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Report of the Forest Practice Advisory Committee

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Introduction/Overview

The Oregon Plan for Salmon and Watersheds

The Oregon Plan for Salmon and Watersheds is conceived as a means to restore our native fish populations and their aquatic systems to productive and sustainable levels that will provide substantial environmental, cultural, and economic benefits.

The success of the Oregon Plan rests on the efforts and contributions of all Oregonians. Given the breadth of the undertaking, accomplishing its goals requires cooperation across the entire economic and geographic spectrum of the state. The Oregon Plan needs an engaged public concerned about the fate of the salmon and our watersheds. A cooperative undertaking, it melds the efforts of state, local, federal, tribal and private organizations, landowners and individuals.

Although it rests on a strong foundation of protective regulations, the Oregon Plan transcends regulation and encourages non-regulatory efforts to improve conditions for salmon and water quality. Some of the most important contributions to the Oregon Plan have been accomplished by private and quasi-governmental actions through watershed councils and voluntary restoration and enhancement activities.

The Oregon Plan spans the range of land uses and activities impacting salmon and water quality, including forest management, agriculture, fisheries, water management, hatchery management, industry and urban development. Governor Kitzhaber recognizes each of these interests and the roles of state agencies to achieve the goal of the Oregon Plan in his Executive Order No. EO 99-01 on the Oregon Plan for Salmon and Watersheds (Appendix 1). Many efforts have been launched to contribute to the Oregon Plan including watershed council plans and projects, Oregon's S.B. 1010 process dealing with the effects of agricultural practices on water quality, and forestland owner voluntary contributions. This report focuses entirely on commercial forest operations and forest practices.

The Ad Hoc Forest Practices Advisory Committee on Salmon and Watersheds

In the spirit of the Oregon Plan and in accordance with Governor Kitzhaber's Executive Order No. EO 99-01, the Board of Forestry created a diverse committee of Oregonians. The committee was charged with: (1) determining what, if any, changes to forest practices, both regulatory and voluntary, are necessary to meet water quality standards and to protect and restore salmonids; and (2) making specific recommendations to the Board of Forestry. The committee's Charter (see Appendix 1) sets forth its background and purpose, parameters and assumptions, charge from the board, membership, and roles and responsibilities.

The Ad Hoc Forest Practices Advisory Committee has thirteen members representing a diverse group of Oregonians who care deeply about our salmon and watersheds; small and large forest landowners, environmental and sports-fishing organizations, logging and commercial fishing interests, local government, and labor unions. The Committee met for a year and a half beginning in January 1999. The members include:

Ron Cease, Chair, Hatfield School of Government, Portland State University
Geoff Pampush, Oregon Trout
Dan Newton, Oregon Forest Industries Council

Paul Ketcham, Portland Audubon
Gary Springer, Oregon Small Woodlands Association
Bill Arsenault, Oregon Small Woodlands Association
Paul Heikkila, Commercial Fishing/OSU Sea Grant Extension
Bill Street, Labor/Machinist Union
Liz Hamilton, Northwest Sportsfishing Industry Association
Blake Rowe, Oregon Forest Industries Council
Sue Cameron, Oregon Counties
Tom Hirons, Associated Oregon Loggers
Mary Scurlock, Pacific Rivers Council

Committee members examined the scientific literature and monitoring results and heard from scientists and policymakers. They received and reviewed a report on forest practices from the Independent Multidisciplinary Science Team (IMST), a distinguished team of scientists that was established by the legislature to analyze and recommend the scientific basis for the Oregon Plan. The committee deliberated on a series of issue papers, sought scientific review of the issue papers, and debated options to achieve objectives relating to fish passage, landslides, roads, landscapes, and riparian functions. The issue papers were organized in a manner to help the Board of Forestry consider scientific, operational, economic and policy issues. The papers set forth a large number of options that were developed and considered by the committee.

Committee members traveled to both the eastern and western sides of the state where they examined forest sites, streams, riparian areas and watersheds, considered fish, water quality and forest management needs, gained a deeper understanding of the scientific issues, operational constraints, tradeoffs and discussed their points of view.

They met a total of 29 days with the first public meeting on January 14, 1999 and their last meeting on June 9, 2000. The meetings were long, often difficult, and thought provoking. Members devoted a significant amount of time learning about the complex interactions between terrestrial and aquatic habitat and the effects on water quality. The full range of options considered is shown in the issue papers. Following lengthy deliberations, the committee achieved consensus or strong agreement on 24 recommendations that included not only regulatory changes but also incentives and voluntary activities. On some recommendations, the views of individual committee members differed, and these differences are noted in the report.

The members of the committee believe their work is complete. The recommendations were supported by members of the committee in the spirit of making significant and positive contributions for salmon and watersheds. The committee members embarked on their task with the understanding that they were working to advance the Oregon Plan. The effort did not attempt to specifically address sufficiency for particular federal laws or regulations, such as the federal Endangered Species Act or Clean Water Act.

There are some follow-up actions that will need to be addressed by the Board of Forestry. These tasks are:

- Further exploration of incentives through the Board charging the Family Forestland Committee to explore and build on the incentive options developed by the FPAC.

- Directing the Department to work with interests in Eastern Oregon to develop riparian measures for eastern Oregon forests.
- Ensuring the rule proposals are supported by the findings required under ORS 527.714.

While there are often 13 different opinions among the committee members, it is fair to say that there are two dominant mindsets. These two mindsets reflect viewpoints regarding a range of issues and how facts are received and interpreted by the committee members. These two mindsets had differences in viewpoints about the desired future conditions, the acceptable levels of risk and the probability of adverse effects. There were also different views on the relative importance of unintended consequences - land use change, disincentives for doing management, and maintaining a viable forest-based economy. The facilitators, committee members, and staff worked diligently to create solutions that considered and balanced the range of viewpoints and that reflected a spirit of compromise.

Summary of Major Issues

In carrying out their charge, the committee chose first to review four major technical issues related to the protection and restoration of salmonids: fish passage, forest roads, landslides, and riparian function. With the September 1999 delivery of the IMST Report to the committee, a fifth issue, "Landscapes" was added for committee discussion.

Fish Passage

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. avoid warm water temperatures, find food, escape predators, avoid competition, etc.). 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. Loss of fish passage at road crossings and other human-caused barriers has many potential effects, including loss of habitat access and changes in fish genetics or community assemblages. "Impediment construction" has been identified as a major factor leading to the decline of salmonids in western Oregon. Fish passage blockages are a problem for virtually every type of land use with many of the most important barriers for salmonids being found on public roads and highways.

Forest 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, altering habitat, reducing growth rates, causing physiological stress, impairing homing instincts, and reducing feeding rates. Historically, forest roads (as opposed to timber harvesting) have been the primary source of sediment from forest management activities in the western United States.

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.

Landslides

Landslides are the dominant processes for erosion 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 (typical dimensions of 3 feet in depth, 30 feet in width, and 40 feet in length), and 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. Landslides can be both beneficial and detrimental to aquatic habitat. For example, they can deliver needed large wood and gravel that will benefit aquatic habitat, but they can also deposit sediment that will clog spawning beds.

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.

Riparian Function

Large wood, shade (stream temperature), bank stability, litterfall, sediment filtration, and floodplain processes are all riparian functions in forests. While some or all of these functions may be provided for either directly or indirectly by the current forest practice rules and Oregon Plan voluntary measures, large wood, bank stability and stream temperature are the primary functions that the rules and measures are designed to address.

Large wood (also referred to as large woody debris; coarse woody debris; large organic debris) is an important component of salmonid habitat. 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. Large wood loading of streams has been correlated to winter survival of juvenile salmonids and can increase fish numbers within a given watershed. Reductions in large wood will often result in habitat simplification, which has been shown to reduce the diversity of fish species.

Stream temperature is an important component of fish habitat and has a direct effect on the growth and survival of salmonids. The effect on fish of changes in stream temperature 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. The various physiological and ecological processes of salmonids that are affected by temperature are well documented. Exposure to temperatures above optimum levels has the potential to adversely affect salmonid survival and recovery. The presence of cool-water refugia can help salmonids avoid areas with adverse stream temperatures and help sustain a population of sensitive species. When ambient stream temperatures are too warm, sensitive aquatic species can inhabit these patches of cool water habitat. Deep pools, cool springs, subsurface flow, and the junction of cooler tributary streams are all examples of cool-water refugia.

Landscapes

The IMST Report includes recommendations of which most could be considered within Oregon's current policy and socio-economic frameworks. One of their two longer-term policy recommendations is that Oregon should develop a new policy framework to encompass landscape (large watershed) level within the range of wild salmonids in Oregon.

The IMST report recommends a number of landscape elements that the Committee considered (see Appendix 2- IMST Report). The committee devoted one full meeting to hearing scientific and policy information on this topic and discussing the issue of "landscapes." During this meeting the committee sought further advice from the IMST Chair about the landscapes' recommendation. Based substantially on input from the IMST Chair and the other participants at the meeting, the committee concluded that this was a longer-term issue outside the sphere of influence of the committee. Therefore, an issue paper was not developed on this particular issue and the committee chose to recommend that the issue be moved forward to other policy-making bodies, including the Board of Forestry, for future action. The recommendations include a number of specific actions to help facilitate the development of landscape approaches.

Incentives

The committee discussed many methods to implement its recommendations. Among these methods were a number of incentive-based efforts. However, the committee recognized that many of the incentive-based methods need further development and that additional ideas are needed to help balance the regulatory recommendations that it has proposed. Therefore, the committee recommends that incentives be further explored through the Family Forestland Committee being charged by the Board to explore and build on the incentive options developed by the committee.

Development of the Issue Papers

The committee developed an issue paper for each of the four major technical issues, outlining the current scientific findings, watershed-scale effects, a description and evaluation of current applicable voluntary and regulatory measures, and suggestions for possible additional voluntary and/or regulatory measures. Each paper was peer reviewed by a number of scientists from across the Pacific Northwest with expertise specific to the issues, and their comments were reviewed and utilized by the committee. The papers also included the analyses and recommendations of the Independent Multi-disciplinary Science Team related to the four issues. The papers served as the basis for evaluating the sufficiency of current voluntary and regulatory measures in maintaining water quality and protecting and restoring salmonids.

Out of these papers came a list of possible options designed to address those issues identified within the papers as opportunities to improve on existing measures. The committee spent many meetings discussing the four major issues and then developing and evaluating the various options under each issue. These papers serve as a permanent record of the breadth of technical information used by the committee in determining what specific recommendations were to go forward to the Board of Forestry.

Executive Summary
Forest Practices Advisory Committee on Salmon and Watersheds
Consensus and Strong Agreement Recommendations

The following is a summary of the recommendations that have received either "consensus" or "strong agreement" among committee members. "Consensus" support means all committee members present or represented by proxy at the meeting where the recommendation was discussed expressed support. "Strong Agreement" means no more than three of the thirteen-committee members expressed non-support. "Majority " support referenced in the body of the report means at least seven committee expressed support, but four to six committee members expressed non-support.

Fish Passage

Recommendation A: The forest practice rules should be revised to ensure that if an upstream reach has the natural capacity to be a fish-bearing stream but is currently a nonfish-bearing stream because of a stream crossing structure that cannot pass fish, the reach will be classified as a fish-bearing stream. The extent of potential fish use upstream of the blockage will be determined using guidance to be developed based on field fish presence surveys and interim criteria. *(See Option #1 under Fish Passage for more information)*

Recommendation B: Forest landowners should accelerate the identification, prioritization, and restoration of existing stream crossing structures (typically culverts) that currently do not pass fish on streams inhabited at any time of the year by anadromous or game fish species or fish that are listed as threatened or endangered species under the federal or state endangered species acts.

A new source of funding is necessary to encourage stream crossing repair work. The new funds could be generated based on forestland ownwership, on timber harvested, on acres harvested, on road miles, or through some other mechanism (a preference for a per acre assessment based on forestland ownership was expressed by the committee). Landowners could then apply for a credit against expenses incurred in voluntarily remediating legacy road and culvert problems. *(See Option #2 under Fish Passage for more information)* The funding mechanism would be phased out as landowners completed repair work.

Recommendation C: The forest practice rules should be revised to incorporate a physical habitat approach to designating fish use and non-fish use streams. ODF has developed interim classification guidelines to designate fish use based upon the physical characteristics of a stream. These guidelines were based upon fish presence survey data and could be used to classify streams that are fish use. The guidelines use either mapped or on-the-ground physical characteristics. The current stream classification rules would be amended to establish that fish use streams are any streams that meet the habitat criteria. The habitat criteria may need to be modified and improved based upon more recent and complete survey data. Key issues that will need to be addressed include the acceptable margin of error in applying a habitat model and opportunities for landowners to request field verification of habitat criteria. Fish presence survey

data, when available, will supercede the guidelines in designating fish or non-fish use. *(See Option #3 under Fish Passage for more information)*

Recommendation D: A funding source should be created for family forest landowners or the state should otherwise assist family forest landowners in obtaining funds from existing sources to expand the current voluntary road assessment effort to non-industrial private forestlands. This financial assistance would also be used to help family forest landowners replace stream crossings that are not adequately passing fish. *(See Option #4 under Fish Passage for more information)*

Forest Roads

Recommendation E: To address existing roads constructed using past practices or methods, such roads should be systematically evaluated and mitigated where appropriate for negative impacts or risks to:

1. Waters of the state;
2. Passage of juvenile/adult anadromous fish; and
3. Downstream passage of habitat elements.

"Other land-use" roads should use at least the same best management practices (BMPs) as required for forestlands.

The department should create specific road maintenance guidelines for high hazard locations, by developing and making available to operators and regulators improved guidance. The department should be given general authority to require additional cross drainage installation as a maintenance requirement prior to an operation when current road condition and a proposed use will impair water quality. *(See Option #6 under Forest Roads for more information)*

Recommendation F: Cross drainage structures on new roads should be installed so that the risk of sediment delivery to waters of the state from new roads is minimized.

While this is the current standard, department should provide better guidance and training for achievement of the rules. Current rules provide authority for installation and maintenance of road cross-drains. Training and improved guidance would be developed and implemented for operators/landowners and regulators that would emphasize the need for adequate spacing and the proper installation of road cross drains.

The forest practice rules should be revised to better clarify the objectives for cross-drainage. For example, the rules might state that the objectives are to ensure that cross drains are installed in adequate numbers and in proper locations so that:

1. Road surfaces are protected from erosion and water retention;
2. Erosion of the roadside ditch is minimized;
3. Ditch water is not discharged onto unstable slopes; and
4. The amount of ditch water (and associated sediment) discharging directly into a stream is minimized. *(See Option #7 under Forest Roads for more information)*

Recommendation G: The forest practice rules should be modified to more specifically address wet-weather hauling. This should include development of two criteria, probably in rule form, to:

1. Address road use in wet weather to ensure that durable surfacing or other effective methods are used on road segments that can deliver sediment to streams; and
2. Require operators to cease heavy truck traffic on roads when the road surface is breaking down (only for segments that are delivering sediment to streams). "Breaking down" would be defined by both depth of ruts and by depth of muddy fine sediment on the road. *(See Option #8 under Forest Roads for more information)*

Recommendation H: The department should develop clear decision-making criteria for evaluating proposed road locations in areas where there is a high risk of landslides, surface erosion, or of direct physical alteration to streams, riparian areas, lakes or wetlands. The criteria should identify preferred locations and construction practices that will result in roads being constructed in a manner that results in the lowest overall impact to water quality and fish habitat while allowing the landowners to achieve their management objectives (Method 5). The criteria should also direct the Department of Forestry to not approve road construction or reconstruction in the sensitive areas described above, if viable alternatives exist. *(See Option #10 under Forest Roads for more information)*

Recommendation I: Means should be developed or provided for the movement of large wood and sediment downstream at those crossings which may otherwise restrict movement. The transport mechanisms for large wood and sediments may be either stream storm flows or channelized debris flows. *(See Forest Roads Option #12 for more information)*

Recommendation J: Improved cooperative road system planning, maintenance and use is needed between federal and private forest landowners. *(See Option #16 under Forest Roads for more information)*

Recommendation K: Future forest road best management practice compliance and effectiveness monitoring should be implemented within the context of the Forest Practices Program's strategic monitoring plan and prioritized in context with available monitoring resources and other monitoring needs *(See Option #18 under Forest Roads for more information)*

Recommendation L: Additional training on forest road construction and maintenance should be provided for landowners and operators. *(See Option #19 under Forest Roads for more information)*

Recommendation M: The forest practice rules should be changed to require prior approval for ground based harvesting on steep slopes where there is a significant risk of sediment delivery to streams. *(See Option #57 under Forest Roads for more information)*

Recommendation N: A road closure program should be developed that forest landowners, the Department of Forestry, and local law enforcement can use to limit public access onto sensitive road systems that have a high risk of delivering sediment to streams, or that directly impact aquatic habitat. (*See Option #59 under Forest Roads for more information*.)

Landslides

Recommendation O: All landslide prone locations (now called "high risk sites") should be identified prior to timber harvest operations. During the notification process, the department should inform the operator of the likely presence of high risk sites in the operation area, based on coarse screen maps. The operator would then be expected to more specifically locate sites within the operation area by field reconnaissance. There is also the expectation that "significant" areas of high risk sites which are not mapped will also be identified by the operator. *(See Option #45 under Landslides for more information)*

Recommendation P: The department should identify stream channels which are prone to debris flows and torrents. Identifying those channels which are capable of transporting large wood to Type F streams could make it possible to focus riparian prescriptions on those streams where greater benefit to aquatic habitats are likely.

The department should inform the operator during the notification process of the likely presence of debris flow prone channels, based on coarse screen maps. The operator would then be expected to more specifically locate debris flow prone channels by field reconnaissance. ODF would provide specific criteria to be used in field identification. *(See Option #46 under Landslides for more information)*

Recommendation Q: The locations most prone to landslides (now called "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 (Method 1) and a better case history basis for evaluating the effectiveness of those practices should be developed (Method 6). These standard practices are designed to minimize ground alteration/disturbance on high risk sites from logging practices. *(See Option #47 under Landslides for more information.)*

Recommendation R: It is important to leave trees or downed wood in locations where they provide wood to be moved by debris flows into fish-bearing streams.

To achieve this objective, it is realistic or appropriate to use a menu of potential methods to leave trees or downed wood, depending upon likelihood of wood delivery and operational efficiency. It is not appropriate to rely on a single strategy to provide this potential source of large wood. The operator should be required to select an appropriate option in cooperation with ODF. *(See Option #61 under Landslides for more information.)*

Riparian Functions

Recommendation S: The active placement of large wood or other structure in streams deficient in wood or other structure is necessary for short-term aquatic habitat improvement, but it should be done in a manner that still assures the timely achievement and maintenance of characteristics of mature forest conditions in the riparian management area in the longer term. A menu of methods should be developed to prioritize and guide placement of large wood. This

menu should include as one method placing wood along streams during an adjacent entry for harvesting. *(See Option #20 under Riparian Functions for more information)*

Recommendation T: Additional department resources should be allocated to monitoring the effectiveness of the water protection rules. At a minimum, current levels of monitoring must be maintained. Adequate resources should also be provided to enable the department to conduct effectiveness monitoring related to the large wood objectives of the Oregon Plan for Salmon and Watersheds and water quality standards, as well as continued best management practices compliance monitoring. Coordination with other agencies on monitoring projects is essential. *(See Option #30 under Riparian Functions for more information)*

Recommendation U: The State of Oregon should develop a clearer and more comprehensive policy on riparian management that addresses all land uses. The committee did not discuss whether such a policy should require uniform protection on all land uses. However, the policy should, at a minimum, establish a baseline standard for resource protection and both clarify and explicitly describe Oregon's expectations for different land uses if some land uses will be required to meet a higher protection standard than others. *(See Option #41 under Riparian Functions for more information)*

Recommendation V: The following list of changes are recommended to increase the protection and restoration of riparian functions. Further clarification and/or guidance on a number of these points will be needed to further develop these concepts.

1. Harvesting Cap 40%
   In western Oregon, manage any harvesting within the RMA so that the retained conifer basal area exceeds the basal area standard target, or 60 percent of the pre-harvest basal area, whichever is greater.

2. No Touch area½ of RMA
   The no-touch width will be equal to one-half the width of the entire RMA.

3. Largest Trees 10 out of 20 largest
   Retain 10 of the 20 largest trees per 1,000' outside of the no-touch width that will best achieve aquatic riparian functions. Subject to FPF approval, the landowner would identify tree locations in a written plan demonstrating how this objective will be met. There would be discretion to also consider operational issues and the value of the trees, as long as best achieving aquatic riparian functions remains the primary objective.

4. Type N Streams FPF discretion
   a. Small Type NT streams are: 1. Perennial Small Type N (temperature) streams that are tributary and contribute at least 30% of the flow to small and medium Type F streams and that have a drainage area larger than X acres (basin size to be set be georegion, 40 acres for the coast range). Initial classification will be based on basin size, but landowners may delist streams or stream segments verified as non-perennial. 2. Small Type N (torrent) streams with drainage basins greater than 30 acres, in which more than 75% of the basin has been mapped as "high" or

50% “extreme” debris flow hazard (by the State Forester) and which have a high probability of wood delivery to Type F streams.

b. Small NT stream protection: 1. Up to the first 500 feet of Type NT (temperature) stream above the confluence with a Type F will have a 50 foot search zone, each side. Within the search zone, retain 4 square feet of trees per each 100 feet of perennial flow (up to 500’) and all non-merchantable conifer on each side of the stream. Trees left along these streams to satisfy the basal area requirement can be counted as in-unit leave trees. 2. “Torrent” type NT streams will be protected as follows - FPF, working with the landowner, has discretion to direct retention of in-unit trees to 50 x 500’ search zone (each side).

5. In-growth 25% adjustment for small streams
The standard target will be recalculated for small Type F streams using the same per-acre basal area as large streams, minus 25 percent for in-growth. The standard target will also be recalculated for medium Type F streams, using the same per-acre basal area as large streams.

6. Riparian Specialist
The Oregon Department of Forestry will designate a riparian specialist in each administrative area who will be available to inventory and prepare riparian prescriptions for landowners, at their request. These specialists will be new positions funded by funds other than the harvest tax.

7. Similar Prescriptions for All Large and Medium Streams
Large and medium Type N stream prescriptions will be the same as the equivalent size Type F.

8. Monitoring
The effectiveness of the small Type N stream prescription will be a monitoring priority.

9. Alternative Vegetation Retention Prescriptions
The existing alternative vegetation retention prescriptions (e.g., hardwood conversions) may be applied to all riparian management areas (RMA’s).

10. Preventing Sediment Delivery
The purpose statement for harvesting rules will be modified to better describe the objective of preventing sediment delivery to channels. The current requirement not to locate skid trails within 35 feet of Type F or D streams will be extended to all streams. Skid trails will be defined as an excavated trail used to yard logs with more than one turn.

11. Measurement of Riparian Management Area/Channel Migration Zone
The riparian management area (RMA) will be measured from the current points of measurement except for areas designated by the State Forester as a channel migration zone (CMZ). A CMZ is an unconstrained reach of stream that in the judgment of the forester is likely to have channel movement that can go outside the RMA widths within the period of a rotation (50-100 years). Within the CMZ, the no touch area will be

measured from the high water mark of the channel (same as current rules). The outer edge of the CMZ will be based upon guidance to be developed by a technical committee. Retained trees in the CMZ shall be no less than the basal area standard target.

12. Type N and Small Type F Streams: Landowners would get credit for in-unit leave trees.

13. Conceptual agreement about the use of "stratification."
In recognizing that riparian stands are not homogenous and that applying a single target for the RMA can prevent appropriate management in patches with conifer "over" stocking, agreement was reached on the concept of stratification. The details of how to do it in the field are to be developed. Stratification could allow an RMA to be divided into segments with a different management approach applied to each segment; based on the specific conditions in the segment.

14. "Provide for placement of large wood" is supported as a concept.
(See "Subcommittee" Riparian Option under Riparian Functions for more information)

Landscapes

Recommendation W: The Board of Forestry should ask the Governor to:

- Convene a collaborative process for landscape scale approaches to protect and recover salmonids and provide and protect clean water across land uses and ownerships:

    1. Identifying and evaluating current policy frameworks and scientific findings related to landscape management;
    2. Developing common protocols for watershed assessment and monitoring;
    3. Review existing and proposed watershed assessment protocols and recommend a means to achieve an effective assessment;
    4. Identifying research needs, regulatory and non-regulatory policies, and technical methods to support landscape scale approaches; and
    5. Improving cooperative approaches and partnerships among local, state, and federal governments and private landowners.

- Strengthen "Oregon Plan for Salmon and Watersheds" support for basin and watershed scale assessment, collaboration, and restoration by:

    1. Linking funding support for OWEB projects to basin and watershed priorities and those projects that are supportive of the goals of the Oregon Plan;
    2. Increasing long term financial support for watershed councils and coordinators;
    3. Boosting funding to state agencies to enhance technical support to watershed councils and restoration activities of watersheds;
    4. Setting priorities, where possible, according to the identification of limiting factors on fish runs;

5. Assembling a local/state/federal team to solve watershed and landscape level problems that involve multiple governmental agencies. The team would recommend positive changes to reduce/eliminate duplication, do away with actions that are counter to the Oregon Plan, and improve communications. Where appropriate, non-governmental representatives should be included; and
6. Ensuring the long term viability of the Oregon Plan by implementing Executive Order EO99-01.

- Support increased funding for scientific research and the establishment of a natural resource research institute to address landscape/watershed scientific questions and Oregon Plan policy issues using a multi-disciplinary approach; and

- Strengthen policies to encourage maintenance of the forestland base and increase it through afforestation of suitable lands since forests provide the best and most essential habitat components for salmonids.

Recommendation X: The Board of Forestry should:

- Include the policy objectives of the Oregon Plan for Salmon and Watersheds as part of its next revision of the Board's strategic plan, *The Forestry Program for Oregon*;

- Investigate, develop, and promote incentives--such as expanding the federal Conservation Reserve Enhancement Program, providing financial assistance, using forest stewardship plans, and easing anti-trust restrictions—so as to encourage forest landowners to encompass broader landscape goals in their management plans; and

- Continue to investigate and analyze forest conditions across the landscape through:

  1. The Department of Forestry's Forest Assessment Project which has forged partnerships with Oregon State University and the Pacific Northwest Research Station; and
  2. Data and models developed in other projects such as the Umpqua Land Exchange and the Sierra Nevada Project.

Discussion of Consensus and Strong Agreement Recommendations

The committee identified and discussed over 60 recommendations. All of these recommendations are identified and discussed in each of the four issue papers (see Sections A – D). For the recommendations with consensus or strong agreement, this section provides detailed information about the recommendation, including its objective, methods for implementation, its benefits and costs, and resources needed for implementation.

Fish Passage Option #1: Riparian Functions Above Fish Impassible Stream-Crossing Structures

Objective:

To provide for riparian functions along stream reaches above fish impassable stream-crossing structures that have a high probability of recolonization by salmonids once the structure is replaced/improved.

Recommendation:

The Committee reached a consensus that the forest practice rules should be revised to ensure that if an upstream reach has the natural capacity to be a fish-bearing stream but is currently a nonfish-bearing stream because of a stream crossing structure that cannot pass fish, the reach will be classified as a fish-bearing stream. The extent of potential fish use upstream of the blockage will be determined using guidance to be developed based on field fish presence surveys and interim criteria.

Additional information on this option:

- In the future, when the barrier is removed, a process that field-verifies reoccupation and establishes the actual end point of fish is desirable and should be planned for. Such a survey could be conducted a set number of years after the barrier removal occurs.
- The Oregon Fish and Wildlife Commission and the Oregon Board of Forestry have entered into a Memorandum of Understanding which affirms the Board's role and the ODF's role in ensuring fish passage is provided when roads are constructed, reconstructed, or maintained in conjunction with commercial forest operations; and specifies under what conditions the statutory requirement to maintain fish passage may be waived by Oregon Department of Fish and Wildlife staff for activities associated with commercial forest operations regulated under the Oregon Forest Practices Act.
- **IMST recommendation #15** calls for culverts and other structures to be modified to permit the passage of juvenile and adult salmonids upstream and downstream at forest road-stream crossings.

Benefits:

The most important benefit of this recommendation is that reaches of a stream that may be reoccupied by fish once a barrier is removed will have retained vegetation to facilitate reoccupation and help maintain and restore good fish habitat over time. Increased riparian vegetation retention could, over time, help to maintain or improve water quality. This option could also remove a disincentive to replace a barrier in a timely manner. It may also remove an incentive to harvest a reach above the barrier before replacement. The option also eliminates an unfair dichotomy about how streams are classified. Currently, if fish presence surveys have not been conducted above a culvert, then 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 barrier, than the entire stream above the barrier is treated as a Type N stream.

Costs:

Landowners/Operators:	Significant, potentially high for some landowners.
State Government:	Potential reduction in harvest and income tax revenues.
Local Governments/Communities:	Potential reduction in tax and income tax revenues.

Additional harvest restrictions will be imposed for those stream reaches with a classification change from non-fish to a fish-bearing stream. Given the relatively large number of stream crossing structures that determine the end of fish use, the length of streams affected could be relatively significant. Based on current RMA widths, one additional acre of forestland would incur total or partial timber harvest restrictions for each 436 feet segment of small stream length reclassified as fish-bearing. Landowner costs, primarily in terms of reduced timber revenues, will be increased. Costs will vary significantly among landowners, and for some the cost could be significant. The actual costs will depend upon the stream length and the level of protection required. This option might also create a potential conflict between upstream and downstream neighbors (for example: where a downstream landowner is reluctant to replace the culvert, while the upstream owner is required to provide Type F stream protection).

Resources needed:

Rulemaking required

Administrative actions required.

A quantitative cost assessment to identify acreage and timber values impacted by this option is needed.

Some form of tracking system will be needed to maintain the identity and location of stream crossing structures that are the end of fish use. In general, these data are available for completed surveys, but not for channels that have not yet been surveyed. Current stream classification maps could be used for this purpose. The interim classification guidelines should be reassessed as part of this process, and may need to be modified. This assessment would be based upon the additional survey information that has been collected since the original guidelines were developed.

Fish Passage Option #2: Restoring Fish Passage at Existing Forest Road Stream Crossings

Objective:

To facilitate the identification, prioritization, and restoration of existing stream crossing structures that currently do not pass fish.

Recommendation:

The committee reached a consensus that forest landowners should accelerate the identification, prioritization, and restoration of existing stream crossing structures (typically culverts) that currently do not pass fish on streams inhabited at any time of the year by anadromous or game fish species or fish that are listed as threatened or endangered species under the federal or state endangered species acts.

Twelve committee members (WS, DN, RC, BA, GS, SC, GP, BR, LH, PK, PH, MS) support the creation of a new revenue source to encourage stream crossing repair work. The revenue source could be generated on forestland ownership, on timber harvested, on acres harvested, on road miles, or through some other mechanism (a preference for a per acre assessment based on forestland ownership was expressed by the committee). Landowners could then apply for a credit against expenses incurred in voluntarily remediating legacy road and culvert problems. (Method 4). This method was initially developed by the committee members representing OFIC and their support of the method was subject to the following five conditions:

1. It being part of a final package of consensus proposals recommended by the Forest Practices Advisory Committee to the Board of Forestry.

2. Agreement among industrial and non-industrial forest landowners on an acceptable taxing mechanism to present to the Legislature as soon as possible.

3. Agreement on a non-bureaucratic, easy-to-administer, landowner-friendly reporting process to certify tax credit-eligible remediation projects. For example, the tax credit form could be the Oregon Watershed Enhancement Board Reporting Form (appropriately modified if needed), with project acceptance by the Department of Forestry and financial audit by the Department of Revenue.

4. When/if the Department of Forestry certifies that remediation of legacy road and culvert problems on a given ownership or ownership block is not needed, or has been completed and no further work is needed, additional taxes for this purpose associated with such ownership would not be assessed.

5. This method replacing and not be in addition to other methods considered under this option (Methods 1, 2, and 3).

Seven committee members (RC, GP, BA, SL, MS, LH, PK) support requiring landowners to inventory fish passage barriers and that such barriers be repaired within a specified time period. The survey could be required over a four-year period and the remediation of fish passage problems completed over a ten-year period (Method 2). Other committee members believe Method 4 is a preferable mechanism to achieve the option objective. It was also pointed out that many landowners are already doing this work voluntarily under the Oregon Plan on very similar timelines. Other landowners may need financial assistance to implement this method.

Six committee members (GP, RC, SC, JS, PK, LH) support requiring that fish passage be restored for any culvert on a road that is within an active harvest operation within one-year after completion of the harvest (Method 1). Other committee members opposed this method as an arbitrary constraint on a landowner's ability to prioritize work, i.e. the highest priority culverts are not necessarily associated with active harvesting. Focusing limited funds on harvest units means higher priority work will not be done. One member stated that the application of this method should be limited to "core areas" or other critical areas.

Four committee members (RC, SC, LH, PK) support the creation of a support service within the ODF for road assessment information. This non-regulatory service would catalog potential fish passage culverts and aid in design standards and in obtaining stewardship grant money, if needed (Method 3). One committee member suggested that the method collect data on a watershed basis. Another member said this method could not stand alone and would have to be combined with other methods. A third member suggested that cataloging may be less important than other tasks, such as aiding in design standards, and implementation and compliance with written plans. Other committee members opposed establishing major new data collection and management function for the department. They also stated such a process should be driven solely by landowner demand for the service. It was also not clear how this method would support the highest priority repair work getting done.

Additional information on this option:

- A large number of stream crossings in Oregon currently do not pass juvenile and adult fish up and downstream.
- Protocols for road assessments have been developed, as have criteria for fish passage. Recent training efforts have been implemented to improve the technical understanding of the design criteria.
- When culverts are replaced on Type F streams under existing rules, written plans are required and some level of design review service is provided for forestlands.
- New or replaced culverts on Type F streams are required to pass both adult and juvenile fish.
- Many landowners are participating with watershed councils to help establish restoration priorities and facilitate grant writing.
- Through the Oregon Plan, OFIC landowners statewide have already implemented a voluntary program to identify risks from roads and to address those risks. The objectives of this program are to:
    1. Implement a systematic process to identify road related risks to salmon and steelhead recovery;

2. Establish priorities for problem solution; and
3. Design and implement actions to reduce road related risks.

- This option is aimed at accelerating culvert replacement above what is currently being done, especially for family forest landowners who often do not have adequate resources to address this issue.
- There are a number of different ways to implement this option. Either a rule-based or voluntary approach could be used.
- For Method 3, there are a number of possible ways of providing a "service" to support road assessment and mitigation. Information could be forwarded to Watershed Councils to be incorporated into watershed assessments and action plans.
- The Method 4 tax program would remain in effect for no more than ten years -- the original time line anticipated for the voluntary legacy roads and culverts commitment made by OFIC landowners. Owners of private forestland who are not OFIC members could choose to either pay the tax or receive a tax credit by addressing legacy problems on their land. Tax revenues collected that are not "refunded" through the tax credit program would be deposited in a special account within the state's watershed enhancement fund. Revenues in the special account would be used exclusively to address legacy road problems on forestland.
- If Method 4 was based on a harvest tax, a sufficient carry-forward and carry-back provision would be included to ensure that infrequent harvesters could take advantage of the tax credit.
- Method 4 could be further developed to address sedimentation issues in eastern Oregon, while focusing on fish passage issues in western Oregon.
- Related issues to this option include the occurrence of forest roads where the maintenance responsibility involves more than one party and poorly maintained public roads that cross private property.
- **IMST recommendation # 15** calls for culverts and other structures to be modified to permit the passage of juvenile and adult salmonids upstream and downstream at forest road-stream crossings.

Benefits:

Method 1: Linking fish passage restoration activities to an active harvest operation would accelerate culvert replacement and tie restoration timing and location to activities that produce revenue.

Method 2: Requiring inventories and remediation activities within a specified time period provides for some flexibility for the landowner.

Method 3: Creating a support service will aid in the tracking of culvert work progress and provided assistance to landowners that lack adequate resources, specifically family forest landowners. This will also potentially aid in the prioritization of culvert work for watershed councils and allow for the more efficient use of limited resources.

Method 4: This tax brings fish passage to every landowner's attention. It rewards actual work and allows exemption when work is complete. This program could be expanded to other land uses.

Costs:

Landowners/Operators:	Significant, potentially high for some landowners. Short- and long-term costs will be increased for landowners with some of these approaches. A key factor in determining costs to a individual landowner will be the number and type of stream crossing structures on their ownership currently not adequately passing fish. Method 1: Linking fish passage restoration activities to an active harvest operation may draw resources away from other higher culvert and road priorities. This would require shifting landowner resources from other actions that may have greater benefits to fish. Method 3: ODF will need additional resources to build and maintain a support service for road assessment information and the personnel necessary to manage such a service. It isn't clear how the data might be used to improve outcomes over current systems. Method 4: A well designed tax program would result in low or no increase in taxes for landowners who aggressively address fish passage barriers on their ownership.
State Government:	Potentially significant administrative costs to implement Methods 3 and 4. Methods 1 and 2 may also increase costs for monitoring and evaluating stream crossing improvements.
Local Governments/Communities:	Insignificant, except as a forest landowner.

Resources needed:

New or amended rules and/or legislation will be needed, as well as resources to monitor the completion of stream crossing inventories and the effectiveness of the repairs to fish passage barriers. Multi-land use inventories of problem culverts and relative length of habitat above the problem barrier could be needed for some methods. Resources to coordinate restoration efforts through ODF, ODFW or a watershed council are needed. For some methods, funding may be needed to assist family forest landowners.

Fish Passage Option #3: Classifying Fish Use Streams Based on Physical Habitat Criteria

Objective:

To provide a more effective and efficient means of classifying streams for "fish use."

Recommendation:

Twelve of the 13 committee members (RC, BA, DN, BR, GS, WS, SC, MS, PH, GP, PK, LH) recommend that the forest practice rules be revised to incorporate a physical habitat approach to designating fish use and non-fish use streams. ODF has developed interim classification guidelines to designate fish use based upon the physical characteristics of a stream. These guidelines were based upon fish presence survey data and could be used to classify streams that are fish use. The guidelines use either mapped or on-the-ground physical characteristics. The current stream classification rules would be amended to establish that fish use streams are any streams that meet the habitat criteria. The habitat criteria may need to be modified and improved based upon more recent and complete survey data. Key issues that will need to be addressed include the acceptable margin of error in applying a habitat model and opportunities for landowners to request field verification of actual fish presence. Fish presence survey data, when available, will supercede the guidelines in designating fish use.

This recommendation does not address the level of protection that should be provided to different types of streams. Some members supporting this option do not endorse using fish use as the main determinant of riparian protection levels.

Additional information on this option:

- 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 ($500,000 per biennium, although costs are relatively low compared to the resources that may or may not be retained based upon the results).
- ODF funded 22 survey crews in 1998 and 14 in 1999; however budget shortfalls prevented the fielding of any crews in 2000.
- Fish presence surveys are becoming more restricted due to the listing of fish under the federal ESA.
- The surveys also provide useful information to identify barriers to fish passage, identify unmapped stream channels, identify restoration opportunities, and create a baseline of fish distribution information. However, surveys can produce unreliable results when fish populations are depressed or there are other environmental factors such as drought or extreme flows.

- The survey-based approach potentially reduces the amount of fish habitat maintained over time. This can occur where salmonid habitat in a given stream reach may not be maintained as well as it might under a Type F classification over time because fish were not present at the time the fish survey was conducted.

- Data indicate that models used to predict fish use in gentle topography have better predictive ability than models applied in steep topography. In either case, a policy choice must be made concerning the acceptable predictive ability. A more conservative model (error on the side of over-predicting fish habitat) may be acceptable since the rules would also have a process to field survey at the initiative of the landowner.

- Stream reaches capable of supporting fish above impassible stream crossing structures would be classified as Type F under Fish Passage Option #1.

Benefits:

This recommendation will potentially increase the amount of habitat available to salmonids over time by requiring the maintenance of riparian management areas in stream reaches that may have historically supported salmonid populations. Funds currently used to conduct the surveys can be partially allocated to other needs/activities. The recommendation may reduce classification problems resulting from survey errors or other survey biases. The recommendation provides an option if the listing of fish precludes the use of efficient survey methods (electroshocking).

Costs:

Landowners/Operators:	Significant, but highly variable among landowners.
State Government:	Insignificant, if existing funding for fish presence surveys is maintained and reallocated. Potential reduction in harvest and income tax revenues.
Local Governments/Communities:	Potential reduction in tax and income tax revenues.

Landowner costs will potentially be increased since additional harvest restrictions will be imposed for those stream reaches where there is a stream classification change from nonfish-bearing to fish-habitat. The other values of the surveys such as identifying barriers to fish passage, unmapped stream channels, and creating a baseline of fish distribution information will be lost. Modeling error could result in either inadequate protection for some fish-use streams or unnecessary costs to landowners.

ODF fielded 13 survey crews in 1999. Budget reductions will result in no Forest Practices Program funds for fish presence in 2000.

Resources needed:

Administrative actions and potential rulemaking required.

A quantitative cost assessment to identify acreage and timber values impacted by this option is needed.

The interim classification guidelines will need to be reviewed and revised to develop predictive models for fish use. Agreement will be needed about the acceptable error rate. Classification maps will need to be updated. A choice will also need to be made when the classification change would occur and whether ODF, ODFW or the landowner will physically survey the stream or apply the mapped-based approach. The choice might well be different based upon topography or region. Resources to provide for an appropriate level of field and guideline verification are necessary.

Fish Passage Option #4: Funding Source for Family Forestland Road Assessments and Stream Crossing Replacements

Objective:

To identify and restore fish passage on family forestlands.

Recommendation:

Eleven committee members (PK, MS, RC, LH, SC, GP, BA, WS, GS, PH, TH) recommend a funding source be created for family forest landowners or that the state otherwise assist family forest landowners in obtaining funds from existing sources to expand the current voluntary road assessment effort to non-industrial private forestlands. This financial assistance would also be used to help family forest landowners replace stream crossings that are not adequately passing fish.

Two members could not support this option objective unless the incentives applied to all forest landowners.

Eight members (RC, LH, PK, SC, BA, BR, GS, WS) support the establishment of a capital investment loan program like the Forest Resource Trust that would provide a low cost loan to family forest landowners for road and culvert repair that would be repaid at the time of a harvest (Method 4). Some members were skeptical that General Funds would be available for this method and that another source would need to be identified.

Seven members (PK, RC, LH, MS, SC, GS, BA) support providing a tax credit for culvert restoration for the next ten-year period that would provide a credit for replacement of culverts that would restore "high" priority habitat (Method 1). One member was concerned that the tax credit remain less than 100 percent. Another member questioned whether the tax credit would motivate new or different restoration efforts and was concerned that otherwise bad stewards could still be rewarded. Two members could not support this option objective unless the incentives applied to all forest landowners.

Seven members (RC, SC, GP, MS, BA, GS, WS) also support establishing a combined account for culvert replacement utilizing earmarked Ballot Measure 66 funds, ODFW Restoration and Enhancement funds, a new fishing license surcharge, public and landowner contributions, and/or federal funds (Method 3). The sources and proportions of source funds raised questions and concerns by some committee members. Two members could not support this option objective unless the incentives applied to all forest landowners.

Five members (SC, BA, RC, GS, WS) support floating a bond issue that would be repaid with Ballot Measure 66 funds to provide a specific account for culvert replacement (Method 2). The committee members expressed concerns and questions regarding mechanisms for bond repayment.

Additional information on this option:

- This option can be compared with the existing Forest Resource Trust which provides financial assistance to forest landowners desiring to reforest underproductive lands through long-term, below market rate loans.
- Some committee members support a menu of methods be offered to forest landowners.
- The proposed methods would need thresholds for high priority habitat to be set based upon factors including size of stream, stream gradient, type of habitat restored, and length of habitat with restored access.
- For Method 1, the tax credit would sunset in ten years and replacement would then be at the cost of the landowner.
- The riparian specialists that would be added to ODF staff under the Riparian Functions options could help identify needs and implement this option.
- **IMST recommendation #15** calls for culverts and other structures to be modified to permit the passage of juvenile and adult salmonids upstream and downstream at forest road-stream crossings.

Benefits:

This option would provide a funding mechanism to accelerate culvert replacements on family forestlands. Since family forestlands tend to be lower in a basin and are often located along larger and lower gradient systems favored by coho salmon, access to substantial overwintering coho habitat might be restored.

Costs:

Landowners/Operators:	Minor.
State Government:	Potential increase in workload for the Forestry Assistance Program of the Department of Forestry. Funding sources or tax credits could reduce funds available for other state programs.
Local Governments/Communities:	Insignificant.

New funding would be needed and may draw resources away from other higher priority state programs. Ideally, the direct costs to family forest landowners would be minor.

Resources needed:

Possibly legislation, funding sources, and a prioritization system.

Forest Roads Option #6: Systematic Evaluation and Mitigation of Existing Substandard Roads

Objective:

To address existing roads constructed using past practices or methods. Existing roads are to be systematically evaluated and mitigated where appropriate for negative impacts or risks to:

1. Waters of the state (turbidity/sedimentation);
2. Passage of juvenile/adult anadromous fish;
3. Downstream passage of habitat elements (wood and gravel).

Recommendation:

The committee reached consensus on the option objective.

The committee recommends that "other land-use" roads should use at least the same BMPs as required for forestlands.

The committee reviewed seven methods to achieve this objective.

Consensus was reached that the department should create specific road maintenance guidelines for high hazard locations, by developing and making available to operators and regulators improved guidance (Method 5).

Consensus was also reached that the department should be given general authority to require additional cross drainage installation as a maintenance requirement prior to an operation when current road condition and a proposed use will impair water quality (Method 7).

Other methods were considered which received less than consensus support:

With funding available and appropriate criteria in place, eight committee members (BR, PK, PH, GP, SC, BA, RC and DN) would support the creation of financial incentives, such as a tax credit to encourage vacating roads in areas where risk to water quality and aquatic habitat is greatest (Method 4).

