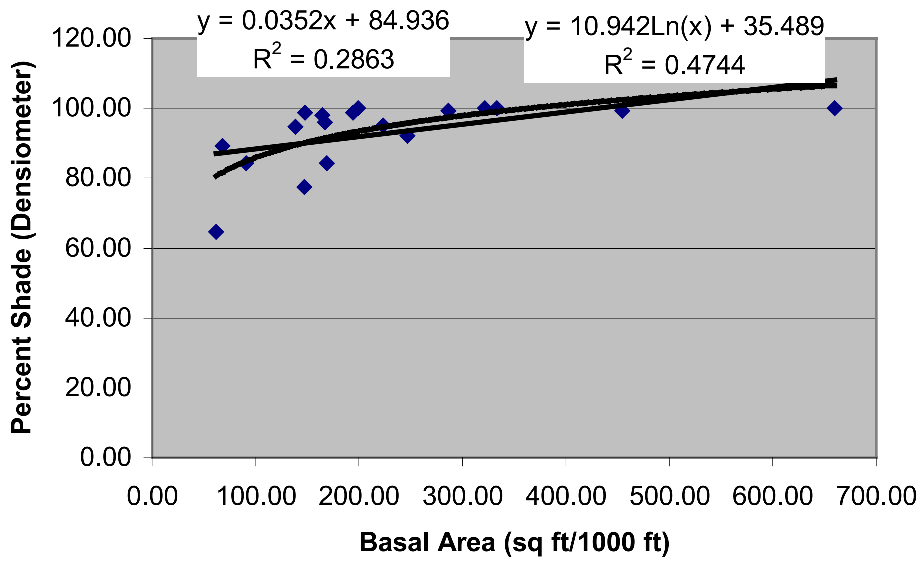


Figure I-20. W. OR Coast Range: Medium Streams Buffer Width = 100ft

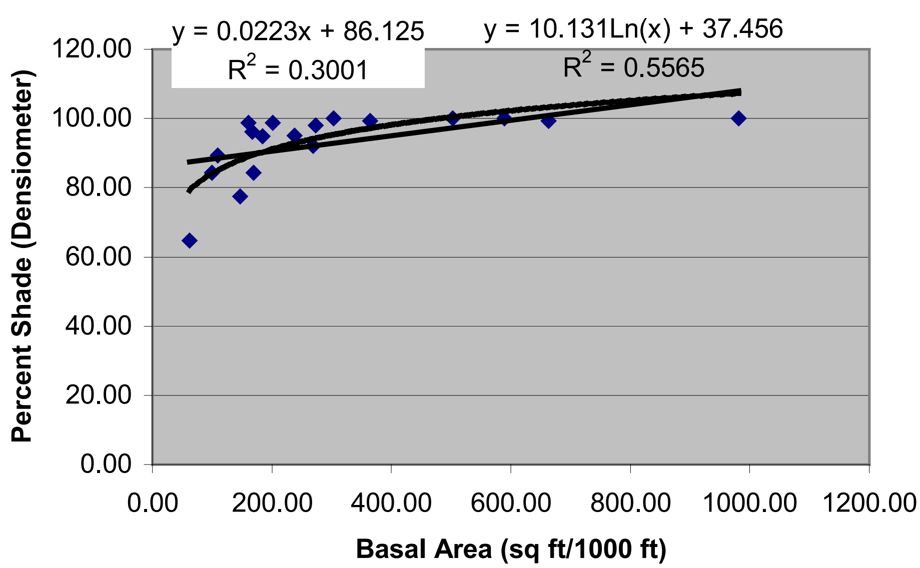