Seven members (PK, GP, PH, MS, LH, -- plus RC, SC if voluntary) supported landowners completing road inventory and mitigation work within operation areas, and potentially also along the haul route at the time of harvest (Methods 1 (operations area) and 2 (haul route)). ODF and the operator would review roads within the harvest unit, and apply appropriate mitigation. Those not supporting are methods expressed concerns that they may not focus on sites which are a high priority for improvement. Mitigation would be a function of where an operation happens to be instead of where the greatest risk to natural resources may be.

Seven committee members (PK, GP, MS, LH, PH, -- plus RC, SC only if voluntary) supported landowners developing and implementing a maintenance plan by ownership (Method 3). This would include a systematic road survey to identify and prioritize road maintenance needs, similar to current Oregon Plan Road Hazard and Risk Reduction project. Those not supporting this method state that it is already being implemented through the OFIC Road Hazard and Risk Reduction Project; and that resources used to develop the plan will be diverted from doing on-the-ground work.

Five members of the committee (MS, LH, SC, GP, RC) support the prioritization of road maintenance and repairs, with those roads that exist on high risk sites being given a high priority (Method 6). Two other members did not support making the high risk site designation an automatic trigger for high priority maintenance and repairs.

Additional information on this option:

This proposal includes a suite of improved practices that would be applied to roads needing improvement:

Past Practice	Improved Practices
1. Sidecast construction on steep slopes. 2. "High" fills. 3. Stream crossing culverts sized to pass up to a 25-year storm event. 4. Downstream side of stream crossing fills not armored with rip-rap. 5. Fills not designed to allow for overtopping by high stream flow. 6. Passage of large wood hindered by stream crossings. 7. Passage of gravels hindered by stream crossings. 8. Fish passage through culverts may be problematic for adults and juveniles. 9. Road cross-drain spacing may not meet standard spacing criteria: a. Ditch erosion b. Discharge onto steep slopes c. Ditch water drains directly into streams. 10. Unneeded roads abandoned "as-is".	1. Full-bench design, end-haul construction on steep slopes. 2. "Low" fills. 3. Steam crossing culverts sized to pass up to a 50-year storm event. 4. Downstream side of stream crossing fills armored with rip-rap. 5. Stream crossing fills designed to allow overtopping by streamflow. 6. Facilitate passage of large wood over/through stream crossing fills. 7. Facilitate passage of gravel over/through stream crossing fills. 8. Adult and juvenile fish passage through culverts and maintenance of passage required. 9. Cross- drain spacing is such that ditch erosion is minimized, drain water not directed onto steep slopes, ditch water not directed into streams. 10. Unneeded roads stabilized and vacated.

- Some forest landowners have implemented a voluntary program under the Oregon Plan to inventory roads and mitigate problems, which includes some of the "improved practices" identified in this option. Protocols for this process have been developed and priorities for mitigation have already been established.
- Where necessary ODF would develop and make available guidance to landowners/operators and regulators on methods to achieve the improved practices.
- The technology would need to be developed for several of these improved practices; however, most are being implemented with current knowledge.

- This option includes a number of practices that fall under current forest practice rules. Administration of the current maintenance rules is often reactive, requiring the FPF to identify likely problem areas. For example, the department currently only has the authority to require additional cross drainage installation as a maintenance requirement prior to an operation when current road condition and a proposed use will impair water quality. The intent of this option is to shift efforts to a more proactive stance.
- Some of the proposed methods could potentially be included as components to a stewardship plan (see OAR Chapter 629, Division 606).
- ODF and OSU on occasion offer forest road design, construction and maintenance training (one such session was held in March 2000).
- This option incorporates elements of **IMST recommendation #s 8** (develop and implement standards or guidelines that reduce the length of roadside drainage ditches that discharge into channels); **9** (implement the standards and guidelines for the length of roadside drainage ditch between cross-drainage structures, especially on steep-gradient roads)**, 10** (require the flow capacity of cross-drainage structures and stream-crossing structures and culverts to meet current design standards); **11** (provide for the stabilization of roads not constructed to current standards in critical locations; and **15** (modify culverts and other structures to permit the passage of juvenile and adult salmonids upstream and downstream at forest road-stream crossings).

Benefits: Actively used road systems will more quickly be bought up to current standards where appropriate. Reduced sediment delivery will further limit possible impacts to salmonids and changes in channel form.

Methods 1 and 2: Harvest often creates positive cash flow (some harvests may not create positive cash flow, such as hardwood conversions and salvage operations) which may make funds available for mitigation projects.

Method 3: A more systematic effort can result in more efficient prioritization and mitigation of problem sites.

Method 4: Reduced road mileage in sensitive locations.

Method 5: Landowners would have access to the latest road techniques.

Method 6: A more systematic effort results in more efficient prioritization and mitigation of problem sites.

Method 7: Cross-drain spacing will be improved on roads where proposed use will impair water quality.

Costs:

Landowners/Operators:	Moderate to high costs for some landowners.
State Government:	Increased workload for Forest Practices Foresters. An administrative mechanism would need to be developed for ODF and Department of Revenue to implement Method 4.
Local Governments/Communities:	Insignificant, except as a landowner.

Methods 1 and 2: Will not address those roads where harvest entry is not planned for some time. Timing of mitigation activities may interfere with harvest/haul; some mitigation work limited to in-stream work period. Timber owner may not control haul route(s). Revenue from the harvest may not cover cost of mitigation. Questions remains as to how much money landowners and operators should be asked to spend on mitigation and how to allocate costs when there are multiple road users.

Method 4: May result in greater road length on non-sensitive sites as replacement access. Difficult to gauge the length and location of road length likely to be vacated. Roads traversing mixed ownerships would be problematic.

Method 7: Linking cross drainage installation to an operation may not be an efficient means to address improper spacing. Also, the operator may not control the haul route.

Resources needed:

Rulemaking required.
Statutory change for tax credit option needed.
Administrative actions required.

Depending on the specific method(s) chosen, some sort of tracking system will be needed to identify road segments where inventory and mitigation is needed and has occurred.

Statutory changes would be needed if the intent is to accomplish the objective of this option on other land use roads or on historic roads not currently subject to Forest Practices Act regulation.

Forest Roads Option #7: Cross Drainage Structures on New Roads

Objective:

To minimize the risk of sediment delivery to streams by ensuring that adequate cross-drainage design and construction occurs on new roads.

Recommendation:

The Committee reached a consensus that cross drainage structures on new roads should be installed so that the risk of sediment delivery to waters of the state from new roads is minimized.

The Committee reached a consensus that, while this is the current standard, the department should provide better guidance and training for achievement of the rules (Method 2). Current rules provide authority for installation and maintenance of road cross-drains. Training and improved guidance would be developed and implemented for operators/landowners and regulators that would emphasize the need for adequate spacing and the proper installation of road cross drains.

The Committee reached a consensus that the forest practice rules should be revised to better clarify the objectives for cross-drainage (Method 3). For example, the rules might state that the objectives are to ensure that cross drains are installed in adequate numbers and in proper locations so that:

1. Road surfaces are protected from erosion and retaining water;
2. Erosion of the roadside ditch is minimized;
3. Ditch water is not discharged onto unstable slopes; and
4. The amount of ditch water (and associated sediment) discharging directly into a stream is minimized.

Six (GS, SC, PK, MS, RC, BA) committee members agreed that it is prudent to make changes to existing rules so that they include specific criteria for installation and spacing of cross drainage structures (Method 1). This would include the maximum culvert spacing by road grade, and maximum distance to cross drains above stream crossings. Both cases would include appropriate alternatives for steep fills and high risk sites. Other members stated that it would be difficult to develop universal criteria given the high variability in site conditions. Method 3 also deals with this issue.

Additional information on this option:

- Other existing road issues are included under Forest Roads Option #6. 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.
- Recent ODF monitoring studies have found that many existing roads have drainage systems that are not designed to filter sediment. A secondary finding (less commonly associated with sediment delivery to streams) was that steep roads often have inadequate spacing of cross-drainage structures (excessive distance between cross-drains).
- Current rules are objective based, and do not include specific cross-drainage spacing criteria.
- Training and improved guidance could be developed and implemented for operators/landowners and regulators that would emphasize the need for adequate spacing and installation of road cross drains.
- For additional information, see Option 19.
- The number of factors that influence proper cross drainage spacing (including but not limited to: soil properties, slope steepness, road grade, rainfall characteristics and proximity to streams) make it very difficult to put a science-based criteria in rule form.
- Current rules could be modified to help operators install culverts to more efficiently keep sediment out of streams.
- **IMST recommendation #8** calls for the department to develop and implement standards or guidelines that reduce the length of roadside drainage ditches that discharge into channels.
- **IMST recommendation #9** calls for the department to implement the standards and guidelines for the length of roadside drainage ditch between cross-drainage structures, especially on steep-gradient roads.

Benefits:

It is possible to further reduce delivery of sediment to streams through improved cross-drainage practices. These practices will also better protect the landowners' investment in their road system.

Training under Method 2 will help improve application of sound road drainage practices.

Application of Method 3 will reduce sediment delivery from newly constructed roads.

Costs:

Method 1:

Landowners/Operators:	Minor, possibly moderate increase in costs associated with some additional installations of cross-drains. Each new culvert installation costs about $500. Other cross-drains (dips and cross-ditches) may cost less than $50 each. Currently, as part of the *Road Hazard and Risk Reduction* project, many landowners are voluntarily adding additional culverts.
State Government:	Minor, for rule revisions, training and administration.
Local Governments/Communities:	Insignificant, unless these practices are applied to all land uses, where the cost would be significant.

Method 2:

Landowners/Operators:	Insignificant costs associated with employees attending training.
State Government:	Minor costs to develop and administer training, some reallocation of resources away from rule administration.
Local Governments/Communities:	Insignificant costs associated with employees attending training.

Method 3:

Landowners/Operators:	Minor costs associated with some increased use of cross-drainage culverts and other structures, and additional on-the-ground design work to more precisely locate new cross-drains.
State Government:	Minor costs to develop rules and training, and for rule administration.
Local Governments/Communities:	Insignificant, unless required to use these practices on local government managed roads, where costs would be significant.

Resources needed:

Minor reallocation of existing staff resources for training.

Additional resources may be needed to implement rule making.

Forest Roads Option #8: Conditions for Wet Weather Hauling

Objective:

To address roads that are at risk of sediment delivery to streams due to hauling operations conducted during periods of significant precipitation.

Recommendation:

The Committee reached a consensus that the rules should be modified to more specifically address wet-weather hauling. This will include development of two criteria, probably in rule form, to:

1. Address road use in wet weather to ensure that durable surfacing or other effective methods are used on road segments that can deliver sediment to streams; and

2. Require operators to cease heavy truck traffic on roads when the road surface is "breaking down" (only for segments that are delivering sediment to streams). Breaking down would be defined by both depth of ruts and by depth of muddy fine sediment on the road.

Additional information on this option:

- During periods of significant precipitation, 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.
- 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. 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.
- The committee stated that BMPs for road use should be extended to other land uses.
- **IMST recommendation #12** calls for the forest practice rules to be changed to require durable surfacing on wet-season haul roads and that operators be required to cease hauling before surfaces become soft or "pump" sediment to the surface.

Benefits:

There is the potential to further reduce delivery of sediment to streams through improved road-surface management practices. These practices will also better protect the landowners' investment in their road system.

Costs:

Landowners/Operators:	Moderate to significant increase in costs associated with expense of additional surfacing, and in some cases temporary loss of ability to haul timber. The cost of additional surfacing is expected to vary from $100.00 to $2500.00 per each stream crossing, depending on the region and length of road that drains to that crossing. The value of temporary loss of road use is very difficult to quantify. The number of crossings affected depends on the planned wet season uses of roads.
State Government:	Moderate, for rule revisions, training and administration of new rules.
Local Governments/Communities:	Insignificant, unless they are required to use similar practices as forest landowners. In that case, costs would be significant.

Resources needed:

Requires rulemaking.

Forest Roads Option #10: Developing Decision Criteria for Evaluating Proposed Road Construction or Reconstruction in Sensitive Sites.

Objective:

To reduce 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.

Recommendation:

The committee reached a consensus that the department should develop clear decision-making criteria for evaluating proposed road locations in areas where there is a high risk of landslides, surface erosion, or of direct physical alteration to streams, riparian areas, lakes or wetlands. The criteria should identify preferred locations and construction practices that will result in roads being constructed in a manner that results in the lowest overall impact to water quality and fish habitat while allowing the landowners to achieve their management objectives (Method 5). The criteria should also direct the Department of Forestry to not approve road construction or reconstruction in the sensitive areas described above, if viable alternatives exist.

Five committee members (GP, PK, SC, PH, MS) support that, in areas where roads constructed using current BMPs are likely to degrade water quality, the department create additional restrictions on the locations of new roads in riparian management areas, high risk sites, unstable slopes, flood plains, wetlands, and side channels (Method 3). Other members did not support this method and requested clarification on what "likely to degrade water quality" means. They believe that new roads constructed under current best management practices, combined with the consensus agreements to increase the requirements for cross drainage, stream crossings, wet weather hauling, etc., are very unlikely to degrade water quality.

Four committee members (GP, PK, MS, LH) recommend the forest practice rules be modified to prohibit construction of roads on high risk sites (Method 4). Other members opposed this method.

Four committee members (GP, PK, SC, MS) recommend the forest practice rules be modified to ensure roads constructed across high risk sites are constructed with no fill and also with 'fail-safe' drainage systems (Method 1). Other members pointed out this outcome is already required, where feasible.

Three committee members (GP, PK, SC) recommend the forest practice rules be modified to require that written plans for road construction and timber harvesting operations on landslide prone locations be prepared by a geoscience professional (Method 2). Other members opposed this method due to the added cost to landowners and because the need for geoscience professional involvement could not be justified in every situation. They also pointed out that the geoscience professional may not always have forest road construction or harvesting experience.

Additional information on this option:

- 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, action should be taken to minimize or eliminate the risks they pose to aquatic resources to the maximum extent practicable.
- More discussion is needed on the appropriate definition of a "high risk site".
- Current rules require that operators shall "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 of the State Forester is required before roads can be constructed or reconstructed in such locations.
- There are cases where roads should not be constructed. The current rule language allows ODF to require written plans and to not approve construction or reconstruction when the risk of such action is too great. However, the application of the current rule language requires a conservative interpretation to ensure that the desired level of resource protection is consistently achieved.
- It is not clear to some on the committee what the basis for decision-making is under current rules. However, the field site visited by committee members in eastern Oregon where ODF did not approve proposed road reconstruction represents the type of decision-making supported by the committee members to present on the tour.
- It was determined that Methods 1 to 4 could be implemented under current rules, but the department lacked a decision-making criteria to evaluate these and other possible methods. Therefore, the committee developed and endorsed Method 5, which could incorporate Methods 1 through 4 into a menu of administrative options.
- The committee expressed consensus support for ODF's current conservative interpretation of existing rules, as demonstrated on the Eastern Oregon tour.
- Some committee members believe the current system under the forest practice rules is working and that it is not possible to develop clear and specific criteria for variable field situations that defy standard solutions. Any option chosen should not reduce the incentive for FPFs to seek "win-win" solutions with operators. Also, the concept of "sensitive areas" is not well defined. They believe the risk to resources is primarily from older roads, not new construction, and that topic is covered by other options.
- **IMST Recommendation #7** calls for the forest practice rules to be changed to eliminate language that equivocates on resource protection in favor or forest operations. **Recommendation #14** calls for continued application of best management practices on high risk slopes.

Benefits:

This option will reduce the risk of major impacts to streams and water quality. This proposal is likely to result in the "removal" over time of high impact (especially draw bottom) roads that might otherwise be proposed for reconstruction where alternatives exist.

Costs:

Landowners/Operators:	Significant, potentially high for some landowners, as compared to current practices. Road construction and timber harvesting costs will be increased in some steep slope areas. Compared to Methods 1 through 4, Method 5 may provide more flexibility to address site-specific situations, perhaps resulting in lower cost solutions. Long-term costs may be reduced by vacating creek bottom roads that require "reconstruction" to maintain their use. Based on past experience, these situations will be relatively uncommon. Costs could be reduced and progress enhanced by providing some grants to assist in vacating some roads. Costs could be reduced by developing equitable procedures for the use of roads on other ownerships, particularly federal lands (See Option #16).
State Government:	Insignificant.
Local Governments/Communities:	Insignificant, except as a landowner.

Resources needed:

Administrative resources are needed. Rulemaking may be needed to formalize decision-making criteria.

The resources needed depend upon how the criteria will be applied in approving or disapproving roads. The focus of the rules will be to require that "roads are located or reconstructed in the location with the lowest overall impact to water quality and fish habitat while meeting land management objectives. These criteria will most likely require additional oversight and review by ODF, and/or professional design by the landowner. While these situations are relatively uncommon, they can require substantial ODF and landowner resources on a case-by-case basis.

Forest Roads Option #12: Stream Crossings that Pass Large Wood and Gravel

Objective:

To provide or develop means for the movement of large wood and sediment downstream at those crossings which may otherwise restrict movement. The transport mechanisms for large wood and sediments may be either stream storm flows or channelized debris flows.

Recommendation:

Twelve of the committee members (RC, BR, DN, PK, MS, GS, BA, TH, PH, GP, LH, WS) supported this objective.

A committee member not supporting this objective expressed concern for downstream impacts of large wood and sediment on public and private property and infrastructure.

Additional information on this option:

- This option proposes to develop a broader range of engineering designs for stream crossing structures that will improve passage of large wood and sediment, both during high flows and for debris flow prone channels.
- Increased use of fords may improve passage of large wood and sediment compared to culverts and bridges.
- A program to move sediment and large wood from the upstream sides of crossings to the downstream sides using machinery might be beneficial. This could be done as a part of routine road maintenance on culverts and bridges as an alternative to removing the material from the stream system.
- This option relates to a topic also referenced by **IMST recommendation #19** which requests the Oregon Forest Research Laboratory, in collaboration with ODFW, to develop forest road-stream crossing strategies that facilitate the passage of large wood at road-stream crossings.

Benefits:

Crossings designed to allow for large wood and sediment passage, as well as machine assisted movement of material would reduce the influence of roads and road fills on the delivery of sediment and large wood to fish-bearing streams, helping restore the natural disturbance regime that has maintained salmonid habitat in the past.

Costs:

Landowners/Operators:	Moderate to high, depending upon the nature of the structure, or amount of wood and sediment which may require removal.
State Government:	Potentially significant increase in workload for forest practices foresters.
Local Governments/Communities:	Low. Potential increase in large wood reaching developed areas downstream.

The practices needed to achieve this objective are largely undeveloped and untested.

Resources needed:

Rulemaking required.

Administrative actions required.

ODF, other agencies, and landowner representatives will need to collaborate on stream crossing designs and other techniques appropriate for passage of large wood and sediment. Technical, administrative and legal barriers should be discussed and removed if they are interfering with the achievement of this objective.

Forest Roads Option #16: Develop Policies and Incentives for Cooperative Forest Road System Planning

Objective:

To encourage cooperative forest road system planning, design and use between different landowners in order to minimize the duplication and construction of unnecessary forest roads.

Recommendation:

The committee reached a consensus that improved cooperative road system planning and use is especially needed between federal and private forest landowners.

Seven of the 13 committee members (PH, GP, MS, PK, LH, BA, RC) recommend that the Board of Forestry and ODF should develop more proactive policies and incentives to encourage cooperative forest road system planning, design and use between different landowners in order to minimize the duplication and construction of unnecessary forest roads.

Stronger consensus was not reached because some committee members believed the recommendation was unnecessary, it would be difficult to compel private landowners to cooperate, or because they believed the recommendation should be solely focused on federal road use issues. The committee did not agree on a regulatory approach to cooperative road planning and use. More study is needed to clarify any legal obstacles that could limit a regulatory approach.

Additional information on this option:

- Forestland in Oregon is often in a checkerboard or fragmented pattern of mixed ownership. There are situations where a landowner may have the opportunity to access his/her property using another landowner's road system and thereby reduce the length of new road that must be built for an operation.
- Currently a number of disincentives exist, especially for federal lands, which prevent private landowners from using road systems on another ownership. Sometimes this results in the duplication of road systems and parallel roads being built on opposite sides of property lines. When these duplicate roads are built in high risk areas, it can increase the risk of sediment delivery and other adverse effects to streams.
- The recommendation of a majority of committee members is to request the Board of Forestry and ODF to be more proactive in their efforts to minimize the construction of unnecessary forest roads that are built due to existing disincentives for cooperative road system planning, design and use.

- Specific approaches that should be considered include, but are not limited to:
    1. Working through administrative and Congressional channels to remove federal disincentives to cooperative federal/private road planning and use;
    2. Encouraging the evaluation of existing road systems on the landscape during watershed assessments, with attention focused on opportunities to reduce or prevent duplicative roads;
    3. Prior to the construction of new roads, alerting landowners to opportunities to use existing multi-landowners road systems that are more efficient and protective of forest resources; and
    4. Recognizing and highlighting examples of successful cooperative road planning and use.
- Incentives will likely be needed to improve private cooperative road system planning and use. Many landowners have already established such agreements. However, development of new agreements with the federal agencies appears to be problematic. It appears that the current system rewards federal agencies for not cooperating with private landowners.
- In other cases, neighboring private landowners (sometimes but not always those who are using their lands for other purposes) may set unreasonable conditions on road use. Costs may be so inflated that it is far less costly for the affected landowner to construct a new road, even when new road construction is expensive (over $100,000.00 per mile of road).
- **IMST recommendation #2** calls for ODF to develop a policy framework to encompass landscape (large watershed) level planning and operations on forests within the range of wild salmonids in Oregon.

Benefits:

There is the potential to reduce the length of new roads built and decrease the risk of sediment delivery to streams where this recommendation prevents unnecessary roads from being built in high risk areas. Landowners will also reduce operational costs if they do not have to build and maintain additional unnecessary roads.

Costs:

Landowners/Operators:	Insignificant costs associated with cooperative planning that is already occurring. The cost of additional incentives is unknown.
State Government:	Insignificant costs associated with cooperative planning that is already occurring. The cost of additional incentives is unknown.
Local Governments/Communities:	Insignificant costs associated with cooperative planning that is already occurring. The cost of additional incentives is unknown.

Private property rights are likely to be a barrier to compelling some landowners to make their roads available to others through regulation. State government has limited influence on federal policies that act as a disincentive to cooperative road system planning, design and use between federal and private land managers.

Resources needed:

At this time, no additional resources have been identified as being needed to implement this recommendation.

Forest Roads Option #18: Road BMP Compliance and Effectiveness Monitoring

Objective:

Evaluate the need for further road compliance and effectiveness monitoring, and implement monitoring as necessary.

Recommendation:

The committee reached a consensus that future forest road best management practice compliance and effectiveness monitoring should be implemented within the context of the Forest Practices Program's strategic monitoring plan and prioritized in context with available monitoring resources and other monitoring needs.

Additional information on this option:

- Road monitoring activities that have been completed include: landslides (in Robison and others, 1999) and road surface drainage (ODF 1996). Currently, ODF has no monitoring information on turbidity associated with winter hauling, or on-the-ground verification of voluntary road hazard and risk reduction project repairs. The need for monitoring under the road hazard and risk reduction project is included in the Oregon Plan for Salmon and Watersheds. However, there are currently no specific plans or funding to implement this monitoring. The fact that the advisory committee is being asked to develop policy recommendations on these topics without monitoring data in hand demonstrates a disconnect that currently exists between policy processes and monitoring processes.
- Currently, as part of the Best Management Practices (BMP) Compliance Audit Project, ODF is monitoring compliance with the road construction and maintenance rules along with a large number of other harvesting and water protection rules. This project is a two-year effort to provide a systematic, random "audit" of forest practice rule compliance.
- ODF will assess the need to continue and expand on this project based on the study results, and through a review process that involves key stakeholders. The BMP pilot study has already identified a need to more specifically monitor BMP effectiveness during rainy-season hauling. The current project is not gathering information on sediment associated with wet weather use of roads.
- Currently available information indicates that roads are the single greatest chronic source of fine sediment delivery to stream systems associated with forest practices. However, currently available information also confirms that when properly implemented, forestry BMPs are effective at reducing delivery of sediment to the waters of the state.
- Instream measures of water quality are an integration of everything upslope. Consequently, instream measurements can be a diluted or exaggerated version of what is occurring higher up in the channel network or on adjacent slopes. It is usually easier to accurately identify a road drainage-related sediment source and to quantify the volume of sediment it produced

than it is to measure sediment in the stream and work backwards to the source. In this context, road-related water quality protection compliance monitoring may reveal more useful information than water quality protection effectiveness monitoring.

Benefits:

The BMP Compliance Audit Project will provide ODF with the most current information on compliance and effectiveness of the construction and maintenance rules over time. The results of this project will be used to determine if an expanded, or perhaps a more focused, compliance and effectiveness monitoring of forest road BMPs is needed and whether such work should be a high priority in future monitoring strategic plans.

Costs:

Landowners/Operators:	Insignificant, limited to a potential increase in harvest taxes to fund expanded monitoring.
State Government:	Significant, if monitoring program is further expanded.
Local Governments/Communities:	Insignificant.

Any further increased emphasis on, and ODF commitment to, long-term road rule compliance and effectiveness monitoring will use limited program resources that could address other high priority monitoring objectives. These objectives change over time in response to new policy processes.

Resources Needed:

Administrative actions and long-term budgetary commitment required.

Additional resources would be needed for ODF to prioritize and maintain a long-term monitoring effort devoted specifically to road issues. However, should the monitoring effort be considered within the current monitoring strategy and prioritized accordingly, no additional resources would be needed.

Forest Roads Option #19: Road Construction and Maintenance Education

Objective:

Provide continuing education for landowners and operators specific to the road construction and maintenance rules.

Recommendation:

The Committee reached a consensus that additional training on forest road construction and maintenance should be provided for landowners and operators.

Additional information on this option:

- ODF and OSU organized a "Road Stewardship Workshop" held on March 7 and 8 of this year.
- A *Forest Road Management Guidebook* has just been completed. This guidebook will help landowners determine what repairs are needed on older roads.
- Engineers working for private forest landowners and ODF have collaboratively provided several training sessions for operators over the last two years
- Many ODF districts have provided road maintenance training for operators over the last two years.

Benefits:

Training is an essential element of a BMP program. Operators cannot effectively protect streams and fish habitat without the appropriate knowledge, skills and abilities.

Costs:

Landowners/Operators:	Minor costs associated with employees helping develop and attend training.
State Government:	Minor costs to develop and administer training, some reallocation of resources away from rule administration.
Local Government:	Insignificant costs associated with employees attending training.

Resources needed:

Funds and personnel needed to develop and implement training.

Forest Roads Option #57: Steep Slope Ground Skidding

Objective:

To reduce the potential of sediment delivery or other undesirable effects to streams from skid roads constructed on steep slopes.

Recommendation:

The Committee reached a consensus that the forest practice rules should be changed to require prior approval for ground based harvesting on steep slopes where there is a significant risk of sediment delivery to streams.

Additional information on this option:

- Skid roads or trails are used by tracked or wheeled skidding machines to move logs from the stump to the landing. They can be constructed and used at much steeper grades than roads used for trucks.
- A prior approval requirement for ground skidding in high erosion hazard locations could reduce the risk of sediment delivery to waters of the state. It will also help operators to better plan operations in these locations, and to modify operations where risk of sediment delivery is greatest. In some cases, planning activity may reduce operational costs.
- In very limited cases, operators will need to use cable yarding instead of ground based harvesting systems.
- A technical process is needed to develop specific criteria.

Benefits:

This option will reduce the risk of sediment delivery to waters of the state. It will also help operators to better plan operations in these locations, and to modify operations where risk of sediment delivery is greatest. In some cases, planning activity may reduce operational costs.

Costs:

Landowners/Operators:	Minor in Northwest Oregon, to moderate in parts of Southwest Oregon and Northeastern Oregon (where ground skidding on steep slopes is not uncommon) In limited cases, the additional planning could reduce operating cost, but in other cases the cost of changing from a ground based to a cable yarding system could be as much as a $50.00 per thousand board foot cost.
State Government:	Minor, for rule revisions, training and administration.

Local Governments/Communities:	Insignificant, although there may be isolated cases where these changes cause a landowner to delay timber harvesting.

Resources needed:

Rulemaking is required.

Forest Roads Option #59: Voluntary Road Closure Program

Objective:

To create a road closure program that forest landowners, the Department of Forestry, and local law enforcement would use to limit vehicle access onto sensitive road systems that have a high risk of delivering sediment to streams, or that can directly impact aquatic habitat.

Recommendation:

The committee reached a consensus that a road closure program should be developed that forest landowners, the Department of Forestry, and local law enforcement can use to limit public access onto sensitive road systems that have a high risk of delivering sediment to streams, or that can directly impact aquatic habitat.

Additional information on this option:

- Legacy roads, roads built on steep slopes and unstable soils, or unsurfaced roads that have the potential to deliver sediment to streams should be closed to public vehicle traffic during the rainy months.
- Currently, ORS 164.270 allows a landowner to close roads to motor-propelled vehicles. This statute is under the criminal trespass laws and it is not clear what the attached penalty is, but enforcement requires a complaint by the landowner through the local district attorney. Enforcement is difficult under the trespass laws.
- Under the proposed approach, landowners would close roads to vehicles for the purposes of protecting water quality.
- Identifying candidate roads could be done with ODF and ODFW input. Road closure signs would be posted to indicate what type of public access is allowed (e.g. foot traffic but no motorized vehicles). User groups, such as motorcycle or off-road clubs, would be informed.
- Agreements for enforcement with local sheriffs or state police would be needed and trespass citations and procedures would need to be clarified. It is envisioned that it would be a misdemeanor offense, subject to uniform citation and civil penalty, to violate a road closure, enforceable by local sheriffs, the state police, or possibly ODF.
- Assessed civil penalties would be deposited to the "Forest Incentive Fund" (also see Forest Roads Option #58). This fund could provide money for gates and posters, plus repairs caused by persons trespassing on closed roads.
- There may be a linkage between this option and Option #16: Cooperative Forest Road System Planning.
- Emphasis is also needed for public outreach and education on the importance of "treading lightly" when recreating on forestlands.
- This option has the potential to greatly reduce public recreation access during the rainy season. Compounded by increasing closures to vehicles on federal lands, this option could particularly restrict big game hunting is some areas and concentrate it elsewhere.

- The committee requested further clarification and development of this option.
- Oregon recently began offering "Oregon Ag" license plates. The plates were designed by the Oregon Agricultural Education Foundation which sponsors and supports community agriculture, forestry, and natural resource education and research projects. The plates cost ten dollars more than regular plates, with a portion of the proceeds supporting the foundation's work. Several committee members supported the development of a similar program specific to forestry, with proceeds going to the "Forest Incentive Fund."
- This option indirectly addresses **IMST recommendation #12** which, in part, calls for operators to be required to cease hauling before surfaces become soft or "pump" sediment to the surface.

Benefits:

This option would reduce the impact of unauthorized vehicle damage done to roads. Such damage can result in significant sediment delivery to streams. Road maintenance costs for landowners may also be reduced if this option is implemented.

Costs:

Landowners/Operators:	Insignificant.
State Government:	Potential administration and enforcement costs to state agencies. There would be a cost of establishing the road closure program and allocating the incentive funds to repair damage.
Local Governments/Communities:	Insignificant.

Resources Needed:

Agency administrative support. Potential rule or statute changes to set up road closure program and Forest Incentive Fund. Enforcement actions require resources. Moving this issue out from "trespass law" to a uniform citation with civil penalty would make enforcement much easier. If ODF was to enforce this option additional resources might be needed particularly in the civil penalty section.

Landslides Option #45: Identifying High Risk Sites

Objective:

To ensure that all landslide prone locations (now called "high risk sites") are identified prior to timber harvest operations.

Recommendation:

The committee reached consensus on the objective.

The committee also reached consensus that a combination of Methods 1 and 2 should be used to achieve the objective. During the notification process, the department should inform the operator of the likely presence of high risk sites in the operation area, based on coarse screen maps (Method 1) . The operator would then be expected to more specifically locate sites within the operation area by field reconnaissance (Method 2). There is also the expectation that "large" areas of high risk sites which happen to not be in the mapped areas will also be identified by the operator.

Five committee members (PK, GL, RC, SC, MS) supported a proposed method that would require identification of high risk sites by a geoscientist employed by the operator. (Method 3) Four members expressed opposition to this method, citing the high cost of hiring a consultant and pointing out the IMST report supports current approaches.

Additional information on this option:

- The current rules require that Forest Practices Foresters inform the operator of the presence of high risk sites (HRS).
- Agreement will be needed on the technical basin for the creation of the coarse screen maps under Method 1.
- This option is intended to create additional tools to ensure that HRS are identified prior to operations. The committee's intent is to focus this option on timber harvest operations. The forest practice rules already address road locations involving high risk sites.
- HRS identification will be a function of operator competency and diligence in locating such sites. By way of analogy, ODF already expects operators to properly notify about the presence or absence of Type F streams and apply appropriate practices, regardless of whether ODF has identified the stream as fish bearing or not.
- IMST Recommendation #13 (tree retention on high risk slopes) and Recommendation #14 (continue to apply BMPs on landslide prone slopes) are recommendations which apply to high risk sites. They do not specifically address site identification; however, proper site identification is implicit for the recommendations to be effective.

Benefits:

Combined Methods 1 and 2 provide a simple, fairly conservative screen for HRS.

Method 3 may provide a more thorough identification of high hazard locations and risk characterization and may result in a more targeted application of harvesting practices commensurate with the downslope risk to resources.

Costs:

Landowners/Operators:	Moderate for combined Methods 1 and 2. Method 3 would typically cost landowners or operators about $500 to $1500/ harvest unit for a geoscientist field reconnaissance and report. Costs could be higher depending on the complexity of the site.
State Government:	Moderate for combined Methods 1, 2, and Method 3.
Local Governments/Communities:	Insignificant; however, identification of high risk sites will require local governments to take actions to prevent future downslope development.

Resources needed:

Rulemaking will be needed to clarify agency and landowner/operator responsibilities and HRS identification criteria. ODF will be required to create and maintain a high risk map or database, notify operators based on screening for high risk sites, review reports on high risk sites, whether done by foresters or geoscientists, and monitor compliance and results.

Landslides Option #46: Identifying Debris Flow Risk for Streams

Objective:

Identify stream channels which are prone to debris flows and torrents. Identifying those channels which are capable of transporting large wood to Type F streams could make it possible to focus riparian prescriptions on those streams where greater benefit to aquatic habitats are likely.

Recommendation:

Consensus was reached that the department should identify stream channels which are prone to debris flows and torrents. Identifying those channels which are capable of transporting large wood to Type F streams could make it possible to focus riparian prescriptions on those streams where greater benefit to aquatic habitats are likely.

The committee reached consensus that the department should inform the operator during the notification process of the likely presence of debris flow prone channels, based on coarse screen maps. The operator would then be expected to more specifically locate debris flow prone channels by field reconnaissance. ODF would provide specific criteria to be used in field identification (Method 1).

Six committee members (PK, SC, LH, GP, MS, RC) recommended that debris flow prone channels be identified by a geoscientist employed by the operator (Method 3). Those opposed cited the high cost of hiring a consultant.

Five committee members (PK, SC, LH, GP, MS) supported the operator identifying the presence of debris flow prone channels using criteria in rule form (Method 2). The operator would notify the department of the presence of such channels during the notification process, using the identification criteria as stated in rule form. Method 2 differs from Method 1 in that ODF would not provide information to the operator based on coarse screen maps. Several other members would apparently support this method if further clarifications/qualifications were made part of the option and method. One member again questioned the need for identifying debris flow prone channels.

Committee recommendations on Riparian Functions options may also relate to this option.

Additional information on this option:

- Currently, the rules do not explicitly require identification or treatment of debris flow prone channels (DFPC) for the purposes of providing large wood to Type F streams.
- This option is directly related to components of the Subcommittee Riparian Option.

- **IMST Recommendation 13** calls for the retention of trees in likely debris torrent tracks to increase the likelihood of large wood transport to streams from debris torrents. Inherent in this recommendation is the need to identify potential debris torrent track channels.

Benefits:

Method 1 provides a simple, fairly conservative screen for DFPC.

Since the operator is entirely responsible for DFPC identification under Method 2, this method lessens the "up-front" agency workload.

Of all three methods, Method 3 may provide the most thorough identification of DFPCs.

Costs:

Landowners/Operators:	Moderate for Methods 1 and 3. Method 3 would typically cost landowners or operators about $500 to $1500/ harvest unit for a geoscientist field reconnaissance and report. Costs could be much higher depending on the complexity of the site.
State Government:	Moderate for Methods 1, 2, and Method 3.
Local Governments/Communities:	Insignificant; however, identification of debris flow prone channel sites will require local governments to take actions to prevent future downslope development.

DFPC identification will be a function of operator competency and diligence in locating such sites. By way of analogy, ODF currently expects operators to properly notify about the presence or absence of Type F streams and apply appropriate practices, regardless of whether ODF has identified the stream as fish bearing or not.

Resources needed:

Rulemaking to clarify responsibilities and DFPC identification criteria.

Landslides Option #47: Management of High-Risk Sites

Objective:

To minimize adverse impacts on soil and water resources that result from management practices on high risk sites.

Recommendation:

Consensus was not reached on the objective wording but the committee did reach a consensus that locations most prone to landslides (now called "high risk sites") should be managed with techniques that minimize impacts to soil and water resources.

The committee also reached consensus that to achieve this objective the best management practices that are currently used in guidance to protect high risk sites should be incorporated into the forest practice rules (Method 1) and a better case history basis for evaluating the effectiveness of those practices should be developed (Method 6). These standard practices are designed to minimize ground alteration/disturbance on high risk sites from logging practices. The IMST recommendation suggests additional case history evaluation of practices used on high risk sites, but it is unclear how such a case study approach would be developed.

Five committee members (GP, LH, PK, MS, SC) agreed that it is prudent to base practices on a written plan prepared by a geoscience professional (Method 2). The other members felt that the cost for this method was greater than the benefit, especially since most geoscientists have a limited understanding of specific forest practices.

The same five committee members supported leaving trees on high risk sites that may influence slope stability (Method 3).

Limiting the percent of high risk sites in young age classes on a watershed level, by ownership, (Method 4) was also supported by five committee members.

Method 5, a harvest prohibition on some or all high risk sites, was ~~only~~ supported by four members. The members that did not support Methods 3, 4 and 5 expressed concern about the high potential cost of these measures, given that the effect of timber harvesting on landslides may be primarily limited to changing the timing of landslide occurrence.

Committee recommendations on Riparian Functions options may also relate to this option.

Additional information on this option:

- Current rules require specific harvesting practices be employed on high risk sites. These practices are designed primarily to limit ground disturbance so that the landslide risk will not be increased.

- The rules and/or guidance do not require merchantable trees to be left on the site to possibly play a role in stabilizing the slope either through mechanical (root reinforcement) or hydrological (water routing) mechanisms.
- Timber harvesting can affect landslide occurrence in areas with high landslide risk. 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, in three out of four ODF storm monitoring study areas. Forested areas between the ages of 10 and 100 years typically had lower landslide densities and erosion volumes than found in the mature forest stands.
- In the locations adjacent to landslides surveyed in the ODF storm monitoring study, landowners and loggers complied with the forest practice harvesting rules (as changed in 1983) to minimize ground disturbance and slash accumulations on landslide prone sites.
- Any disturbance that removes vegetation on steep, landslide prone locations may result in a temporary increase in 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.
- Some evidence indicates small areas tree retention on high risk sites may increase landslide occurrence.
- **IMST Recommendation #13** (tree retention on high risk slopes) and **Recommendation #14** (continue to apply best management practices on landslide prone slopes) are recommendations which apply to the management of high risk sites.

Benefits:

Combined Methods 1 and 6 provide some additional assurance that harvesting methods will reduce ground disturbance on high risk sites, and that an attempt will be made to develop more case study information on the effectiveness of different practices.

Method 2 will improve the assessment of potential debris flow initiation and characteristics, and the resources that could be affected by landslides from high risk sites.

Managing the quality of high-risk sites (i.e., the amount of large wood left on the site) will potentially increase the amount of large wood delivered to streams (Method 3); however, Option 46 is more likely to affect wood delivery to channels than this option.

Method 4 will control the portion of high risk site in vegetative conditions with higher rates of landslide occurrence in watersheds and may result in lower long-term costs than a strict prohibition of operations on high risk sites.

Method 5 might prevent some or most of the temporary increase in landslide occurrence in most landslide surveys.

Costs:

Combined Methods 1 and 6:

Landowners/Operators:	Little change from current practice.
State Government:	Moderate cost of developing and implementing the necessary case studies.
Local Governments/Communities:	Insignificant.

Method 2:

Landowners/Operators:	Method 2 would typically cost landowners or operators about $500 to $1500/ harvest unit for a geoscientist field reconnaissance and report. Costs could be much higher depending on the complexity of the site. There would also be the increased cost associated with leaving additional trees, since geotechnical reports are typically conservative.
State Government:	Possible reduction in harvest and income tax revenues.
Local Governments/Communities:	Possible reduction in harvest and income tax revenues.

Methods 3 and 5:

Landowners/Operators:	Significant to very major increased costs associated with leaving large areas volumes of timber (especially under method 5) unharvested, possibly in perpetuity. Potential increase in landslide occurrence from windthrow.
State Government:	Possible reduction in harvest and income tax revenues.
Local Governments/Communities:	Possible reduction in harvest and income tax revenues.

Method 4:

Landowners/Operators:	Moderate to significant increased costs associated with delays in harvesting timber, depending on land ownership.
State Government:	Moderate costs associated with increased administration for complex regulations. Possible reduction in harvest and income tax revenues.
Local Governments/Communities:	Possible reduction in harvest and income tax revenues.

Resources needed:

A quantitative cost assessment to identify acreage and timber values impacted by this option is needed.

Rulemaking will be needed to describe current practices in rule form.

Additional resources may be needed for administration of practices.

Rulemaking and potential statute changes to implement Methods 2 through 5.

Landslide Option #61: Large Wood Sources From Hillslope Areas and Debris Flow Channels.

Objective:

To supply large wood inputs from debris flow prone channels and hillslope areas that have the potential to deliver large wood to fish-bearing streams of a quality and quantity sufficient to provide important habitat functions in those streams.

Recommendation:

All committee members except one (TH) agreed that it is important to leave trees or downed wood in locations where they provide wood to be moved by debris flows into fish-bearing streams. There was concern expressed by several committee members about the potential high cost of this option.

To achieve this objective, all committee members but one (TH) agreed that is was appropriate to use a menu of potential methods to leave trees or downed wood, depending upon likelihood of wood delivery and operational efficiency (Method 5). The committee felt that is was not appropriate to rely on a single strategy to provide this potential source of large wood. The operator would be required to select an appropriate option in cooperation with ODF.

Five members (GS, BA, SC, GP and MS) supported the placement of additional "down large wood" on sites or channels with the likelihood to deliver the wood to Type F streams (Method 6).

Four committee members (MS, LH, GP AND PK) supported leaving trees on high risk sites likely to deliver wood to Type F streams (Method 1).

Four committee members (PK, MS, GP and LH) supported leaving additional trees in headwall and upslope areas (Method 3).

The same four members supported using a riparian management area for small, Type N debris flow prone channels (Method 4). Note: "Strong agreement" was reached for a similar method as part of the riparian proposal.

Two committee members (MS and GP) supported locating in-unit leave trees (some or all of the current two per acre) in hillslope and headwall areas (Method 2).

Additional information on this option:

- There is increasing scientific evidence that wood contained in debris flows is an important source of large wood for downstream fish habitat. These areas include likely debris flow paths, which are typically steep hillslopes below high risk (hazard) sites, and above steep stream channels (a portion of small Type N streams). While these areas are providing some

level of functional large wood inputs under the current rules, the rules were not specifically designed to provide sources of large wood from these areas.

- Debris torrents that traveled further than expected in the ODF study were on average larger and had younger riparian vegetation near their terminus. Thus in terms of 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 be important secondary factors.
- This option is directly related to components of the Subcommittee Riparian Option and there is the opportunity to explore Option #61 as an element of that option.
- **IMST Recommendation 13** calls for the retention of trees on "high risk slopes" and in likely debris torrent tracks to increase the likelihood that large wood will be transported to streams when landslides and debris torrents occur.

Benefits:

Methods 2 and 3 could result in some increased wood delivery to channel, but will also result in fewer trees in other locations on the landscape.

In most cases, Method 4 is believed to be the most efficient means of providing wood for debris flows.

Method 5 provides the greatest landowner flexibility and may result in better site-specific prescriptions.

Method 6 may be the lowest cost method for landowners and may be most efficient where wood loadings are low or where tree retention is unworkable.

Costs:

Given the lack of specifics under Option 61, it is very difficult to evaluate costs. Therefore, this discussion is limited in accuracy.

Trees in some locations (especially certain actively moving landslides) have a fairly high potential to be moved into stream channels. However, most high risk sites fail very infrequently, so leaving trees on the actual high risk site (Methods 1, 2, and 3) may be a very inefficient means for ensuring hillslope delivery of large wood.

Landowners/Operators:	It is likely that Method 2 will result in little or no increased cost to landowners. Methods 1, 3, 4, 5, and 6 will increase landowner costs. The significance of this increase depends on the number of additional trees or logs that are left on site, and could very well be significant.
State Government:	Reduced harvest tax revenues could result, depending on the number of trees left on site. Also,

	increased costs for administration of practices, depending on the complexity of these practices.
Local Governments/Communities:	Reduced harvest tax revenues depending on the number of trees left on site.

Resources needed:

A quantitative cost assessment to identify acreage and timber values impacted by this option is needed. Rulemaking may be needed. Possibly additional agency resources needed to administer more complex regulations.

Riparian Functions Option #20: Active Placement of Large Wood

Objective:

To provide additional large wood large wood to streams by actively placing the wood in areas where it will provide the greatest benefits to salmonids, while assuring the timely achievement and maintenance of characteristics of mature forest conditions.

Recommendation:

The committee reached a consensus that the active placement of large wood in streams is necessary for short-term aquatic habitat improvement, but it should be done in a manner that still assures the timely achievement and maintenance of characteristics of mature forest conditions in the longer term. The committee also agreed that a menu of methods should be developed to prioritize and guide large wood placement activities. This menu should include placing wood along streams during an adjacent entry for harvesting as one method.

The committee could not agree on whether the current system of basal area credits for active large wood placement should be continued. Some members (LH, PK, MS, GP) are concerned about any short-term reduction in riparian function as a trade-off for active large wood placement. Other committee members believe landowners will be less likely to initiate active large wood placement projects unless some sort of incentive is provided.

Possible methods for active large wood placement supported by a majority of committee members in a menu approach include:

Method 1: Placing wood along fish-bearing streams during an adjacent entry for harvesting Some committee members (GS, BA, and SC) felt that harvest should not be the only trigger.

Method 2: Placing large wood along Type N and D streams prone to debris flows that are likely to deliver the wood to fish-bearing streams downstream. Some committee members (LH, PK, and GP) preferred to leave the trees standing so that other RMA functions were retained until natural deliver could take place.

There was little committee support (RC, SC, LH, DN, BR, MS, GS, BA, PK, and GP not supporting) for placing large wood upslope (i.e. in small draws and hollows) of Type N and Type D streams prone to debris flows that are likely to deliver the wood to fish-bearing streams downstream (Method 3). The basis for the lack of support by some committee members is the high degree of uncertainty of eventual large wood delivery to the stream. For large wood that is not placed directly in Type F streams there will be a time lag between when it is placed and when it is utilized for fish habitat. If this time lag is too long the large wood may be at a stage of decomposition where it can no longer provide the same level of function as a “fresh” piece of large wood.

Additional information on this option:

- It is widely believed that current levels of large wood in many streams are significantly lower than what occurred historically. Where riparian areas are generally lacking in large diameter trees the active placement of key pieces from off-site sources can be critical to the creation of habitat functions in the short-term. In order to accelerate the rate of large wood inputs that is occurring under the current rules and measures, additional large wood can be actively placed in the appropriate streams.
- The active placement of large wood is dependent upon the availability of source wood and the cost of placement.
- The 1999 Oregon Plan restoration guide recommends that the large wood for active placement come from outside the riparian management area.
- The opportunity to implement this option may be limited by federal permit requirements.

Benefits:

The most important benefit of this recommendation is the potential for immediate habitat improvement, provided the overall effectiveness of the RMA is not reduced.

The placement of large wood during an adjacent entry for harvesting (Method 1) is an expedient means of achieving immediate habitat improvement, because the equipment necessary for placement is already at the site. An added benefit is that LW can be strategically placed for maximum habitat improvement and retention. In areas well stocked with conifers, felling some trees into or across streams as a part of a thinning operation may also improve the growth potential of the remaining standing trees.
The benefit of Method #2 is that large wood could potentially be delivered to the stream via debris flows, thus reducing the time and cost involved in active placement.

The benefit of Method #3 is that large wood would be available for delivery through debris flows.

Costs:

Landowners/Operators:	Significant, potentially high for some landowners for placement and forgone timber revenue. Incentives, such as basal area credits, in-unit leave tree credits, or tax credits may offset this cost.
State Government:	Insignificant.
Local Governments/Communities:	Large wood inputs may increase downstream risks to developments in or near streams.

There is a direct financial cost to the landowner from the cost of placement and of the material used.

Resources needed:

Rulemaking required. Administrative actions required. Possible incentive legislation needed.

Riparian Functions Option #30: Water Protection Rule Compliance and Effectiveness Monitoring

Objective:

To continue monitoring forest practice water protection rule effectiveness and compliance.

Recommendation:

The committee reached a consensus that additional department resources should be allocated to monitoring the effectiveness of the water protection rules. At a minimum, current levels of monitoring must be maintained. Adequate resources should also be provided to enable the department to conduct effectiveness monitoring related to the large wood objectives of the Oregon Plan for Salmon and Watersheds (OPSW) and water quality standards, as well as continued best management practices compliance monitoring. Coordination with other agencies on monitoring projects is encouraged.

Additional information on this option:

- Monitoring the effectiveness of the forest practice rules in protecting riparian functions must occur in order to understand how the rules are being implemented and to evaluate whether or not they are achieving their objectives. Such work has been the highest priority for the Forest Practices Monitoring Program since the 1994 rule revisions.
- Currently, ODF is also monitoring compliance with the water protection rules**.** This work is part of a broader three-year project to monitor compliance with the forest practice rules in general.
- **IMST recommendation #6** calls for completion the study of the effectiveness of the forest practice rules in providing large wood for the short- and long-term.

Benefits:

Maintaining, and if possible, increasing resources allocated to effectiveness and compliance monitoring will allow a more thorough analysis of the actual effect of the rules related to aquatic large wood and stream temperature issues. This work will also allow for a continuation of ODF compliance monitoring over time and potentially increase the quantity of useful information available to evaluate forest practice rule implementation. Additional resources allocated to monitoring will also allow an evaluation of the implementation and effectiveness of other Oregon Plan measures.

Costs:

Landowners/Operators:	Potential minor increase in harvest tax rates to increase monitoring resources.

State Government:	A stable source of long term funding is needed to maintain or increase monitoring resources.
Local Governments/Communities:	Insignificant.

Resources needed:

Long-term budgetary commitment needed.

A long-term budgetary commitment to monitoring is needed since studies often take more than one biennium to complete successfully. Additional resources are especially needed if the program will be asked to expand its monitoring efforts.

Riparian Function Option #41: Statewide Riparian Management Policy

Objective:

To develop a statewide riparian management policy.

Recommendation:

The committee reached a consensus that the State of Oregon should develop a clearer and more comprehensive policy on riparian management that addresses all land uses. *The committee did not discuss whether such a policy should require uniform protection on all land uses.* However, the policy should, at a minimum, establish a baseline standard for resource protection and both clarify and explicitly describe Oregon's expectations for different land uses if some land uses will be required to meet a higher protection standard than others.

Additional information on this option:

- Currently there are conflicting policies across the state that deal with the management of riparian areas and large wood in streams.
- Riparian vegetation and instream wood protection policies and regulations vary substantially across the state and between different land use sectors. As an example, a number of cities and counties are actively removing large wood to reduce the risks of flooding and property damage. At the same time forestland owners upstream are being asked to put more large wood into streams.
- Inconsistent riparian protection policies may unintentionally be encouraging the conversion of forestland to other land uses, resulting in a potential decrease in fish habitat and water quality.
- Uniform riparian buffers may not be practical and could result in unintended consequences, such as increased pressure to expand urban growth boundaries.
- If a statewide policy explicitly sets different protection goals for different land uses, perhaps the policy could be used as a basis for rewarding, through incentives or tax breaks, those private landowners who are asked to provide disproportionate protection to public resources.
- **IMST recommendation #2** calls for ODF to develop a policy framework to encompass landscape (large watershed) level planning and operations on forests within the range of wild salmonids in Oregon.

Benefits:

A uniform standard of riparian protection across all land uses would spread the burden of managing riparian areas and providing large wood to streams equally among all landowners. There is the potential to increase the total stream miles that provide high quality fish habitat by maintaining vegetation and large wood on streams in land uses that currently do not provide such habitat. Since the majority of large wood originates from areas closest to the stream, this option

will provide significantly more large wood inputs as compared to an equivalent widening of buffers of forestlands only. For example, creating 100-foot buffers on large fish bearing streams regardless of land ownership would provide significantly more large wood as compared to doubling the 100-foot riparian management area on large fish bearing streams on forestlands only.

Costs:

Landowners/Operators:	Potential additional costs for agricultural and urban landowners if additional limitations are placed on the use of their lands.
State Government:	Insignificant.
Local Governments/Communities:	Potentially significant cost if required to expand regulation and riparian protection.

The addition of large wood to some streams in agricultural and urban areas could increase physical hazards to property and public safety. Where additional large wood creates debris dams and diverts stream flows in lowland areas during periods of high runoff, there will be an increase in the potential for flood damage and channel migration.

Resources needed:

Interagency coordination and statutory changes required.

State agency and stakeholder coordination through the Oregon Plan Core Team and the 1999 HB 3393 Large Wood Working Group is needed to begin development of this policy.

"Subcommittee" Riparian Option
(in lieu of Options 26, 38, 62, 63, 64, 65, 66, and 67)

In January 2000, a 6-member subcommittee was appointed by the full committee to address riparian issues. This was difficult work for obvious reasons. The subcommittee met on several occasions and joined in one field tour. The subcommittee's work was conducted with the assistance of facilitators and the Governor's Office. Eventually, a 4-person negotiating team was formed from the subcommittee. Several negotiating sessions were conducted. Ultimately, the negotiating team and the subcommittee came to agreement on the "riparian package" described below.

Objective:

The Riparian Subcommittee did not agree to an objective for this option.

Recommendation:

Ten committee members (WS, SC, RC, BR, BA, GS, DN, LH, GP, PH) support the following proposal. Further clarification and/or guidance on a number of these points will be needed to further develop these concepts.

Riparian Subcommittee
Points of Agreement

1. Harvesting Cap 40%
   In western Oregon, manage any harvesting within the RMA so that the retained conifer basal area exceeds the basal area standard target, or 60 percent of the pre-harvest basal area, whichever is greater.

2. No Touch area ½ of RMA
   The no-touch width will be equal to one-half the width of the entire RMA.

3. Largest Trees 10 out of 20 largest
   Retain 10 of the 20 largest trees per 1,000' outside of the no-touch width that will best achieve aquatic riparian functions. Subject to FPF approval, the landowner would identify tree locations in a written plan demonstrating how this objective will be met. There would be discretion to also consider operational issues and the value of the trees, as long as best achieving aquatic riparian functions remains the primary objective.

4. Type N Streams FPF discretion
   a. Small Type NT streams are: 1. Perennial Small Type N (temperature) streams that are tributary and contribute at least 30% of the flow to small and medium Type F streams and that have a drainage area larger than X acres (basin size to be set be georegion, 40 acres for the coast range). Initial classification will be based on basin size, but landowners may delist streams or stream segments verified as

non-perennial. 2. Small Type N (torrent) streams with drainage basins greater than 30 acres, in which more than 75% of the basin has been mapped as "high" or 50% "extreme" debris flow hazard (by the State Forester) and which have a high probability of delivery to Type F streams.

b. Small NT stream protection: 1. Up to the first 500 feet of Type NT (temperature) stream above the confluence with a Type F will have a 50 foot search zone, each side. Within the search zone, retain 4 square feet of trees per each 100 feet of perennial flow (up to 500') and all non-merchantable conifer on each side of the stream. Trees left along these streams to satisfy the basal area requirement can be counted as in-unit leave trees. 2. "Torrent" type NT streams will be protected as follows - FPF, working with the landowner, has discretion to direct retention of in-unit trees to 50 x 500' search zone (each side).

5. In-growth 25% adjustment for small streams
The standard target will be recalculated for small Type F streams using the same per-acre basal area as large streams, minus 25 percent for in-growth. The standard target will also be recalculated for medium Type F streams, using the same per-acre basal area as large streams.

6. Riparian Specialist
The Oregon Department of Forestry will designate a riparian specialist in each administrative area who will be available to inventory and prepare riparian prescriptions for landowners, at their request. These specialists will be new positions funded by the General Fund.

7. Similar Prescriptions for All Large and Medium Streams
Large and medium Type N stream prescriptions will be the same as the equivalent size Type F's.

8. Monitoring
The effectiveness of the small Type N stream prescription will be a monitoring priority.

9. Alternative Vegetation Retention Prescriptions
The existing alternative vegetation retention prescriptions (e.g., hardwood conversions) may be applied to all riparian management areas (RMA's).

10. Preventing Sediment Delivery
The purpose statement for harvesting rules will be modified to better describe the objective of preventing sediment delivery to channels. The current requirement not to locate skid trails within 35 feet of Type F or D streams will be extended to all streams. Skid trails will be defined as an excavated trail used to yard logs with more than one turn.

11. Layout of Riparian Management Area where a Channel Migration Zone Exists
The riparian management area (RMA) is measured from the current points of measurement except for areas designated by the State Forester as a channel migration zone (CMZ). A CMZ is an unconstrained reach of stream that in the judgment of the

forester is likely to have channel movement that can go outside the RMA widths within the period of a rotation (50-100 years). Within the CMZ, the no touch area will be measured from the high water mark of the channel (same as current rules). The outer edge of the CMZ will be based upon guidance to be developed by a technical committee. Retained trees in the CMZ shall be no less than the basal area standard target.

12. Type N and Small Type F Streams: Landowners would get credit for in-unit leave trees.

13. Conceptual agreement about the use of "stratification."
In recognizing that riparian stands are not homogenous and that applying a single target for the RMA can prevent appropriate management in patches with conifer "over" stocking, the committee agrees to the concept, the details of how to do it in the field are to be developed. Stratification could allow an RMA to be divided into segments with a different management approach applied to each segment; based on the specific conditions in the segment.

14. "Provide for placement of large wood" is supported as a concept. No agreement on details.

Additional information on this option:

The IMST has recommended the following with regard to riparian protection issues:

- Better address flood plains and areas where channels may migrate beyond current areas protected within RMAs.
- Ensure retention of larger trees.
- The target for mature conifer forest should be based upon the characteristics of 160-year-old stands.
- For medium and small streams increase the retention level for conifer trees.
- There is not a scientific basis to treat nonfish-bearing streams differently than fish-bearing streams.

ODF monitoring data has indicated that:

- Variability of riparian stands is great.
- Stocking of conifer, particularly along small and medium sized streams is generally better than assumed in calculating the original basal area targets.
- Changes in measurable shade after harvest are common for small streams, though most changes are less than a 30 percent reduction and are temporary. Pre-operation shade levels may recover within 2 to 3 years after harvest.
- Average diameter distribution does not substantially change after harvest entry.
- A limited number of large trees are selectively harvested from RMAs.
- More often than not, RMAs are not managed under the various options available to landowners.

Other conclusions:

- The incentive most effective to encourage management is the ability to harvest trees, now and in the future.
- Thinning in the short-term can increase tree growth rates and potential large wood delivery in the long-term.
- Thinning in the short-term may reduce the probability of wood delivery and other riparian functions in the short-term.
- Based upon the ODFW stream habitat assessment data, the number of conifer trees in RMAs over 20 inches dbh is relatively low.
- Based upon the ODFW stream habitat assessment data, instream key pieces of large wood (>24 inches) are limited within stream channels.
- Based upon the ODFW stream habitat assessment data, in the coast range, conifer seedlings are rare within the RMAs.
- Other land uses have not generally protected riparian functions at levels near current FPA standards.

Benefits:

The amount of large wood and other riparian function available to streams is likely to be significantly increased in the short-term. The amount of potential large wood left standing within RMAs that will be available in the future will roughly double as compared to what the current rules achieve. The various options available under this proposal maintain flexibility to tailor riparian management prescriptions to site-specific conditions. This flexibility is more likely to better optimize riparian function and emulate historical conditions as compared to the current rules.

Increased vegetation along small Type F and N streams, and along medium Type N streams will provide additional shade levels that in some cases will improve stream temperatures and may provide additional summer habitat for salmonids.

The elements of this option regarding debris torrents are also related *to the committee recommendations under Landslides Options #46 and #61.

Costs:

Landowners/Operators:	Additional costs, significant for many landowners resulting from decreased timber harvest revenue.
State Government:	Significant costs to fund three riparian specialists. (Approximately $500,000 in the first biennium)

Local Governments/Communities:	Potential reduction in harvest tax revenues. Potential effects from movement of increased levels of large wood from forested streams. Significant to local governments that actively manage forestland for timber harvest.

The incentive to actively manage the RMA is reduced. If active management does not occur in those RMAs that can most benefit from it, in terms of maximizing riparian functions, short- and long-term large wood inputs will not be optimized. Landowner costs, in terms of timber not available to harvest, will roughly double as compared to what is not available to harvest under the current rules. Harvesting, roading, and silvicultural costs will increase due to the increase in extent and content of RMAs.

Incentives available to encourage restoration each will be reduced.

Resources needed:

A quantitative analysis of timber and acreage values impacted and benefits provided. Funding for three riparian specialists. Staff time and resources to complete rulemaking, training and monitoring.

Section A
Fish Passage Restoration

Issue: What are the adverse effects of forest road stream crossings on the distribution and movement of fish? How might these effects be further reduced?

Forest Practices Advisory Committee on Salmon and Watersheds

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I. Current Scientific Findings

Overview

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.

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.

The Botkin Report (1995) and other studies have identified "impediment construction" as a major factor leading to the decline of salmonids in western Oregon.

Discussion

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).

Information about the swimming ability of Pacific Northwest salmonids is not abundant, especially for juveniles. It appears, however, that for most species the greater the fork length (length from nose to fork of tail), the greater the swimming ability (Jones et al., 1974; Bell, 1986). There is a marked difference in performance between adult and juvenile coho, as well as a demonstration of superior swimming capability of steelhead. The swimming ability of a fish can also be affected by the distance already traveled, turbidity, temperature, oxygen levels, water depth, water velocity, and the general health of the fish.

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 1).

Table 1: 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.[1] 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

The ODFW and Oregon Department of Forestry (ODF) have 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 2 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 2, 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.[2]

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[1] 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."

[2] 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.

Table 2: 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.

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. For a comprehensive discussion on these considerations refer to Appendix A.

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 six 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 six 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.

II. Watershed-Scale Effects

Natural Variability

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 watershed-scale impact to fish with migratory life histories and specialized habitat needs such 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.

Forest Management

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 watershed-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.

Other Land Uses

All other land-uses also have impacted or disrupted the movement of fish. However, due to different regulatory mechanisms and much less voluntary action, the potential to manage the fish passage problems associated with other land-uses appears less optimistic. Nonforest road crossings often do not fall under the regulatory oversight of the Oregon Removal/Fill Act: only crossings that require more than 50 cubic yards of fill, or exist within streams identified as "Essential Indigenous Anadromous Salmonid Habitat" will have regulatory oversight. Since other land-uses often create barriers lower in a drainage system, the potential negative impacts from these activities may be relatively greater.

III. Objectives of Current Measures and Rules

Oregon Plan Objectives

The Oregon Plan objectives include the elimination of artificial obstructions to fish passage necessary to access key habitat for critical life stages of salmonids:

- Identify all human-created passage impediments to coastal stream segments usable or potentially usable by salmonids, and categorize those segments according to the amount and/or quality of potential habitat by 2010. Establish and maintain a list of "significant" barriers for restoration priority or that block access to more than 600 feet of stream.
- Ensure that human activities in coastal streams currently accessible to salmonids do not block or otherwise segment those streams so as to limit accessibility.
- Remedy 15 percent of the significant human-created impediments to fish passage in coastal streams per biennium.

FPA Objectives

The fish passage objectives of the Forest Practices Act are to allow and maintain upstream and downstream passage for both adult and juvenile fish during conditions when fish movement normally occurs. This objective applies to all stream crossings installed after September 1994. A second objective is to require restoration of fish passage through crossing structures installed prior to 1994 at the time the structure would be replaced under a normal life span. A final objective is to encourage voluntary restoration of passage prior to replacement under a normal life span.

The purpose of the water classification rules is to match the physical characteristics and beneficial uses of a water body to a set of appropriate protection measures. In the current classification system, fish use is a key beneficial use. For the purpose of the classification system, "fish use" means "inhabited at any time of the year by anadromous or game fish species, or fish that are listed under the federal or state endangered species act."

IV. Description of Measures and Rules

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 nonforest lands, 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 15 and ODF 25). These two voluntary measures target the identification and correction of road-related problems on private industrial forestlands over the next ten years. In addition, Oregon's Watershed Enhancement Board (OWEB) and ODFW's Restoration and Enhancement Board provide funding to projects that enhance fish habitat and watershed function, including fish passage improvement projects.

Oregon Plan Measures

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 1S: *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 2S: *State Forest Lands Road Erosion and Risk Project –*
This measure, similar to ODF 1S, 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.

ODF 16S: *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 46S: *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 5S - North Coast Salmonid Habitat Restoration Project
ODF 6S - Mid-Coast Restoration Project
ODF 10S - Forest Practices Monitoring Program
ODF 13S - Storms of 1996 Monitoring Project
ODF 23S - BMP Compliance Audit Program
ODF 25S - Fish Presence/Absence Surveys and Fish Population Surveys
ODF 32S - Fish Presence Survey
ODF 52S - South Coast Technical Advisory Team

FPA Standards and Rules

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.

(c) 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."

V. Evaluation of Measures and Rules

Voluntary Measures

The following basic steps to restoring fish passage at road/stream crossings are in place for a large portion of forestland and for state and county highways:

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.

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

For example, the Oregon Plan Watershed Restoration Inventory reports that 530 culverts were removed, replaced, upgraded or installed for fish passage in 1996-97. In 1998, about 300 culverts were removed, replaced, upgraded, or installed for fish passage, opening 200 miles for fish use. About 80 percent of the effort was by industrial forest landowners. The actual number of structures is likely higher, since between 2 percent and 20 percent of road improvement projects did not provide information on culverts affected.

Stakeholders on forestlands are committed to continuing these types of activities into the future. Industrial forest landowners have estimated spending approximately $13 million a year, or $130 million over the next 10 years, on these projects in the coastal Evolutionary Significant Units (ESUs) alone. State Forest Lands have committed to spending over $2.5 million during the '99-'01 biennium for the restoration of roads and replacement of culverts and other stream crossing structures damaged by the 1996 storm. State Forest Lands are also proposing to spend an additional $2.5 million dollars in each of the next three biennia to improve roads, including stream crossing structures.

How successful these and future activities will be in restoring fish passage is uncertain at this time. Nonetheless, road issues, especially fish passage restoration, are being emphasized statewide and significant 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.

Current Rules

Fish use surveys have been completed on approximately 20 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. Issues that have arisen with regard to the classification system include concerns about classifying streams as nonfish 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.

At the current survey rate, it is expected that the fish presence surveys will be about 80 to 90 percent complete in the next six to eight years at a total cost of $3 to 4 million. There are

significant concerns that this level of funding may not be available for these efforts. Some also question whether this is the most productive area to spend limited salmon restoration funds.

The ODF fish passage guidance was released in June 1995 and is updated as new information becomes available (last updated June 1999). 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 is currently conducting a stream crossing compliance pilot study that is discussed below. Significant training about fish passage design was provided by ODF and others to help address some of the issues identified by the pilot study.

Under the new rules, fish passage is required for those stream crossings that have been 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 that the upstream reach has the capacity to be a fish bearing stream but is currently a nonfish bearing stream because of a culvert that cannot pass fish, that upstream reach will remain classified as a nonfish bearing stream.

Stream Crossing Study Preliminary Results

The ODF conducted a pilot study in the summer of 1998 to examine compliance with the ODF fish passage guidance. Twenty of the stream crossings monitored were volunteered for assessment ("volunteer sites"). An additional 37 sites were selected in a random stratified manner so that sites with both Type F streams and a newly constructed or reconstructed road were included. The study focused on juvenile fish passage.

Since the 1998 sample is not a random sample, the results presented from these data may not be representative. The 1999 sample will be able to confirm or reject these preliminary findings with statistical validity. Nonetheless, the 1998 data provide the best information available to date and therefore policy decisions are likely to be based in part on the results of this study. The preliminary data indicate that guidelines, education, and outreach need to be emphasized to increase the likelihood that stream crossing structures will meet the ODF guidelines.

Preliminary results are presented in three categories: Written Plans, Implementation of Guidelines, and Juvenile Fish Passage. In the following discussions, results will often be reported separately for "selected" versus "volunteered" sites.

<u>Written Plans:</u> Thirty-three out of 57 sites (58 percent) contained the necessary information to determine which fish passage alternative was being used. It is important that written plans reflect this information for both administrative and monitoring purposes. When the fish passage alternative is not clearly stated (42 percent of the sites), assumptions must be made to determine if the guidelines were properly implemented and if the installation goals were achieved.

Did the written plan contain the recommended information for the particular alternative?
Only eight of 29 of the selected sites (28 percent) and 4 of the volunteered sites (20 percent) contained the minimum amount of recommended information. The technical ODF guidelines provide a list of data that should be included in written plans to allow department personnel to judge the soundness of the installation proposal.

Was the written plan properly implemented?
This is the most basic compliance question that can be answered. Forty percent of the selected sites and 60 percent of the volunteered sites implemented the alternatives described in the written plans (Table 3). Eleven percent of the selected sites and 15 percent of the volunteered sites did not implement the alternatives described in the written plans. The remaining sites fall into one of two categories: unknown and undecided. Unknown alternatives will not be assigned an alternative, because of a lack of information in the written plan. Undecided will be assigned one of three alternatives after further review.

Table 3. Selected Sites That Achieved The Alternatives Described In The Written Plan.

Category	Number of Sites		Percent of Total	
	Selected	Volunteer	Selected	Volunteer
Unknown	8	4	22%	20%
Undecided	10	1	27%	5%
Yes achieved written plan	15	12	40%	60%
No did not achieve written plan	4	3	11%	15%
TOTAL	37	20	100%	100%

Likelihood to Pass Juvenile Fish: There are four assumptions made in determining the likelihood of an installation to pass juvenile fish: (1) bridges and open-bottom arches are likely to pass juvenile fish; (2) culverts installed at or less than 0.5 percent gradient with no outlet drop are likely to pass juvenile fish; (3) stream-simulated culvert strategies are likely to pass juvenile fish; and (4) baffled culverts with no outlet drop are likely to pass juvenile fish. Based on these assumptions, survey results indicate that the selected sites had less likelihood of passing fish than the volunteer sites. Fifty-one percent of the selected sites were likely to pass juvenile fish, while 80 percent of the volunteered sites were likely to provide juvenile fish passage (Table 4). These results indicate that the selected and volunteered sites should not be pooled together. The ODF guidelines provide much greater detail and breadth of scenarios that need to be considered when installing structures, and this is discussed below.

Table 4. Likelihood of Passing Fish by Site Selection Process.

Site Selection Process	Juvenile fish passage	Number of sites (Percent)
Selected	Yes	19 (51%)
Selected	No	18 (49%)
Volunteer	Yes	16 (80%)
Volunteer	No	4 (20%)

Implementation of Guidelines on the Selected Sites: Field data collected at each selected site (excluding the volunteer sites) were compared with the appropriate guidelines. Each installation was evaluated against the specific criterion defined in the ODF alternatives regarding stream and valley characteristics, outlet jump, outlet mitigation, culvert dimensions, and sediment retention.

For the 22 selected sites where the alternative was identified, the installation was rated as "accept" (i.e., the guidelines were properly implemented), "further review" (i.e., borderline instances), or "reject" (i.e., the guidelines were not properly implemented). The standards by which to do this are described in the ODF guidelines (Robison, 1995 and 1997). Results indicate that 36 percent of the installations implemented the guidelines successfully, 36 percent warrant further review, and 28 percent did not implement the guidelines properly (Table 5).

Guideline implementation and the likelihood of the installation to pass juvenile fish can be evaluated together. This evaluation identifies an apparent discrepancy in Table 5. For example, a site may not meet the ODF guidelines yet pass juvenile fish, or visa versa. Of the six sites that did not implement the guidelines, one was likely to pass juvenile fish. This situation was a countersunk culvert (Alternative 4), which based on field data, was actually installed at a gradient lower than recommended for the stream gradient. Under Alternative 4, culverts should not be countersunk such that the stream gradient minus the culvert gradient is greater than 1 percent. However, the culvert was retaining sediment and therefore was assumed likely to pass juvenile fish. The juvenile fish passage rates did not change much from that shown in Table 3, when the unknown alternatives were dropped. Fifty-five percent of the sites are likely to pass juvenile fish, and 45 percent are not likely (Table 5).

Table 5. Proper Implementation Of Stream Crossing Guidelines And Providing For Juvenile Fish Passage (Excludes Volunteer Sites And Sites Where The Alternative Was Unknown).

LIKELIHOOD TO PASS JUVENILE FISH	**Determination of Proper Implementation of the ODF Guidelines**			
	Accept	Further Review	Reject	Total
Yes	8	3	1	12 (55%)
No	0	5	5	10 (45%)
Total	8 (36%)	8 (36%)	6 (28%)	22

Juvenile Fish Passage Summary

The results indicate that only 40 percent of the selected sites were in compliance with their written plans. Furthermore, only 22 percent contained the minimum amount of information recommended in the guidance. Compliance with the written plan was slightly improved for volunteered sites (60 percent). Fifty-eight percent of all the sites contained enough detail to determine which ODF alternative was being used. These results suggest a need for an increased emphasis on written plan criterion and tools for department personnel to use when determining compliance.

Only 51 percent of the selected sites are likely to pass juvenile fish, while 80 percent of the volunteered sites are likely to pass juvenile fish. The majority of the selected sites either successfully implemented the guidelines (36 percent) or needed further review (36 percent). Twenty-eight percent did not meet the guidelines. With such a small sample size, it is dangerous to apply these numbers to the total population of new installations. However, it does emphasize two important points:

1. ODF is on a fairly steep learning curve at this point with regard to successful implementation of the guidelines. The guidelines are fairly new (two years for the most recent), and the

landowner, operators, and department personnel are still learning how to achieve the fish passage standards. In addition, ODF guidelines are very specific in terms of achieving juvenile fish passage and require rigorous designs not yet seen on other ownerships (e.g., 0.5 percent gradient). Furthermore, when comparing these compliance rates with those reported from other agencies, it is critical to know what criterion the other agencies are using and what monitoring techniques were used. ODF is unaware at this point of any other agency performing such detailed measurements of compliance.

2. While the sample size is extremely low, these results emphasize the need for increased training on the guidelines and the need to incorporate some of the technical guideline criterion into the ODF Guidance Manual.

VI. Possible Additional Measures and/or Rules

Option #1

Objective:
To 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.

Description:
If an upstream reach has the capacity to be a fish bearing stream but is currently a nonfish bearing stream because of a stream crossing structure that cannot pass fish, the forest practices rules would be amended or voluntarily applied so that the upstream reach would be classified as a fish bearing stream. The extent of potential fish use upstream of the blockage would be determined using the interim guidance criteria.

Methods/Approaches:
ODF has developed interim guidelines to designate fish use based upon the physical characteristics of a stream. These guidelines were based upon the fish presence survey data and would be used for stream segments above human-caused barriers to designate the Type F reach. The guidelines use either a map or on-the-ground physical characteristics.

1. Voluntary – landowners could agree to implement this approach following the interim fish use guidelines on a voluntary basis. This approach would be easy to implement and track since it would be done on an operation by operation basis.

2. Regulatory – the current stream classification rules would be amended to establish that when fish use ends at a human-caused culvert (or other barrier), then the classification of fish use will be extended above the culvert to a point that would be established following the current interim criteria.

In either case, a process that field-verifies reoccupation in the future and establishes the actual end point of fish use may be desirable and would be included. Such a survey could be conducted

a set number of years after the culvert replacement occurs. Also in either case, a process to consider options other than restoring fish passage for very short lengths of stream could be allowed so long as the appropriate length of stream above the culvert was protected as fish bearing as part of the mitigation for loss of habitat.

Benefits:
The most important benefit is that reaches of stream that will be reoccupied by fish once a culvert is replaced will have retained vegetation to facilitate reoccupation and help maintain and restore good fish habitat over time. This option could also remove a disincentive to replace a culvert in a timely manner. It may remove an incentive to harvest a reach above the culvert before culvert replacement. The option eliminates an unfair dichotomy about how streams are classified. Currently, if fish presence surveys have not been conducted above a culvert, than 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, than the entire stream above the culvert is treated as a Type N stream.

Costs:
Landowner costs will be increased. Additional harvest restrictions will be imposed for those stream reaches with a classification change from nonfish to a fish bearing stream. Given the relatively large number of culverts that determine the end of fish use, the length of stream affected could be relatively significant. The actual costs will depend upon the stream length and the level of protection required. This option might also create a potential conflict between upstream and downstream neighbors: for example, where a downstream landowner is reluctant to replace the culvert, while the upstream owner is required to provide Type F stream protection.

Resources needed:
Some form of tracking system will be needed to maintain the identity and location of culverts that are the end of fish use. In general, these data are available for completed surveys, but not for channels that have not yet been surveyed. Current stream classification maps could be used for this purpose. The interim classification guidelines should be re-assessed as part of this process and may need to be modified. This assessment would be based upon the additional survey information that has been collected since the original guidelines were developed.

Option #2

Objective:
To facilitate the identification, prioritization, and restoration of existing culverts that currently do not pass fish.

Description:
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. When stream crossings are established or replaced on Type F streams, written plans are required and some level of design review service is provided for forestlands. Many landowners are participating with watershed councils to help establish restoration priorities and facilitate grant writing. Recent training efforts have been implemented to

improve the technical understanding of the design criteria. This option is aimed at accelerating culvert replacement above what is currently being done, especially for family forestland owners who often do not have adequate resources to address this issue.

Methods/Approaches:
There are a number of different ways to implement this option. Either a rule-based or voluntary approach could be used. Listed below are specific methods that have been deliberated by the Forest Practices Advisory Committee (FPAC):

1. Require that fish passage be restored for any culvert on a road that is within an active harvest operation within one year after completion of the harvest.
2. Require that landowners inventory fish passage barriers and that such barriers be repaired within a specified time period. The survey could be required over a four-year period and the remediation of fish passage problems completed over a ten-year period. This could be part of an overall road inventory and risk reduction plan. Financial incentives may be needed to fully implement this method.
3. Create a support service within the ODF for road assessment information. There are a number of possible ways of providing a "service" to support road assessment and mitigation. This nonregulatory service would catalog potential fish passage culverts and aid in design standards and in obtaining stewardship grant money, if needed. Information could be forwarded to watershed councils to be incorporated into watershed assessments and action plans.
4. The Conditional OFIC Proposal (in the Forest Roads Issue Paper). Part of this proposal is to address fish passage problems associated with legacy roads and culverts.

Benefits:
Linking fish passage restoration activities to an active harvest operation would accelerate culvert replacement and tie restoration timing and location to activities that produce revenue. Requiring inventories and remediation activities within a specified time period provides for some flexibility for the landowner. Creating a support service will aid in the tracking of culvert work progress and provide assistance to landowners who lack adequate resources, specifically nonindustrial private landowners (NIPLs), also known as family forestland owners. This will also potentially aid in the prioritization of culvert work for watershed councils and allow for the more efficient use of limited resources.

Costs:
Short- and long-term costs will be increased for landowners with some of these approaches. Linking fish passage restoration activities to an active harvest operation may draw resources away from other higher culvert and road priorities. This would require shifting landowner resources from other actions that may have greater benefits to fish. The ODF will need additional resources to build and maintain a support service for road assessment information and the personnel necessary to manage such a service. It is not clear how the data might be used to improve outcomes over current systems.

Resources needed:
New or amended rules and/or financial incentives. A method of tracking the completion of restoration actions tied to operations. A process to track the inventory and repair of barriers. Multi-land use inventories of problem culverts and relative length of habitat above the problem

barrier. Resources to coordinate restoration efforts through ODF, ODFW, or a watershed council. Funding for restoration.

Option #3

Objective:
To provide a more effective and efficient means of classifying streams for "fish use."

Description:
Revise the forest practice rule definition of Type F and Type N streams based upon a physical habitat approach to classify fish use and nonuse streams.

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 also 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 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 can occur 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 because fish were not present at the time the fish survey was conducted.

Methods/Approaches:
ODF has developed interim classification guidelines to designate fish use based upon the physical characteristics of a stream. These guidelines were based upon fish presence survey data and could be used to classify streams that are "fish habitat." The guidelines use either mapped or on-the-ground physical characteristics. The current stream classification rules would be amended to establish that fish habitat streams are any streams that meet the habitat criteria. The habitat criteria may need to be modified and improved based upon more recent and complete survey data. One of the key issues that will need to be addressed is the acceptable margin of error in applying a habitat model. Data indicate that models used to predict fish use in gentle topography have less error than models applied in steep topography. In either case, a policy choice must be made concerning the acceptable predictive error. A more conservative model (error on the side of over-predicting fish habitat) could be used since the rules would also have a process to field survey at the request of the landowner. This option would most likely need to be applied in combination with Option #1 to avoid a range of potential inconsistencies.

Benefits:
This will potentially increase the amount of mature forest habitat available to salmonids over time by allowing the maintenance of such habitat in stream reaches that may have historically

supported salmonid populations. Funds used to conduct the surveys can be allocated to other needs/activities. May reduce classification problems resulting from survey errors or other survey biases. Provides an option if the listing of fish precludes the use of efficient survey methods (electroshocking).

Costs:
Landowner costs will potentially be increased since additional harvest restrictions will be imposed for those stream reaches where there is a stream classification change from nonfish bearing to fish habitat. Conversely, this may also potentially decrease the amount of mature forest habitat available to salmonids over time if the habitat model incorrectly classifies habitat that is used by fish as nonfish habitat. The other values of the surveys such as identifying barriers to fish passage, unmapped stream channels, and creating a baseline of fish distribution information will be lost.

Resources needed:
The interim classification guidelines would need to be reviewed and revised to develop predictive models for fish use. Agreement would be needed about the acceptable error rate. Classification maps would need to be updated. A choice would also need to be made when the classification change would occur and whether ODF, ODFW or the landowner would physically survey the stream or apply the mapped-based approach. The choice might well be different based upon topography or region. Resources are probably adequate to process field survey requests, assuming that demand for this service does not increase substantially. However, some accommodation for scheduling surveys would be necessary due to the limited field season.

Option #4

Objective:
To identify and restore fish passage problems on family forestland owners (5,000 acres or less).

Description:
Create a funding source for family forestland owners or assist family forestland owners in obtaining funds from existing sources to expand the road assessment effort to family forestland owners. This financial assistance would also be used to help family forestland owners replace stream crossings that are not adequately passing fish. The program might be similar to the Forest Resource Trust.

Methods/Approaches:
1. Provide a tax credit for culvert restoration for the next ten-year period which would restore access to “high” priority habitat. The thresholds for high priority habitat would be set based upon factors including size of stream, stream gradient, type of habitat restored, and length of habitat with restored access. The credit would sunset in ten years and replacement would then be at the cost of the landowner.
2. Float a bond issue that would be repaid with Ballot Measure 66 funds to provide a specific account for culvert replacement. This approach would also have a priority system.

3. Establish a combined account for culvert replacement utilizing earmarked Ballot Measure 66 funds, ODFW Restoration and Enhancement funds, new fishing license surcharge, public and landowner contributions, and/or federal funds. This approach would also have a priority system.
4. Establish a capitol investment loan program like the Forest Resource Trust that would provide a low cost loan to family forestland owners for road and culvert repair that would be repaid at the time of a harvest. This approach would also have a priority system.

Benefits:
This would provide a funding mechanism to accelerate culvert replacements on family forestlands. Since family forestlands tend to be lower in a basin and are often located along larger and lower gradient systems favored by coho salmon, access to substantial overwintering coho habitat might be restored.

Costs:
Funding would be needed and may draw resources away from other higher priorities. Ideally, the direct costs to family forestland owners would be minor.

Resources needed:
Possibly legislation, funding sources, and a prioritization system.

Option #5

Objective:
Encourage the use of bridges as the stream crossing design standard of choice.

Methods/Approaches:
Amend the rule guidance to encourage the use of bridges instead of culverts to the maximum extent practicable.

Benefits:
Fish passage would be ensured wherever a bridge would be installed. Bridges have a more limited likelihood of resource damage from catastrophic failure as compared to culverts and fills. Bridges are also are more likely to provide for the downstream movement of large woody debris and sediment.

Costs:
Bridges are very costly to install compared to other options that can also successfully pass fish, though long-term maintenance costs are less. Focusing limited resources on bridges would very likely mean that other efforts to improve fish passage could be significantly reduced.

Resources needed:
Lower cost design and construction options for bridges. Possible financial incentives.

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Appendix A

Water Velocities

When flows through a drainage feature create conditions that are impassable to fish, their up or downstream movement is delayed for as long as that condition persists. This can occur at either extreme of high or very low flow conditions. Adult spawning migrations are commonly timed with freshets that may result in excessive velocities or other impassable conditions in culverts for a period of time. Migration delays can result in a number of negative impacts on fish (Fish Commission of Oregon, 1969; Groot and Margolis, 1991; Travis and Tilsworth, 1986):

1. **Increased metabolic cost--**Excessive delays in migration cause fish to expend stored energy necessary for successful migration, maturation and spawning before reaching their destination, resulting in weakened fish more disposed to disease or pre-spawning mortality. Salmon usually stop feeding before entering fresh water and depend on bodily reserves of fat and protein for migration, further maturation, spawning and redd defense until they die. Body fat reserves of sockeye salmon in the Fraser River were observed to be over 90 percent depleted in females and nearly 90 percent depleted in males at the time of death after spawning. Considering that some salmon species, like those on the Snake River runs, will travel up to 900 miles to reach their spawning grounds, efficient use of stored energy reserves is critical to successful reproduction.
2. **Delay in spawning timing under favorable conditions--**Delayed fish may arrive at holding or spawning areas later than normal thus missing their normal spawning periods, which may be timed with crucial flow and water temperature conditions necessary for egg and fry survival.
3. **Reduced spawner distribution--**The distribution of spawning fish can be adversely affected by delays. If fish cease to move upstream, headwater areas may be poorly seeded with redds while the number of nests below the barrier may be beyond the carrying capacity of the area. Late spawners in areas with high redd densities may dig up eggs previously deposited, resulting in mortality to the progeny of earlier spawning fish.
4. **Increased mortality due to predation--**During a study of the ability of Arctic grayling to pass through a 110-foot long, 5-foot diameter highway crossing pipe, the fish were prevented from passing through for eight days during a period of high flow (Travis and Tilsworth, 1986). The study observed that sport fisherman took a substantial number of fish holding in the pool below the culvert.
5. **Reduced female fecundity--**Female fish subject to harassment, disease, poor environmental conditions, depletion of bodily reserves or high spawning densities have been noted to not fully spawn but retain a substantial percentage of eggs.
6. **Reduced juvenile survival--**Juveniles or resident fish seeking more abundant food, cover, or favorable water temperature conditions, as well as refuge from high flows or predation, may have to remain in less than ideal habitat conditions while passage conditions are unsuitable.

The pattern of water velocity in a natural channel is very complex. A wide variety of swimming conditions are available for fish, ranging from high velocities and turbulence in the main flow to quite slow, calm water along the stream edge, around large boulders and wood, or within side channels. Even though average stream velocities could be much greater than the ability of adult

or juvenile fish to pass, there are abundant low-velocity zones near and within the boundary layers of roughness elements such as bed material and logs that facilitate upstream movement.

Coho salmon observed navigating rapids in the Somass River, British Columbia, swam quickly through the rapids then held in a quiet pool for some time (Groot and Margolis, 1991). This burst and rest pattern is likely the way that fish maneuver through high velocity zones and jumps in drainage features, fish ladders, weirs or baffle systems. If the maximum time for maintaining either sustained or burst speeds is reached before a resting area is available the fish will be swept back downstream.

The potential energy due to differences in elevation can result in increased water velocities as water moves down hill. The greater the elevation change between a culvert inlet and the outlet, the more challenging managing water velocity becomes. The velocity profile of a culvert can present a rather homogenous pattern of high water velocities with few zones of slow, calm water. This may lead to the assumption that fish pass through a culvert at their maximum possible speed in order to minimize their exposure to increased water velocity. It has been observed, however, that fish do not always pass through culverts at their maximum possible speed. Behlke et al. (1989) speculate that fish navigating through culverts of unknown lengths will not expend energy at their full potential but will move ahead slowly to conserve energy. This theory is supported by field observations where fish passage through culverts took longer than expected.

Fish tend to occupy areas of water that have lower velocities (Powers et al., 1998; and Belhke et al., 1990). In culverts that have obstructions to flow, there tends to be more areas of slower water that fish can occupy and rest between periods when they must negotiate high velocity water. Common areas where low velocity occurs are along the margin of the culvert, immediately downstream of boulders, and along the bottom of the stream. Examination of the *average* velocity of most steep gradient streams shows that natural streams are out of compliance for juvenile fish passage. The reason fish can negotiate these streams is because of these areas of relatively low water velocity dispersed throughout steep gradient streams. One reason wide or embedded culverts are preferable is to provide more opportunities for these low velocity areas. Culverts in which the water is constricted into a narrow flume provide little opportunity for these low velocity rest areas to occur.

Juvenile salmon swimming upstream in culverts have been observed to take advantage of low velocity zones located close to the culvert wall (Barber and Downs, 1996). Apparently, up to certain velocities, the roughness of the corrugated culvert wall provides a low velocity boundary zone where passage for these small fish is possible. At higher velocities, however, the turbulence created by pipe corrugations can overwhelm small, juvenile fish, whereas a smooth pipe may still allow fish passage. The following are some of the ways in which culverts can become velocity barriers to fish passage:

- Reduce the cross-sectional area of flow
- Reduce roughness
- Increase the gradient (by straightening the stream channel)
- Present a uniform velocity distribution with a lack of resting areas

Placing a culvert at too steep of a gradient is a common cause of excessive velocities, though even moderate velocities can be a barrier if the culvert length is beyond the endurance of the fish. Sudden changes in velocity at the culvert inlet, outlet or within the barrel due to debris or culvert design can also be barriers to fish.

On relatively flat streams (streams from 0-3 percent) there is little elevation change to contend with, and several strategies can work to manage the small amount of potential energy. However, on steep streams (greater than 10 percent), the challenge becomes difficult and limited options are available to reduce velocities to acceptable levels. There are essentially four ways to prevent excessive velocities from becoming a barrier to fish passage inside a culvert.