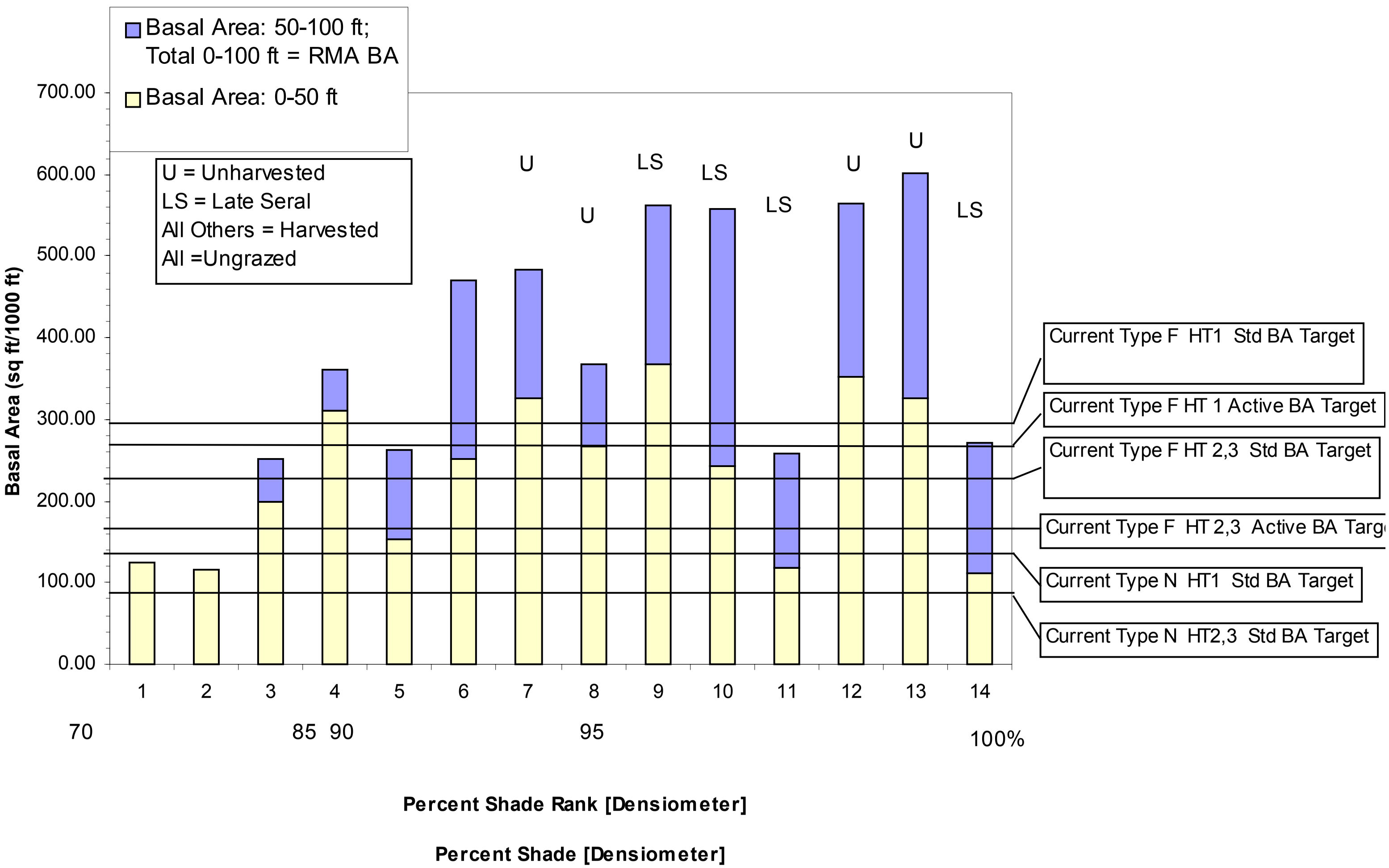


Figure I-21. W. OR Coast Range: Large Streams (Shade Study Data: 1999)