1. Eliminate high velocities by making the culvert flat.
2. Create roughness to cause energy dissipation so that most of energy does not go into velocity production.
3. Use backwatering and drops and pools to dissipate the energy instead of constant high velocity
4. Create velocity "shadows" or resting places inside a culvert so that fish can rest or stop inside the culvert in areas with low velocity.

Placing a culvert at a low gradient is one of the best design strategies to provide for fish passage. In essence, the design is simple in that it reduces velocity by reducing potential energy dissipated in the culvert (i.e., change in elevation between the inlet and the outlet). Since culverts typically have very low roughness, it is important to place the culvert flat as most energy will be converted to velocity in bare culverts. Excessive velocities for juvenile fish passage can be found in culverts with as little as 0.5 percent gradient so careful installation is necessary to create culverts that are very close to level.

Roughness in a culvert causes the potential energy to be expended in other ways than velocity, creating turbulence with areas of reduced velocity. Streambed simulation designs attempt to mimic the natural roughness of a stream channel inside a culvert. Traditionally (i.e., before fish passage was a significant concern) a hydraulically efficient culvert was thought to be one that converts most energy into velocity and has very little roughness. Therefore, an efficient culvert could convey more water with the same opening size. Unfortunately for fish, an "efficient culvert" has extreme velocities, and excess velocity and energy often scours the streambed resulting in an excessive drop at the outlet.

The ODFW guidelines regarding maximum allowable velocities in culverts are designed to allow the weakest fish to swim at a sustained speed through a culvert without resting. Streambed simulation designs such as bridges, open arch culverts, and embedded culverts are the preferred design alternatives and do not have design water velocities, but nonembedded culvert designs that can meet the maximum allowable velocities are acceptable.

The assignment of risk is used in determining how large a streamflow the culvert is designed to handle during peak flow events. The ODFW guidelines recommend that road/stream crossing accommodate the largest streamflow that would occur in a given hundred-year period (i.e., the

100-year flow) "to the integrity of the structure."[3] The ODF, in contrast, calls for culvert designs for the 50-year flow to the top of the culvert, or to three feet below the bridge bottom for bridges. In terms of culvert sizing, the difference between a 50-year and 100-year flood is about 20 percent in most cases. However, designing to the integrity of the crossing structure such as ODFW requires would allow for smaller culverts and bridge openings than designing to the top of the culvert. Also, understanding the integrity of the stream crossing structure requires advanced geotechnical analysis for culvert fills and is difficult to regulate or give guidelines for. For this reason, the ODF guidelines require a design for the 50-year peak flood flow and uses the top of the culvert or three feet below the bridge bottom as design criteria. (Likewise, stream crossings that use a streambed simulation design must also be able to pass a 50-year flow and still be able to pass fish.)

Culvert Drops

Salmonids in media images are shown performing amazing feats of jumping and swimming ability. It is important to consider, however, that like many engineering problems, a factor of safety is desired, a "fish safety factor" (Gebhards and Fisher, 1972). A given run of fish may have several different age classes and sizes, so it is desirable to design for the smaller, weaker fish in order to obtain a maximum percentage of fish passage.

Fish have been observed to jump considerable heights and distances to clear obstacles, especially adult salmon on their upstream spawning migration. Few studies of the ability of fish to jump have actually been conducted, however, and this is especially true for young and small fish.

Drops in water surface can occur at the inlet, inside, and at the outlet of the culvert. The most common drop seen in old culverts is the outlet drop in which erosion downstream from the outlet has caused the culvert to become perched. Unless the drops are minimal and there is an adequate pool downstream and upstream for resting, these drops can inhibit or block fish passage. Outlet drops are due to excess energy in the culvert being applied to the streambed downstream, causing scour of the streambed. Narrow culverts that concentrate flow and have little roughness create excess velocity that is dissipated downstream. Designing a culvert that is adequately wide and has adequate roughness should prevent downstream scour. However, additional steps like backwatering from a downstream weir or rip-rapping the downstream end may be desirable to prevent scour downstream and provide adequate water depth inside the culvert.

The culvert inlet can also have a drop if the culvert is sunken relative to the streambed and no material has collected inside the culvert. In this case the fish will be moving through a culvert which typically has less resting areas and they now must use burst speed to move through this inlet drop. For juvenile fish this may not be possible. For this reason (as well as others), sunken culverts should be embedded so as to prevent inlet drop.

Inlet drop can also occur when a culvert constricts flow at the inlet. This occurs when a wide stream enters a narrow culvert (especially one that has a projecting inlet). In these situations,

[3] "To the integrity of the structure" means that any flow above the 100-year flow will over-top the structure. If the structure were a bridge this would mean to the top of the bridge. If it were a culvert, "the structure" would be to the top of the fill.

water concentrates and water velocity increases at the inlet, causing the water elevation to drop. When there is a flow constriction, material tends to scour out and embedded culverts become bare near the inlet, creating the bed drop described above. The use of wide pipe-arch culverts sized to match the active stream width can potentially prevent this kind of inlet drop from occurring.

Drops can occur inside the culvert because of wood and sediment deposition ("clumping"), or by the culvert settling into the sub-grade, creating an uneven slope. To prevent material from clumping together, field checks of culverts are critical. To prevent settling, steps need to be taken to make sure the sub-grade is stable before installation.

Culverts placed at slopes substantially less than the stream gradient can result in impassable jumps at the culvert outlet. Designs that do not adequately account for the potential for streambed scour below the culvert can also result in excessive outlet jumps. The lack of a resting pool below the outlet can also impede fish passage.

Water Depth

Research concerning conditions for successful upstream migration of adult salmon and trout show that the depth of water in a drainage structure is critical to fish passage for the following reasons (Dane, 1978):

1. Partially submerged fish do not get maximum thrust from body and tail movements.
2. Incompletely submerged gills promote oxygen starvation and reduced swimming ability and endurance.
3. Shallow water increases bodily contact with the channel bottom, causing physical injury and increasing the risk of predation.

A number of conditions can lead to insufficient depth in culverts including: placing structures at too steep of a gradient; using wide, flat-bottomed structures; or having a structure in a site where it is necessary to design for highly variable flow conditions (very high and very low flows). Aprons for bridges or concrete box culverts can also result in depths that are too shallow for fish passage.

Section B
Forest Roads

Issue: What are the effects of forest roads on the sediment regime and on aquatic habitat? Are these effects preventing the recovery of salmon and what might be done to reduce possible adverse effects?

Forest Practices Advisory Committee on Salmon and Watersheds

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I. Current Scientific Findings and Monitoring Results

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 and 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 (pp. 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 and 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 and 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.

Different studies report variable effects of forest roads on the hydrology of forested basins. Adams and Ringer (1994) reviewed the results of 14 published research reports that examined the relationship between forest roads and water quantity. The findings of these studies were mixed. The reviewers state the following:

> "Some studies have shown no effects of roads, while others found that forest road construction increased peak flows in small, upland watersheds. In these locations, streamflow effects appear to be directly related to the total area within the watershed of roads and other heavily compacted surfaces that are relatively impermeable to water. In larger watersheds, little or no effect on streamflows is expected because forest roads and other impermeable areas on forest lands typically represent a relatively small area."

King et al. (1984), examined a number of streamflow variables following forest road construction (maximum streamflow, date of maximum streamflow, annual minimum streamflow, annual water yield, and the 5 percent, 25 percent and 75 percent exceedance flows). No significant changes in the above parameters were detected, with the exception that an increase occurred in the 25 percent exceedance flow in one watershed and a decrease in the 5 percent exceedance flow in another watershed. Thomas and Megahan (1998) re-examined a study by Jones and Grant (1996) examining road building and harvesting effects on peak flows. For large watersheds (60-600 km^2), no peak flow effects were detected on one watershed and the results were inconclusive for two others. For small watersheds, (60-101 hectares[1]):

> "Peak flows were increased up to 90 percent for the smallest peak events on the clear-cut watershed and up to 40 percent for the smallest peak flows on the patch-cut and roaded watershed. Percentage treatment effects decreased as flow event-size

[1] 1 hectare = 2.47 acres.

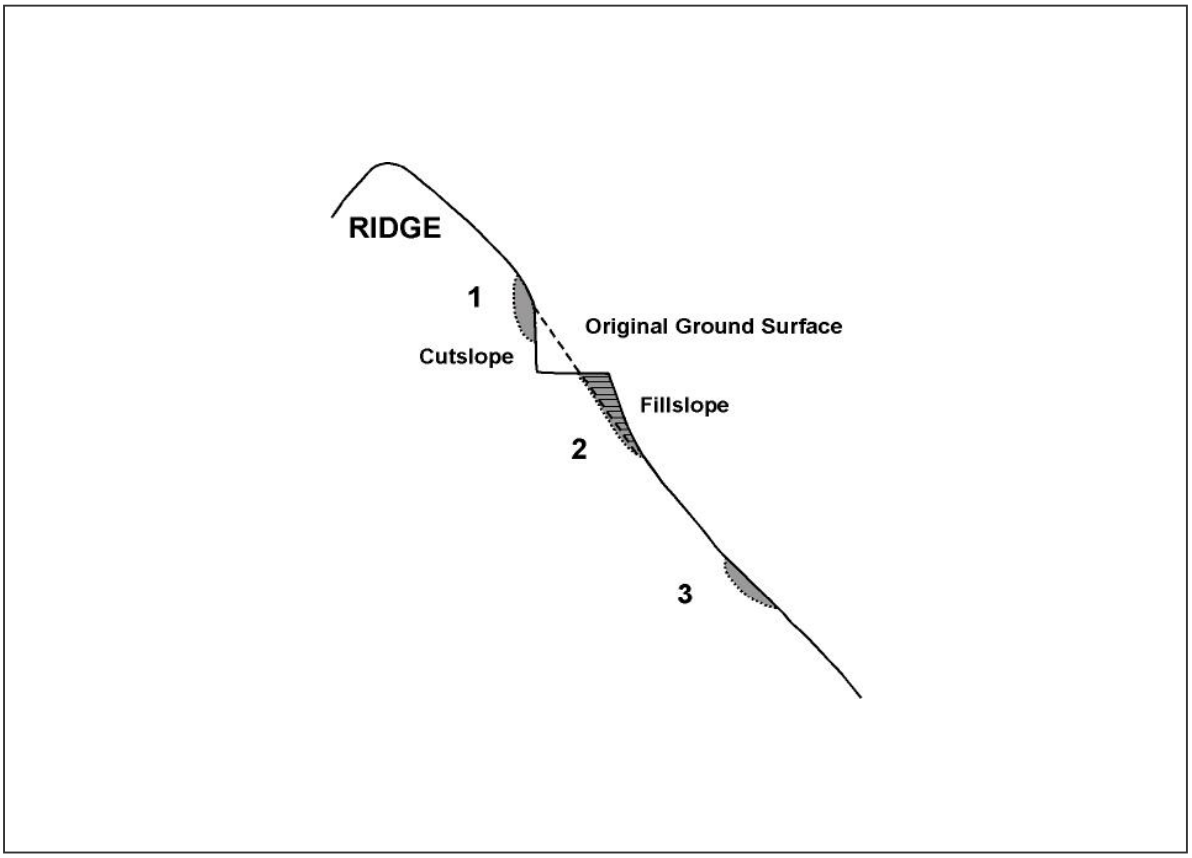
increased and were not detectable for flows with 2-year return intervals or greater on either treated watershed." (Thomas and Megahan, 1998)

Roads create a contiguous linear physical alteration to hillslopes, as shown in Figure 1. 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 was 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, and/or 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 landslides 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).

Road systems may have the potential to block the downstream movement of large wood (LW). Where a stream crossing blocks the passage of LW there is the potential for a dam-break flood to occur as debris and water back up behind the crossing. Dam-break floods can result in a debris torrent causing significant impacts to the downstream reach in the form of scour and deposition. While debris torrents are a naturally occurring phenomenon that can add needed wood and sediment to a stream reach, an increase in the frequency and magnitude of debris torrents caused by human activity can have negative effects on aquatic habitat and riparian functions. The blockage of LW can also have downstream effects even if a dam-break flood does not occur. Where a downstream reach depends on a supply of large wood delivered during peak flows, road crossings not designed to pass LW can reduce upstream sources of wood and have a negative effect on riparian functions and aquatic habitat conditions.

Figure 1. 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).

II. Watershed-Scale Effects

Forest Roads

Forest road systems can have watershed-scale effects. These effects can be similar to natural processes, or may be related to non-naturally occurring physical and chemical alterations. Determining the specific causes of watershed-scale effects can be difficult or impossible, especially in watersheds with a history of multiple disturbances. However, it may be possible to associate some of the aforementioned conditions with certain road practices at specific locations.

Watershed-scale effects of forest road systems may 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.

Cumulative sedimentation impacts from timber harvesting and other forest management activities are often overshadowed by those of roads (Reid, 1993). Cumulative effects have been the focus of much modeling. Watershed-scale effects, or cumulative effects within a watershed, may be the result of a single source, the additive result of many sources, or the complex interactions between a number of different sources.

The dominant road-related sources for direct watershed-scale effects 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 roads.

Indirect effects of forest roads are sometimes considered cumulative effects. These depend 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 watershed-scale 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.

Past models have often evaluated cumulative effects using road density (USFS, 1988). Reid (1993) describes a number of problems with the use of the Equivalent Roaded Area (ERA) model and other older cumulative effects models. The Distributed Hydrology-Soil-Vegetation Model (DHSVM) is designed to look at hydrologic changes (peak flows) associated with roads and other forest practices (Storck et al., 1998). Models are being developed to evaluate the generation of surface erosion from roads. These include SEDMODL through the efforts of Boise Cascade Corporation (George Ice, personal communication, 1999) and WEPP under development by the U.S. Forest Service (Tysdal et. al., 1997).

One problem with using road density to evaluate potential watershed-scale effects is that, depending on road size, design, location, construction and maintenance techniques, roads can have very different effects on water resources. 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."

Watershed-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 the watershed-scale effects of forest roads. 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).

Specific watershed-scale effects that can be attributable to increased sedimentation from roads include:

- Aggradation or degradation (both processes can change channel morphology and in-stream habitat);
- Debris flow or dam-break-flood scour or deposition;
- Straightened channels and increased gradients;
- Chronic high turbidity;
- Channel bed instability; and
- Deposition of fine sediment in gravels, especially during low flow periods.

Indicators of high potential for possible watershed-scale effects from roads may include:

- A higher amount of roads connected to stream channels (over 40 percent is above average), especially on watersheds with "high" traffic levels;
- Many fill or sidecast constructed roads on steep slopes;
- A large number of older stream crossing fills over 15 feet deep;
- Wide distances between road cross drains;
- Active winter hauling on a large percent of a watershed where roads are connected to streams and the road surface is not adequately rocked with durable materials; and
- Road drainage directed onto unstable slopes.

Most roads will have some effect on their watersheds. Determining when this effect is at a level that is degrading water quality is difficult to determine without some understanding of the following issues:

- The background variability in the disturbance parameter;
- The nature of the channel system and streamflows;
- The size of sediments supplied to the channels;
- The effects of the disturbance parameter on aquatic life;
- The extent of the disturbance in streams; and
- The recovery period.

Watershed-scale effects related to current practices can be mitigated by:

- Alternative BMPs;
- Avoiding or limiting the extent of certain practices (i.e., roads in steep terrain and adjacent to channels); and
- Limiting the timing of disturbance (i.e., reducing heavy truck traffic during very wet periods on roads that pose an unacceptable risk of delivering fine sediment).

Watershed-scale effects that have already occurred are often difficult or impossible to mitigate over short time periods (relative to several generations of the fish species of concern). Watershed-scale effects that have not occurred (e.g., potential fill-related landslides and subsequent debris flows from roads on steep slopes) can be prevented in many cases through certain road management techniques.

Most of the potential watershed-scale effects of roads are likely related to roads designed and constructed under older administrative rules. These make up the majority of the roads on the landscape and were often constructed with practices that present a greater risk of adverse effects to aquatic habitat. These practices included:

- Placement of fills and waste materials on very steep slopes;
- Construction of roads up "stream bottoms;"
- Undersized and deteriorated stream crossing structures;
- Inadequate cross drainage; and
- Inadequate surfacing.

Treatment of older roads may be the most effective means of reducing watershed-scale effects. Sidecast pull-back, road vacation and relocation, replacement of undersized culverts, installation

of additional cross drains, resurfacing, and other practices are methods available to mitigate impacts from older roads. Effectiveness of these treatments probably depends on many factors, including original road construction practices, proximity to stream channels, slope steepness, soil properties, on-site vegetation, and channel morphology.

The IMST report states "3. Develop policy that brings roads not constructed to current standards, and other hazardous settings in critical locations into compliance with current standards. This means having the current OFPA Rules applied to actions taken before the current Rules were in force. In many cases, the operator acted in good faith and within the rules of the day, but the outcome is not scientifically consistent with the mission of the Oregon Plan; thus, a provision by which remediation is accomplished is needed."

Other Land-Uses

Forest roads should be viewed within the context of all roads. Historical settlement patterns and ease of construction (relative to mountainous slopes) have resulted in many miles of roads built in valley bottoms near streams to access agricultural, rural and urban areas. These roads often parallel low gradient streams (which historically tended to have very productive salmonid habitat) and cross numerous tributaries. Culverts in these areas that are barriers to fish passage may block many miles of stream habitat on these low gradient streams. In a recent survey of county and state highways in western Oregon, over 1,200 culverts were found to be barriers to fish passage (Office of the Governor, 1999). These highways are typically located downstream of forestlands and therefore may limit or block access to upstream fish habitat. Many of the same road construction practices that occurred historically on forestland also occurred on other lands, and thus will have similar potential watershed-scale effects. The relatively large network of nonforest roads in close proximity to streams that are currently providing, or have the potential to provide, quality fish habitat are likely to have significant impact on the maintenance and recovery of salmonids.

III. Objectives of Current Measures and Rules

Oregon Plan Objectives

The following are interim habitat objectives for substrate conditions (sediment) under the Oregon Plan:

> i.) In cooperation with local groups and federal agencies, refine, by reach or stream type, all the substrate elements needed to support healthy salmonid stocks in all coastal streams by 2002.
>
> ii.) In the interim, habitat objectives for substrate conditions are to provide:
> For streams that have from 1 - 4 percent stream gradient, the objective is 35 percent gravel availability in 70 percent of the stream length - that is, deposits predominately gravel sized with less than 10 percent fines (% area). For streams outside this gradient range, available gravel is expected to be lower because of natural processes.

iii.) In cooperation with watershed councils, private landowners, and local, state and federal agencies, create watershed assessments and action plans in every basin in all steelhead ESUs that gives the status of current channel substrate conditions and prioritizes options for further study, restoration, and protection by 2002.

iv.) Ensure that existing programs prevent, minimize, or mitigate the effects of human activities that would modify substrate composition in coastal streams, or the upstream and upland processes that generate instream substrate diversity, to the detriment of salmonids beyond present (1997) conditions.

v.) Restore substrate abundance and distribution elements necessary for healthy salmonid stocks, and/or the upstream and upland processes that would replenish them naturally in 2 to 5 percent of altered stream miles per biennium. Altered streams would be identified via published reports and watershed assessments.

FPA Objectives

Purpose 629-625-000

(3) "The purpose of the road construction and maintenance rules is to establish standards for locating, designing, constructing and maintaining efficient and beneficial forest roads; locating and operating rock pits and quarries; and vacating roads, rock pits, and quarries that are no longer needed, in manners that provide the maximum practical protection to maintain forest productivity, water quality, and fish and wildlife habitat."

IV. Description of Measures and Rules

Oregon Plan Measures

The Oregon Plan Road Hazard Identification and Risk Reduction Projects (measures ODF 1S and ODF 2S) 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 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 Hazard Identification and Risk Reduction 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 2S, 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.

In addition to ODF 1S and 2S, there are additional measures under the Oregon Plan that address road management concerns:

ODF 16S - 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 34S - 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 Standards and Rules

For the purposes of this issue paper, 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 paper. 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 (see Attachment A) 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 and 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.

V. Evaluation of Measures and Rules

Voluntary Measures

Evaluation of the Oregon Plan voluntary measures is limited since the Plan has been in effect for less than two years. It is difficult to assess the effectiveness of measures that have not been given a chance to work. The Oregon Plan measures must be examined in light of what they attempt to achieve, and some assessment of risk must be determined in terms of how likely it is that the current measures will achieve the stated goals.

The Oregon Plan Road Hazard Identification and Risk Reduction Project (measures ODF 1S and ODF 2S) is currently being implemented within the Core Areas, on State Forest Lands, and on private forestlands. Table 1 is a summary of all road and culvert improvement activities that have occurred under the Oregon Plan in 1996-97. Table 2 shows the trend in the miles of roads surveyed.

Table 1: Summary of 1996-97 Road Improvement Activities (From: The Oregon Plan Watershed Restoration Inventory, 1998)

Road Improvements	Miles of Road*
Roads Surveyed	3769
Roads Upgraded/Improved (Legacy Road Reconstruction)	843
Roads Closed/Vacated	52
Roads Obliterated/Decommissioned	9
Roads Relocated	5
Culvert Improvements	**# of Structures***
Culverts replaced, upgraded, or installed for peak flow passage/surface drainage	3350
Culverts removed, replaced, upgraded or installed for fish passage	530

*Miles of road and number of structures are underestimated. Depending on the activity, between 2 percent and 20 percent of road improvement projects did not provide information on mileage or number of structures.

Table 2: Trends in Road Miles Surveyed 1995-1998 (From: S. Maleki, Governors Watershed Enhancement Board)

Year	Miles of Road
1995	308
1996	703
1997	3007[1]
1998	7629

[1] Discrepancy in miles surveyed for this year compared to Table 1, due to differences in database.

How much these and future improvement activities will affect the recovery of salmonids is uncertain. This must be evaluated over time through continued implementation and effectiveness monitoring.

Current Rules

Evaluation of current rules is based in large part on the results of ODF monitoring since practices used in other regions may be very different, and also because road management practices have changed significantly over time.

How effective are the current BMPs at minimizing the delivery of sediment to channels? The latest ODF monitoring data shows that about one-third (29 -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 sediment to be delivered from these sources during hauling operations, especially during 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:

1. Monitoring has shown that there is a general lack of filtering of drainage waters near streams. A number of cases were observed where cross drainage structures where not in place to filter road runoff before reaching stream crossings.
2. 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.
3. There are inconsistencies in drainage practices between georegions, with special concerns in the Siskiyou georegion.
4. In some areas, road maintenance and repair is inadequate according to the rules.

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.

1. Landslides associated with forest roads made up a smaller percentage of the total landslides in the ODF study than road-associated landslides did in most previous studies.
2. The 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.
3. 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.
4. Road fill placed on steep slopes creates an increased landslide hazard even where no drainage water is directed to those fills.
5. Road-drainage waters directed onto very steep slopes create an increased landslide hazard even when there is no road fill placed on those very steep slopes.
6. 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).
7. 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 as well as 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 (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 relative to roads constructed using pre-1984 practices (Sessions, 1987).

Independent Multidisciplinary Science Team (IMST) Recommendations

The IMST made a total of 19 recommendations in its forestry project report of September 14, 1999. Ten of their recommendations are directly or indirectly related to the effects of forest roads on the sediment regime or on aquatic habitat. These ten recommendations are listed below, followed by the applicable issue paper options.

Recommendation 2. ODF should develop a policy framework to encompass landscape (large watershed) level planning and operations on forests within the range of wild salmonids in Oregon.

Roads Issue Paper Option(s):
Option #13 - Watershed-Scale Effects
Option #16 - Cooperative Road Use and Planning (Combination of Options 16 and 53)

Recommendation 7. Provide enhanced certainty of protection for "core areas".

Roads Issue Paper Option(s):
Option #10 - New Roads in High-risk Sites/Sensitive Areas (Combination of Options 10, 49, 50, and 51)
Option #11 - More Specific Rule Objectives
Option #57 - Ground-based harvesting on steep slopes.

Recommendation 8. Develop and implement standards or guidelines that reduce the length of roadside drainage ditches that discharge into channels.

Roads Issue Paper Option(s):
Option #7 – Cross Drainage Structures

Recommendation 9. Implement the standards and guidelines for the length of roadside drainage ditch between cross drainage structures, especially on steep-gradient roads.

Roads Issue Paper Option(s):
Option #7 – Cross Drainage Structures

Recommendation 10. Require the flow capacity of cross drainage structures and stream crossing structures and culverts to meet current design standards.

Roads Issue Paper Option(s):
Option #6 - Road Maintenance and Repair (Combination of Options 6, 9, 14, 17, 52, and 55)

Recommendation 11. Provide for the stabilization of roads not constructed to current standards (including "old roads and railroad grades") in critical locations. Stabilization means reduction or elimination of the potential for failure.

Roads Issue Paper Option(s):
Option #6 - Road Maintenance and Repair (Combination of Options 6, 9, 14, 17, 52, and 55)

Recommendation 12. Require durable surfacing on wet-season haul roads and require that hauling cease before surfaces become soft or "pump" sediment to the surface.

Roads Issue Paper Option(s):
Option #8 - Wet-Weather Hauling

Recommendation 14. Continue to apply the current best management practices (BMP) approach to the management of forestlands with significant landslide potential, and develop a better case history basis for evaluating the effectiveness of BMP in this area.

Roads Issue Paper Option(s):
Option #10 - New Roads in High-risk Sites/Sensitive Areas (Combination of Options 10, 49, 50, and 51)

Recommendation 16. Oregon Department of Fish and Wildlife (ODFW) and ODF should develop a collaborative program of monitoring to quantify the linkages between parameters of ecosystem condition and wild salmonid recovery.

Roads Issue Paper Option(s):
Option #18 - Roads Monitoring Program

Recommendation 19. The Oregon Forest Research Laboratory (FRL) in collaboration with ODFW, should develop forest road stream crossing strategies that facilitate the passage of large wood at stream crossings.

Roads Issue Paper Option(s):
Option #12 – Stream Crossing Designs

This issue paper includes options that deal with all of the IMST recommendations that are related to roads. Two options in this issue paper are not directly addressed in the IMST recommendations (Options 15 and 19). It is recognized that all options require further technical policy development.

VI. Possible Additional Measures and/or Rules

Option #6: Road Maintenance and Repair (Combination of Options 6, 9, 17, 52, and 55, with portions of 5, 7, 12 and 60 proposed for inclusion)

Objective:

This option is intended to address old roads that were constructed using past practices or methods. Existing roads are to be systematically evaluated and mitigated where appropriate for negative impacts or risks to:

1. Waters of the state (turbidity/sedimentation)
2. Passage of juvenile/adult fish
3. Downstream passage of habitat elements (wood and gravel)

This broadened option number 6 also includes the portions of these following options:

#5 - encourage the use of bridges (in the fish passage paper)
#12 - stream crossings to pass large wood
#60 - upstream/downstream program
#7 - cross drain spacing

Description:
Currently, there exists a large network of active roads across forested lands that were not built to current FPA design standards. This situation has been recognized by a number of landowners that have implemented a voluntary program under the Oregon Plan to inventory roads and mitigate problems. Protocol for this process has been developed and priorities have been established.

There appears to be consensus that action should be taken to reduce this risk and remedy those roads that are likely to deliver sediment to streams and result in adverse effects. These actions might include, but are not limited to, comprehensive road maintenance plans, improved road maintenance guidelines, and the prioritization of current and future road maintenance and repair activities. This proposal would include a suite of improved practices that would be applied to roads needing improvement.

"Legacy " roads includes those built prior to 1972 and not used since then (and therefore not subject to current FPA regulations). "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). Since legacy roads have not been used for at least 25 years, they often support stands of trees. In many cases, it will be necessary to reconstruct the road in order to provide equipment access to repair the segment in question.

While old roads 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 effect water quality and the maintenance and recovery of salmonids. Where necessary, ODF and others would develop, and make available, guidance to landowners/operators and regulators on methods to achieve the improved practices. The technology would need to be developed for several of these improved practices; most could be implemented with current knowledge.

Past Practice	Improved Practices
1. Sidecast construction on steep slopes.	**1. Full-bench design, end-haul construction on steep slopes.**
2. "High" fills.	**2. "Low" fills.**
3. Stream crossing culverts sized to pass Q25 or whatever fit.	**3. Steam-crossing culverts sized to pass Q50.**
4. Downstream side of stream crossing fills not armored with riprap.	**4. Downstream side of stream crossing fills armored with riprap.**
5. Fills not designed to allow for overtopping by high stream flow.	**5. Stream crossing fills designed to allow overtopping by stream flow.**
6. Passage of large wood hindered by stream crossings.	**6. Facilitate passage of large wood over/through stream crossings.**
7. Passage of gravels hindered by stream crossings.	**7. Facilitate passage of gravel over/through stream crossings.**
8. Fish passage through culverts may be problematic for adults and juveniles.	**8. Adult and juvenile fish passage through culverts and maintenance of passage required.**
9. Road cross drain spacing may not meet standard spacing criterion: **a. ditch erosion** **b. discharge onto steep slopes** **c. ditch water drains directly into streams**	**9. Cross drain spacing is such that ditch erosion is minimized, drain water not directed onto steep slopes, ditch water not directed into streams.**
10. Unneeded roads abandoned "as is."	**10. Unneeded roads stabilized and vacated.**

Current FPA Administration:
This option includes a number of practices that fall under the current FP rules. It also includes some options which should be considered new and require further development before implementation in the field can occur. There are a number of practices operators are required to comply with in the Road Maintenance rules (629-625-600). In the field administration of these rules, the forest practices forester is sometimes required to determine if maintenance or repair is required to reduce risk to waters of the state. Administration of the maintenance rules is often reactive; in some cases the problem may not be identified until resource impacts occur. In addition, legacy roads do not fall under the regulatory umbrella of the FPA, at least as currently understood.

Methods/Approaches:
There are many different ways in which this option can be implemented. Listed below are specific methods that have been deliberated by the committee:

Method 1

Immediately after the time of harvest, road segments within or bordering the harvest unit should be inspected and remedied for fill failure and washout risks. ODF and the operator would review roads (old and legacy) within the harvest unit. This option could be implemented on either a mandatory or voluntary basis (possibly as a stewardship plan provision).

Benefits:
Commercial harvest often creates positive cash flow (note: some harvests may not result in positive cash flow, e.g., hardwood conversions, salvage operations, etc). This may be viewed as an opportunity to use a portion of those funds to improve existing roads. Thus the link to harvesting.

Costs:
Timing of mitigation activities may interfere with harvesting or be limited to in-stream work period. Practical access to legacy road segments may not exist, as these roads may have been abandoned by previous landowners several decades ago.

Method 2

The same as above, except also include those roads used as part of the hauling route.

Benefits:
Same as above.

Costs:
Same as above. In addition, timber owner may not own haul route.

Method 3

Landowner to develop and implement a road maintenance plan by ownership or operating areas that includes a systematic road survey to identify and prioritize road maintenance needs. This option could be implemented on either a mandatory or voluntary basis. There may be an opportunity for a landowner to include a road maintenance plan as a component of a stewardship plan.

Method 4

Create financial incentives (probably a tax credit) to encourage vacating roads in sensitive areas and relocating these roads to lower-risk areas.

Method 5

Create specific road maintenance guidelines for high hazard locations by developing and making improved guidance available to operators and regulators.

Method 6

In the prioritization of road maintenance and repair, those roads that pose the greatest risk to waters of the state should be given a high priority.

Method 7

Give ODF general authority to require additional cross drainage installation as a maintenance requirement prior to an operation when current road condition and a proposed use will impair water quality.

Benefits:
This option could bring existing roads up to improved standards. Road maintenance plans will result in a systematic means for remedying road problems. Creating financial incentives will encourage operators to be proactive. A prioritization scheme will help to ensure that those areas that are most in need of repair get tended to first. This option has the potential to reduce sedimentation to streams, allow for a higher level of road maintenance, decrease the number of citations for FPA violations, and reduce long-term road management costs through the more efficient allocation of limited resources for road repairs and maintenance.

Costs:
This option could potentially increase short-term operating costs associated with a harvesting operation. Additional resources will be needed to build and maintain a road survey program and the personnel necessary to manage such a program. Linking "problem" roads to harvest operations may not address those road segments that most need attention, and will not address those road systems where harvest entry is not planned for some time. The party that controls the haul route may not be the same party that owns the timber, creating potential operational problems. Additional ODF resources will be needed to implement some of these methods.

Option #7 – Cross Drainage Structures on New Roads

Objective:
To minimize the risk of sediment delivery by ensuring that adequate cross drainage design and construction occurs on new roads. Existing roads are included under Option 6. 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.

Description:
The objectives of cross drains are:

1. To protect the road surface from erosion and retaining water.
2. To reduce erosion of the roadside ditch. Soil eroded from a ditch may be delivered to waters of the state.
3. To prevent ditch water from discharging onto unstable slopes.

4. To reduce the amount of ditch water (and associated ditch water sediment) discharging directly into a stream.

Recent monitoring studies have found that many existing roads have drainage systems that are not designed to filter sediment. A secondary finding (less commonly associated with sediment delivery to streams, was that steep roads (>12 percent grade) often have inadequate spacing of cross drainage structures (excessive distance between cross drains) (ODF, 1996). These conditions existed on both older and more recently constructed roads. There are two spacing issues: cross drain spacing based on road slope and soil type, which could be an erosion problem; and cross drain spacing based on the delivery of ditch water to a stream where the ditch discharges directly into a stream, which could be a sediment delivery problem.

Among other things, an insufficient drainage design can result in unfiltered surface runoff entering streams and have adverse effects on the maintenance and recovery of salmonids. This option would require specific criteria for the spacing of cross drains on steeper-gradient roads to provide for adequate drainage. Applying a strict spacing criterion on any given road may be problematic. Site-specific judgement is necessary in determining the best place to locate a cross drain. Applying cross drain spacing without regard to where the water will discharge may exacerbate slope instability. These criteria would be applied to new roads and during the maintenance and repair of existing roads. This option could be implemented on either a mandatory or voluntary basis.

Current FPA administration: OAR 629-625-330 (1) through (5) address road drainage practices. The rule states:

(1) Operators shall provide a drainage system using grade reversals, surface sloping, ditches, culverts and/or waterbars as necessary to effectively control and disperse surface water to minimize erosion of the road.
(2) Operators shall not divert water from channels except as necessary to construct stream crossings.
(3) Operators shall locate dips, waterbars, or cross-drainage culverts above and away from stream crossings so that road-drainage water may be filtered before entering waters of the state.
(4) Operators shall provide drainage when roads cross or expose springs, seeps, or wet areas.
(5) Operators shall not concentrate road drainage water into headwalls, slide areas, or high-risk sites.

The rule is not especially clear about the objectives for cross drainage, nor does it provide specific standards or examples of cross drainage spacing or the maximum length of ditch that should drain into a stream.

FPFs currently have the authority to require installation and maintenance of cross drains. Monitoring has shown that there is room for improvement. Training and improved guidance could be developed and implemented for operators/landowners and regulators that would emphasize the need for adequate spacing and installation of road cross drains.

Methods/Approaches:
There are several different approaches which may be taken, as described below:

Method 1

Make changes to existing rules so that they include specific criteria for installation and spacing of cross drainage structures. This would include the maximum culvert spacing by road grade, and maximum distance to cross drains above stream crossings. Both cases would include exceptions for steep fills and high-risk sites.

Method 2

Provide better guidance and training for use of the existing rules. Current rules provide authority for installation and maintenance of road cross drains. Training and improved guidance could be developed and implemented for operators/landowners and regulators that would emphasize the need for adequate spacing and installation of road cross drains.

Method 3

Provide changes in existing rules to better clarify the objectives for cross drainage. For example, the rules might state that the objectives of cross drainage are to ensure that cross drainage in number and location so that:

- Road surfaces are protected from erosion and retaining water.
- Erosion of the roadside ditch is minimized.
- Ditch water is not discharged onto unstable slopes.
- The amount of ditch water (and associated sediment) discharging directly into a stream is minimized.

Benefits:
These methods will reduce the risk of fill failures, washouts, and direct delivery of road runoff to streams on existing roads where the cross drain spacing is currently inadequate, and on new roads where the current maintenance guidelines would not have resulted in adequate cross drainage spacing.

Costs:
There will be increased operating costs associated with harvesting in areas where additional cross drains are needed. It will be difficult to develop 'universal' spacing criteria appropriate for the various soil and landform conditions across the state. If the spacing criteria are not developed and implemented correctly, there is a risk that water could be discharged onto unstable slopes, increasing the potential for sediment delivery to streams.

Option #8 – Wet Weather Hauling

Objective:
To address road surfaces that are at risk of delivering sediment to streams during hauling operations in wet weather.

Description:
Require durable rocking of roads during winter use in locations where there is a higher likelihood of sediment entering waters of the state. Prohibit 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.) that will minimize delivery of sediment to waters of the state.

Methods/Approaches:
Specific criteria for determining if a road was at risk of sediment delivery, which might include precipitation amounts necessary to trigger hauling prohibition, would be developed. Develop specific construction and maintenance standards for wet weather hauling roads and require these standards for roads determined to be at risk for sediment delivery.

There are two methods which are probably needed to implement this option, as described below:

Method 1

Develop criteria for winter-use roads, probably in rule form, to ensure that durable rock is used on road segments that can deliver sediment to streams.

Method 2

Develop a second criteria, probably also in rule form, that requires operators to cease heavy truck traffic on roads when the road surface is breaking down (only for segments that are delivering sediment to streams). Breaking down would be defined by both depth of ruts and by depth of surface "slop" on the road.

Benefits:
This will further minimize the risk of sediment entering waters of the state during the wet season from active hauling roads.

Costs:
There may be increased operating costs associated with harvesting in areas where quality rocking of roads is needed. The availability of durable rock in parts of the central Coast Range is problematic. Additional rock pit development is a potential source of chronic point-source sediment.

Option #10 – Locating New Roads and Road Reconstruction in Locations with High Potential Resource Impacts (Combination of Options 10, 49, 50, and 51)

Objective:
To reduce 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.

Description:
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, action should be taken to minimize or eliminate the risks they pose to aquatic resources to the maximum extent practicable. There are also cases where roads should not be constructed. Current rules require that operators shall "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 of the State Forester is required before roads can be constructed or reconstructed in such locations.

This current rule language allows ODF to require written plans and to not approve construction or reconstruction when the risk of such action is too "great." However, the application of this rule requires a "conservative" interpretation to ensure that the desired level of resource protection is consistently achieved. It is not clear to some on the committee what the basis for decision-making is under this rule. However, the field site visited in eastern Oregon where ODF denied road reconstruction represents the type of decision-making supported by all the committee members present on the tour.

Methods/Approaches Explored:
Several different specific sub-options to address concerns about locating roads in high-risk sites and other sensitive areas were deliberated by the committee including:

1. Ensure roads constructed across high-risk sites are constructed with no fill and also with 'fail-safe' drainage systems.
2. Require that written plans for road construction and timber harvesting operations on landslide-prone locations be prepared by a geoscience professional.
3. In areas where roads constructed using current BMPs are likely to degrade water quality, create additional restrictions on the locations of new roads in riparian management areas, high-risk sites, unstable slopes, flood plains, wetlands, and side channels.
4. Prohibit construction of roads on high-risk sites.
5. Develop clear and specific criteria for road location in these sensitive areas, which includes preferred locations, and criteria to "say no" when there are better alternatives, or when the road poses very high risk to fish, especially in "core" areas. Roads should be built in the location with the lowest overall impact to water quality and fish habitat while meeting land management objectives.

Agreement on methods 1-4 did not occur during the October 14-15, 1999, meetings. From one perspective there is a belief that the current rules are adequate (in part because ODF can apply any of the sub-options listed above under some conditions). Another perspective is the belief

that the department does not or will not say "no" to some proposed roads (in part because it is not clear if, or when ODF may apply any of the sub-options). The committee agreed that rule or guidance clarification supportive of ODF's current "conservative" or "stringent" interpretation of the existing rules as demonstrated by the eastern Oregon example was an appropriate action. Therefore, option 5 above is proposed for committee recommendation. In this context it is expected that specific rule language may be adopted about when, if ever, reconstruction of creek bottom roads might be approved.

Benefits:
Method 5 will reduce the risk of major impacts to streams and water quality. This proposal is likely to result in the "removal" over time of high-impact (especially creek bottom) roads that are proposed for reconstruction.

Costs:
Costs to landowners will increase slightly as compared to current practices. Road construction and timber harvesting costs will be increased in some steep slope areas. Long-term costs may be reduced by vacating creek bottom roads that require "reconstruction" to maintain their use. Based on past experience, these situations will be relatively uncommon. Costs could be reduced and progress enhanced by providing some grants to assist in vacating some roads. Costs could be reduced by developing equitable procedures for the use of roads on other ownership, particularly federal lands.

Resources needed:
The resources needed depend upon how the criteria will be applied in approving or disapproving roads. The focus of the rules will be to require that "roads are located or reconstructed in the location with the lowest overall impact to water quality and fish habitat while meeting land management objectives." These criteria will most likely require additional oversight and review by ODF, and/or professional design by the landowner. While these situations are relatively uncommon, they can require substantial ODF and landowner resources on a case-by-case basis.

Option #11 - More Specific Rule Objectives

Objective:
Provide more specifics in regard to the rule objectives through more specific rule language, guidance, and/or training.

Description:
Objective-based rules, such as "minimizing sediment delivery," allow flexibility but sometimes lack the specificity needed to insure that objectives are met. For example, in regards to meeting the objectives of the Forest Practice Rules, there may be room for improvement in the areas of wet weather hauling, constructing and maintaining effective cross drainage structures, and "public" roads. This option proposes to use more specific language within the rules to help ensure that the objectives are being met.

Methods/Approaches:

Rewrite those road construction and maintenance rules where the flexibility of generalized, objective-based language is precluding an effective evaluation of whether or not specific objectives are being met. The revised rules would spell out specific objectives that operators must meet in order to be in compliance. Note that Options 7, 8, 10, and 57 deal with most of these issues. Adopting specific practices under these options, and adding additional information in the "purpose" rules will provide a great deal more specificity in rules and rule objectives.

Benefits:
There will be a higher likelihood of success at achieving the objectives if they are more clearly defined.

Costs:
This will reduce the flexibility of the rules and could result in the requirement of forest practices that do not provide optimal resource protection for a given operation.

Option #12 – Stream Crossings that Pass Large Wood and Gravel

Objective:
To construct stream crossings that will pass large wood and gravel downstream, and to provide other means for passage of large wood and sediment at those crossings which restrict this passage. The transport mechanisms for large wood and gravel may be either stream storm flows or channelized debris flows.

Description:
Most stream crossing culverts restrict or prevent the passage of large wood. New culverts in Type F streams, and designed with streambed simulation, will pass gravel, but their ability to pass large wood is also limited. Stream crossing structures have been designed primarily to pass water. In the last few years, there has been an increased effort to design stream crossings so that they effectively pass fish as well. 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. This option proposes to provide a broader range of engineering options for stream crossing designs that will pass large wood and sediment, both during high flows, and for steep channels, when debris flows occur.

Methods/Approaches:
ODF would research and compile descriptions of the most current engineering options for designing stream crossings to pass large wood. These designs could be included as part of the rule guidance and recommended to operators to use where appropriate. These designs would not be appropriate in areas where large wood is not mobilized by the stream (i.e., where average annual flow is too low or debris flows are not likely to occur).

Strategies for passage of large wood and gravel may depend upon the crossing type, e.g., a ford may easily pass large wood and gravel, while a traditional fill with culvert installation may require machine activity to remove material from the upstream side and deposit on the downstream side. Financial incentives could be provided to encourage the use of more effective

options that may have a higher cost. Additional designs might include approaches that are better at preventing stream flow diversions down roads, be able to withstand debris torrents by passing such events, and be able to allow for the downstream delivery of large wood to fish bearing streams.

For existing culverts, this should include methods to allow movement of sediment and large wood that have been trapped above culverts. These provisions would probably be in rule form. Material would not be removed from, or placed in, water (where the risk of increased turbidity is high). Sediment and wood would be replaced outside of the active channel (normal bed and streambanks), and where it does not restrict the culvert outlet. Since most activity occurs during routine road maintenance, prior approval would not be required for these operations.

Benefits:
These practices would reduce the influence of roads and road-fill on the delivery of sediment and large wood to fish bearing streams, helping to restore the natural disturbance regime that has maintained salmonid habitat in the past.

Costs:
These practices are largely undeveloped and untested. They would have to be monitored over time to ensure they are performing as expected. These types of stream crossings may also be more expensive to construct as compared to traditional methods, resulting in a potential increase in short-term costs. The use of fords as a stream crossing structure may conflict with ODFW and/or DEQ policy related to their use.

Option #13 - Watershed-Scale Effects

Objective:
To address the potential compounding effects of road-related sediment inputs from a watershed perspective.

Description:
Current BMPs aim to reduce the risk of sediment delivery from roads by addressing road issues on a site-specific scale. The assumption is that if the risk of sediment delivery is being minimized on a site-specific scale, then it is being minimized on the watershed-scale as well. However, BMPs do not eliminate all potential sediment sources, and even if every 'site' (i.e., road segment) within a given watershed that has the potential to deliver sediment to the stream has a low risk for delivery, additional road building in certain areas could still increase risk. The higher the number of sites that exist, even if the risk is minimized at each site, the higher the cumulative risk that increased sedimentation will occur. To address this potential problem, this option proposes that a watershed-scale analysis be conducted of combined watershed effects of both existing roads and new road construction in moderate- to high-risk areas. This option will allow for potential watershed-scale effects to be evaluated before additional road building occurs in certain portions of the landscape.