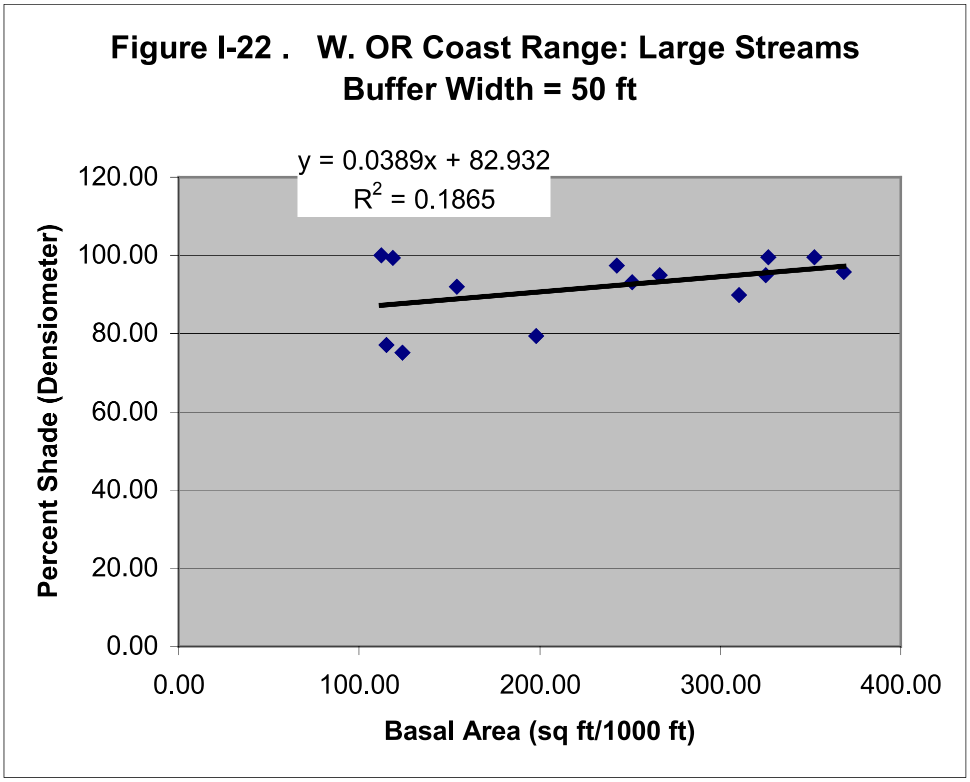


Figure I-22 . W. OR Coast Range: Large Streams
Buffer Width = 50 ft
y = 0.0389x + 82.932
R^2 = 0.1865
Percent Shade (Densiometer)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
100.00
200.00
300.00
400.00
Basal Area (sq ft/1000 ft)