Methods/Approaches:

For new roads proposed in moderate- to high-risk areas, landowners would provide a written plan that examines the current status of roads within the watershed in terms of the cumulative risk of sediment delivery. The current status of existing roads would be determined using the Oregon Plan Road Hazard and Risk Reduction procedure. Depending on the findings from this examination, the written plan may also discuss alternatives to new road construction, examine the decommissioned roads that are at high risk of delivering sediment to waters of the state, and/or discuss why new road construction is the most practicable option. This might also be accomplished through voluntary stewardship agreements. Specific implementation criteria would need to be developed. "Watersheds of concern" could probably be identified. If field work verified these concerns, ODF could work with landowners to:

1. Focus on road repairs.
2. Encourage vacating of unneeded or unrepairable roads.
3. Prevent construction of new roads where viable alternatives exist.
4. Prevent new construction where risk to resources is high and cannot be effectively mitigated.

Benefits:
This has the potential to minimize the construction of unnecessary new roads that may increase the risk of sediment entering waters of the state. It would also be a vehicle towards addressing older roads on the landscape that may be high risk. By targeting only those roads that have the potential to deliver sediment or water to the stream, this option could be an efficient means to reduce adverse watershed-scale effects.

Costs:
This will increase short-term costs to the landowner. If mandatory, it would also increase FPF workloads by adding another step in the notification processes. Evaluation of risk to the watershed could be very time-consuming.

Option #15 – Geographic Information Systems (GIS) Database

Objective:
Build and maintain a GIS database of all roads in forestlands for the state of Oregon.

Description:
The ODF has maps for most of the major roads that exist in forestlands in Oregon. The department does not, however, maintain digital maps (i.e., GIS) that identify every single road segment that exists in forestlands, nor does it have data on the condition of those roads (year built, maintenance history, risk assessment results, etc.). The acquisition of this data could be used to help the ODF assess road systems and prioritize restoration efforts. (Note: the SEDMODL described above utilizes this type of data for estimating sediment yield to streams). This option proposes to build such a database to enable the ODF to effectively keep an inventory of forest roads and potentially aid in the management of those roads.

Methods/Approaches:
The database could be compiled and maintained either in a central location like Salem, or at the field offices where each district would be responsible for maintaining the database for their area. An adequate full-time staff would be needed to conduct annual updates and maintain the database.

Benefits:
The database would provide the ODF with up-to-date reliable road data to be used as needed.

Costs:
Substantial resources would be needed to provide the personnel and equipment necessary to create and maintain such a database for the state of Oregon. Where private landowners are not willing to provide the ODF with their current road maps, aerial photographs would need to be taken on a regular basis to acquire the information needed to keep the database current. It may not be possible to obtain useful ground-based information without landowner cooperation.

Option #16 - Cooperative Road Use and Planning (Combination of Options 16 and 53)

Objective:
To encourage cooperative road system planning, design and use between different landowners in order to minimize the duplication and construction of unnecessary forest roads.

Description:
Forestland in Oregon is often in a checkerboard pattern of mixed ownership. There are situations where a landowner may have the opportunity to access their property using another landowner's road system and thereby reduce the length of new road that must be built for an operation. Current rule (OAR629-625-200(5)) states:

"[t]o reduce the duplication of road systems and associated ground disturbance, operators shall make use of existing roads where practical. Where roads traverse land in another ownership and will adequately serve the operation, investigate options for using those roads before constructing new roads."

Historically, this rule has been applied as an advisory rule. Guidance does not establish a specific threshold for "investigate options" or "where practical" to apply this rule.

Currently, a number of disincentives exist, especially for federal lands, which prevent private landowners from using road systems on another ownership. Sometimes this results in the duplication of road systems and parallel roads being built on opposite sides of property lines. When these duplicate roads are built in high risk or sensitive areas, it can increase the risk of sediment delivery and other adverse effects to streams. This option proposes taking action to minimize the construction of unnecessary forest roads that are built due to existing disincentives for cooperative road system planning, design, and use.

Methods/Approaches:

Develop incentives for cooperative road system planning, design, and use between different landowners. Landowners could also be asked to make existing roads available to other landowners as needed.

To be effective, there would probably need to be strong incentives for landowners to share road use. Many landowners have already established such agreements. However, development of new agreements with the federal agencies appears to be problematic. It appears that the current system rewards federal agencies for not cooperating with private landowners.

In other cases, neighboring private landowners (sometimes, but not always, those who are using their lands for other purposes) may set unreasonable conditions on road use (typically costs that are so inflated that it is cheaper for the affected landowner to construct a new road). This occurs even when new road construction is expensive (over $100,000 per mile of road). Conflicts related to rural residential uses versus forest management cause road-use problems in more developed areas.

Benefits:
There is the potential to reduce the length of new roads built and decrease the risk of sediment delivery to streams where this option prevents unnecessary roads from being built in high-risk or sensitive areas. Landowners will also reduce operational costs if they do not have to build and maintain additional unnecessary roads as a result of this option.

Costs:
Private property rights are likely to be a barrier to compelling some landowners to make their roads available to others. State government may have [has] limited influence on federal policies that act as a disincentive to cooperative road system planning, design, and use between federal and private land managers.

Option #18 – Roads Monitoring Program

Objective:
Evaluate the need for further road compliance and effectiveness monitoring.

Description:
Road BMP compliance and effectiveness monitoring is currently being conducted 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. The pilot study results and recommendations will be considered within the context of the strategic monitoring plan and prioritized in context with available monitoring resources and other monitoring needs.

Methods/Approaches:
Roads are generally considered the single greatest chronic source of fine sediment associated with forest practices. However, currently available information also confirms that when properly implemented, BMPs are effective at reducing delivery of sediment from roads. Instream

measures of water quality are an integration of everything upslope. Consequently, instream measurements can be a diluted or exaggerated version of what is occurring higher up in the channel network or on adjacent slopes. It is usually easier to accurately identify a road drainage-related sediment source and to quantify the volume of sediment it produced than it is to measure sediment in the stream and work backwards to the source.

Currently, as part of the BMP Compliance Audit Project, ODF is monitoring compliance with the road construction and maintenance rules along with a large number of other harvesting and water protection rules. This project is a two-year effort to provide a systematic, random "audit" of forest practice rule compliance. ODF will assess the need to continue and expand on this project based on the study results and through a review process that involves key stakeholders. ODF is not currently monitoring road sediment associated with winter road use, nor is it gathering information on road repairs completed under road hazard and risk reduction projects.

Benefits:
Monitoring can provide the most current information on compliance and effectiveness of the construction and maintenance rules over time.

Costs:
Additional resources would be needed to prioritize and maintain a long-term monitoring effort devoted specifically to road issues. However, should the monitoring effort be considered within the current monitoring strategy and prioritized accordingly, no additional resources would be needed.

Option #19 - Continuing Education

Objective:
Provide continuing education for landowners and operators specific to the road construction and maintenance rules.

Description:
Use outreach efforts to achieve this objective.

Methods/Approaches:
Workshops and other types of outreach efforts could be organized by the ODF and coordinated with organizations like the OFIC to provide continuing education for landowners. ODF and OSU held a "Road Stewardship Workshop" in March 2000.

Benefits:
Those landowners and operators that currently do not have a thorough understanding of the rules and their objectives will potentially be better informed.

Costs:
Additional resources will be needed to implement such a program. Depending on the mechanism used to provide continuing education, there is a risk that this type of program will be "preaching to the choir." Those landowners and operators that may need information the most

(i.e., those who have not been proactive in the past about gaining a complete understanding of rules and their objectives) may not take advantage of continuing education unless concerted efforts are made to reach them.

Option #57 – Ground-Based Harvesting on Steep Slopes

Objective:
To reduce the potential of sediment delivery or other undesirable effects to streams from skid roads constructed on steep slopes.

Description:
Ground-based harvesting on steep slopes has a 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 is neither clear nor specific.

Methods/Approaches:
Add a prior approval requirement for ground skidding in high-erosion hazard locations. This could be based on slope steepness, or combination slope steepness and soil criteria. This approach could be used everywhere, or only for "core" areas. For example, prior approval could be required for ground skidding on slopes over 45 percent (i.e., if over 200 feet or if a skid trail is located on these slopes). Prior approval could also be required for slopes over 50 percent (average soils) and 40 percent (high-erosion hazard soils).

Benefits:
This will reduce the risk of sediment delivery to waters of the state. It will also help operators to better plan operations in these locations, and to modify operations where risk of sediment delivery is greatest. In some cases, planning activity may reduce operational costs.

Costs:
For those cases where prior approval would be required (a minority of current operations), there would be a moderate increase in operational costs. In some cases, operating costs would be reduced. In other cases (where the operator must switch to cable yarding and wood volume is low), costs could increase significantly.

Option #58 – License Plate Funding to the "Forest Incentive Fund"

Objective:
To create a special license plate that would contribute to a fund that specifically supports stream restoration, fish passage, or road improvement projects on forestland.

Description:
First, a fund would be established. This proposed fund would be called the "Forest Incentive Fund" (referred to in Options #59 and #60). Second, proceeds from the sale of Oregon license plates that have a forestry theme would be used to help support the fund.

Methods/Approaches:
Idaho has implemented such a license plate program. Idaho has several special designs dedicated to specific natural resource categories including big game, nongame, parks, and forestry. The forestry plate appears to attract mainly forestland owners. Many industrial and small landowner vehicles have the plate. One advantage of this program is that each time the license is renewed some revenue is generated.

Landowners with limited financial resources to implement the Oregon Plan's voluntary measures could apply for cost-sharing grants from the fund. Project examples include the cost of fixing, or removing, legacy roads or culverts, or using heavy machinery to place large wood in streams. Alternately, the funds might be used to buy portable bridges for use by landowners.

Grants would be administered at the local ODF offices, requiring the coordinated input from ODF service foresters or forest practice foresters, and ODFW biologists. Watershed council involvement would be encouraged.

The design phase of the plate could be used to attract attention to the forestland restoration efforts.

One alternative to a new plate would be to allow purchasers of the "salmon" plate to specify whether the additional funding should go to the "Forest Incentive Fund" or to the general (Oregon Watershed Enhancement Board) OWEB fund.

Benefits:
Financial incentives will encourage more landowners to implement the voluntary measures that are key to the success of the Oregon Plan. It would create an identity for, and ownership of, the effort to restore salmon on forestlands.

Costs:
There would be a cost of establishing the license plate design and sales with Department of Motor Vehicles (DMV), creating the fund through legislation, and operating the program. This plate might compete with other plates currently available.

Option #59 – Road Closure Program

Objective:
To create a [voluntary] road closure program that forest landowners, the Department of Forestry, and local law enforcement would use to limit [public] vehicle access onto sensitive road systems that have a high risk of delivering sediment to streams or that can directly impact aquatic habitat.

Description:
Legacy roads, roads built on steep slopes and unstable soils, or unsurfaced roads that have the potential to deliver sediment to streams should be closed to public vehicle traffic during the rainy months. Road closure signs would indicate what type of public access in allowed (e.g., foot

traffic but no motorized vehicles). It would be a misdemeanor offense subject to uniform citation and civil penalty to violate a road closure, enforceable by local sheriffs or the state police (or possibly by ODF).

Methods/Approaches:
Currently ORS 164.270 allows a landowner to close roads to motor-propelled vehicles. This statute is under the criminal trespass laws and it is not clear what the attached penalty is, but enforcement requires a complaint by the landowner through the local district attorney. Enforcement is difficult under the trespass laws.

Under the proposed approach, landowners would close roads to vehicle access [to the public when not in use during rainy months] for the purposes of protecting water quality. Identifying candidate roads could be done with ODF and ODFW input. User groups, such as motorcycle, or off-road clubs, would be informed. [Agreements for enforcement with local sheriffs or state police would be needed.] [Trespass citations and procedures would need to be clarified.] Violation of a closed road would be subject to citation that could be issued by a law officer and would receive a set civil penalty amount. Assessed [fines] civil penalties would be deposited to the "Forest Incentive Fund".

The "Forest Incentive Fund" (see Option #58) would provide money for gates and posters, plus repairs caused by persons [trespassing on] using closed roads.

Benefits:
Reduce the impact of unauthorized vehicle damage done to roads that results in sediment delivery to streams. The "Forest Incentive Fund" provides a financial incentive to landowners.

Costs:
There would be a cost of establishing the road closure program and allocating the incentive funds to repair damage.

Resources Needed:
Enforcement actions require resources. Moving this out from "trespass law" to a uniform citation with civil penalty would make enforcement much easier. If ODF was to enforce this, additional resources might be needed, particularly in the civil penalty section.

Option #60 – Upstream-Downstream Program

Objective:
To promote the placement of large wood that is removed from the up-stream side of a bridge or culvert (i.e., large wood that has backed up behind a stream crossing structure) to an appropriate location below that bridge or culvert.

Description:
Forest landowners are asked in the Oregon Plan's voluntary measures to place large wood as a part of stream habitat improvement. Large wood, whether placed by humans or transported by

the stream, has the potential to threaten the integrity of culverts, bridges, and the road prism during high stream-flow events. If a forest landowner removes this large wood to address this potential threat, this option would have the landowner place that large wood in a suitable down-stream location rather than end-hauling it and removing the wood from the stream system entirely. This option could be implemented on a voluntary, or regulatory, basis.

Methods/Approaches:
Landowners could be encouraged (voluntary, incentive-based) or required (regulatory) to remove large wood from upstream locations and put this material in an appropriate downstream location. Projects would be coordinated with ODF and ODFW. Watershed council involvement would be encouraged. The "Forest Incentive Fund" (see Option #58) could be used to provide money to the landowner.

Benefits:
The removed large wood would be used in a nearby downstream project, possibly on the same stream system. The program would address the concern that large wood can damage human-built structures. The program would provide a financial incentive to the participating forest landowner.

Costs:
Existing agency administration would be used to implement the program. Funds would be needed from the "Forest Incentive Fund."

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ATTACHMENT A

Road Construction and Maintenance Rules

629-625-000 - Purpose
(1) Forest roads are essential to forest management and contribute to providing jobs, products, tax base and other social and economic benefits.
(2) OAR 629-625-000 through 629-625-650 shall be known as the road construction and maintenance rules.
(3) The purpose of the road construction and maintenance rules is to establish standards for locating, designing, constructing, and maintaining efficient and beneficial forest roads; locating and operating rock pits and quarries; and vacating roads, rock pits, and quarries that are no longer needed in manners that provide the maximum practical protection to maintain forest productivity, water quality, and fish and wildlife habitat.
(4) The road construction and maintenance rules shall apply to all forest practices regions unless otherwise indicated.

629-625-100 - Prior Approval
(1) A properly located, designed, and constructed road greatly reduces potential impacts to water quality, forest productivity, fish, and wildlife habitat. To prevent improperly located, designed, or constructed roads, prior approval of the State Forester is required in the sections listed below.
(2) In addition to the requirements of the water protection rules, operators shall obtain prior approval from the State Forester before:
(a) Constructing a road where there is an apparent risk of road-generated materials entering waters of the state from direct placement, rolling, falling, blasting, landslide, or debris flow.
(b) Conducting machine activity in Type F or Type D streams, lakes, or significant wetlands.
(c) Constructing roads in riparian management areas.
(3) In the Northwest Oregon and Southwest Oregon Regions, operators shall obtain prior approval from the State Forester before constructing roads on high-risk sites.
(4) Operators shall obtain written prior approval from the State Forester of a written plan, as described in OAR 629-625-320(1)(b)(B), before constructing any stream-crossing fill over 15 feet deep.
(5) In addition to the requirements of the water protection rules, operators shall obtain prior approval from the State Forester before placing woody debris or boulders in stream channels for stream enhancement.

629-625-200 - Road Location
(1) The purpose of this rule is to ensure roads are located where potential impacts to waters of the state are minimized.
(2) When locating roads, operators shall designate road locations which minimize the risk of materials entering waters of the state and minimize disturbance to channels, lakes, wetlands, and floodplains.
(3) Operators shall avoid locating roads on steep slopes, slide areas, high-risk sites, and in wetlands, riparian management areas, channels, or floodplains where viable alternatives exist.
(4) Operators shall minimize the number of stream crossings.

(5) To reduce the duplication of road systems and associated ground disturbance, operators shall make use of existing roads where practical. Where roads traverse land in another ownership and will adequately serve the operation, investigate options for using those roads before constructing new roads.

629-625-300 - Road Design
(1) The purpose of OARs 629-625-300 through 629-625-340 is to provide design specifications for forest roads that protect water quality.
(2) Operators shall design and construct roads to limit the alteration of natural slopes and drainage patterns to that which will safely accommodate the anticipated use of the road and will also protect waters of the state.

629-625-310 - Road Prism
(1) Operators shall use variable grades and alignments to avoid less-suitable terrain so that the road prism is the least disturbing to protected resources, avoids steep sidehill areas, wet areas, and potentially unstable areas as safe, effective vehicle use requirements allow.
(2) Operators shall end-haul excess material from steep slopes or high-risk sites where needed to prevent landslides.
(3) Operators shall design roads no wider than necessary to accommodate the anticipated use.
(4) Operators shall design cut- and fillslopes to minimize the risk of landslides.
(5) Operators shall stabilize road fills as needed to prevent fill failure and subsequent damage to waters of the state using compaction, buttressing, subsurface drainage, rock facing, or other effective means.

629-625-320 - Stream-Crossing Structures
(1) Operators shall design and construct stream-crossing structures (culverts, bridges and fords) to:
(a) Minimize excavation of side slopes near the channel.
(b) Minimize the volume of material in the fill.
(A) Minimizing fill material is accomplished by restricting the width and height of the fill to the amount needed for safe use of the road by vehicles, and by providing adequate cover over the culvert or other drainage structure.
(B) Fills over 15 feet deep contain a large volume of material that can be a considerable risk to downstream beneficial uses if the material moves downstream by water. Consequently, for any fill over 15 feet deep, operators shall obtain approval of the State Forester of a written plan that describes the fill and drainage structure design. Approval of such written plans shall require that the design be adequate for minimizing the likelihood of surface erosion, embankment failure, and other downstream movement of fill material.
(c) Prevent erosion of the fill and channel.
(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.

(3) An exception to the requirements in subsection (2)(a) of this rule is allowed to reduce the height of fills where roads cross wide flood plains. Such an exception shall be allowed if:
(a) The stream-crossing site includes a wide flood plain; and
(b) The stream-crossing structure matches the size of the active channel and is covered by the minimum fill necessary to protect the structure;
(c) Except for culvert cover, soil fill is not placed in the flood plain, and
(d) The downstream edge of all fill is armored with rock of sufficient size and depth to protect the fill from eroding when a flood flow occurs.

629-625-330 - Drainage
(1) Operators shall provide a drainage system using grade reversals, surface sloping, ditches, culverts, and/or waterbars as necessary to effectively control and disperse surface water to minimize erosion of the road.
(2) Operators shall not divert water from channels except as necessary to construct stream crossings.
(3) Operators shall locate dips, water bars, or cross-drainage culverts above and away from stream crossings so that road-drainage water may be filtered before entering waters of the state.
(4) Operators shall provide drainage when roads cross or expose springs, seeps, or wet areas.
(5) Operators shall not concentrate road-drainage water into headwalls, slide areas, or high-risk sites.

629-625-340 - Waste Disposal Areas
Operators shall select stable areas for the disposal of end-haul materials, and shall prevent overloading areas which may become unstable from additional material loading.

629-625-400 - Road Construction
OARs 629-625-400 through 629-625-440 provide standards for disposal of waste materials, drainage, stream protection, and stabilization to protect water quality during and after road construction.

629-625-410 - Disposal of Waste Materials
Operators shall not place debris, sidecast, waste, and other excess materials associated with road construction in locations where these materials may enter waters of the state during or after construction.

629-625-420 - Drainage
(1) Operators shall clear channels and ditches of slash and other road construction debris which interferes with effective roadway drainage.
(2) Operators shall provide effective cross drainage on all roads, including temporary roads.
(3) Operators shall install drainage structures on flowing streams as soon as feasible.
(4) Operators shall effectively drain uncompleted roads which are subject to erosion.
(5) Operators shall remove berms on the edges of roads, or provide effective drainage through these berms, except for those berms intentionally designed to protect road fills.

629-625-430 - Stream Protection

(1) When constructing stream crossings, operators shall minimize disturbance to banks, existing channels, and riparian management areas.
(2) In addition to the requirements of the water protection rules, operators shall keep machine activity in beds of streams to an absolute minimum. Acceptable activities where machines are allowed in streambeds, such as installing culverts, shall be restricted to periods of low water levels. Prior approval of the State Forester for machine activity in Type F or Type D streams, lakes, and significant wetlands is required by 629-625-100(2)(c).
(3) For all roads constructed, or reconstructed, operators shall install water crossing structures where needed to maintain the flow of water and passage of adult and juvenile fish between side channels or wetlands and main channels.
(4) Operators shall leave or reestablish areas of vegetation between roads and waters of the state to protect water quality.
(5) Operators shall remove temporary stream-crossing structures promptly after use, and shall construct effective sediment barriers at approaches to channels.

629-625-440 - Stabilization
(1) Operators shall stabilize exposed material which is potentially unstable or erodible by use of seeding, mulching, riprapping, leaving light slashing, pull-back, or other effective means.
(2) During wet periods, operators shall construct roads in a manner which prevents sediment from entering waters of the state.
(3) Operators shall not incorporate slash, logs, or other large quantities of organic material into road fills.

629-625-500 - Rock Pits and Quarries
(1) The development, use, and abandonment of rock pits or quarries which are located on forestland and used for forest management shall be conducted using practices which maintain stable slopes and protect water quality.
(2) Operators shall not locate quarry sites in channels.
(3) When using rock pits or quarries, operators shall prevent overburden, solid wastes, or petroleum products from entering waters of the state.
(4) Operators shall stabilize banks, headwalls, and other surfaces of quarries and rock pits to prevent surface erosion or landslides.
(5) When a quarry or rock pit is inactive or vacated, operators shall leave it in the conditions described in section (4) of this rule, shall remove from the forest all petroleum-related waste material associated with the operation, and shall dispose of all other debris so that such materials do not enter waters of the state.

629-625-600 - Road Maintenance
(1) The purpose of this rule is to protect water quality by timely maintenance of all active and inactive roads.
(2) Operators shall maintain active and inactive roads in a manner sufficient both to provide a stable surface and to keep the drainage system operating as necessary to protect water quality.
(3) Operators shall inspect and maintain culvert inlets and outlets, drainage structures, and ditches before and during the rainy season as necessary to diminish the likelihood of clogging and the possibility of washouts.

(4) Operators shall provide effective road surface drainage, such as water-barring, surface crowning, constructing sediment barriers, or outsloping, prior to the rainy and runoff seasons.
(5) When applying road oil, or other surface stabilizing materials, operators shall plan and conduct the operation in a manner as to prevent entry of these materials into waters of the state.
(6) In the Northwest and Southwest Oregon Regions, operators shall maintain and repair active and inactive roads as needed to minimize damage to waters of the state. This may include maintenance and repair of all portions of the road prism during and after intense winter storms, as safety, weather, soil moisture, and other considerations permit.
(7) Operators shall place material removed from ditches in a stable location.
(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 during periods 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 practicable, keep structures cleared of woody debris and deposits of sediment that would impair fish passage.
(c) 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.

629-625-650 - Vacating Forest Roads
(1) The purpose of this rule is to ensure that when landowners choose to vacate roads under their control, the roads are left in a condition where road related damage to waters of the state is unlikely.
(2) To vacate a forest road, landowners shall effectively block the road to prevent continued use by vehicular traffic, and shall take all reasonable actions to leave the road in a condition where road-related damage to waters of the state is unlikely.
(3) Reasonable actions to vacate a forest road may include: removal of stream-crossing fills; pullback of fills on steep slopes, frequent cross ditching, and/or vegetative stabilization.
(4) Damage which may occur from a vacated road, consistent with Sections (2) and (3) of the rule, will not be subject to remedy under the provisions of the Oregon Forest Practices Act.

Section C
Landslides

Issue: How Well Do Current Forest Practices Maintain the Aquatic Habitat Functions Provided by the Natural Landslide Regime?

Forest Practices Advisory Committee on Salmon and Watersheds

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I. Current Scientific Findings

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 20mm/year. After three years the displacement rate returned to the pre-logging rate of 3mm/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).

Hydrological effects of vegetation on the hillslope include interception, evapotranspiration, and water routing. Interception is the storage of rain and/or snow on the leaves and branches of vegetation. Evapotranspiration is the removal of water from the soil or vegetation by plant growth or climate. Water routing is influenced by macropores and stemflow. Macropores can be relatively large (diameter measured in inches) pipe-like structures in the soil that can influence subsurface flow patterns during a rainfall event (Figure 1). Stemflow is the interception and routing of rainfall or snowmelt by the branches and stems and can create concentrated areas of flow.

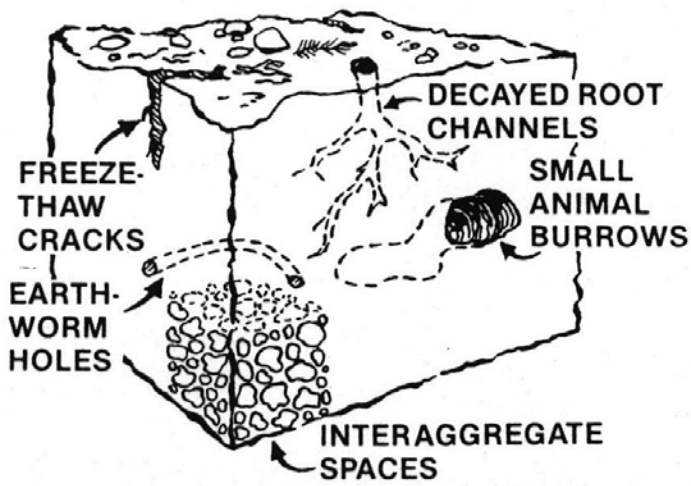

Figure 1: Illustration of various types of macropores in forest soils (from Sidle, 1980).

Mechanical effects of vegetation on slope stability are varying and sometimes contradictory. They include the following:

- root reinforcement: the penetration of roots into a potential landslide failure surface resulting in increased slope stability;
- buttressing and arching: trees at the base of a potential landslide act like piles and help stabilize the slope;
- surcharge loading by trees, logs and/or debris: the weight of these materials may add to the gravity force on the slope;
- wedging and loosening of soil by roots, thereby lowering the strength of the slope; and
- windthrow: soils are displaced and oversteepened, and also subject to vibration, as a result of the blow-down of trees.

Tree removal can also have varying effects on slope stability. They include the following:

- a reduction in interception or evapotranspiration.
- alteration of the forest canopy, thus changing water routing.
- the alteration and accumulation of snow and snowmelt patterns.
- a reduction in root reinforcement.
- a loss of buttressing and arching.
- a reduction in "surcharge loading."

The tree falling and log yarding process might effect soil by:

- alteration of macropores, thus changing water routing.
- a reduction in the soil infiltration rate due to compaction.

Most of the research on the effects of vegetation on forest slope stability in northwest forests has concentrated on the potential reduction in root reinforcement, or 'root strength.' The root strength concept is somewhat analogous to the effect of steel in reinforcing concrete. Most root strength models are two-dimensional and assume that roots penetrate the failure surface; that roots are anchored and do not move downslope with the landslide; and that the tensile strength of roots is fully mobilized during a mass wasting event (Greenway, 1987). Roots are fully mobilized if all of their potential strength is used by the weight of the material that is pulling in the downslope direction.

"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)." (Sidle et al.,1985)

The magnitude of the effects of root strength on slope stability as the primary mechanism affecting slope stability on Pacific Northwest forestlands is not universally accepted. From a geomechanics perspective there are a number of reasons why some relatively simple models of root reinforcement to soil shear strength may not be valid. Soil strength values cited in the technical literature that are attributed to root reinforcement would lead to the conclusion that forested sites cannot fail and all high-risk sites that are harvested must fail (Skaugset, 1997). It is well documented from extensive ground-based landslide surveys that this is not the case (Hughes and Edwards, 1978; Ketcheson and Froehlich, 1978; Robison et al., 1999). Problematic assumptions in landslide analyses, inconsistencies in obtaining representative forest soil samples, difficult testing procedures, the importance of vegetation other than trees, and soil mechanics

incompatibilities are just some of the factors that are causing some slope stability experts to reexamine the current root strength/slope stability paradigm.

Landslides and Stream Channel Modifications

The principal landslide-related effects of major storms, such as those which 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).

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 that are areas with high levels of observed slides). However, in nonred 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 through scour of hillslopes and channels than the initiating landslide. 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 and 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).

Landslide Studies

Numerous studies have examined the differences in landslide rates between forested and recently harvested sites (Table 1, page C-33). Table 1 lists studies throughout the Pacific Northwest in which landslide rates (number of slides for a given time period) and/or densities (number of slides per unit area) under different stand treatments were compared directly. In all, there were 35 forest treatment comparisons found from 24 published or semi-published studies. Several compilations of past studies have been used to draw conclusions about the effects of forest harvesting on landslide rates (Ice, 1985; Sidle et al., 1985; and Meehan et al., 1991). As Table 1 indicates, most studies (28 of the 35 comparisons on Table 1) are based partially or completely on aerial photo interpretation. In the past, there has been debate on whether it is appropriate to use aerial photos to compare recently harvested area landslide densities and erosion rates with those areas that contain mature forests. For instance, a classic exchange occurred in a discussion on a research paper by Pyles and Froehlich (1987), followed with a reply by Wolfe and Willams (1987). In the discussion Pyles and Froehlich laid out, on theoretical grounds, several reasons why landslides cannot be reliably detected on aerial photos due to photo angles and the obscuring effect of tall trees. In reply, Wolfe and Williams pointed out that Pyles and Froehlich had no empirical data to verify their findings. In particular they stated:

> "Unfortunately Pyles and Froehlich have failed to provide documentation of these statements. It certainly would be of value to know how dramatic the differences are between these two types [ground vs. air based] of inventories."

The study by Swanson et al. (1977) utilized an aerial photo inventory to determine landslide frequency in clearcut areas, and a ground survey of 1,300 acres to find landslides in older forests. The study was conducted in the Mapleton Ranger District of the Siuslaw National Forest and overlapped one of the study sites used in Robison et al. (1999). Swanson found that erosion rates were higher in clearcuts than unmanaged stands. The clearcut erosion rates ranged from 1.2 to 1.3 times higher than unmanaged stands for most land types. For the land types most prone to landslides (i.e., steep slopes), clearcut erosion rates were 4.0 times higher than in unmanaged stands. Since not all landslides can be detected on aerial photos even in clearcuts,

and the study compares an air-based clearcut sample to a ground-based in forest sample, these erosion rate ratios may be artificially low.

Ketcheson and Froehlich (1978) field-investigated small watersheds (100 acres or less) that were unaffected by forest roads in an area near Mapleton, Oregon. The watersheds were inspected by walking on one side of the drainage and examining headwalls. They found 104 landslides in a 1,076 acre study area. Landslide data were collected on failures as old as 15 years with unspecified dating techniques. This study found that the erosion rate in clearcuts was approximately 3.7 times higher than that of undisturbed forests.

There are also landslide studies that have attempted to understand the behavior of landslides rather than simply comparing rates between forests of different ages. A study site located northeast of Coos Bay in Oregon has been the location of several of these types of studies (Montgomery et al., 1997). Detailed field measurements of a specific landslide-prone site have been made for over a decade. The study site is covered with an array of instruments to determine soil pore-water pressure, interactions between rock and soil water, long-term weathering rates, and many other physical processes. The role of vegetation in the stability of this site is also being examined. A debris slide/flow occurred at this site in the November 1996 storm and is providing a unique opportunity for the study of specific factors associated with landslide initiation.

Information from this site was also used to help develop a topographic model for the assessment of landslide hazard areas (Montgomery and Dietrich, 1994). This particular model uses a geographic information system (GIS) to calculate areas of high landslide potential based on slope steepness, slope convergence (watershed area), and steady-state rainfall. Other slope stability factors such as soil depth and potential root reinforcement can also be added to the model when site-specific data is available. The Bureau of Land Management (BLM) and at least one industrial private forestland company have utilized this model to help identify and manage landslide hazard areas.

The OSU headwall leave area study (Martin, 1997) also was conducted in the Mapleton area. The headwall leave area technique has been used to try and reduce landslides associated with timber harvesting. Headwalls (very steep concave slopes that contain no channels) are first identified. Once identified, trees on these headwalls are protected from harvest activities. Martin (1997) identified landslides in forested headwalls, clearcut headwalls, and headwalls protected with leave areas. They found no statistical difference in landslide occurrence between mature forests, leave areas, and clearcuts. However, the period of time such sites were subject to landslide producing storms was longer for the forested headwalls, a factor which may have overestimated the comparative failure rate of the forested headwalls.

The headwall leave area technique is recommended by Forest Ecosystem Management Assessment Team (FEMAT) (1993) for federal forestlands based on a study by Swanson and Roach (1987). Specifically, FEMAT recommended that minimum leave areas of three to ten acres in steep headwall areas be protected from timber harvesting. Due to the small amount of harvesting on federal lands, and the fact that many headwall leave areas overlap with areas receiving riparian protection near seasonal streams, there is little information available to

evaluate the effectiveness of the headwall leave area technique. Anecdotal evidence from Swanson and Roach (1987) and Martin (1997) also indicate that headwall leave areas may increase the risk of windthrow, and therefore probably landslide occurrence as well.

Landslide inventories based totally on aerial photographs have limited use for identifying those landslides most common in steep forested terrain, especially in areas with dense forest cover. In Robison et al. (1999), aerial photographs of a number of different scales were obtained for the eight study areas that were inventoried (1:6000, 1:12000, and 1:24000). Although aerial photographs have utility for many purposes, their use for identification of shallow-rapid landslides results in biased and incomplete landslide inventories. This bias significantly underestimates the landslide frequency and erosion volume across all forest stand age classes. For example, in the Mapleton and Vida study areas of Robison et al. (1999), 72 percent of all landslides identified from the ground-based survey were not detected using 1:6000 aerial photographs. The majority (72-98 percent) of shallow-rapid landslides were not visible on aerial photographs of any scale. In terms of erosion volume, the landslides that were not identified from aerial photographs accounted for 53 percent and 41 percent of the total landslide related sediment volume delivered to stream channels in the Vida and Mapleton study areas, respectively (1:6000 scale). Landslide identification is most problematic in areas with mature or semi-mature timber. For instance, roughly 50 percent of the landslides were detected in recently harvested areas (0-9 years old) but less than 5 percent of the landslides were detected in mature stands (older than 100 years) (Robison et al., 1999). Aerial photo analysis will significantly magnify landslide density and erosion volume per unit area for recently harvested areas relative to older forested areas.

As a result of this bias in aerial photo inventories, comparisons that use this method result in greater apparent increases in landslide density and erosion volume associated with stands recently clearcut than do ground–based inventories. Table 2 shows the average and range of landslide densities for the various studies given in Table 1. The average ratio between clearcut and mature landslide densities for aerial photo inventories is about five times the average for the ground-based inventories (15-fold increase versus 3-fold increase).

Table 2. Increase in landslide occurrence after clearcutting as reported by studies (from Table 1) using different methods for landslide identification. (See note with Table 1 for the method definitions.)

Method	Number of Comparisons	Average Ratio	Maximum Ratio	Minimum Ratio
Air	6	15.8	30	6.1
Ground	6	3.3	8.0	0.8
Mixed	7	5.4	17.0	1.2
Air/Field Visits	12	9.7	23.5	0.0
Air/Size	4	7.7	13.5	2.6
All Studies	35	8.6	30.0	0.0

In light of the limitations of aerial photographs, the few ground-based studies that have been completed offer the most reliable conclusions in terms of landslide-rate comparisons between clearcuts and mature forest conditions. Of the studies listed in Table 1, only six are completely

ground based (four different study areas within Robison et al. (1999) are each considered as a separate 'study'). The rate of landslides in recently harvested areas ranged from 0.8 to 8.0 times that observed in mature forests for these six studies. Thus, while it is possible during the period immediately following harvesting that landslide rates will remain unchanged (Elk Creek study area in Robison et al. 1999), it is much more likely that the landslide rate will increase. These studies, however, only address landslide rates during the first few years after harvest. Landslide rates in areas with established second-growth forests have received very little attention in past landslide studies. Robison et al. (1999) is the only ground-based study listed here that examines landslide rates in forests between 10 and 100 years old. These forests were generally found to have landslide densities and erosion volumes lower than that of mature forests.

The conclusions from Robison et al. (1999) only apply to single, extreme storm events, however, and cannot address the issue of long-term effects of harvesting on the landslide regime. Sidle et al. (1985) provided a summary of the then current state of knowledge about long-term landslide rates as influenced by forest harvesting:

"The long-term effect of timber harvesting on erosion caused by debris avalanches cannot readily be ascertained from landslide inventories (except by repetition throughout one or more harvesting rotations). . . . Clearcutting may actually only change the timing of natural landsliding, and over long periods the total erosion from shallow-rapid failures may be independent of timber removal (Froehlich 1978, Swanson et al. 1981, Swanson and Frederiksen 1982). After harvesting, an acceleration in soil mass movement is frequently observed for 10 to 15 years, but subsequent erosion (before the next cutting) may actually decline below "natural" levels. This hypothesis has not been substantiated by field data."

For a single extreme storm event, Robison et al. (1999) observed a reduction in landslides in most study areas for second growth forests (i.e., 10-100 year age class). While this does not specifically address the question of how long-term rates of landslides are influenced by harvesting, it does give more credibility to the hypotheses stated above that erosion rates for second-growth forests may decline below "natural" levels. It should be noted, however, that even though the ODF study looked only at a single storm rather than at landslides occurring over a longer time period, it is believed that the largest storms result in the occurrence of most shallow-rapid landslides (Ice et al., 1988).

There are others that argue for an alternative hypothesis, namely, that harvesting can dramatically increase the rate of landsliding relative to "natural" levels and that over the long-term, timber harvesting causes an increase in erosion to a degree that landscapes are denuded of soil (David Montgomery, MOA Landslide Workshop). Reneau and Dietrich (1991) analyzed the colluvial deposits in nine hollows in the Oregon Coast Range located in roadcut exposures. These hollows had maximum depths between 4.3 to 13.6 feet, slope steepness between 53 and 75 percent, and drainage areas between 0.02 to 1.01 acres. Using radiocarbon dating from charcoal deposits throughout a cross section of the colluvial deposits, they concluded that the average residence time of the sediment in these hollows was 5,000-6,000 years. This corresponds to a weathering rate of 0.062 to 0.130 mm per year, which is consistent with estimates of weathering rates for the Oregon Coastal Range (Reneau, 1988). If shallow-rapid landslides "naturally" recur on a given site every 5,000-6,000 years, and current harvest rotations

are significantly shortening this recurrence interval, it is possible that these portions of the landscape (i.e. areas where landslides are the dominant erosional process) are being denuded of soil over the long-term.

When a landslide-prone site excavates (i.e., soil moves off the site exposing bedrock or a partially-filled void on the hillslope or hollow), it takes a certain amount of time to recharge (i.e., refill with soil, either through bedrock weathering or adjacent soil creep into the excavated area). There are a number of scientific opinions on this "time to recharge", but there is very limited data available to resolve the debate. Results from Robison et al. (1999) suggest that the time to recharge (or time to fail) is variable, depending on slope steepness and site-specific geomorphological processes. For example, modeling results from Montgomery and Dietrich (1994) has shown that steeper slopes with greater drainage areas have a greater risk of failure (and thus may be expected to fail more frequently) than less-steep slopes with smaller drainage areas. The data provided by Reneau and Dietrich (1991) are from nine sites that could be considered to have less steep slopes and smaller drainage areas. Of the nearly 500 landslides identified in Robison et al. (1999) that were not associated with roads, less than 10 percent had maximum depth, slope, and drainage area characteristics similar to these nine sites. The 5,000 to 6,000-year "time to recharge" from Reneau and Dietrich (1991), if correct, may only apply to a small proportion (less than ten percent) of the total landslide population. Since this sub-set of landslides has less steep slopes and smaller drainage areas, it makes sense that they would occur less frequently than the majority of shallow-rapid landslides.

That the sites most susceptible to landslides may fail more frequently than every 5,000 to 6,000 years is not incompatible with the estimate of the weathering rate (0.062 to 0.130 mm per year) calculated by Reneau (1988). Comparing this weathering rate to the total erosion calculated in Robison et al. (1999) would mean that about 20 years of weathering was delivered to stream channels in a single storm event, at least for the coastal red-zone study areas. The largest storm event previous to 1996 was in 1964 (32 years earlier), which translates roughly to 63 percent of the total weathering since 1964 (20/32 years) occurred in 1996. These calculations are consistent with the belief that the largest storms result in the occurrence of most shallow-rapid landslides (Ice et al., 1988).

While there may be merit to both the "timing" and "denuding" hypotheses, there are currently no studies that have been effective in confirming or disproving either one. It will likely take continued research over long periods of time to resolve this scientific debate.

The Independent Multidisciplinary Science Team (IMST) report 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 nonroad-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."

II. Watershed-scale Effects

Forest Management

Potential watershed-scale effects of forest management may influence both the quantity and quality of landslides. Regardless of which hypothesis is applied (timing versus denuding), 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 watershed-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.

Other Land Uses

Any land use that alters either the physical or biological (vegetative) slope properties can influence slope stability. Urban and rural development that creates or increases a road network and the percent of impervious surface in a given watershed can have a significant effect on the slope properties in terms of water routing. Macropore alterations and the routing of sub-surface flow into areas where water does not normally flow are examples of how development can influence landslide occurrence. The conversion of forests to some other land use will also influence the hydrological properties of the watershed by reducing the interception and evapotranspiration capacity of the soil (other effects of vegetation removal listed on page C-2). On a site-specific basis, rural and urban developments have the potential to result in much greater slope and drainage alterations than do forest practices. Development often results in extensive excavation into hillslopes and the creation of impervious surfaces that significantly influences water routing and other hillslope properties.

III. Objectives of the Current Measures and Rules

Oregon Plan Objectives

The Oregon Plan for Salmon and Watersheds (OPSW) does not include any specific objectives for the management of landslides and/or debris flows. Riparian functions that are associated with this issue include sediment and large wood, which are discussed in other issue papers.

Forest Practices Act Objectives

OAR 629-630-000 – Purpose (Harvesting Rules)

(1) Harvesting of forest tree species is an integral part of forest management by which wood for human use is obtained and by which forests are established and tended.

(2) Harvesting operations result in a temporary disturbance to the forest environment.

(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.

IV. Description of Measures and Rules

Oregon Plan Measures

The Oregon Plan for Salmon and Watersheds (OPSW) does not include any specific measures for the management of landslide and/or debris flow occurrence. ODF 61S (Analysis of "Rack" Concept for Debris Flows) is a voluntary measure that addresses the issue of landslide and debris flow quality. Under this measure:

"Oregon Forest Industries Council (OFIC) members will conduct surveys to determine the feasibility and value of retaining trees along small Type N streams with a high probability of debris flow in a "rack" just above the confluence with a Type F stream. The rack would extend from the Riparian Management Areas (RMA) along the Type F stream up the Type N stream some distance for the purpose of retaining trees that have a high likelihood of delivery to the Type F stream."

The primary goal of this measure is to influence the type of debris that is transported by the landslide, and not necessarily to influence the movement of individual landslides. ODF 20s is another measure that addresses the quality of landslides and debris flows. This measure involves the placing of large wood in stream channels that are potential debris flow paths (discussed in the Riparian Function issue paper).

Forest Practices Act Standards and 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.

V. Evaluation of the Measures and Rules

Voluntary Measures

The Oregon Plan for Salmon and Watersheds (OPSW) does not include any specific measures for the management of landslide and/or debris flow occurrence. ODF 61S (Analysis of "Rack" Concept for Debris Flows) is a voluntary measure that addresses the issue of landslide and debris flow quality; however, there is no information on the use or effectiveness of this measure. Riparian functions that are associated with this issue include sediment and large wood, which are discussed in previous issue papers. The evaluation of measure ODF 20S is considered in previous issue papers (specifically, large wood and stream temperature).

Current Rules

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.

Identification of Landslides and Landslide Hazards:

- Landslide inventories using only aerial photographs without significant on-the-ground surveying do not identify the majority (over 75 percent) of shallow-rapid type landslides, and on average, detect about 50 percent of the erosion volume associated with landslides. The fact that the forest canopy can significantly obscure the ground surface makes it difficult to identify or accurately measure landslides in forested terrain. Therefore, landslide inventories based solely on aerial photographs have limited use for identifying those landslides most common in steep forested terrain, especially in areas with dense forest cover.
- Air photo landslide inventories, on average, overestimate the ratio of landslide occurrence in clearcuts versus mature forests by a factor of five. Robison et al. (1999) shows as much as a ten-fold overestimation of this ratio.
- Coarse-scale digital elevation models (30-meter) underestimate slope steepness, especially in areas with irregular, steep slopes.
- In the forests of western Oregon, ground-based investigation provides the most reliable information on landslide occurrence and their characteristics.
- Slope steepness, landform shape, and drainage area above the landslide are important factors for determination of those sites most susceptible to landslides.
- The factors currently used in the determination of high-risk sites could be modified to improve accuracy in identifying those sites prone to debris slides and flows, and may need to include differences by geologic unit.
- The highest hazard for shallow-rapid landslides in western Oregon occurs on slopes of over 70 percent to 80 percent steepness (depending on landform and geology). There is a moderate risk of these landslides on slopes of between 50 percent and 70 percent.
- Subsequent scour by debris flows and torrents, and not the initial landslide volume, represent most (90 percent) of the landslide-related sediment that is carried into and through stream channels.

Landslides and Forest Stand Condition:

- Timber harvesting can affect landslide occurrence in areas with a moderate to high landslide risk. 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, in three out of four ODF storm monitoring study areas. Forested areas between the ages of 10 and 100 years typically had lower landslide densities and erosion volumes than found in the mature forest stands (Robison et al., 1999).
- There is significant background landslide risk on very steep slopes, 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.

Landslides and Timber Harvesting Practices:

- In the locations adjacent to landslides surveyed in the ODF storm monitoring study ("the ODF study"), landowners and loggers complied with the forest practice harvesting rules (as changed in 1983) to minimize ground disturbance and slash accumulations on landslide prone sites.
- 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 any specific practices, therefore, will be difficult to evaluate until the landscape has experienced major storms and/or prolonged exposure to geologic processes.

Stream Channel Impacts:

- 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 further than predicted by the Benda-Cundy model (Benda and Cundy, 1990). The debris torrents that traveled further than predicted were on average larger and had younger riparian vegetation near their terminus. Thus, in terms of 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 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.

Independent Multidisciplinary Science Team (IMST) Recommendations

The IMST made a total of 19 recommendations in its forestry project report of September 14, 1999. Three of their recommendations are directly or indirectly related to the effects of landslides on the sediment regime or on aquatic habitat. These three recommendations are listed below, followed by the applicable issue paper options.

Recommendation 2. ODF should develop a policy framework to encompass landscape (large watershed) level planning and operations on forests within the range of wild salmonids in Oregon.

Landslides Issue Paper Option(s):
Option # 46, method 3 (geoscientist evaluation of debris flow hazard)
Option # 47, method 4 (limiting young age class over watershed)

Recommendation 13. Retain trees on "high-risk slopes" and in likely debris torrents tracks to increase the likelihood that large wood will be transported to streams when landslides and debris torrents occur.

Landslides Issue Paper Option(s):
Option # 45, all methods (to identify sites prone to landslides)
Option # 46, all methods (to identify debris flow-prone channels)
Option # 47, method 2 (practices based on geoscientist hazard and risk evaluation)
Option # 47, method 3 (leaving some trees)
Option # 47, method 5 (prohibition of harvesting)
Option # 61, leaving trees in or near debris flow-prone channels

Recommendation 14. Continue to apply the current best management practices (BMP) approach to the management of forest lands with significant landslide potential, and develop a better case history approach for evaluating the effectiveness of BMP in this area.

Landslides Issue Paper Option(s):
Option # 45, all methods (to find high-risk sites)
Option # 47, method 1 (current practices with possible minor modification)
Option # 47, method 3 (leaving some trees, [and monitoring for case studies])

VI. Possible Additional Measures and/or Rules

Option #45: Identifying High-Risk Sites

Objective:
Ensure that all landslide-prone locations (now called "high-risk sites") are identified prior to operations.

Description:
The current rules require that where high-risk sites are identified by the forest practices forester (FPF), specific harvesting practices must be utilized. Each FPF is responsible for identifying high-risk sites either before or during harvest operations. The FPFs currently do not have the tools or time to systematically inventory the landscape to be sure that all high-risk sites are identified. This option proposes creating additional tools to ensure that all high-risk sites are identified prior to operations.

Methods/Approaches:
Current guidance could be modified to better identify those sites with the highest hazard for shallow landslides. Note that these sites are most appropriately called "high hazard." Hazard is the presence of a conditions that might lead to some potentially damaging or dangerous outcome (i.e., steep slopes that could produce a landslide. Risk is a measure of the likelihood that this undesired outcome will both occur and will also have consequences (i.e., the landslide occurs and becomes a debris flow that scours stream channels). Hazards exist that have very low risk to resources (steep slopes above a large bench, where there is no potential for a debris flow or other sediment will enter stream channels).

Three specific methods are proposed for consideration as follow:

1. As per current practice, ODF notifies operator that high-risk (hazard) sites meeting set criteria are in the proposed operation area and provides operator with information on high-risk (hazard) site characteristics. ODF bases this notification on an office screening using available maps, or with a field pre-operation inspection as time permits. The office screen is intended to be a coarse screen only. As per current practice, it is the operator's responsibility to more specifically locate sites within the operation area.
2. Operator identifies presence of high-risk (hazard) sites using criteria in rule form. The difference between method 1 (above) and this method is that the operator would notify ODF of the presence of sites during the notification process.
3. High-risk (hazard) sites are identified by geoscientist working for the operator. High-risk (hazard) site determinations would be based on ODF criteria and professional judgement.

ODF would refine the current high-risk (hazard) site criteria based on results from the "storm impacts" study. High-risk (hazard) sites for methods would be slightly modified from current guidance as follow:

1. actively moving landslides;
2. concave slopes steeper that 70 percent for most areas, except 65 percent for Tertiary sedimentary rocks in western Douglas, western Lane and Coos counties. Western means west of I-5;
3. any slope steeper than 80 percent (except 75 percent for Tertiary sedimentary rocks) excluding competent rock outcrops; and
4. other sites determined to be of marginal stability by ODF (applies only to method 1).

Note that there are certain landforms with high landslide hazard that would not be identified using the criteria listed above. Nor does this criteria address "risk" or the potential consequences of these landslides. Most foresters do not have the geologic interpretative skills to make these more complicated judgements.

Method 1

Benefits:
This method provides a simple, fairly conservative screen for high-risk (hazard) sites.

Costs:
This method results in a fairly low cost to operators. It also may provide the least certainty and consistency in high-risk (hazard) site identification. Many sites identified as high hazard will in fact be relatively stable, and there will be some sites that are not identified that will fail. Operators will still be required to more specifically locate high-risk (hazard) sites on the ground. Requiring the operator to identify these sites is problematic, since most lack the skills needed for this work, nor does ODF have the resources to consistently identify sites.

Method 2

Benefits:
This method also provides a fairly simple means for identification of high-risk (hazard) sites. It is likely that with either methods, 1 or 2, operators would have the final responsibility to show location of high-risk (hazard) sites in the written plan. This method could provide more consistency in high-risk (hazard) site identification.

Costs:
This method results in the lowest cost to ODF and an intermediate cost to landowners. Landowners that fail to identify high-risk (hazard) sites may incur added liability for forest practices violations associated with not identifying high-risk (hazard) sites. Again, many sites identified as high hazard will in fact be relatively stable, and there will be some sites that are not identified that will fail. Some sites may be missed, since other marginally stable sites (as per criteria 4 above) would not be identified. Requiring the operator to identify these sites is problematic, since most lack the skills needed for this work.

Method 3

Benefits:
This might result in the most complete identification of high hazard locations. It will also allow characterization of risk level, so that practices could be based on the level of risk to resources. If the geoscientist also develops management measures under Option 47, this method should result in more appropriate harvesting practices being applied to existing high-risk (hazard) sites. Further characterization of the hazard may help define the appropriate regulations for these locations, and result in a more targeted application of appropriate harvesting practices.

Costs:
On the ground geoscientist investigations place an additional expense on the operator. Because of incomplete scientific understanding about mechanisms that cause landslides to occur, it is not possible to identify all the locations where landslides will occur.

Option #46: Identify Debris Torrent Risk for Streams

Objective:
Identify stream channels prone to debris flows and torrents.

Description:
To move large wood from headwall or zero-order channels into larger streams requires a debris flow or torrent. Only certain stream channels are at risk for debris flows. Finding those channels that are capable of moving large wood to Type F streams could make it possible to focus riparian prescriptions on those streams where greater benefits to aquatic habitats and salmonids are more likely. The appropriate management of riparian areas in these areas may be different from other areas since wood on steep slopes can move long distances down these slopes (possible channel entry from greater distances). If these streams are to be managed in an optimal manner for the maintenance and recovery of salmonids, they must first be identified. Current technology will allow reasonably accurate identification of these streams and facilitate the application of appropriate riparian management measures.

Methods/Approaches:
ODF is currently completing a debris flow mapping project that includes different hazard categories (low, moderate, high and extreme). This could be combined with ground verification that there is an actual risk of debris flows entering stream channels.

As with Option 45, three specific methods are proposed for consideration as follow:

1. ODF notification to operator that debris flow-prone channels are in the proposed operation area based on current debris flow hazard maps. This is intended to be a coarse screen only, it would be the operators responsibility to field verify these conditions.
2. Operator identifies presence of debris flow-prone channels using criteria in rule form.
3. Debris flow-prone channels are identified by geoscientist working for the operator using professional judgement. Relative risk of delivery to fish bearing stream channels is also identified.

Method 1

Benefits:
This method could provide a simple screen for debris flow-prone channels, based on debris flow hazard maps.

Costs:
This method results in the lowest initial cost to operators. It also may provide the least certainty and consistency in identification of debris flow-prone channels. Determination of actual debris flow hazard on the ground would be problematic.

Method 2

Benefits:
This method also provides a fairly simple means for identification of debris flow-prone channels.

Costs:
This method results in the lowest cost to ODF and an intermediate cost to landowners. Developing a simple criteria for field determination of debris flow-prone channels could be based upon the Benda-Cundy (1990) model. With this method, operators that fail to identify debris flow-prone channels may incur added liability for forest practices violations associated with not identifying high-risk (hazard) sites.

Method 3

Benefits:
This might result in the most complete identification and characterization of debris flow-prone channels. It will also allow characterization of risk level, so that practices could be based on the level of risk to resources. If the geoscientist also develops management measures, this method should result in more appropriate practices being applied debris flow-prone channels.

Costs:
On-the-ground geoscientist investigations place an additional expense on the landowner or operator. Because of incomplete scientific understanding about mechanisms that affect debris flow movement, it is not possible to identify all the locations where debris flows will occur, or how often they occur. If management prescriptions include conifer retention on high-risk (hazard) sites or along debris flow-prone streams, additional landowner costs will be incurred.

Option #47: Management of High-Risk Sites

Objective:
Moderate or limit management activities believed to increase the occurrence of slope failure.

Description:
This objective is a direct quote from the IMST report (page 27). Current rules require specific harvesting practices be employed on high-risk sites. These practices are designed primarily to limit ground disturbance so that the landslide risk will not be increased. The rules and/or guidance do not require practices that require merchantable trees to 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. Additional silvicultural approaches that utilize the functions of vegetation could be made available for the management of high-risk sites, depending on risk to resources. The goal of these approaches is two-fold. Management prescriptions might be used to minimize the risk of landslide occurrence, and also to influence the quality of the landslide if/when it does occur (i.e., ensuring that large wood and sediment will deliver to the stream, as opposed to sediment without the large wood).

Since hazards and risks are variable, it is logical to develop practices consistent with the potential for landslide delivery to streams. The hazard is also related to the percent of the watershed that is subject to debris flows and in a condition with reduced forest cover. Managing the quality of high-risk sites (i.e., the amount of large wood left on the site) will potentially increase the amount of large wood delivered to streams.

Methods/Approaches:
Listed below are different methods that might be used to protect high-risk (hazard) sites during harvesting operations and subsequent stand management:

1) Standard practices defined in rule to include clearcut harvest with no hillslope alterations (skid roads, gouging) followed by rapid reforestation (the most common current practices). This may or may not require a written plan.
2) Written plans for harvesting operations on high-risk (hazard) sites prepared by a geoscience professional, with practices consistent with the level of risk to resources.
3) Leave trees that are likely to influence slope stability on high-risk (hazard) sites. (This is related to Method 1 under Option 61.)
4) Within a given watershed or ownership, limit the percent-area of high-risk (hazard) sites in a young age class.
5) A harvesting prohibition on some or all high-risk (hazard) sites (leave areas).
6) Continue to apply the current best management practices (BMP) approach to the management of forest lands with significant landslide potential and develop a better case history basis for evaluating the effectiveness of BMP in this area. (IMST Recommendation #14.)

Method 1

Benefits:
Based on results from Robison and others (1999), operators comply with current practices and minimize ground disturbance. It may also be possible to develop reforestation practices that further reduce the "window of increased landslide vulnerability" that occurs after timber harvesting on steep slopes. This would probably entail avoiding intense slash burns and applying herbicides so that nonconifer vegetation is not completely eliminated.

Costs:
Little or no additional costs to landowners. Landslide occurrence would occur at an increased rate for some period after harvesting, at least in most cases. This is likely to be followed by longer period of reduced landslide occurrence. Effects to fisheries would be watershed specific, depending on the components of the debris flow and its travel distance. It would be difficult to make practices contingent on risk to resources. Achieving "free-to-grow" reforested seedlings may be more difficult.

Method 2

Benefits:
Since hazards and risks are variable, it is logical to develop practices consistent with the potential for landslide delivery to streams. Geoscientist evaluation provides the best assessment of potential debris flow initiation and characteristics, and on relative risk to resources. If protection methods were contingent on risk, a geoscientist evaluation would be essential.

Costs:
Additional cost to landowner for the geoscientist evaluation. The required prescription may also have additional costs in terms of trees left or alternative yarding systems. In some cases, this option would include leaving merchantable trees. Most geoscientists have very limited understanding of forest harvesting systems or other forest practices, so development of specific prescriptions would be difficult.

Method 3

Benefits:
Since hazards and risks are variable, it is logical to develop practices consistent with the potential for landslide delivery to streams. Managing the quality of high-risk sites (i.e., the amount of large wood left on the site) will potentially increase the amount of large wood delivered to streams.

Costs:
There is no scientific information upon which to base the choice of different silvicultural options (the optimum mix of trees per acre, canopy closure, or other measure of retained trees). Management prescriptions will need to be tested over time to see if they are in fact achieving the desired objective. The cost to landowners is potentially high, as this could entail alternative management over large areas of forestland. Areas mapped as high debris flow hazards encompass hundreds of thousands of acres.

Method 4

Benefits:
The risk to resources (i.e., number of debris flows per unit area) is probably related to the percent of the watershed that is subject to debris flows and in a condition of reduced forest cover. This method will allow evaluation of risk at a watershed level.

Costs:
The cost to landowners is potentially high, as this could entail alternative management over large areas of forestland. Unless carefully crafted (for example, to consider each ownership separately), such a method could be seen as inconsistent with federal antitrust laws.

Method 5

Benefits:
Use of this method might prevent some or most of the temporary increase in landslide occurrence observed in Robison and others (1999) and in other landslide surveys. According to the "timing" theory, harvesting may increase short-term landslide occurrence, but may not affect long-term erosion.

Costs:
The cost to landowners is potentially very high, as this could preclude timber harvesting over large areas of forestland. Areas mapped as high debris flow hazards encompass hundreds of thousands of acres. Also, unless provided with a wind firm buffer, practices such as headwall-leave areas may increase the incidence of landslides. The prevalent notion that leaving a small number of trees on a high hazard site ignores the high probability of those trees blowing over and at the least negating any potential for reducing landslide occurrence on those sites.

Method 6

Benefits:
This is the IMST recommendation No. 14 and is similar to method No. 1 above.

Costs:
Little or no additional costs to landowners. Landslide occurrence would occur at an increased rate for some period after harvesting at least in most cases. This is likely to be followed by longer period of reduced landslide occurrence. Effects to fisheries would be watershed specific, depending on the components of the debris flow and its travel distance. It is not clear how a "case history basis for evaluating BMP effectiveness" could be developed, since it is unlikely that options different from standard practices will be commonly used.

Option #61: Large Wood Sources from Hillslope Areas and Seasonal Type N Streams

Objective:
To supply large wood inputs from seasonal Type N streams and hillslope areas that have the potential to deliver large wood to fish bearing streams of a quality and quantity sufficient to provide important habitat functions in those streams.

Description:
There is increasing scientific evidence that wood contained in debris flows is an important source of large wood for downstream fish habitat. These areas include likely debris flow paths, which are typically steep hillslopes below high-risk (hazard) sites, and above steep stream channels (a portion of small Type N streams). While these areas are providing some level of functional LW inputs under the current rules, the rules were not specifically designed to provide sources of LW from these areas. Action should be taken to increase the LW input potential from these areas. There are two general strategies: Leave trees on the slope at potential initiation

sites, or leave trees that are likely to enter fish bearing streams at some point below potential initiation sites.

Methods/Approaches:
Listed below are possible methods for the committee to consider:

1. Leave trees on high-risk (hazard) sites that are likely to deliver to Type F streams. Trees would be of a minimum age or diameter. (This is related to Method 3 under Option 47.)
2. Locate the in-unit leave trees currently required (two per acre) in hillslope and headwall areas below potential high-risk (hazard) sites that are likely to deliver to Type F streams.
3. Require additional leave trees to be located in hillslope and headwall areas below potential high-risk (hazard) sites that are likely to deliver to Type F streams. Trees would be of a minimum age or diameter.
4. Utilize a riparian management area (RMA) for small seasonal Type N channels that are prone to debris flows. (This method is currently proposed under the revised version of Option 38.)
5. Utilize a number of the options above, depending on the likelihood of wood delivery and on operational efficiency concerns.

Method 1

Benefits:
Trees in these locations have some potential to be carried by debris flows into stream channels. This is especially true for certain actively moving landslides.

Costs:
Except for actively moving landslides, these locations probably have a fairly low likelihood of delivering wood to stream channels, since individual sites fail very infrequently. Therefore, much of the value in trees retained on site may never provide a large wood function in streams.

Method 2
Benefits:
This method results in little or no increased cost to the landowner. Trees in these locations are likely to enter debris flow-prone channels.

Costs:
There is little or no current information on how many trees need to be left. This option may not provide what is considered an optimum wood volume. There may be other consequences for wildlife from moving in-unit trees to steep stream channels.

Method 3

Benefits:
Trees in these locations have some potential to be carried by debris flows into stream channels.

Costs:
These locations probably have a lower likelihood of delivering wood to stream channels.

Method 4

Benefits:
The RMA could supply a fairly continuous source of wood for debris flows that might occur. Trees in these locations have a high potential to enter debris flow-prone channels. These should also have a higher likelihood of being moved by a debris flow into larger Type F channels, where this wood may help the formation of both pools and gravel deposits.

Costs:
There are many very small channels subject to debris flows. Some of these channels have a low likelihood of delivering material to Type F streams. There is little or no current information on how many trees would need to be left.

Method 5

Benefits:
Wood delivery by debris flow depends on a number of factors. Using this method might allow the wood to be placed in the locations where it has the greatest potential to by moved be a debris flow to a place where it provides quality habitat.

Costs:
If additional leave trees were required, this would be an increased cost for landowners. There is currently no well-established methodology for deciding how many trees to leave or precisely where to leave them. A significant amount of analysis will be necessary if different scenarios are to be evaluated. There is currently no analysis for determining how much wood is sufficient, nor is there a mechanism (voluntary or regulatory, or some combination) to ensure sufficient wood will be left.

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Attachment

Table 1. Studies of comparative landslide ("L.S.") densities and erosion rates in recently harvested forests versus unharvested mature forests.

Reference	Site	Measure-ment Type*	Recently Harvested		Road Right of Way	
			Ratio L.S. Density	Ratio L.S. Erosion	Ratio L.S. Density	Ratio L.S. Erosion
Amaranthus et al., 1985	Siskiyou Mtn., Oregon	Air	19.0	6.8	138.0	111.0
Bishop and Stevens, 1964	S.E. Alaska, Maybeso Cr.	Air	19.5	NA	NA	NA
Bush et al., 1997	Oregon Coast Range	Air/Size	2.6	NA	31.6	NA
Chesney, 1982	Oregon Cascades, 1949	Air/Field Visit	0.0	NA	11.1	NA
" "	Oregon Cascades, 1959	Air/Field Visit	3.7	NA	33.3	NA
" "	Oregon Cascades, 1967	Air/Field Visit	12.9	NA	208.0	NA
" "	Oregon Cascades, 1972	Air/Field Visit	21.8	NA	705.0	NA
" "	Oregon Cascades, 1979	Air/Field Visit	4.7	NA	254.0	NA
Dyrness, 1967	Oregon Cascades, H.J. Andrews	Air/Size	9.8	5.0	309.0	60.1
Fiksdal, 1974	Olympic Pen. Washington, Sequaleho Cr.	Air/Field Visit	0.0	0.0	1600.0	224.0
Gresswell et al. 1979	Oregon Coast Range, Mapleton Area	Air/Field Visit	23.5	NA	72.2	NA
Hicks, 1982	Oregon Cascades, Middle Santiam	Air/Field Visit	3.6	3.4	73.7	95.3
Hughes and Edwards, 1978	Oregon Cascades, Umpqua basin	Ground	8.0	10.0	NA	NA
Johnson, 1991	Washington Cascades; S Fk. Canyon Cr.	Mixed	5.3	NA	97.0	NA
Ketcheson and Froehlich, 1978	Oregon Coast Range, Mapleton Area	Ground	2.2	3.4	NA	NA
Lyons, 1982	Oregon Cascades, 1959-67	Air/Field Visit	22.8	29.5	NA	NA
" "	Oregon Cascades, 1967-72	Air/Field Visit	6.8	10.0	NA	NA
Marion, 1981	Oregon Cascades, Blue River	Air/Field Visit	10.0	9.0	106.0	44.0
McHugh, 1987	S.W. Oregon	Air/Field Visit	7.0	NA	48.0	NA
Morrison, 1975	Oregon Cascades, Alder Creek	Air/Size	13.5	2.6	415.0	343.0

NA = Not available

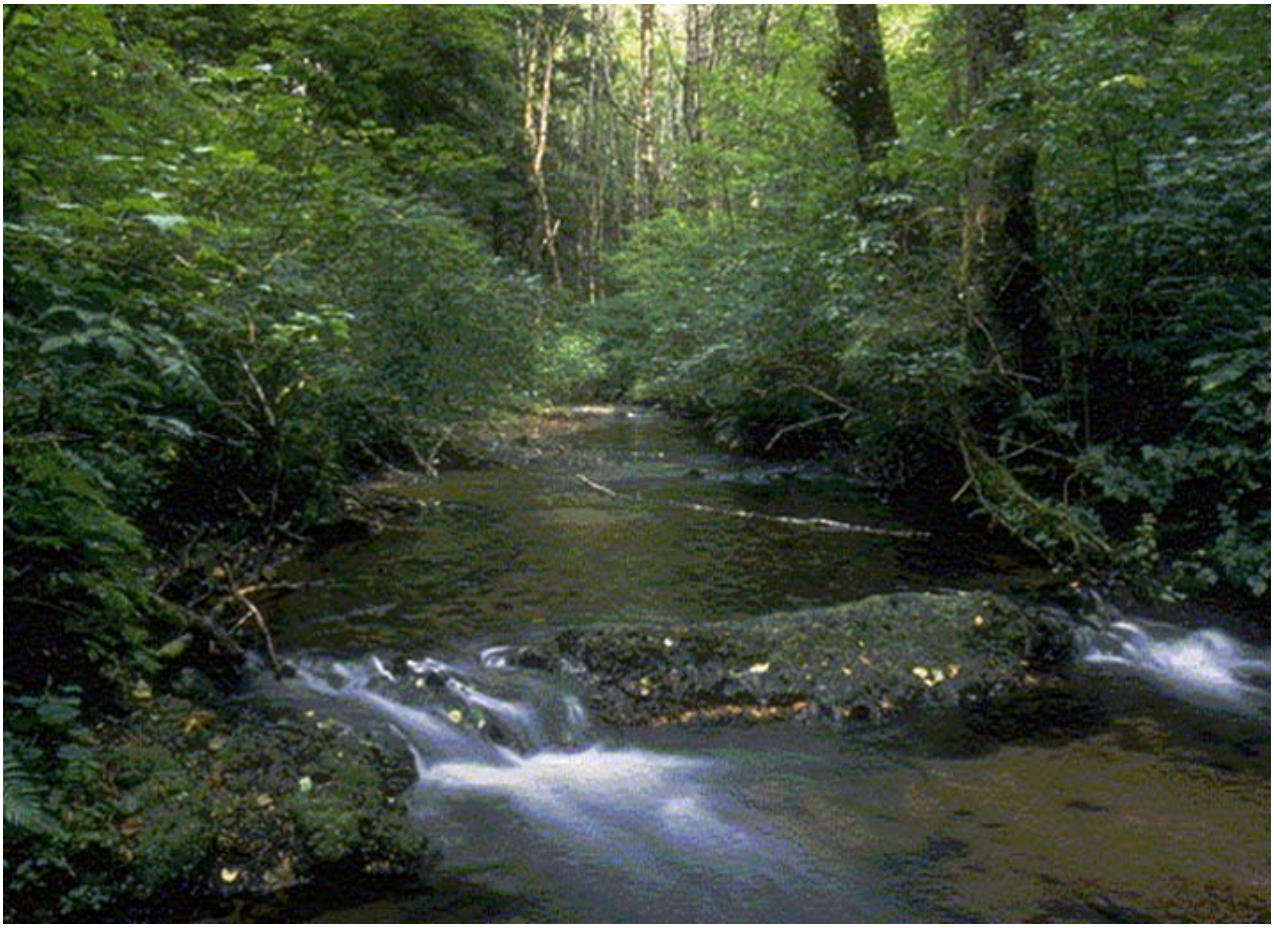
Table 1 (Continued). Studies of comparative landslide ("L.S.") densities and erosion rates in recently harvested forests versus unharvested mature forests.

Reference	Site	Measure-ment Type*	Recently Harvested		Road Right of Way	
			Ratio L.S. Density	Ratio L.S. Erosion	Ratio L.S. Density	Ratio L.S. Erosion
Robison et al., 1999 (This study)	Oregon Cascades, near Vida	Ground	1.4	3.2	2.7	40.9
" "	Oregon Coast Range, Elk Creek	Ground	0.8	0.3	1.0	0.8
" "	Oregon Coast Range, Mapleton	Ground	1.9	1.5	5.0	13.6
" "	Oregon Coast Range, Scottsburg	Ground	5.2	2.6	NA	NA
Rood, 1984	British Columbia; Graham and Moresby Island	Air	30.0	31.2	76.7	89.7
Schroeder and Brown, 1984	Oregon Coast Range, Palouse Cr.	Air	9.6	NA	NA	NA
" "	Oregon Coast Range; Larson Cr.	Air	6.1	NA	NA	NA
Schwab, 1983	British Columbia, Queen Charlotte Islands	Mixed	17.0	5.0	41.0	46.0
Smith, 1996	Oregon Cascades; Weak Rock, Steep Slopes	Air	10.7	NA	NA	NA
Swanson and Dyrness, 1975	Oregon Cascades, H.J. Andrews Unstable	Mixed	3.2	2.8	33.0	30.0
Swanson and Grant, 1982	Oregon Cascades, WNF Mod. Stable	Mixed	3.0	2.5	47.0	37.0
" "	Oregon Cascades, WNF Unstable	Mixed	7.0	5.0	336.0	250.0
Swanson et al., 1977	Oregon Coast Range, Cedar Cr.	Mixed	1.2	NA	15.0	NA
" "	Oregon Coast Range, Soil Type 47	Mixed	1.3	4.0	15.5	30.8
Swanston and Swanson, 1976	S.W. British Columbia Coast Range	Air/Size	5.0	2.2	20.0	25.2

***Measurement types: 1. "Air" - Studies based on air photos with or without ground verification regarding the size of landslides and whether or not the feature was actually a landslide. 2. "Air/Size" – Studies based on air photos with a minimum landslide size used to decrease the chance of bias between old and young stands. 3. "Mixed" – Studies combine more that one method of detection. For instance, one study used air photos to detect landslides in clearcuts and a ground-based sample in older forests. 4. "Air/Field visit" – Studies using air-based sampling with informal field visits used to get some inclinations that most landslides are being found. 5. "Ground" – Studies that detect landslides based on a systematic sampling of all landslides using the channel network and/or an orderly walking of slope contours to search for landslides.**

Section D
Riparian Functions

Issue: How well do current riparian protection practices on forestland provide for and maintain large wood inputs and stream temperatures necessary to maintain and recover salmonids?



Forest Practices Advisory Committee on Salmon and Watersheds

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I. Current Scientific Findings

Riparian Functions

Large wood, shade (stream temperature), microclimate, streambank stability, litterfall, sediment filtration, and floodplain processes are all riparian functions that are provided for by riparian forests (Naiman et al., 1998; Spence et al., 1996; FEMAT, 1993; Chamberlin et al., 1991; Sullivan et al., 1987; CH2MHill et al., 1999). While some or all of these functions may be provided for either directly or indirectly by the current forest practice rules and Oregon Plan voluntary measures, large wood and stream temperature are the primary functions that the rules and measures are designed to address. For this reason, this paper focuses almost exclusively on these two issues. This section of the paper provides an overview of the current scientific findings and what is generally understood in terms of forest management effects upon large wood inputs and stream temperature. A later section in this report will examine the adequacy of current efforts in providing for these two functions. For additional information on other riparian functions, see the references cited above.

Large Wood

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 (LW) 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 LW 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[1]. 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 (Reeves et al., 1993). 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 LW 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)[2]. 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

[1] 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.

[2] See Appendix C for the figures and tables referenced below.

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] (Figure 9). . . . 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 (Table 8). The median value for the reference reaches is 1.8 key pieces per 100 m of stream channel (Table 8). Again, the North Coast and Willamette areas had higher levels of key pieces of woody debris than any other area (Figure 10). 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 (Figure 13). (Thom et al., 1999, see Appendix C for figures and tables referenced here)

The density of large riparian conifers was also examined to understand current conditions in terms of future LW 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 (Figure 8). 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 (Table 7). (Thom et al., 1999)

While the frequency and distribution of total pieces of LW 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 LW there appears to be a shortage of potential key pieces of LW 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 LW in the future.

A number of different factors are responsible for the lower levels of key pieces of LW 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 LW in the system. As LW 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 LW from continuing downstream and being utilized by the stream

system. Stream cleaning also occurred in the 1970s and early 1980s because it was believed LW was a barrier to fish passage. During this period there was an effort to remove large accumulations of LW 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 LW. 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 LW being transported to fish bearing streams), reducing the future supply of key pieces of LW.

There are essentially three ways in which LW 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 LW 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 LW 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 LW 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 LW inputs in terms of the total LW 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 LW, 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 LW comes from vegetation in close proximity to the channel, with diminishing amounts coming from distances farther from the stream (Figure 1).

The incidence of windthrow affects the frequency and distribution of LW 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 LW 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 LW 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 fifty 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.

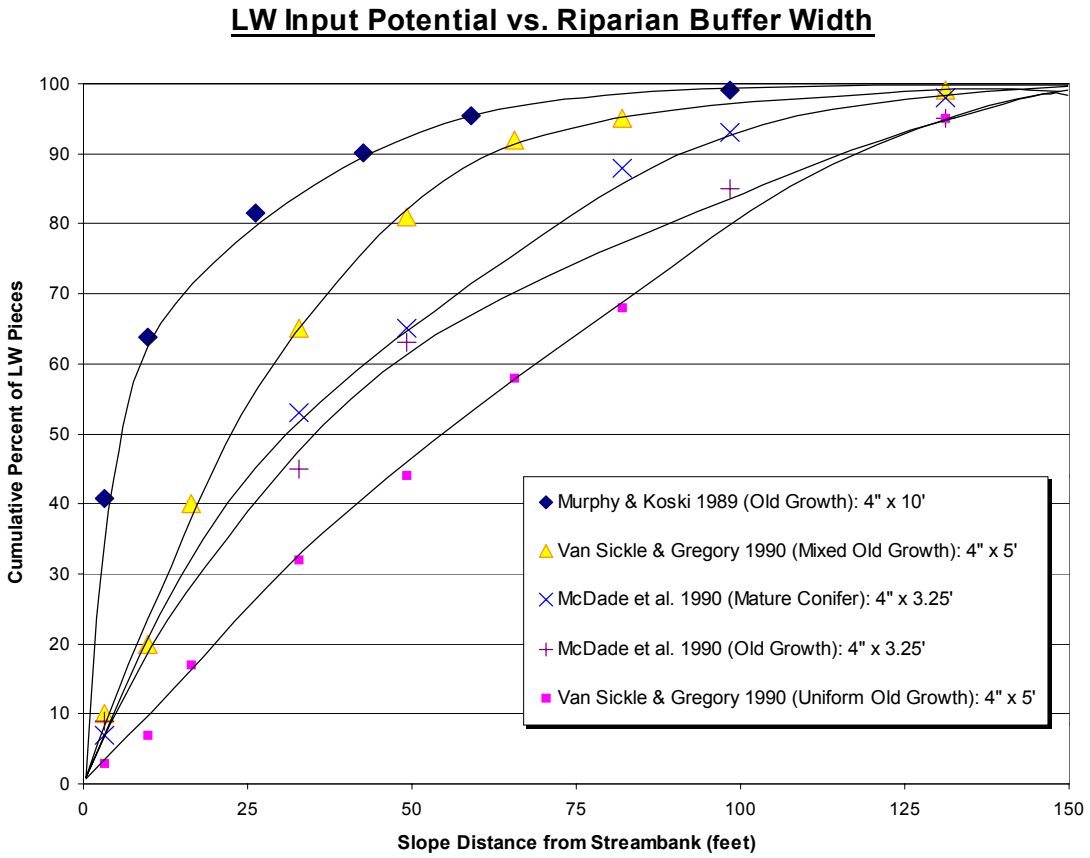

Figure 1: Compilation of current studies relating buffer width to large wood input potential. Murphy and Koski (1989) conducted their study in Alaska, the McDade et al. (1990) data is from the Oregon Cascades, Van Sickle and Gregory "mixed old growth " data is from the Oregon Cascades, and the Van Sickle 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 LW, potential inputs are not limited to stream-adjacent locations. Upstream or upslope areas can also be a source of LW 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 LW 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 LW 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 LW 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 LW to downstream riparian functions. These sources of LW have been referred to as both "upslope" and "upstream" sources. For the sake of clarity, the following terminology will be used to define LW sources for this discussion.

Near-stream riparian:

Areas directly adjacent to the stream. LW 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 LW 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. LW 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 LW source. He found that the LW 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 LW originated from upstream versus upslope areas. McDade et al. (1990) also

identified about 50 percent of the LW 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 LW downstream, it is difficult to determine what pieces of transported LW 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 LW sources. In terms of upslope sources, the relative importance of potential LW 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 LW 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 LW 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 LW 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 LW 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 LW downstream is stream flow. For this population of streams, the hydrologic regime will determine what sizes of LW 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 LW can be stable in smaller streams. Other research has found that the amount and distribution of LW will vary with channel size. Smaller channels contain more abundant amounts of randomly distributed LW, while larger streams more easily transport LW, resulting in fewer pieces and reduced aggregation of LW (Bilby and Bisson, 1998). On very large, main-stem channels, LW 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).

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[3]
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[4]	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., 1993).

[3] The optimal temperature for rearing and the lethal limit may actually be different from the values listed in Table 1. Preliminary results of on-going research by Dr. Bob Danehy concludes that the optimal rearing and lethal limit are closer to 54-58°F and 69°F, respectively (Bob Danehy, personal communication.)

[4] See Appendix E for more information on state water quality standards and rules.

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 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, Figure 2 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 salmonids may be significant.

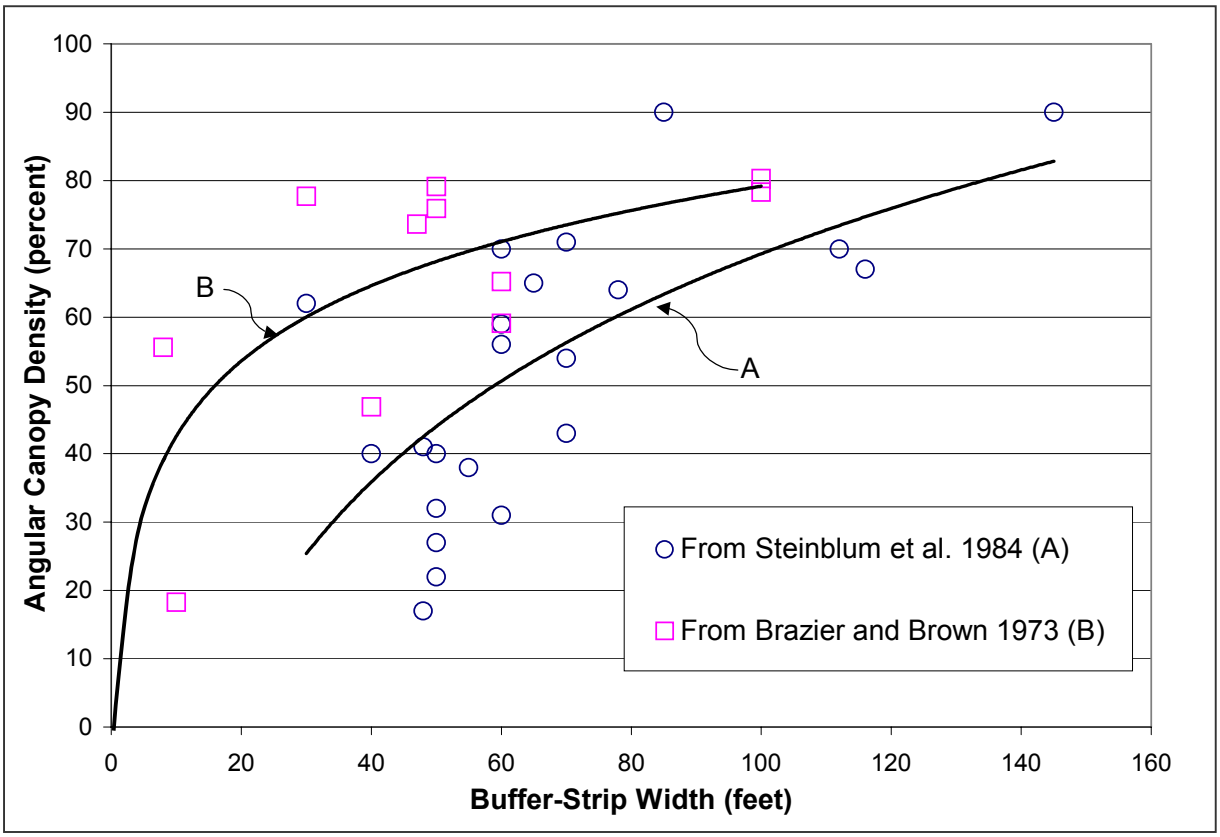

Figure 2: Relation between angular canopy density (ACD) and buffer-strip width for small streams in western Oregon (from Beschta et al., 1987).

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).

II. Watershed-Scale Effects

Natural Variability

The historic condition of riparian forests in which salmonids evolved and thrived was significantly influenced by natural disturbance (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.

The spruce and Douglas fir forests of the Oregon Coastal Range and Cascade Range were historically subjected to infrequent (every 175-250 years), high-intensity fires, while the pine forests of eastern Oregon experience frequent (every 10-30 years) low-intensity fires. Portions of both eastern and western Oregon also experience a moderate-intensity fire regime, where semi-frequent (every 30-175 years) fires would result in a patchwork of stands of various ages (Agee 1998). High intensity fires tend to "reset" the landscape by killing all live vegetation resulting in even-aged forests. Low intensity fires tend to burn mostly understory vegetation leaving the larger trees unimpacted, resulting in a forest of widely spaced larger trees with a relatively open understory (Agee, 1998).

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).

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)

Riparian functions and the maintenance of riparian forests have important implications in terms of disturbance regimes and watershed-scale effects. Riparian forests can provide important functions that include the delivery of large wood to streams, corridors for wildlife, and stream temperature protection for threatened and endangered fish. There is evidence, however, that riparian areas maintained as reserves where management is excluded can become corridors for severe wildfire (Segura and Snook, 1992, *in* Agee, 1998). However, there is limited data available to evaluate the susceptibility of different riparian community types to severe fire (Agee, 1998). 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.

Forest Management

Large Wood

Watershed-scale effects can be an issue for small Type N streams and on steep hillslopes with the potential to deliver LW via debris flows and landslides. Currently, the rules do not address the issue of potential LW inputs from upslope sources (i.e. source areas that do not require riparian buffers). In watersheds where periodic debris flows and landslides are an important part of the natural disturbance regime, the possibility exists for a significant percentage of these source areas to be harvested and potential LW inputs removed. Therefore, different harvesting patterns will result in different watershed-scale effects in terms of potential upslope sources of LW. For those forestlands that are not characterized by steep slopes, where small Type N streams do not have the potential to deliver LW to Type F streams, watershed-scale effects due to habitat foregone by the lack of recruitment of LW are unlikely to occur.

The hardwood conversion option also presents an opportunity for watershed-scale effects to be an issue. If within a certain watershed there are a significant number of operations that take advantage of this option, while in another watershed this option is generally not being used, a watershed-scale effect could be observed as a result of the hardwood conversions. The effect would likely be a short-term loss in potential LW and possible temperature effects, in return for an anticipated long-term gain once conifers can be re-established. It should be noted that the

potential LW lost is of nondurable hardwoods that persist for a significantly shorter period of time in the channel as compared to the conifers. Currently, however, landowners are rarely exercising this option.

Stream Temperature

Under 'natural' conditions, summertime stream temperatures generally tend to increase in a downstream direction and approach the mean basin air temperature at some distance from the watershed divide.

> Because stream discharge (and water depth) increases in a downstream direction, the capability of incoming solar radiation to increase summertime stream temperatures also tends to diminish downstream. Further, as small shaded streams combine to form larger streams with intermediate levels of shading, and these in turn combine to form relatively wide and mostly unshaded rivers, the relative importance of stream-adjacent vegetation for providing shade becomes a less significant component of a stream's energy balance. . . . [T]he harvesting of streamside vegetation and its ability to increase summertime stream temperatures is generally most critical for small- to intermediate-sized (perhaps 3rd to 4th-order) streams (Sullivan and Adams, 1990; in Beschta et al., 1995).

The potential for watershed-scale effects to occur depends on the combination of the degree of impacts from harvesting and the size of the stream that is impacted. Caldwell et al. (1991) concluded that there is a 150-meter "zone of concern" (about 500 feet) downstream of the smallest perennial streams where there is a potential for a cumulative effect to occur. As long as there is at least a 150-meter shaded reach between these streams where the canopy has been removed, there is a minimal risk of a cumulative downstream temperature impact (Caldwell et al., 1991). Temperature increases that result from harvesting near larger streams generally require a longer distance under canopy to return the "equilibrium temperature", but this will depend on the magnitude of the increase and the thermal dynamics of the downstream reach (e.g., existing shade, channel morphology, groundwater inflows, hyporheic zones).

Beschta et al. (1995) offers another perspective on the relevance of the tendency for temperatures to increase in the downstream direction and potential harvesting effects.

> The tendency for water temperatures to increase in a downstream direction may seemingly imply that the effects of timber harvest are not of significance in relation to the naturally occurring downstream increases, or that temperature increases can be tolerated in smaller tributaries because they are less likely to contain fish. However, if the temperatures in headwater streams were to be elevated by reductions in riparian shading, warmer waters may occur along intermediate sized reaches of a stream network and perhaps shift the preferred habitat of thermally sensitive fish and other aquatic species towards the steeper tributaries.

While there is merit to this hypothesis, there are currently no studies that have been effective in either confirming or disproving it. The ODF monitoring program has been collecting stream

temperature data at both the reach and basin scale over the past few years that may help evaluate this hypothesis. Final results from data collected for a number of stream temperature-related projects that will help address the adequacy of the rules in terms of meeting water quality standards will be available by 2001.

Other Land Uses

Figure 3 is a flow chart illustrating the many pathways by which all land uses can influence stream temperature changes and what processes need to be considered. Urban and agricultural lands generally do not require riparian buffers of the type that are prescribed for forestlands under the current water protection rules. Riparian prescriptions on urban lands vary throughout the state, depending on city and county development practices. Under SB1010 that was passed in 1993, the Oregon Department of Agriculture requires that landowners' activities be conducted in a manner that will adequately address water quality limiting factors. However, no guidance or BMPs are prescribed by the ODA that instructs the landowner on how to comply.

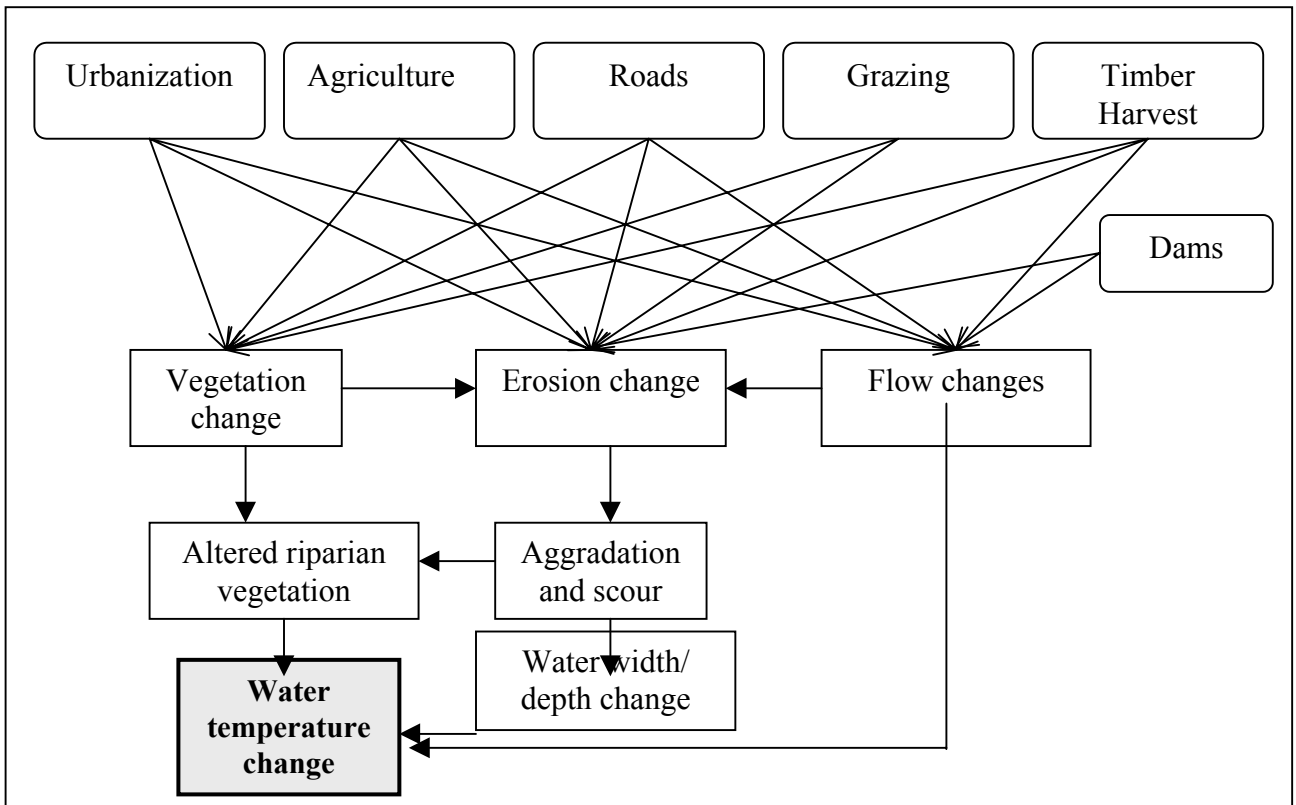

Figure 3: Pathways and processes by which different land uses influence stream water temperatures (adapted from Ziemer 1998).