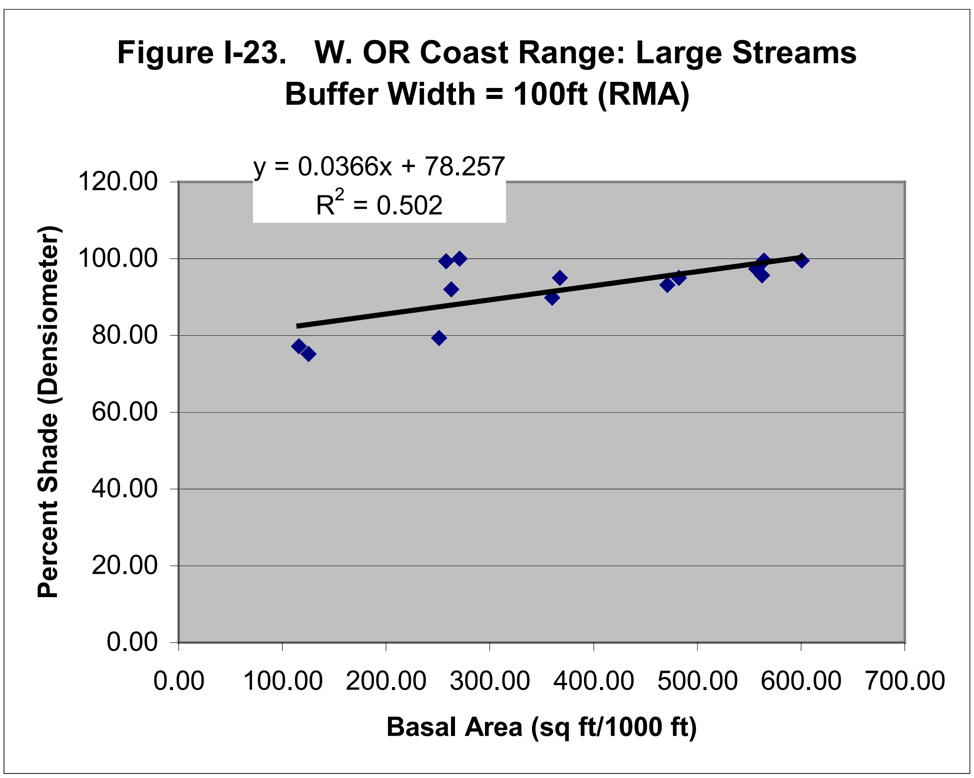
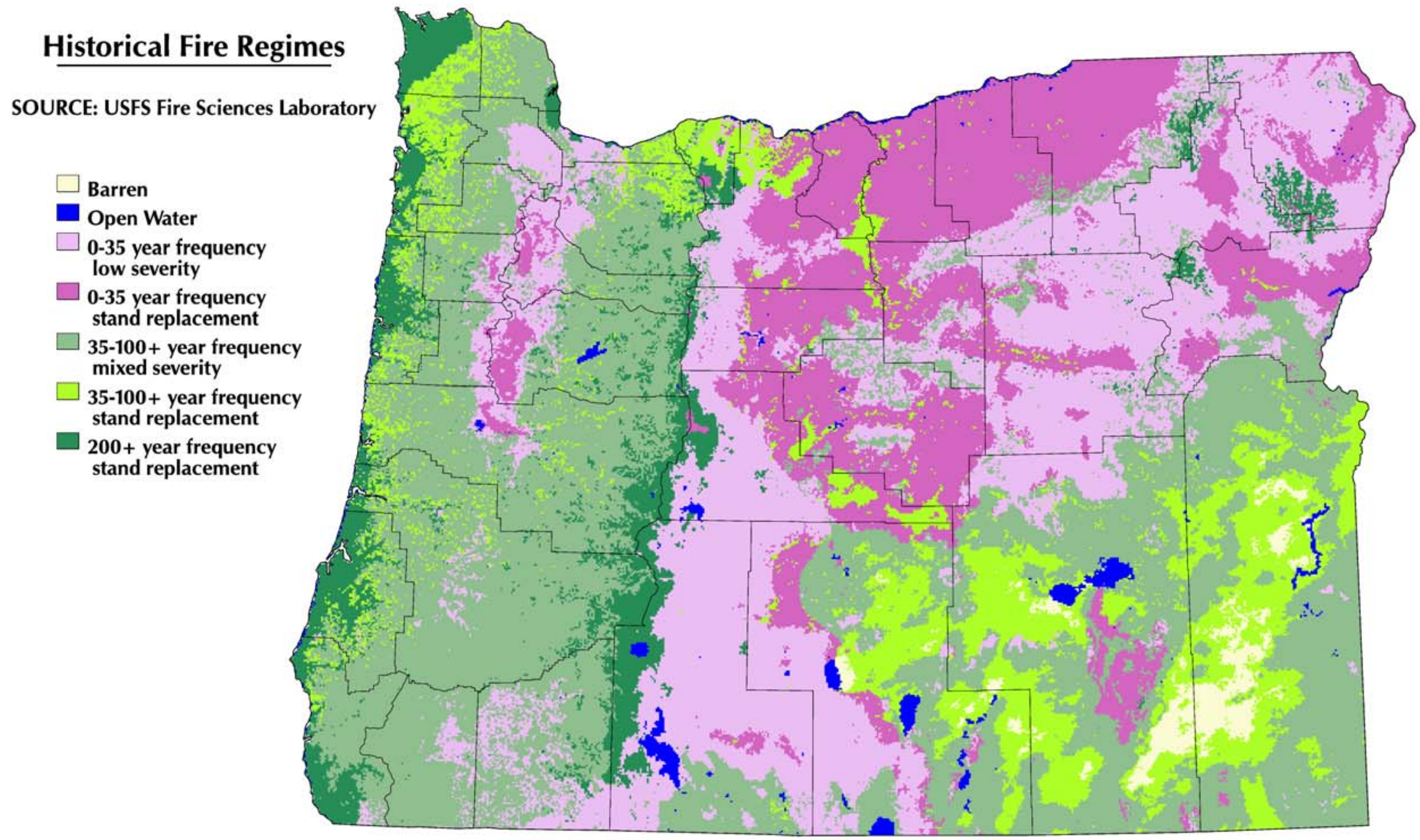
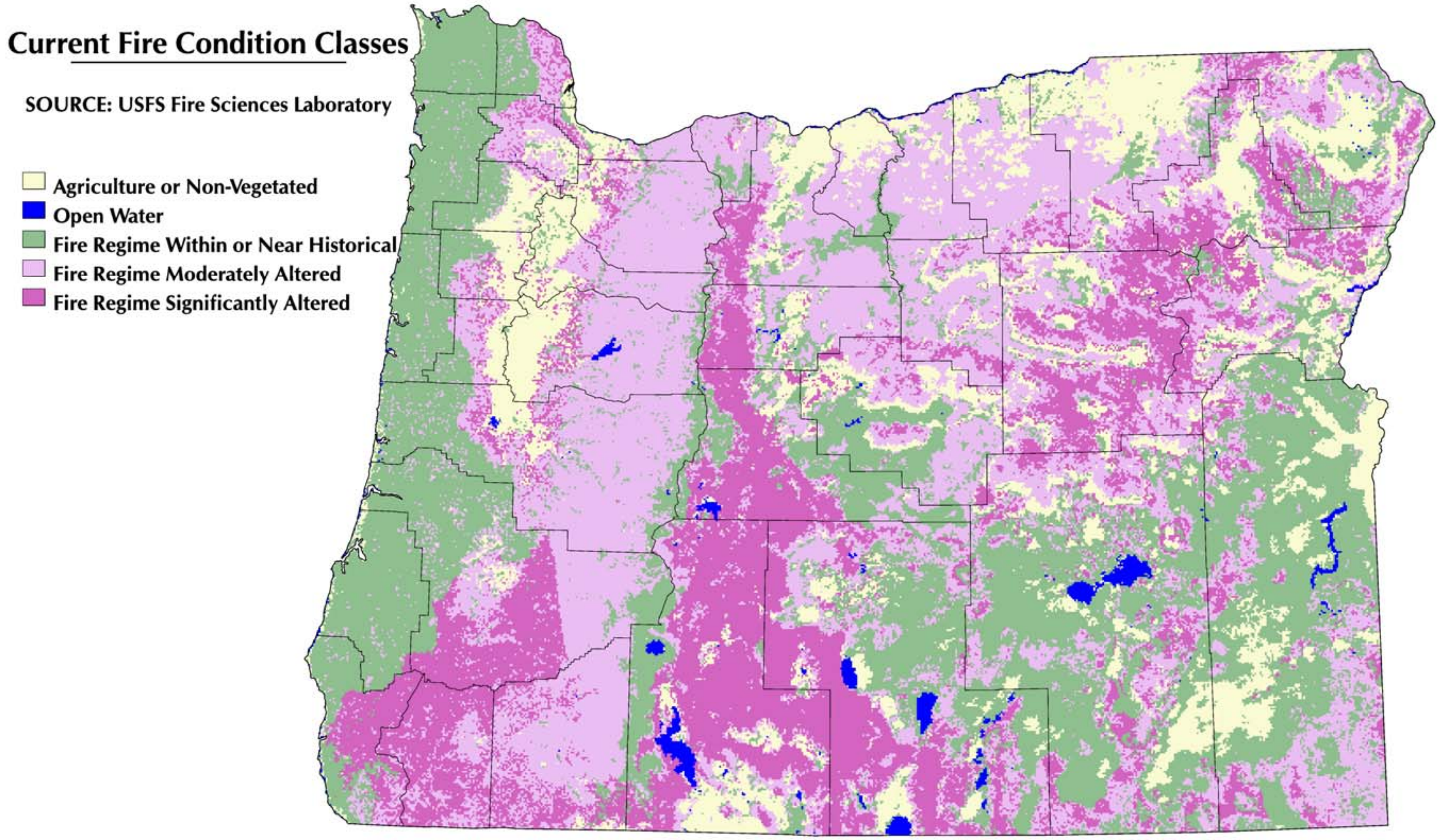


Figure I-23. W. OR Coast Range: Large Streams
Buffer Width = 100ft (RMA)
y = 0.0366x + 78.257
R^2 = 0.502
Percent Shade (Densiometer)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
100.00
200.00
300.00
400.00
500.00
600.00
700.00
Basal Area (sq ft/1000 ft)

APPENDIX J: HISTORICAL FIRE REGIMES AND CURRENT FIRE CONDITION CLASSES




Current Fire Condition Classes
SOURCE: USFS Fire Sciences Laboratory
Agriculture or Non-Vegetated
Open Water
Fire Regime Within or Near Historical
Fire Regime Moderately Altered
Fire Regime Significantly Altered

Oregon Department of Forestry
2600 State Street
Salem, Oregon 97310

Oregon Department of Environmental Quality
811 SW Sixth Avenue
Portland, OR 97204-1390