Removal of LW from the stream is sometimes required for public safety and infrastructure considerations. Large wood originating from upland forests can work its way downstream, collecting against bridges and other stream crossing structures. When LW becomes backed up behind these structures, it can cause damage associated with lowland flooding in urban, agricultural, and residential areas. The structural integrity of the crossing can also be at risk

when LW is held back during high water. There is a potential issue here about how upstream activities in forestlands may affect downstream landowners. Where LW and migrating organic dams move downstream into agricultural and urban environments, there can be a conflict between what might be good for fish versus what might have negative impacts upon landowners and the general public.

Where the effective shade is reduced for streams adjacent to other land uses, the potential watershed-scale effects are essentially the same as what would occur on forestlands. Where there are combined land uses, such as grazing and timber harvesting in areas of eastern Oregon, it can be difficult to sort out the relative contributions to stream temperature effects.

III. Objectives of the Current Measures and Rules

Oregon Plan Objectives

Appendix B contains the interim objectives under the Oregon Plan for "instream roughness" (large wood) and temperature ("temperature biological objectives"). There are no explicit interim objectives for streambank stability (root strength), litterfall, microclimate, sediment filtration, and floodplain processes.

FPA Objectives

Statutes

ORS 527.710

(8) If based upon the analysis required in section 15 (2)(f), chapter 919, Oregon Laws 1991, and as the results become available, the board determines that additional rules are necessary to protect forest resources pursuant to ORS 527.630, the board shall adopt forest practice rules that reduce to the degree practicable the adverse impacts of cumulative effects of forest practices on air and water quality, soil productivity, fish and wildlife resources and watersheds. Such rules shall include a process for determining areas where adverse impacts from cumulative effects have occurred or are likely to occur, and may require that a written plan be submitted for harvests in such areas.

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.

(2) The board shall consult with the Environmental Quality Commission in adoption and review of best management practices and other rules to address nonpoint source discharges of pollutants resulting from forest operations on forestlands.

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.

Administrative Rules

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.

Additional administrative rules are listed in Appendix D.

IV. Description of the Measures and Rules

Oregon Plan Measures

The Oregon Plan contains several voluntary measures to supplement the conifer stocking within riparian areas and the recovery rate for LW to streams. This is accomplished during harvest operations by (1) placing appropriate-sized LW within streams that meet parameters of gradient, width, and existing wood in the channel; and (2) relocating in-unit leave trees in priority areas[5] to maximize their benefit to salmonids while recognizing operational constraints, other wildlife needs, and specific landowner concerns.

The measures include the following:

ODF 8S: Riparian Conifer Restoration

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 Debris (LWD) in a timelier manner. This process will be modified to require an additional review process before the implementation of conifer restoration within core areas.

ODF 19S: Additional Conifer Retention along Fish Bearing Streams in Core Areas

This measure retains more conifers in RMAs by 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 20S: Limited RMA for Small Type N Streams in Core Areas

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 21S: Active Placement of LW during Forest Operations

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

ODF 22S: 25 Percent In-unit Leave Tree Placement and Additional Voluntary Retention

This measure has one nonvoluntary component and two voluntary components:

[5] 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 61S: Analysis of "Rack" Concept for Debris Flows

OFIC members will conduct surveys to determine the feasibility and value of retaining trees along small type N streams with a high probability of debris flow in a "rack" just above the confluence with a Type F stream. The rack would extend from the RMA along the Type F stream up the Type N stream some distance for the purpose of retaining trees that have a high likelihood of delivery to the Type F stream.

ODF 62S: Voluntary No-Harvest Riparian Management Areas

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 waterbodies 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 waterbodies 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 waterbodies 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 is selected.

The measures can be described as either active restoration measures, or passive restoration measures that provide long-term LW recruitment. Voluntary measures ODF 8S and 21S are active restoration activities. ODF 8S 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 21S addresses LW placement if stream surveys determine there is a need. Measures ODF 19S, 20S, 22S, and 62S provide future LW 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.

1) Small and medium Type F streams.
2) 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.
3) Streams identified as having a water temperature problem in the DEQ 303(d) list of water quality limited waterbodies, or as evidenced by other available water temperature data; especially reaches where the additional trees would increase the level of aquatic shade.
4) Potentially unstable slopes where slope failure could deliver large wood.
5) Large Type F streams, especially where low gradient, wide floodplains exist with multiple, braided, meandering channels.
6) Significant wetlands and stream-associated wetlands, especially estuaries and beaver pond complexes, associated with a salmon core area stream.

FPA Standards and 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 2 lists the required RMA widths based on stream size and type.

Table 2. 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 LW 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 LW 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 a few 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. And 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[6]. 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[7]. The specific levels of LW inputs that the rules are designed to achieve vary by stream size and type. Given the potential LW 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 LW 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 regrowth. 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.

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[6] Small Type D streams require a 20-foot no-harvest RMA. Type N streams do not require an RMA.
[7] 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.

The ODF is also the designated management agency (DMA) for water quality management on nonfederal forestlands. To improve the coordination between the ODF and the DEQ, the two agencies signed a memorandum of understanding (MOU) in June of 1998. The purpose of the MOU is to guide coordination between the ODF and DEQ regarding water quality limited streams on the 303d list. An evaluation of rule adequacy will be conducted (also referred to as a "sufficiency analysis") through a water quality parameter-by-parameter analysis. This statewide demonstration of forest practices rule effectiveness in the protection of water quality will address the following specific parameters and will be conducted in the following order:

1) Temperature
2) Sediment and turbidity
3) Aquatic habitat modification
4) Bio-criteria
5) Other parameters

By statute, forest operators conducting operations in accordance with the ODF best management practices (BMPs) are considered to be in compliance with Oregon's water quality standards Also, the 1994 Water Protection Rules were adopted with the approval of the Environmental Quality Commission as meeting water quality standards. However, there are several provisions within the Forest Practices Act and rules that call for rule re-evaluation as needed at the state, regional, and watershed scale. The statewide sufficiency analysis initiated by the MOU is such a re-evaluation process.

Currently, the two agencies are working cooperatively in the continued development and refinement of the stream temperature simulation model developed by the DEQ. This model will eventually be used to calculate TMDL values for all 303d listed streams. In addition, these analyses will address attainment of the state anti-degradation policy. These sufficiency analyses will be reviewed by peers and other interested parties prior to the final release. They will also be designed to provide background information and techniques for watershed-based assessments of BMP effectiveness and water quality assessments for watershed with forest and mixed land uses.

V. Evaluation of the Measures and Rules

Voluntary Measures

Evaluation of the Oregon Plan voluntary measures is limited since the Plan has only been in effect for a short while. It is very difficult to assess the effectiveness of measures that have not yet been given a chance to work. An evaluation at this point would be little more than speculation and opinion. Therefore, the Oregon Plan measures must be examined in light of what they attempt to achieve, and some assessment of risk must be determined it terms of how likely the current measures are to achieve the stated goals. It is likely that the Oregon Plan measures will result in additional LW primarily in priority areas, and also to some degree in other areas. It is uncertain as to exactly how much LW will be added under these measures. This must be evaluated through implementation and effectiveness monitoring over time.

The Oregon Plan Watershed Restoration Inventory (1998) does provide some statistics on LW placement activities that occurred in 1996-97. Of the total instream restoration activities reported, 45 percent (n=206) of them were LW placement activities. Forty-four percent of these LW placement activities included placing logs into structures with boulders and rootwads, while the other 56 percent were the placement of LW alone.

The bulk of the voluntary measures that directly address stream temperature issues are implemented by the DEQ. However, the ODF does have measures ODF 8S, ODF 19S, and 20S that are indirectly related to the stream temperature issue. The Oregon Plan Watershed Restoration Inventory (1998) reports that there were 204 riparian restoration projects completed under measures ODF 19S, 20S, and 22S that treated in excess of 73 miles of stream channel. It was noted that this is an underestimation of total stream miles treated because, depending on the activity, seven percent to 20 percent of the projects did not report the extent of the riparian corridor treated.

The following tasks have been completed under DEQ2S (Development of 303(D) List and Identification of Priorities for TMDL Development):

- Task 1: Maintain and update the 303(d) list of waters that do not meet state water quality standards by April 1, 1998, and every two years thereafter.
  Deliverables: Updated list for U.S. Environmental Protection Agency approval with a focus on priority coastal basins. The 1998 303(d) list resulted in a 13 percent increase of listed temperature water quality limited stream miles (entire State) (1533 miles added for a total of 12,102 miles). This results in a 26 percent increase of listed stream segments (entire state) between data evaluated in 1994/1996 compared to data evaluated in 1998 (253 stream segments added for a total of 940 segments). More than one quarter of those stream miles listed for temperature occurred on private forestlands.
- Task 2: Develop process for prioritizing and targeting waterbodies on the 303(d) list.
  Deliverables: Document describing a process to prioritize and target waterbodies on the 303(d) list for TMDL development.
- Task 3: Prioritize the list and target water bodies for development of TMDLs.
  Deliverables: Prioritized waterbodies with a list of targeted waters for which TMDLs will be developed prior to the next listing cycle (April 2000). The following tasks under DEQ6S (Implement Antidegradation Water Quality Standard) are ongoing and progress is being made in each area. ODF and DEQ are fully engaged in this process.
- Task 4: Provide technical assistance to ODF in monitoring, evaluation and development of forest practices rules to protect water quality and beneficial uses and to implement antidegradation policies.
  Deliverables: Technical assistance provided to ODF.
- Task 5: Provide financial assistance to ODF for monitoring and evaluation of forest practices effectiveness to protect water quality.
  Deliverables: Final reports for two Section 319 funded projects: 1) the evaluation of riparian buffer effectiveness for stream temperature protection; and 2) forest road best management plans for erosion control.

- Task 6: Provide technical assistance to ODF in the development of water quality management plans.
  Deliverables: Technical assistance provided to ODF.

Current Rules

Large Wood

Since the Water Protection Rules were enacted in 1994, there has not been enough time to observe significant changes in riparian characteristics on the ground. Given this fact, how can we determine if under these rules LW levels are in fact increasing towards what would exist under mature conifer forests? Initial monitoring results can help evaluate the validity of some of the assumptions built into the rules, and in turn allow us to evaluate the potential effectiveness of the current rules given the adequacy of these assumptions.

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 has to do with the adequacy of the RMA widths, and the second with the adequacy of the RMA management prescriptions.

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 LW 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. While the largest streams, on the one hand, have the capacity to move very large pieces of large wood, the smallest streams do not normally move the larger wood during high flows. They may be dominantly used by resident fish species, in which relatively small wood normally functions in step-pool formation. In considering on-site effects of LW, 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.

Historically, however, large diameter trees were present along all sizes of streams 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 LW, 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).

During a recent riparian aquatic habitat workshop, a number of studies were referenced that examined buffer width versus potential LW inputs. In general, the findings show that nearly all of the potential LW from *stream-adjacent sources* originates from within 60 to 130 feet of the stream (see Appendix A). The law of diminishing returns dictates that the majority of potential LW comes from relatively close to the stream, and the potential inputs rapidly diminish at distances beyond 60 to 130 feet. Close to 100 percent of the potential LW originates from within this distance from the stream. To achieve the entire 100 percent of potential LW, the buffer would need to extend an additional 100-150 feet, or to about one site-potential tree height.

The Water Protection Rules require an RMA between 50 to 100 feet on all streams except small, Type D and N. Small Type D streams require a 20-foot RMA. Small Type N streams do not have an RMA (they do require the protection of the bed and banks and water quality). The inner 20-foot RMA is a no-harvest zone. Harvesting may be allowed within that portion of the RMA outside of the no-harvest zone depending on the existing basal area.

For riparian areas managed to achieve mature forest conditions (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 rotation (in 25 years). This range of RMA widths is believed to supply between approximately 65 percent and 95 percent of the potential conifer LW of a mature forest, assuming that these zones will contain conifer stocking of a mature forest (McDade et al., 1990). There is a reasonable probability that for those streams where 50- to 100-foot RMAs of mature conifer forests are maintained, the potential LW supply from adjacent riparian stands will be close to what would exist under mature forest conditions. This is not the case for LW delivery from small Type D and N streams where RMAs are 20 feet or less.

Murphy (1995) presents an analysis of 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 LW 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 LW 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 LW 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 LW delivery. In addressing the adequacy of the Oregon stream rules, Murphy states the following:

> "Oregon's rules are based on the expectation that basal area will increase by 59 percent within 25 years, thereby achieving the level of LW 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 LW 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 LW sources (conifer volume) present *immediately after* timber harvest, assuming the retention of the minimum basal area only, pursuant to the forest practices requirements of the different western states. Based upon his analysis, Murphy estimated that approximately 58 percent of potential conifer LW 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 procedure to Medium and Small Type F streams in this region results in estimates of approximately 38 percent and 15 percent potential conifer LW sources after harvest in medium and small stream RMAs, respectively (Table 3). Where stream enhancement activities and harvest to the "active management target" occurs, the potential conifer LW retained in these RMAs immediately following harvest is less.

Since the publishing of Murphy (1995), Murphy has corrected calculations of the percent of LW sources at mid-rotation in mature forests for Type F streams in Oregon. Instead of the 92 percent quoted above, Murphy estimates that the percent of LW 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).

The second issue that must be addressed is the adequacy of the RMA management prescriptions in achieving mature forest conditions. During the development of the 1994 Water Protection Rules, it was necessary make a number of assumptions where data was lacking. Through effectiveness and implementation monitoring, these assumptions will be tested and revised as warranted. Basal area targets were developed for the seven different georegions, and it was believed that these targets would be reasonably accurate in describing the potential of a given riparian stand in a given georegion. Another assumption was made regarding conifer stocking on small, medium, and large streams. This assumption held that hardwood species would dominate the first 20 feet of the RMA across the landscape. A third assumption was made regarding incentives for landowners to manage within the RMA. This assumption held that 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 highly likely that conifer existed historically. It was also believed that the standard and active management basal area targets would provide an incentive for landowners to grow trees in excess of what must be retained so that the excess may be harvested. A final assumption was that 25 percent and 75 percent of the LW 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 validated by monitoring.

Table 3. Percentage conifer large wood sources[8] following clearcut harvest to current FPA basal area retention standards on Type F streams.

Georegion	Target	Potential Large Wood Sources After Clearcut Harvest[9] (% 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	**Standard**	**58**	**92**	**126**	**38**	**60**	**82**	**15**	**24**	**33**
	Active Mgmt.	**43**	**68**	**93**	**28**	**44**	**60**	**8**	**13**	**18**
South Coast	**Standard**	**57**	**91**	**124**	**37**	**59**	**81**	**15**	**24**	**33**
	Active Mgmt.	**42**	**67**	**92**	**28**	**45**	**61**	**8**	**13**	**17**
West Cascades	**Standard**	**59**	**94**	**129**	**38**	**60**	**83**	**13**	**21**	**28**
	Active Mgmt.	**43**	**68**	**94**	**30**	**48**	**65**	**6**	**10**	**13**
Interior	**Standard**	**58**	**92**	**126**	**37**	**59**	**81**	**13**	**21**	**28**
	Active Mgmt.	**42**	**67**	**92**	**29**	**46**	**63**	**6**	**10**	**13**
Siskiyou	**Standard**	**58**	**92**	**126**	**37**	**59**	**81**	**16**	**25**	**35**
	Active Mgmt.	**45**	**72**	**98**	**30**	**48**	**65**	**8**	**13**	**17**

[8] Potential conifer large wood source estimates follow the analysis procedure described by Murphy (1995).

[9] For example, for a clearcut harvest along a large Type F stream in the Coast georegion 58 percent of the total potential LW 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 LW 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 LW will be present. Medium and small streams have lower levels of potential LW due in part to narrower RMAs. This is also due in-part to the fact that additional LW from in-growth 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.

Monitoring data collected by the ODF over the last four years has provided preliminary results pertaining to the validity of some of these assumptions. As for the first assumption about basal area targets, there are initial 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 the second assumption regarding hardwood species dominating the first 20 feet of the RMA may not be valid, particularly for small, confined channels. A preliminary look at the monitoring data indicates that variability is prevalent across all sizes of streams, and that 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 assumed to be the case. 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, in fact, the case, the actual retention will be significantly less than assumed and it may not support the expected range of functions (including shade and LW) at the level that was assumed.

Finally, there is a possibility that incentives for landowners to actively manage RMAs to "develop characteristics of mature forest stands in a timely manner" may by inadequate. About 60 percent of the 52 RMA sites surveyed by ODF monitoring crews were not harvested down to the basal area target (Liz Dent, personal communication, 1999). These findings also show that the estimates made by Murphy (1995) discussed above are not valid for 60 percent of the RMAs

sampled since more basal area was retained than the minimum. It should be noted that data was not collected to understand why the landowner stayed out of the entire RMA on these sites. Possible reasons include that the stocking levels were too low for harvesting within the RMA to be an option, or that the landowner chose not to manage for their own reasons. More specific information is needed in order to determine *why* 60 percent of the sites were not harvested down to the minimum basal area target.

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. The hardwood conversion option also 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 (i.e., unfavorable market conditions). Also, landowners might be wary to exercise this option out of fear that they may inadvertently commit a violation in trying to implement this option. 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.

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 (outside of what is necessary to protect the bed and banks) under the current rules. In terms of structural LW, small Type N streams can only provide for inputs to salmonid habitat if they are of the type where 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 LW inputs in this manner. The current rules assume that the newly regenerated stand will likely provide some level of smaller LW inputs over time, but this assumption has not been validated. The significance of a lack of larger LW in these streams is uncertain, but nonetheless a reduction from this potential source does exist.

Another concern is in regards to the opportunity for LW 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[8]. This creates the possibility that the LW 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 that 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, that some level of LW inputs will occur even if it cannot be quantified.

[10] So long as the basal area and minimum tree number requirements are met.

There is also the issue of potential LW inputs from sources other than near-stream areas. By its very definition, upstream riparian sources are maintained where RMAs are established above a given stream reach. Upslope sources of LW are currently not maintained where a harvest operation occurs in the potential source area. The potential for delivery of upslope LW only exists, however, in areas with steep slopes that are prone to landslides and/or debris flows that enter the channel. Exactly what proportion of LW 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 in terms of LW supply from these three sources must be determined qualitatively using professional judgement.

Finally, information received on the eastern Oregon field tour (FPAC tour, August 1999) 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 that 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 high productivity, 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 the 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 F for a more detailed discussion)

Stream Temperature

The ODF has an ongoing stream temperature monitoring program. The focus is on monitoring the effectiveness of RMA prescriptions and riparian conifer restoration (RCR) in maintaining stream temperatures. A report on the results from 1995 monitoring data has provided some new information on how the rules are performing in terms of impacts to stream temperatures (Dent and Walsh, 1997). The monitoring sites included in this study are mostly 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 of 1995 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 RCR 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 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. (Dent and Walsh, 1997)

Two types of statistical analyses were conducted on the 1995 data set with contradictory results. One test was a repeated-measures Analysis of Variance (ANOVA) of the residuals that showed no statistical 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. Those 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 the treatment reach.

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. 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 as to the performance of the current rules in terms of temperature effects from harvesting to the edge of small Type N streams. 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[9].

> In cases where a single stream channel changed from a Type 4 to a Type 3 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)

[9] 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.

This study also observed that several of the Type 4 stream reaches monitored for temperature exceeded the 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 standards. 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 were 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)

Based on current 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. For small, headwater streams, while stream temperatures 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). 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 temperature standard. Dent and Walsh (1997) do 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 inherent downstream increases in stream temperatures. Additional analysis is needed to determine how these increases compare to the 'natural' rate of temperature increase in the downstream direction. 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 evaluate the effectiveness of the rules. The analysis of additional temperature monitoring data will be available in the spring and summer of 2000, that may help address some of the unresolved issues.

Other Riparian Functions

Other riparian functions besides large wood and stream temperature (shade) include microclimate, streambank stability, litterfall, sediment filtration, and floodplain processes. It is generally assumed that these other functions will be provided for, to some extent, by the Water Protection Rules. It should be noted that 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 protection for microclimate, litterfall, streambank stability, and sediment filtration. Floodplain processes will also be provided for 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 protection of floodplain functions 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 will 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 in terms of providing these other riparian functions will take continued effectiveness monitoring.

Independent Multidisciplinary Science Team (IMST) Recommendations

The IMST made a total of 19 recommendations in its forestry project report of September 14, 1999. Six of their recommendations are directly, or indirectly, related to riparian functions. These recommendations are listed below, followed by the issue paper options that address the recommendations.

Recommendation 2:

ODF should develop a policy framework to encompass landscape (large watershed) level planning and operations on forests within the range of wild salmonids in Oregon.

Riparian Issue Paper Option(s)

Option #41, all (partially addresses this recommendation)

Recommendation 3:

Treat nonfish bearing streams the same as small, medium, and large fish bearing streams when determining buffer-width protection.

Riparian Issue Paper Option(s)

Option #26, method 8
Option #62, method 5

Recommendation 4:

Provide increased riparian protection for the 100-year floodplains and islands.

Riparian Issue Paper Option(s)

Option #63, method 3

Recommendation 5:

Increase the conifer basal-area requirement and the number-of-trees requirement for RMAs, with increases in these requirements for medium and small streams regardless of fish presence.

Riparian Issue Paper Option(s)

Option #26—methods 1, 2, 3, 5, and 6

Recommendation 6:

Complete the study of the effectiveness of the OFPA rules in providing large wood for the short- and long-term.

Riparian Issue Paper Option(s)

Option #30—method 2

Recommendation 13:

Retain trees on "high risk slopes" and in likely debris torrent tracks to increase the likelihood that large wood will be transported to streams when landslides and debris torrents occur.

Riparian Issue Paper Option(s)

Option #38, all methods

VI. Possible Additional Measures and/or Rules

Option #20: Active Placement of Large Wood

Objective:
Provide additional large wood (LW) to streams by actively placing the wood in areas where it will provide the greatest benefits to salmonids.

Description:
It is widely believed that current levels of LW in many streams are significantly lower than what occurred historically. Where riparian areas are generally lacking in large diameter trees the active placement of key pieces from off-site sources can be critical to the creation of habitat functions in the short-term. In order to accelerate the rate of large wood inputs that is occurring under the current rules and measures, additional large wood should be actively placed in the appropriate streams.

Methods/Approaches:

1) Place LW along fish bearing streams during an adjacent harvest entry. (This is currently part of an Oregon Plan for Salmon and Watersheds (OPSW) voluntary measure, ODF 21S.)
2) Place LW along Type N and D streams prone to debris flows that are likely to deliver the wood to fish bearing streams downstream.

3) Place LW upslope of Type N and D streams prone to debris flows that are likely to deliver the wood to fish bearing streams downstream (i.e. in small draws and hollows)

Benefits:
This would provide more LW input in the short term and accelerate the creation of new salmonid habitat in streams where there is currently a LW deficit.

Costs:
If the additional LW is taken from the RMA, it may affect the long-term LW input potential of the RMA. If the additional LW is taken from the adjacent harvest unit outside the RMA, there will be a financial cost to the landowner. (The 1999 OPSW restoration guide recommends that the LW come from outside the RMA.) For LW that is not placed directly in Type F streams there will be a time lag between when it is placed and when it is utilized for fish habitat. If this time lag is too long, the LW may be at a stage of decomposition where it can no longer provide the same level of function as a "fresh" piece of LW.

Option #22: Manage RMAs for Shade

Objective:
Establish management prescriptions for RMAs that will provide sufficient shade to achieve and maintain state water quality standards for stream temperature.

Description:
Shade is an important riparian function that regulates the amount of solar energy reaching the stream surface. The more forest canopy that reduces shade that is removed, 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. To protect streams from adverse temperature increases that may violate water quality standards, the current rules use a combination of a 20-foot, no-harvest area and basal area retention targets adjacent to streams. It is assumed that the shade produced by the Water Protection Rules will maintain stream temperatures within water quality standards. Current monitoring data has shown that there is the potential for short-term stream temperature increases after harvesting under the current rules, particularly with riparian conifer restoration blocks (RCRs). This option proposes using a more prescriptive and direct approach to achieve shade levels necessary to maintain water quality standards.

Methods/Approaches:
Shade management prescriptions could be employed on a small sub-set of streams (e.g. reaches where RCR is conducted), a combination of specific stream types, or on all streams. Listed below are some specific approaches that have been deliberated by the Committee.

1) Establish basal area and tree retention prescriptions that provide adequate shade sufficient to meet temperature standards for all streams. A method of relating shade to basal area and tree retention would need to be developed that can accurately determine the RMA characteristics necessary to achieve adequate shade. (The Department of Environmental Quality (DEQ) is currently developing such a method, referred to as a "shade calculator.")

2) Use a shade standard to manage RMAs as was done previous to the 1994 rule changes. A shade standard based on an "effective shade" target, the percent of pre-operation shade, or no shade reductions below a predetermined threshold could be used.
3) RCR prescriptions become conditional to a site-specific plan.
4) Retain shade-producing vegetation on the south side of streams in RCRs.

Benefits:
The current RMA prescriptions are based primarily on a combination of basal area and tree retention requirements. Developing and utilizing a predictable relationship between these criteria and effective shade would be a relatively efficient method of managing for shade. A prescriptive approach will also provide a direct means of managing for shade, as opposed to managing primarily for mature stand conditions under the assumption that adequate shade will be provided. Site-specific plans for RCRs would avoid a one-size-fits-all approach. Where temperatures are known to be a significant problem, the RCR blocks could be custom designed to minimize temperature effects on the stream.

Costs:
Using a combination of basal area and tree retention requirements to manage for shade is dependent on an effective model, or shade calculator, that can translate RMA conditions into effective shade for all parts of the state. Although there is one in development, it would be the first of its kind and would need to be adequately tested. Trade-offs must be considered when considering the management of RMAs primarily for shade. A management option that may be ideal for creating shade may not be ideal for providing adequate riparian function in terms of large wood. In terms of using a shade standard, site-specific shade measurements are extremely variable and are problematic in the winter months when hardwoods are defoliated. Monitoring has shown that the use of a shade standard tends to be subjective and lacks consistency. The use of a shade standard was abandoned in 1994 for these reasons. Even with a site-specific plan for RCR prescriptions, there may still be a reasonable potential for temperature increases to occur in the short term. There may still be cases where a decision must be made between short-term and long-term effects. The additional effort required for a site-specific plan can also be a disincentive for active management, reducing the potential for achieving mature stands conditions in a timely manner.

Option #26: RMA Basal Area Targets and Management Prescriptions

Objective:
Ensure that basal area retention within RMAs is consistent with achieving characteristics of mature forest conditions and desirable levels of LW inputs and shade functions over time.

Description:
The Water Protection Rules were designed to provide a level of LW inputs based on some assumptions about the capabilities of riparian areas to grow wood. Preliminary monitoring data indicates that 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. Also, preliminary monitoring data shows that 60 percent of harvest operations are not managing within

the RMAs. Monitoring has also shown that some of the current RMA prescriptions may result in short-term temperature increases, however the significance of the potential temperature increases is uncertain. Action should be taken to ensure that the level of LW inputs being provided by the RMAs is consistent with the goals of the rules, which includes the goal of achieving the desired future condition in a timely manner. This option aims to increase the level of LW inputs over the short and long term to achieve this end, and to ensure that adequate shade is maintained to protect water quality by adjusting RMA basal area targets and/or RMA management prescriptions.

Methods/Approaches:

1) When managing the RMA for the basal area target, require that the entire basal area target be achieved within the portion of the RMA outside of the 20-foot, no-harvest buffer (i.e., the basal area in the first 20 feet could not be counted).
2) To address areas where the current basal area targets may not be optimizing the shade and large wood potential for a given site, re-examine the basal area targets, and the assumptions therein, and adjust them appropriately.
3) Develop site-specific prescriptions for the retention of trees in the RMA based upon actual conifer basal area within the RMA. Basal area targets will be set based upon a target of retaining at least 75 percent of the pre-harvest basal area within the RMA, but at a minimum, retaining at least the current standard target. The objective for the site-specific prescription is to manage the tree selection to meet the desired future condition in a timely manner. Continue to provide active management basal area credits, allowing harvesting to less than 75 percent of pre-harvest basal area if combined with stream enhancement measures (the standard target would remain the minimum). Also, change the language of the rules to require that the basal area that is removed from the RMA be distributed in such a way as to optimize the opportunity for the remaining trees to increase in basal area in a timely manner.
4) Use conifer regeneration corridors (CRCs) instead of the current method for actively managing the RMAs. Retain the current RMA width classifications and replace the current thinning option and basal area targets with the CRC prescription. Under this prescription, the landowner would be allowed to harvest a corridor into the RMA perpendicular to the stream up to the no-harvest buffer. The larger trees very close to the 20-foot buffer might be felled toward/into the stream to provide immediate and short-term LW inputs. The corridors would be designed such that re-entry into the same corridor would only occur after multiple rotations for the adjacent stand outside the RMA (every 200-300 years). The corridor widths would also need to be designed such that successful Douglas-fir regeneration (where appropriate) would occur. Some degree of thinning might occur into the RMA adjacent to the CRC to ensure successful regeneration. The Water Protection Rules would remain in place as the default option for those operations where the CRC is not feasible.
5) Create a voluntary conservation reserve program (CRP) similar to the program under the same name currently administered by the Natural Resource Conservation Service. This program leases agricultural land adjacent to streams, lakes, and wetlands and manages these lands for water quality and wildlife habitat functions. Under this program, the State would lease land within the RMA for a period of time and the State Forester would prescribe site-specific management plans. The lease period would need to be long enough to ensure that the intended habitat functions are achieved. The landowner would retain full ownership rights to the property, whereby the State would only lease the rights to manage the property

over the duration of the lease. Priority would be given to lands that have high value in terms of riparian function, or that have a high potential to develop quality riparian conditions in a timely manner. The Water Protection Rules would remain in place as the default option for those landowners choosing not to use the CRP option.

6) Increase the minimum number criteria for trees retained in the RMA (**IMST recommendation #5**).
7) Increase the minimum size criteria for trees size retained in the RMA. (The objective of this approach would be to increase the potential for key pieces of LW to be grown in the RMA and delivered to the stream.)
8) Treat nonfish bearing streams the same as small, medium, and large fish bearing streams when determining basal area requirements (**IMST recommendation #3**).
9) Use a range of site classes to determine basal area targets for RMAs in eastern Oregon instead of the uniform basal area targets that are currently used.

Benefits:
Additional salmonid habitat will be created in streams over time that currently lack the complex structure large wood provides.

Methods:

1) Disregarding the 20-foot no-touch zone in meeting the basal area target will prevent the basal area targets from being satisfied completely within the 20-foot no-touch zone. This will result in greater effective buffer widths that provide increased LW inputs and effective shade. This will provide more assurance that key pieces of LW, beyond what exists in the first 20 feet, will be retained in the RMA and provide inputs at some time in the future.

2 and 3) A site-specific basal area target will be more effective at maximizing the growth potential of a given stand, allowing for more LW to be grown more quickly. Basal area targets that better reflect the growth potential will be more effective at maximizing the LW input potential of a given stand.

4) This will allow for conifer regeneration to occur in the RMAs. This will also preserve the integrity of the buffer widths over most of the RMA as currently prescribed under the rules. There would be no removal of trees in the majority of the length of RMA, which will eliminate the possibility of an effective buffer width that is something less than what is prescribed under the rules. The risk of windthrow may be reduced. LW will be put into the stream in the short term from dispersed locations that correspond to the spacing of the CRCs. The relative ease of harvesting a CRC as compared to a thinning will be more of an incentive for active management.

5) This would allow the state direct control over managing the RMAs in the most optimal manner for LW and other riparian functions. Once a lease is signed, there would no longer be a need for measures encouraging active management by the landowner, as the state would take over this role.

Costs:
Substantial cost to the landowner could be expected, due to increases in conifer retention along all stream classes.

Methods:

2 and 3) The 75 percent of existing basal area approach leaves the basic structure of the current rules intact and simply changes the method of calculating the basal area available for harvest. This does not change the situation for the 60 percent of the RMAs that are not being actively managed. Language requiring an even thinning of the RMA (where applicable) may be even more of a disincentive for active management, since this will require more sophisticated harvesting techniques. Readjusting the basal area targets in and of itself does not create any more of an incentive for active management within the RMA. It also may, or may not, create additional costs for the landowner, depending on how the basal area targets are changed.

4) There is the risk that CRCs might cause stream temperature increases depending on the design. To minimize this risk and achieve LW objectives, the CRCs will need long rotation periods where a majority of the RMA is left intact and mature forest conditions are allowed to develop over a majority of the RMA. There may be cases where this is very difficult to achieve given the size and location of a harvest operation. Multiple ownership along a stream could be problematic for this option. This option would need to be studied carefully from both an ecological and operational perspective to determine if it is desirable.

5) This will require additional resources from the state, both for the additional staff necessary to manage the RMA leases, as well as for the cost of the leases. There may be logistical problems as well. The most cost-effective way for the state to manage the RMAs would be to do so at the same time the landowner is harvesting adjacent areas. This could mean multiple operations distributed across the state at any given time. ODF field offices will need the additional resources necessary to handle the increased workload and the flexibility needed for this type of program.

6 and 7) There will be a financial cost to the landowner if the largest trees that must be retained have a higher value than a number of smaller trees with equivalent basal area. Depending on where these trees are that must be retained, there may be additional operational costs to the landowner.

Option #30: Riparian Monitoring Program

Objective:
Maintain a riparian monitoring program

Description:
Continued monitoring of the rules protecting riparian functions must occur in order 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 OPSW and water quality standards, as well as continued compliance monitoring.

Methods/Approaches:

1) Increase the resources available to fund additional monitoring of rules and measures affecting riparian functions above and beyond what is currently being done.
2) Ensure that adequate resources are available to continue the riparian monitoring work that is currently being done.

Benefits:
1) This will allow for a more thorough analysis of OPSW measures that goes beyond the straightforward list of what measures were implemented. Additional resources will allow for an examination of the actual effect of the rules related to LW and stream temperature on fish populations. This will also allow for a continuation of ODF compliance monitoring over time and potentially increase the quantity of useful information available to evaluate forest practice rule implementation.

Costs:
1) This will require a significant increase in monitoring staff and a long-term commitment of resources, as these types of monitoring efforts can take years to implement successfully. These additional resources are necessary if the ODF is to continue its monitoring efforts related to issues other than the OPSW and rule compliance.

Option #38: LW Inputs and Shade Functions for Small Perennial Type N Streams

(Option #61 in the Landslide issue paper addresses LW inputs from seasonal Type N streams prone to debris flows)

Objective:
To ensure that adequate LW inputs and shade are maintained for riparian areas along small perennial Type N streams.

Description:
There is increasing scientific evidence that small nonfish 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 LW inputs and shade production under the current rules, the rules were not specifically designed to provide significant sources of LW and shade in these areas. Action should be taken to increase LW inputs along small perennial Type N streams prone to landslides and debris flows, and to ensure that adequate shade is maintained along small perennial Type N stream segments that may influence Type F streams downstream.

Methods/Approaches:
Listed below are specific methods that apply to small perennial Type N streams (areas upslope of small perennial Type N streams are addressed in the Landslides issue paper):
1) Create no-harvest buffers on small perennial Type N streams.
2) Create RMAs on small perennial Type N streams (i.e., allow for active management).
3) Create RMAs only on small perennial Type N streams that are prone to landslides and debris flows and have the potential to influence downstream water temperatures.

4) Create RMAs only on small perennial Type-N streams that are prone to landslides and debris flows and have the potential to influence downstream water temperatures, upstream a specified distance (e.g., 100, 300, or 500 feet) from the junction with a fish bearing stream. The distance could be scaled to the basin size, debris flow delivery probability, and/or georegion.

Benefits:
This option will create additional LW inputs to small Type N streams. Some increase in the delivery of 'key pieces' of large wood to downstream fish bearing streams will also occur in areas with steep slopes where the occurrence of landslides and debris flows are a part of the natural disturbance regime. It is also likely to increase the amount of effective shade along small Type N streams. The relative benefit of a wider or longer RMA will depend on what and where trees are retained. Leave-trees would serve a dual purpose. They would provide both the conventional leave-tree functions the current rules aim to achieve, as well as potential LW in the future for fish bearing streams downslope. Where the current number of leave-trees required under the rules are simply located in a different area, there will be no extra financial cost to the landowner.

Costs:
The cost of retaining some type of riparian buffer on small Type N streams (whether it is a no-harvest, actively managed, or a combination of the two) will be proportional to the number and size of trees that are retained. The potential cost to the landowner in creating RMAs along these streams, however, is high. There may be some ecological costs associated with clustering leave-trees in areas prone to landslides and debris flows as opposed to leaving them in other areas across the harvest unit. If additional leave-trees are required, there will be a financial cost associated with this option.

Option #41: Statewide Riparian Management Policy

Objective:
Develop a statewide riparian management policy.

Description:
Currently, there are conflicting policies across the state that deal with the management of riparian areas and LW in streams. Riparian vegetation and instream wood protection policies and regulations vary substantially across the state, and between different land use sectors. As an example, a number of cities and counties are actively removing LW to reduce the risks of flooding and property damage. At the same time, forestland owners upstream are being asked to put more LW into streams. This option would work towards a statewide policy on the management of riparian areas in streams across all land uses.

Methods/Approaches:
Have similar riparian protection zones on all other land uses that are designed to achieve temperature standards and retain large wood. Work towards a statewide policy on the management of riparian areas across all land uses.

Benefits:
This will spread the burden of managing riparian areas and providing LW to streams equally among all landowners. There is the potential to increase the total stream miles that provide fish habitat by maintaining vegetation and LW on streams in land uses that currently do not provide fish habitat. Since the majority of LW originates from areas closest to the stream, this option will provide significantly more LW inputs as compared to an equivalent widening of RMAs on forestlands only. For example, creating 100-foot buffers on large fish bearing streams regardless of land ownership would provide significantly more LW as compared to doubling the 100-foot RMA on large fish bearing streams on forestlands only.

Costs:
This will create additional costs to agricultural and urban landowners that will have limitations placed on the use of their land. The addition of LW to some streams in agricultural and urban areas could increase physical hazard risks. Where additional LW creates debris dams and diverts stream flows in lowland areas during periods of high runoff, there will be an increase in the potential for flood damage.

Option #62: RMA Widths

Objective:
Ensure that the width of RMAs are consistent with achieving mature forest conditions and desirable levels of LW inputs and shade functions.

Description:
The Water Protection Rules were designed to provide a level of LW inputs based, in-part, on the relationship between the proximity of woody vegetation to the stream and the potential for that vegetation to deliver wood to the stream. Action should be taken to ensure that the level of LW inputs and shade being provided is consistent with the goals of the rules. This option aims to increase the level of LW inputs and to ensure that adequate shade is maintained to protect water quality by increasing the width of RMAs.

Methods/Approaches:
1) Increase the width of the RMA on small streams.
2) Increase the width of the RMA on medium streams.
3) Increase the width of the RMA on large streams.
4) Increase the width of the 20-foot no-harvest buffer.
5) Treat nonfish bearing streams the same as small, medium, and large fish bearing streams when determining buffer widths (**IMST recommendation #3**).

Benefits:
This will increase the LW input potential of the RMA. The relative benefit of a wider RMA will depend on what and where trees are retained, however, beyond about 100 feet this relative benefit will be small. For RMAs where the basal area (BA) target is significantly less than the growth potential, increasing the width of the RMA will have little effect on LW inputs. (For

example, if the BA target is satisfied in the first 20 to 30 feet, increasing the buffer width will not significantly change the volume of LW retained after the RMA is managed to the target.)

Costs:
Where the BA target is equal to the growth potential, there will be a financial cost to the landowner. Where the BA target is significantly greater than the growth potential, this option will result in an even greater cost to the landowner. Methods 1-5 would have major financial impacts to landowners due to increased numbers of trees and acres taken out of timber production and set aside for improving stream habitat.

Option #63: Floodplain protection

Objective:
To ensure adequate protection of floodplain functions necessary to maintain and recover salmonids and meet state water quality standards.

Methods/Approaches:
1) Monitor the effectiveness of the rules and measures to evaluate the current level of floodplain protection provided for by the rules and voluntary measures. Provide additional protection where current floodplain protection is inadequate.
2) Provide for additional floodplain protection outside of what is provided for under the current rules and voluntary measures.
3) Provide increased riparian protection for the 100-year floodplains and islands. (**IMST recommendation #4**).

Costs and benefits have not been developed for this option.

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Appendix A: MOA Riparian Workshop Summary Points

MOA Committee Riparian Aquatic Habitat Workshop: Summary Points

1) Riparian systems are complex systems and not well understood. Given the current state of knowledge, LWD, shade, litterfall, and fluvial geomorphology factors are the most 'important.'
2) LWD levels are low in western Oregon streams. Beschta figure generally depicts a model of LWD temporal dynamics as influenced by forest practices on private lands.
3) High variability in space and time as to how riparian characteristics influence habitat. One size does not fit all.
4) There is a difference between "optimal" and "healthy viable population" in terms of goals of riparian needs.
5) Hardwoods can provide for important functions other than LWD and shade.
6) Some form of active management in riparian areas can accelerate the development of a desired condition.
7) We do not have a clear demonstration that adding LWD and artificial structures has a meaningful effect on overall fish populations, due to the long time and basin-wide scale needed to measure a statistically meaningful response.
   - We <u>have</u> demonstrated that for a given stream-reach, fish populations will increase with additional LWD and structure. We just don't know if this is a reshuffling of the existing population, or a true increase in total population.
8) "Upslope areas" contribute some additional LWD above and beyond what adjacent riparian stands contribute.
9) "The curve can be shifted." (re: Beschta figure)
10) LWD in the stream is good, but the devil is in the details.
11) Regeneration of conifer in riparian areas is very difficult with rules that only allow for thinning of the existing stand.
    - With current conifer retention standards, replacement of those conifers is likely precluded due to low light conditions. Increased growth will occur with thinning, but regeneration will be difficult. (See Dave Hibbs' data on understory shade vs. what is needed for regeneration.)
12) Small streams make an ecological contribution, but the contribution varies by stream. (The implication is that management prescriptions around small streams should be done on a site-specific basis.)
13) In terms of the distance from stream edge, the data that define how the various riparian functions are provided by riparian vegetation are generally limited and variable. Nonetheless, most functions are provided by vegetation within a distance somewhere between 60 to 130 feet (60 feet to 40 meters) of the stream. The law of diminishing returns exists for all the functions as distance increases.
14) Disturbance regimes are variable across western Oregon, but fire, wind and floods "reset" the landscape with different return intervals and intensities of disturbance.

Appendix B: Oregon Plan Objectives

Instream Roughness

i.) In cooperation with local groups and federal agencies, refine by reach or stream type, the amount of instream roughness necessary to support healthy salmonid stocks in all coastal streams by 2002.

ii.) The interim habitat objectives for instream roughness for streams west of the Oregon cascade crest are 50 percent of the stream length (orders 2-5) will have more than three functional large wood key pieces/100 meters of stream length. A functional key piece is woody debris that has adequate length and diameter to be "stable" and create habitat within a channel. This is a piece that is greater than 1.5 times as long as the channel is wide with a rootwad attached and 2 times as long as the channel is wide with no rootwad. Functional diameter is 18 inches or greater on the small end of the piece[10].

iii.) In cooperation with watershed councils, private landowners, and local, state and federal agencies, create watershed assessments and action plans in every basin in all steelhead ESUs that gives the status of current channel large roughness conditions and prioritizes options for further study, restoration, and protection by 2002[11].

iv.) Ensure that existing programs prevent, minimize or mitigate the effects of human activities on present (1997) instream roughness elements important to salmonids.

v.) Ensure that instream roughness elements important to salmonids deposited and transported during floods and other natural events remain in place to the extent consistent with public health and safety.

vi.) In steelhead streams deficient in instream roughness elements important to salmonids, actively restore those elements and/or the upstream and upland processes that will restore them naturally, in 5 percent of the deficient stream miles per biennium.

Temperature Biological Objectives

1. In ESU watersheds that support or have historically supported steelhead, where water quality currently is equal to, or better than, the Department of Environmental Quality (DEQ) water quality standard for temperature, manage activities such that water quality is not degraded.

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[10] For streams with a bankfull width less than 10 feet, the functional diameter is 10 inches; 10 to 20 feet = 16 inches; 20 to 30 feet = 18 inches; greater than 30 feet = 24 inches.

[11] This time frame was drafted when the Oregon Plan applied only to the coastal ESU watersheds. Now that the implementation of the plan is statewide, the time frame may need to be extended.

2. To meet the DEQ water quality standard for temperature in ESU watersheds that support steelhead, or have historically supported steelhead, according to the following milestones (% of watersheds meeting numeric criteria for temperature):

Year	Coast ESUs	Lower Columbia ESUs	Upper Willamette ESU	Snake Basin ESU	All Steelhead ESUs
1997	18%	39%	11%	7%	18%
2007	35%	45%	20%	20%	35%
2012	45%	60%	40%	40%	45%
2017	65%	80%	60%	60%	65%
2027	90%	90%	90%	90%	90%

3. To identify watersheds in the steelhead ESUs not meeting the water quality standard for temperature through biennial updates to the 303(d) list according to the following milestones (% of watersheds measured):

2002 - 50%
2007 - 95%

4. To identify temperature conditions within unimpaired or least-impaired reference sites in the steelhead ESUs according to the following milestones (% of reference sites monitored per ESU):

Proposed Number of Reference Sites per ESU			
Klamath Mountains and Oregon Coast	SW Washington and Lower Columbia	Upper Willamette River	Snake River Basin
75	50	50	50

Year	Sites Sampled	Total Sites Sampled
1998	First 20%	20%
1999	Second 20%	40%
2000	Third 20%	60%
2001	Fourth 20%	80%
2002	Last 20%	100%
2003+	Repeat cycle by re-sampling beginning with first 20%	

5. To determine the status and trend of temperature conditions within the steelhead ESUs through randomly selected monitoring sites according to the following milestones (% of random sites monitored per ESU):

Proposed Number of Random Sites per ESU			
Klamath Mountains and Oregon Coast	SW Washington and Lower Columbia	Upper Willamette River	Snake River Basin
150	100	100	100

Year	Sites Sampled	Total Sites Sampled
1998	First 20%	20%
1999	Second 20%	40%
2000	Third 20%	60%
2001	Fourth 20%	80%
2002	Last 20%	100%
2003+	Repeat cycle by re-sampling beginning with first 20%	

6. To evaluate the effectiveness of restoration projects and Agricultural Water Quality Management Plans (AWQMP) by developing and implementing monitoring strategies for assessing temperature conditions following the implementation of such activities within steelhead ESUs. DEQ will rely heavily on watershed councils or other agencies for these data. DEQ will provide technical assistance as needed.

7. Review the numeric criteria in the temperature standard during each Triennial Review Period to determine if the standard needs to be scheduled for revision to ensure it remains protective of beneficial uses based upon the most current scientific information.

Appendix C: Figures from Thom et al. (1999)

The figures and tables on the following pages are taken directly from Thom et al. (1999).

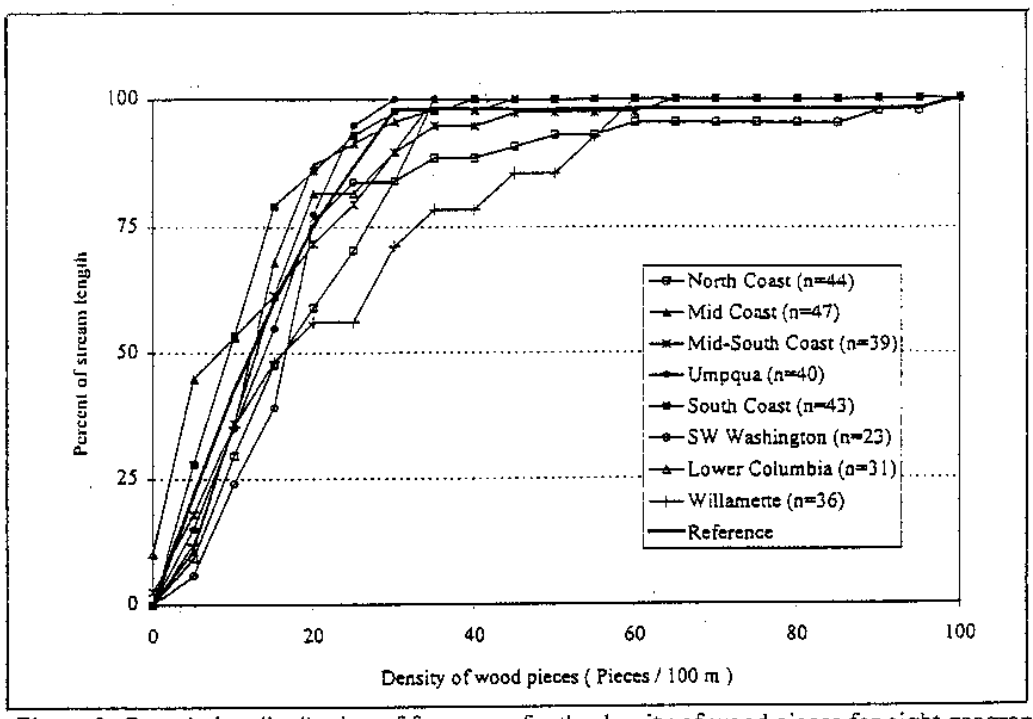


Figure 9: Cumulative distribution of frequency for the density of wood pieces for eight geographic areas in western Oregon.

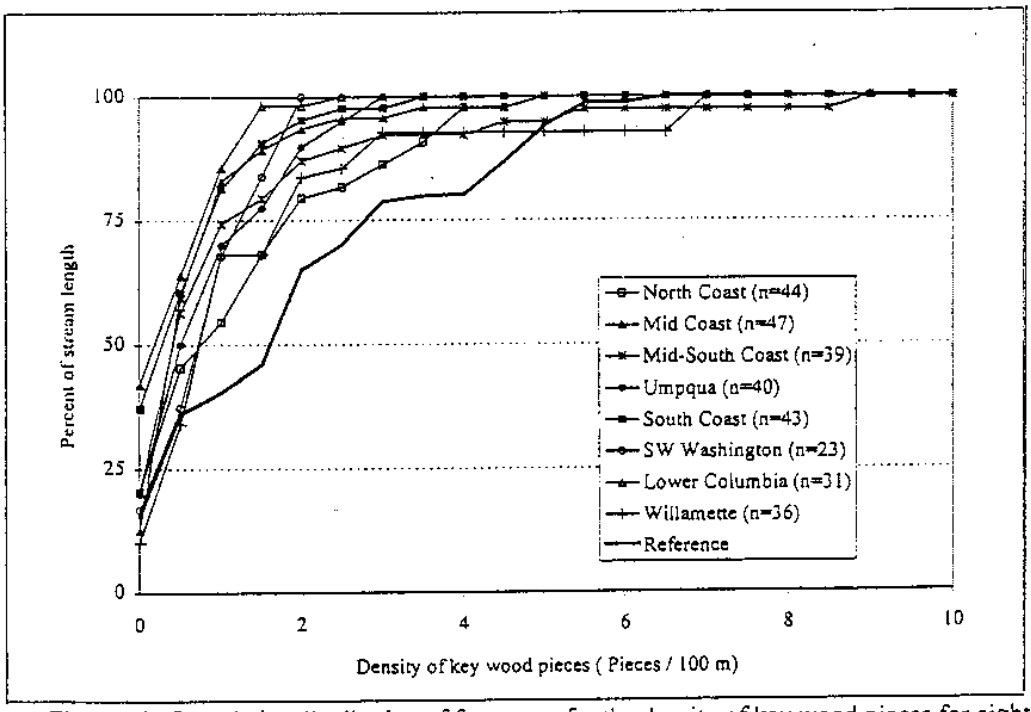


Figure 10: Cumulative distribution of frequency for the density of key wood pieces for eight geographic areas in western Oregon.

Table 7. Cumulative frequency distribution quartiles for the number of riparian conifers > 50 cm.

Analysis Area	Quartile		
	25th	50th	75th
North Coast	0	0	85
Mid-Coast	0	0	50
Mid-South Coast	0	0	<20
Umpqua	0	<20	50
South Coast	0	<20	105
Southwest Wash.	0	0	95
Lower Col.	0	25	120
Willamette	0	<20	60
Reference	25	90	240

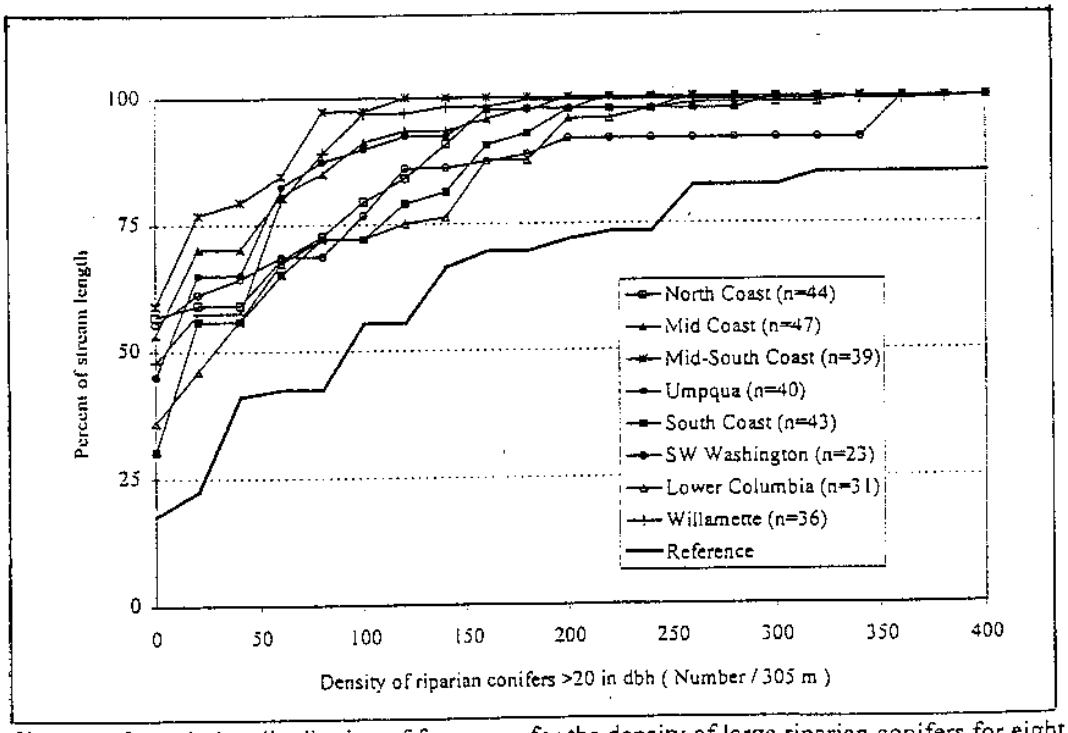


Figure 8: Cumulative distribution of frequency for the density of large riparian conifers for eight geographic areas in western Oregon.

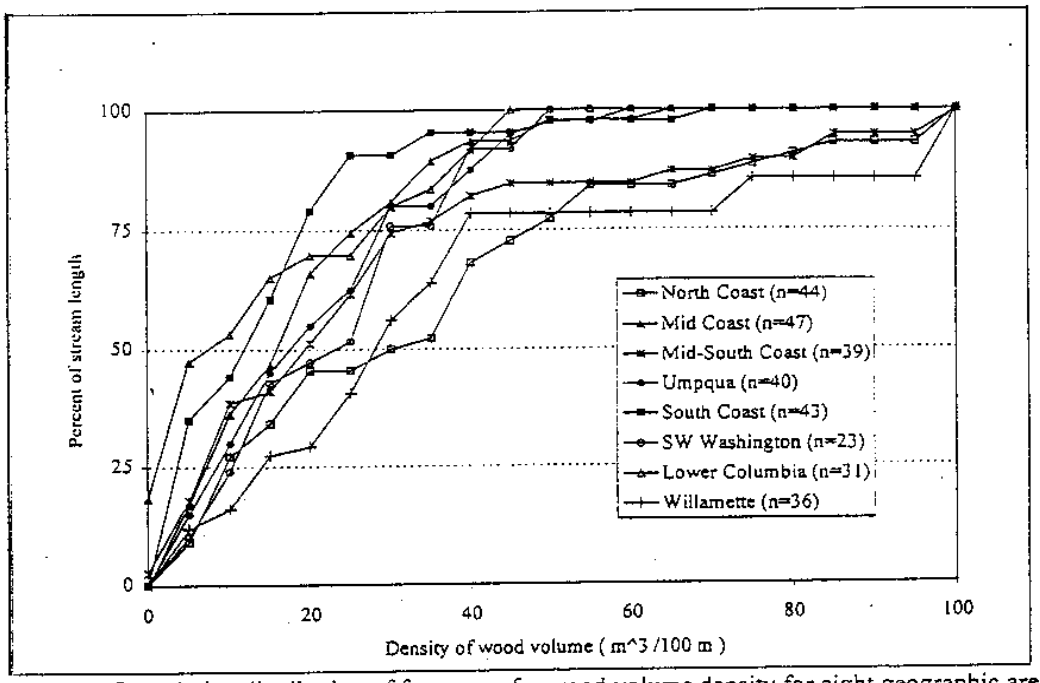


Figure 13: Cumulative distribution of frequency for wood volume density for eight geographic areas in western Oregon.

Table 8. Cumulative frequency distribution quartiles for the number of key pieces of wood. Habitat quality increases with increased number of key wood pieces.

	Quartile		
Analysis Area	25th	50th	75th
North Coast	<0.5	<0.5	1.8
Mid-Coast	<0.5	<0.5	<1.0
Mid-South Coast	<0.5	<0.5	1.1
Umpqua	<0.5	0.6	1.4
South Coast	0.0	<0.5	<1.0
Southwest Wash.	<0.5	0.6	1.2
Lower Col.	0.0	<0.5	<1.0
Willamette	<0.5	0.6	1.7
Reference	0.5	1.8	2.7

Appendix D: Additional Administrative Rules

OAR 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.

OAR 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.

(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;

OAR 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 exceedance 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 E: State Water Quality Standards and Rules

LISTING CRITERIA for OREGON'S 1998 303(d) LIST of WATER QUALITY LIMITED WATER BODIES [Oregon Department of Environmental Quality October 1998]:

BACKGROUND:

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 stringent enough to achieve that state's water quality standards. For these waters, states are required to establish total maximum daily loads (TMDLs) in accordance with a priority ranking. The requirements for listing water quality limited streams still in need of a TMDL are contained in several parts of the Code of Federal Regulations 40 CFR. The most recent updates were published July 24, 1992 and became effective August 24, 1992. In addition, the U. S. Environmental Protection Agency (EPA) Region 10 has established guidance entitled, "Guidance Document for listing water bodies in the Region 10 Section 303(d) Program," (November 1995, available upon request).

The clarification of the intent of Section 303(d) in 1992 required the State to "demonstrate good cause" for not listing a water body and puts the burden of proof on the State to justify exclusion of any water body (Federal Register, Volume 57, No. 143, Friday July 24, 1992, pg 33047, preamble to Section 130.7 TMDLs). The State must use all existing and readily available water quality data to prepare the Section 303(d) list. At a minimum, the following sources of data 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.

Standards are typically designed to protect the most sensitive beneficial use within a water body. Listings can be based on: evidence of a numeric standard exceedence; evidence of a narrative standard exceedence; evidence of a beneficial use impairment; or antidegradation (i.e. a declining trend in water quality such that it would exceed a standard prior to the next listing period).
When a state submits its Section 303(d) list and supporting documentation to EPA for review and approval, the submission will constitute the bulk of the administrative record supporting EPA's approval of the list. The submission should include: the Section 303(d) list including pollutants impairing water quality and the priorities and waters targeted for TMDL development during the next listing cycle; a description of the process the state used in developing the list; any criteria and guidelines used by the state in developing the list; the basis for listing decisions made; and a summary of the response to public comments.

This is a summary of the listing process and criteria used by the Oregon Department of Environmental Quality (DEQ) to develop its 1998 303(d). The 303(d) list decision matrix for developing the 303(d) list is contained in separate documentation. This guidance was based on the following documents: Oregon Water Quality Standards (OAR 340-41) and "Guidance Document for listing water bodies in the Region 10 Section 303(d) Program."

PARAMETER: Temperature
BENEFICIAL USES AFFECTED: Resident Fish and Aquatic Life, Salmonid Fish Spawning and Rearing
STANDARDS or CRITERIA: OAR 340-41-(basin)(2)(b)
Standards applicable to all basins (adopted 1/11/96, effective 7/1/96):
Seven (7) day moving average of the daily maximum shall not exceed the following values unless specifically allowed under a Department-approved basin surface water temperature management plan:
64° F (17.8° C);
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);
64° 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]

WATER QUALITY LIMITED CRITERIA: Rolling seven (7) day average of the daily maximum exceeds the appropriate standard listed above. In the cases where data was not collected in a manner to calculate the rolling seven (7) day average of the daily maximum, greater than 25 percent (and a minimum of at least two exceedences) of the samples exceed the appropriate standard based on multi-year monitoring programs that collect representative samples on separate days for the season of concern (typically summer) and time of day of concern (typically mid to late afternoon).
TIME PERIOD:
Rearing: June 1 through September 30;
Spawning through fry emergence: October 1 to May 31 or water body specific as identified by ODFW Biologists;
DATA REQUIREMENTS:
Data collected since Water Year 87 (10/86). Earlier data will be considered on a case by case basis. Given the statistical basis of the proposed standard, continuous monitoring data was preferred and should reflect conditions during the warmest months (typically July and August) or period of interest. Multi-year monitoring programs with monthly data collection or single year monitoring programs with weekly data collections (not continuous monitoring data) were utilized to fill in data gaps where there was no continuous monitoring data available and if they had quality assurance available and collected representative samples on separate days for the season of concern (typically summer) and time of day of concern (typically mid to late afternoon).

EXAMPLES OF DATA USED FOR 1998 LISTING:
Continuous temperature monitoring data collected by the Departmental of Environmental Quality, U.S. Geological Survey, U.S. Forest Service, Bureau of Land Management, Confederated Tribes of the Umatilla Indians, Oregon Department of Fish and Wildlife, and the Cooperative Extension Service.

Department of Environmental Quality, U.S. Geological Survey, U.S. Bureau of Reclamation and Unified Sewage Agency of Washington County routine or intensive monitoring data.

PARAMETER: Sedimentation

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

STANDARDS or 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 CRITERIA: Documented 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 percent or less of the expected reference community **for both** multimetric scores and multivariate model scores are considered impaired. Streams with either multimetric scores or multivariate scores between 61 percent and 75 percent of expected reference communities are considered as streams of concern. Streams greater than 75 percent of expected reference communities using either multimetric or multivariate models are considered unimpaired.
-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.

TIME PERIOD:
Annual

DATA REQUIREMENTS:
Data collected since Water Year 87 (10/86) 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 1998 LISTING:
U.S. Forest Service and Bureau of Land Management Watershed Analyses or Wild and Scenic River Environmental Impact Statements or other published reports.

Appendix F: Eastern Oregon Riparian Areas 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.

Site Productivity Background:

Site Class 1	> 225	cubic feet/acre/year at culmination of mean annual increment (best westside ground)
Site Class 2	165-224	
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)

Fred Hall's Recommendations for Eastern Oregon Riparian Areas:

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/acre/year-ponderosa pine, grand fir/white fir, Douglas-fir, incense cedar)

120 square feet BA/Ac

Site Class 6 (30 cubic feet/acre/year-pure ponderosa pine, some incense cedar)

80 square feet BA/Ac

Site Class 7 (12 cubic feet/acre/year-western juniper with some ponderosa pine)

40 square feet BA/Ac

Current standard targets in rules converted to basal area/acre

Harvest Method	*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**

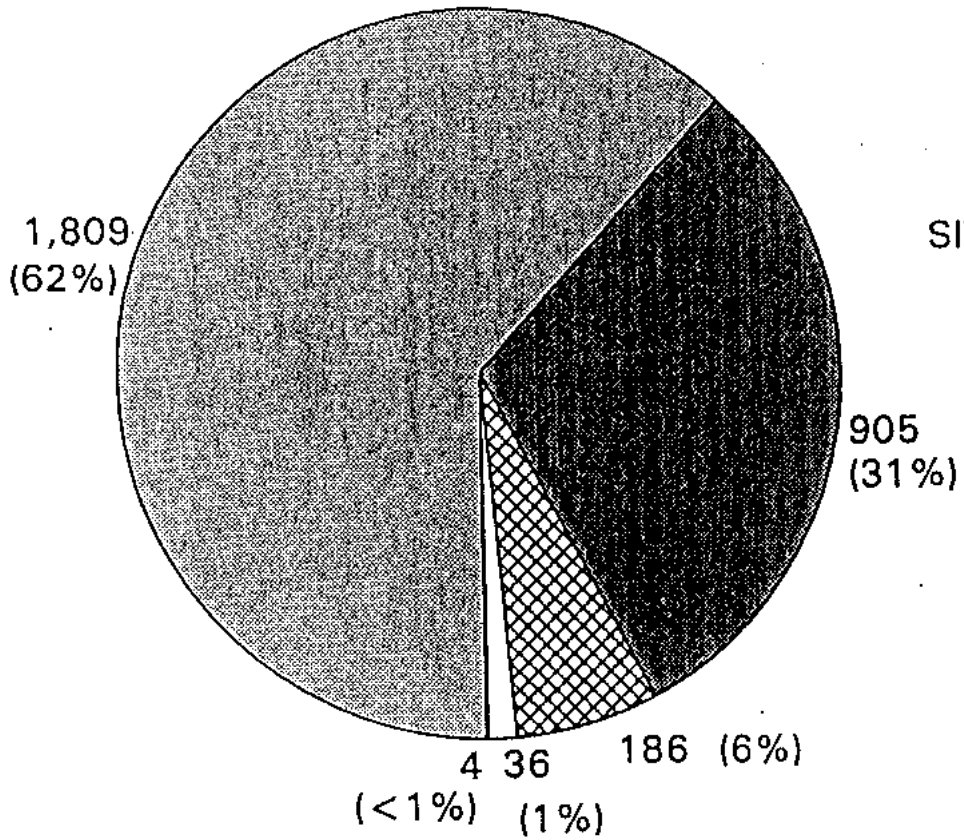
Important note: The rule targets are not directly comparable to Fred Hall's recommendations because they are stocking standards to be met immediately after harvest, and do not include regrowth that will occur prior to the next harvest entry. The rules assume a 50-year return interval for Harvest Type 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.

(see figure on next page)

EASTERN OREGON NON-FOREST SERVICE FOREST LAND BY CUBIC FOOT SITE CLASS



AREA BY SITE CLASS IN THOUSANDS OF ACRES

ANNUAL CUBIC FOOT GROWTH RATE

SITE CLASS II	165 to 224
III	120 to 164
IV	85 to 119
V	50 to 84
VI	20 to 49

Based on CMAI in fully stocked natural stands.

Appendix 1

Executive Order 99-01 And Committee Charter

Office of the Governor
State of Oregon

EXECUTIVE ORDER NO. EO 99-01

THE OREGON PLAN FOR SALMON AND WATERSHEDS

The purpose of the Oregon Plan for Salmon and Watersheds (the "Oregon Plan") as stated in the Plan and reaffirmed in this Executive Order is to restore Oregon's wild salmon and trout populations and fisheries to sustainable and productive levels that will provide substantial environmental, cultural, and economic benefits and to improve water quality. The Oregon Plan is a long-term, ongoing effort that began as a focused set of actions by state, local, tribal and private organizations and individuals in October of 1995. The Oregon Plan first addressed coho salmon on the Oregon Coast, was then broadened to include steelhead trout on the coast and in the Lower Columbia River, and is now expanding to all at-risk wild salmonids throughout the state. The Oregon Plan addresses all factors for decline of these species, including watershed conditions and fisheries, to the extent those factors can be affected by the state. The Oregon Plan was endorsed and funded by the Oregon Legislature in 1997 through Oregon Senate Bill 924 (1997 Or. Laws, ch. 7) and House Bill 3700 (1997 Or. Laws, ch. 8). The Oregon Plan is described in two principal documents: "The Oregon Plan," dated March 1997, and "The Oregon Plan for Salmon and Watersheds, Supplement I -- Steelhead," dated January 1998. As used in this Executive Order, the Oregon Plan also incorporates the Healthy Streams Partnership (Oregon Senate Bill 1010, 1993 Or. Laws, ch. 263).

The Oregon Plan is a cooperative effort of state, local, federal, tribal and private organizations and individuals. Although the Oregon Plan contains a strong foundation of protective regulations -- continuing existing regulatory programs and speeding the implementation of others -- an essential principle of the Plan is the need to move beyond prohibitions and to encourage efforts to improve conditions for salmon through non-regulatory means. Many of the most significant contributions to the Oregon Plan are private and quasi-governmental efforts to protect and restore salmon on working landscapes, including efforts by watershed councils.

Salmon and trout restoration requires action and sacrifice across the entire economic and geographic spectrum of Oregon. The commercial and sport fishing industries in Oregon have been heavily affected by complete or partial closures of fisheries. The forest industry operates under the Oregon Forest Practices Act, and has contributed substantially to salmon recovery through habitat restoration projects on private lands and by funding a large part of the state recovery efforts. The agriculture and mining industries are also taking actions that will protect and restore salmon and trout habitat and improve water quality (including financial support of restoration efforts by the mining industry). Urban areas are developing water conservation programs, spending funds for wastewater treatment improvements to reduce point source pollution, reducing non-point source pollution and reducing activities that degrade riparian areas. All citizens of Oregon share responsibility for declining populations of wild salmon and trout,

and it is important that there be both a broad commitment to reversing these historic trends and a sense that the burdens of restoration are being shared by all of society.

It is also important that there be independent scientific oversight of the Oregon Plan. This oversight is being provided by the Independent Mutidisciplinary Science Team (IMST), established under Oregon Senate Bill 924 (1997 Or. Laws, ch. 7). Additional legislative oversight for the Oregon Plan is being provided by the Joint Legislative Committee on Salmon and Stream Enhancement (the "Joint Committee").

Under the federal Endangered Species Act (ESA) the U.S. Fish & Wildlife Service (F&WS) and the National Marine Fisheries Service (NMFS) are responsible for identifying species that are threatened or endangered, and for developing programs to conserve and recover those species. F&WS and NMFS have now listed salmonids under the ESA on the entire Oregon Coast, the lower Columbia River (including most of the Portland metropolitan area), the Klamath River basin, and in the upper Columbia and Snake River basins. More listings are expected within the next year.

To date, the F&WS and NMFS generally have not had the resources to develop and implement effective recovery plans for fisheries. In addition, in many areas a large proportion of the habitat that listed salmonids depend on is located on private lands, where the regulatory tools under the ESA are relatively ill-defined and indirect. Finally, federal agencies alone, even if they take an active regulatory approach to recovery, will not restore listed salmonids. The federal ESA may work to prohibit certain actions, but there is simply too much habitat on private lands for restoration to succeed without pro-active involvement and incentives for individuals, groups, and local governments to take affirmative actions to restore habitat on working landscapes.

In April, 1997 the State of Oregon and NMFS entered into a Memorandum of Agreement (MOA) under which the State agreed to continue existing measures under the March 1997 Oregon Plan and to take certain additional actions to protect and restore coho salmon on the Oregon Coast. On May 6, 1997, NMFS determined that the Oregon Coast Evolutionarily Significant Unit (ESU) of coho salmon did not warrant listing as a threatened or endangered species under the ESA.

On June 2, 1998, the U.S. District Court for Oregon ordered NMFS to reconsider itsdecision without taking into account any parts of the Oregon Plan or MOA that are not "current enforceable measures." The U.S. District Court for Oregon also held that the MOA was speculative, due to the fact that it provided for termination by either party on thirty days notice, and that therefore the MOA could not be considered by NMFS in its listing decision.

Under court order, NMFS reconsidered its decision without taking into account the application in the future of the harvest and hatchery measures contained in the Oregon Plan, or the habitat

improvement programs being undertaken under the Oregon Plan, or the commitments made by the State of Oregon in the MOA for improvement of applicable habitat measures. Accordingly, NMFS listed Oregon Coast coho as threatened under the ESA on or about October 2, 1998.

The MOA provided for the State of Oregon to take actions necessary to ensure that Oregon Coast coho did not warrant listing as a threatened or endangered species under the federal ESA. Now that Oregon Coast coho are listed as a threatened species as a result of the U.S. District Court's order, the central purpose of the MOA has been eliminated. Due to the uncertainties created by the District Court's decision and the increasing extent of salmonids listed or proposed for listing under the federal ESA, it is important that the status of the State of Oregon's substantive commitments under the MOA and the purpose of the Oregon Plan be clarified.

Through this Executive Order, the State of Oregon reaffirms its intent to play the leading role in protecting and restoring Oregon Coast coho and other salmonids through the implementation of the Oregon Plan. This Executive Order provides the framework and direction for state agencies to implement (to the extent of their authorities) the Oregon Plan in a timely and effective manner. This Executive Order also provides a framework for extending the state's efforts beyond a focus on Oregon Coast coho, to watersheds and fisheries statewide. Consistent with the principle of adaptive management, this Order applies the experience gained to date in implementing the Oregon Plan to provide additional detailed direction to state agencies. Finally, this Executive Order establishes a public involvement process to prioritize continuing efforts under the Oregon Plan.

NOW THEREFORE, IT IS HEREBY ORDERED AND DIRECTED:

(1) Overall Direction

(a) Agencies of the State of Oregon will, consistent with their authorities, fully implement the state agency efforts described in the Oregon Plan and in this Executive Order.

(b) The overall objective for state agencies under the Oregon Plan and this Executive Order is to protect and restore salmonids and to improve water quality.

(c) The Governor will, in cooperation with the Joint Committee, IMST, affected state agencies, watershed councils, and other affected local entities and persons develop and implement a process to set biological and habitat goals and objectives to protect and restore salmonids on a basin or regional basis as soon as practicable. Once these goals and objectives are established, they will be used by state agencies to evaluate their regulatory and non-regulatory programs and measures relating to the protection and restoration of salmonids. Through this on-going evaluation, state agencies will determine any changes to their programs or measures that may be necessary to meet the biological and habitat goals and objectives. In the

interim, the following objectives in subsections (d) and (e) shall apply to agencies' implementation of the Oregon Plan and this Executive Order.

(d) Actions that state agencies take, fund and/or authorize that are primarily for a purpose other than restoration of salmonids or the habitat they depend upon will, considering the anticipated duration and geographic scope of the actions:

(A) to the maximum extent practicable minimize and mitigate adverse effects of the actions on salmonids or the habitat they depend on; and

(B) not appreciably reduce the likelihood of the survival and recovery of salmonids in the wild.

(e) State agencies will take, fund and/or authorize actions that are primarily for the purpose of restoring salmonids or the habitat they depend upon, including actions implementing the Oregon Plan, with the goal of producing a conservation benefit that (if taken together with comparable and related actions by all persons and entities within the range of the species) is likely to result in sustainable population levels of salmonids in the foreseeable future, and in population levels of salmonids that provide substantial environmental, cultural and economic benefits to Oregonians in the long term.

(f) With the broadening of the Oregon Plan, prioritizing all agency actions according to coho core areas is no longer appropriate. Each state agency participating in the Oregon Plan, in consultation with ODFW and other partners involved in the implementation of the Plan and through a public involvement process, will modify their existing work programs in the Oregon Plan to prioritize agency measures to protect and restore salmonids in a timely and effective manner. The work programs will continue to identify key specific outcomes, refine and improve designations of priority areas, and establish completion dates. These modifications will be submitted to the Governor, the Joint Committee, and to the appropriate boards and commissions as soon as possible, but in no event later than June 1, 1999. Progress reports on action plans will be submitted to the Governor, the Joint Committee, and to the appropriate boards and commissions on an annual basis. In prioritizing their efforts, state agencies shall consider how to maximize conservation benefits for salmonids and the habitat they depend on within limited resources and whether their actions are likely to increase populations of salmonids in the foreseeable future.

(g) State agencies will work cooperatively with landowners, local entities and other persons taking actions to protect or restore salmonids.

(h) As the Oregon Plan grows in geographic scope and in intensity of activity, there is a growing need to streamline and prioritize state agency activity at the regional level. One

proposal has been to organize state natural resource agency field operations along hydrologic units. Therefore, state agencies will consider this proposal and, through the collective efforts of state agency directors, develop an organization plan that focuses state agency field effort on the activities and areas of highest priority under the Oregon Plan.

(i) State agencies will continue to encourage and work with agencies of the U.S. government to implement the federal measures described in the Oregon Plan. In addition, the state agencies will work with the federal government to develop additional means of protecting and restoring salmonids. Where appropriate, state agencies will request that federal agencies obtain incidental take permits under Section 7 of the federal ESA for state actions that are funded or authorized by a federal agency.

(j) State agencies will help support efforts to evaluate watershed conditions, and to develop specific strategic plans to provide for flood management, water quality improvement, and salmonid restoration in basins around the state, including the Willamette basin through the Willamette Restoration Initiative.

(k) The IMST will continue to provide oversight to ensure the use of the best scientific information available as the basis for implementation of and for adaptive changes to the Oregon Plan. State agencies will ensure that the IMST receives data and other information reasonably required for its functions in a timely manner. The Governor's Natural Resources Office (GNRO) has requested that the IMST's initial priority be review of the freshwater habitat needs of coho and the relationship between population levels, escapement levels, and habitat characteristics. The GNRO also will continue to request that the IMST annually review monitoring results and identify where the Oregon Plan warrants change for scientific or technical reasons and make recommendations to the appropriate agency on those adjustments that appear necessary. Agencies will report their responses to any recommendations by the IMST to the Governor and to the Joint Committee. Any other changes identified by the IMST as necessary to achieve properly functioning riparian and aquatic habitat conditions required to protect and restore salmonids will be forwarded to the appropriate governmental entity for its consideration of the adoption of new, changed, or supplemental measures as rapidly as possible while providing for public involvement. Each state agency, by June 1, 1999, will ratify a monitoring team charter through an interagency memorandum. A draft of the charter is contained in the 1998 Oregon Plan Annual Report.

(l) Monitoring is a key element of the Oregon Plan. Each state agency will actively support the monitoring strategy described in the Oregon Plan. Each affected agency will participate on the monitoring team to coordinate activities and integrate analyses. Each agency will implement an appropriate monitoring program to assess the effectiveness of their programs and measures in meeting the objectives set forth in the Oregon Plan on an annual basis. In addition, agencies with regulatory programs that are included in the Oregon Plan will determine

levels of compliance with regulatory standards and identify and act on opportunities to improve compliance levels.

(m) If information gathered regarding the effectiveness of measures in the Oregon Plan shows that existing strategies within state control are not achieving expected improvements and objectives, the agency(ies) responsible for those measures will seek appropriate changes in their regulations, policies, programs, measures and other areas of the Oregon Plan, as required to protect and restore coho and other salmonids. Such modification or supplementation will be done as rapidly as possible, consistent with public involvement.

(n) Agencies are using geographically-referenced data in their efforts under the Oregon Plan, and will be using Geographic Information Systems (GIS) in the analysis of these data. In doing so, the State GIS Plan, developed by the Oregon Geographic Information Council (OGIC) (see Executive Order 96-40) will be followed, with specific adherence to the Plan guidance on data documentation, coordination and data sharing. The agency with primary responsibility for gathering and updating the specific data will be responsible for meeting the requirements of the Plan, and to ensure coordination with OGIC, the State Service Center for GIS and other cooperating agencies. In addition, state agencies will cooperate with the Governor's Watershed Enhancement Board (GWEB), Soil and Water Conservation Districts (SWCDs), local watershed councils, landowners and others in making these essential data available.

(o) Geographically-based strategies to assess and achieve habitat needs and adequate escapement levels will be used, and the state agencies will continue with the development of standardized watershed assessment protocols, including a cumulative effects assessment. State agencies will also continue with the development of habitat restoration guides to evaluate and direct habitat restoration efforts.

(2) Continuation and Expansion of Existing Efforts. Without limiting the generality of section (1)(a) of this Executive Order, the following subsections of this Executive Order describe some of the many efforts in the Oregon Plan where the initial phase of work has been completed, and where efforts will be continued.

(a) The Oregon Fish & Wildlife Commission (OFWC), the Oregon Department of Fish & Wildlife (ODFW), and the Pacific Fishery Management Council (PFMC) are managing ocean and terminal fisheries according to the measures set forth in the Oregon Plan (ODFW I-A.1 and III-A.1). These measures set a maximum mortality rate (resulting from other fisheries) for any of four disaggregated stocks of coho of fifteen percent (15%) under poor ocean conditions. In 1997, the mortality rate from harvest is estimated to have been between nine and eleven percent (9-11%). ODFW and OFWC will continue these measures in state waters, and will actively support continued implementation of the ocean harvest measures by the PFMC (Amendment 13

to the Council's salmon management plan) until and unless a different management regime agreeable to NMFS is adopted.

(b) The OFWC and ODFW will ensure that the fish hatchery measures set forth in the Oregon Plan are continued by the OFWC and ODFW. ODFW is marking all hatchery coho on the Oregon Coast. This marking will allow increased certainty in estimating hatchery stray rates beginning in 1999. Available data on hatchery stray rates for coho and steelhead are being provided to NMFS on an annual basis. The number of hatchery coho released is estimated to have been 1.7 million in 1998 -- substantially below the level called for in the Oregon Plan. This number will be reduced to 1.2 million in 1999. In addition, ODFW has, and will continue to provide annual reports regarding: (i) the number of juvenile hatchery coho that are released by brood year, locations and dates of release, life stage, and broodstock origin; (ii) the number of adult coho taken for broodstock for each hatchery, the location and date of collection, and the origin (hatchery or natural); (iii) the number of hatchery coho estimated to have spawned in natural habitat by basin; (iv) the estimated percentage of hatchery coho in the total natural spawning population; and (v) the mortality of naturally-spawning coho resulting from each fishery. NMFS may provide comments about hatchery programs affecting coho to ODFW, with any concerns to be resolved between NMFS and ODFW.

(c) In addition to recent modifications to hatchery practices and programs, a new vision is needed for how Oregon will utilize hatcheries in the best and most effective manner. Therefore, the ODFW and the OFWC shall engage in a process to create a strategic plan for fish hatcheries in Oregon over the next decade (including state and federally-funded hatcheries, private hatcheries, and the STEP program). The essential elements of this process are as follows:
(i) Impartial analysis -- conduct an impartial analysis of the scientific bases, and the social and economic effects of Oregon hatchery programs utilizing existing analyses and review where feasible, but conducting new analyses if necessary; (ii) Review the Wild Fish Management Policy (WFMP) -- because the future plan for hatcheries in Oregon is dependent on implementation of the WFMP, ODFW shall conduct a science and stakeholder review to determine if this significant policy should be revised and shall make any revision by July 2000; (iii) Frame alternative strategies -- convene a group of stockholders to frame alternative strategies, including outcomes and descriptions, of how hatcheries will be used in Oregon over the next decade (these strategies will address the use of hatcheries for wild fish population recovery including supplementation, research and monitoring, public education, and sport and commercial fishing opportunities); (iv) Public review and selection of a strategy -- the OFWC shall, after public review and comment, adopt a strategic plan to guide development of future hatchery programs, incorporating the strategy developed and adopted in accordance with subpart (iii) of this paragraph.

(d) Criteria and guidelines directing the design of projects that may affect fish passage have been established in a Memorandum of Understanding (MOU) between the Oregon

Department of Transportation (ODOT), ODFW, the Oregon Department of Forestry (ODF), the Oregon Department of Agriculture (ODA), the Division of State Lands (DSL) and the Federal Highway Administration. These guidelines apply to the design, construction and consultations of projects affecting fish passage. Under the MOU, projects requiring regulatory approvals that follow these criteria and guidelines are expedited. Oregon agencies will continue to provide technical assistance to ensure that the criteria and guidelines are applied appropriately in restoration projects, as well as any other projects that may affect fish passage through road crossings and similar structures. ODFW will work with state agencies, local governments, and watershed councils to ensure that Oregon's standards for fish passage set forth in Exhibit A to the MOU are understood and are implemented.

(e) Fish presence, stream habitat, road and culvert surveys have been conducted for roads within ODOT jurisdiction and county roads in coastal basins, the Lower Columbia basin, the Willamette basin, and the Grande Ronde/Imnaha basins. Among the results of these surveys is the finding that culvert barriers to fish passage affect a substantial quantity of salmonid habitat. For example, surveys of county and state highways in western Oregon found over 1,200 culverts that are barriers to passage. As a result, ODOT is placing additional priority on restoring fish access. For 1998, ODOT repaired or replaced 35 culverts restoring access to 101 miles of salmonid habitat. For 1999, the Oregon Transportation Commission will be asked to fund approximately $4.0 million for culvert modification. ODOT and the Commission will continue to examine means to speed restoration of fish passage and to coordinate priorities with ODFW.

(f) Draft watershed assessment protocols have been developed and are being field tested. Beginning in 1999, SWCDs, watershed councils and others will be able to use the protocols as the basis for action plans to identify and prioritize opportunities to protect and restore salmonids. Watershed action plans have already been completed in a number of basins including the Rogue, Coos, Coquille and Grande Ronde. State agencies will work to support these watershed assessments and plans to the maximum extent practicable. Where watershed action plans have been developed under the protocols, GWEB will ensure that projects funded through the Watershed Improvement Grant Fund are consistent with watershed action plans, and other state agencies will work with SWCDs and watershed councils to ensure that activities they authorize, fund or undertake are consistent with watershed action plans to the maximum extent practicable.

(g) The State of Oregon has developed interim aquatic habitat restoration and enhancement guidelines for 1998. State agencies involved with restoration activities (ODFW, ODF, DSL, ODA, DEQ, and GWEB) will continue to develop and refine the interim guidelines for final publication in April 1999. The guidelines will be applied in restoration activities funded or authorized by state agencies. The purpose of the guidelines will be to define aquatic restoration and to identify and encourage aquatic habitat restoration techniques to restore salmonids.

(h) ODA and ODF have each entered into a Memorandum of Understanding with the Oregon Department of Environmental Quality relating to the development of Total Maximum Daily Loads (TMDLs) and Water Quality Management Area Plans (WQMAPs). ODA will adopt and implement WQMAPs (through the Healthy Streams Partnership) and ODF will review the adequacy of forest practices rules to meet water quality standards. ODF and ODA will evaluate the effectiveness of these measures in achieving water quality standards on a regular basis and implement any changes required to meet the standards.

(i) Agencies are implementing a coordinated monitoring program, as described in the Oregon Plan. This program includes technical support and standardized protocols for watershed councils, stream habitat surveys, forest practice effectiveness monitoring, water withdrawal monitoring, ambient water quality monitoring, and biotic index studies, as well as fish presence surveys and salmonid abundance and survival monitoring in selected subbasins. State agencies are also working to coordinate monitoring efforts by state, federal, and local entities, including watershed councils. State agencies will work actively to ensure that the monitoring measures in the Oregon Plan are continued.

(j) GWEB has put into place new processes for identifying and coordinating the delivery of financial and technical assistance to individuals, agencies, watershed councils and soil and water conservation districts as they implement watershed restoration projects to improve water quality and restore aquatic resources. Over $25 million has been distributed for watershed restoration projects in the last ten years. During the present (1997-99 biennium) GWEB has awarded over $12 million dollars in state and federal funds for technical assistance and watershed restoration activities to implement the Oregon Plan. GWEB and state agencies will continue to seek financial resources to be allocated by GWEB for watershed restoration activities at the local and statewide levels.

(k) State agencies will continue to encourage, support and work to provide incentives for local, tribal, and private efforts to implement the Oregon Plan. In addition, state agencies will continue to provide financial assistance to local entities for projects to protect and restore salmonids to the extent consistent with their budgetary and legal authorities, and consistent with their work programs in the Oregon Plan. To the maximum extent practicable, state agencies will also provide technical assistance and planning tools to provide local conservation groups to assist in and target watershed restoration efforts. These efforts (during 1996 and 1997) are reported in "The Oregon Plan for Salmon and Watersheds: Watershed Restoration Inventory, 1998." Just a few of the important efforts that have been completed include:

(A) Eighty-two watershed councils have joined with forty-five Soil and Water Conservation Districts as well as private and public landowners to implement on-the-ground projects to protect and restore salmonids. During 1996 and 1997, a reported $27.4 million was spent on 1,234 watershed restoration projects on non-federal lands. Both the amount spent and

the number of projects represent significant increases (of over 300 percent) over prior years. In 1996-97, watershed councils, SWCDs and other organizations and individuals completed: (i) 138 stream fencing projects, involving at least 301 miles of streambank; (ii) 196 riparian area planting projects, involving at least 111 miles of streams; and (iii) 458 instream habitat improvement projects.

(B) Private and state forest landowners are implementing key efforts under the Oregon Plan, including the road risk and remediation program (ODF-1 and 2). Under this effort in 1996 and 1997, close to 4,000 miles of roads have been surveyed to identify risks that the roads may pose to salmonid habitat. As the risks are identified, they are then prioritized for remediation following an established protocol. Already, 52 miles of forest roads have been closed, 843 miles of road repair and reconstruction projects to protect salmonid habitat have been completed, and an additional 14 miles of roads have been decommissioned or relocated. In addition, 530 culverts have been replaced, upgraded or installed for fish passage purposes, improving access to a reported 146 stream miles.

(C) Organizations working in Tillamook County have developed the Tillamook County Performance Partnership. The Partnership is implementing the Tillamook Bay National Estuary Program by addressing water quality, fisheries, floodplain management and economic development in the county. Among the actions that the Partnership has already accomplished are: (i) the closure of seven miles of degraded forest roads and the rehabilitation of 469 miles of roads to meet current standards, at a cost of $18 million; (ii) the fencing of 53 miles of streambank, and the construction of three cattle bridges and 100 alternative cattle watering sites, at a cost of $214,000; and (iii) the completion of 24 instream restoration projects and 34 barbs protecting 4,200 feet of streambank, at a cost of $1.3 million dollars.

(D) The Confederated Tribes of the Grande Ronde Community of Oregon have completed a forest management plan that establishes standards for the protection of aquatic resources that are comparable to those found in the Aquatic Conservation Strategy of the Northwest Forest Plan.

(E) A combination of funding from the Oregon Wildlife Heritage Foundation and the National Fish and Wildlife Heritage Foundation (private, non-profit organizations) is providing support for seven biologists to design restoration projects. These projects are prioritized based on stream surveys, and are carried out with the voluntary participation and support of landowners. A ten-year monitoring plan has been funded and implemented to determine project effectiveness.

(F) The Oregon Cattlemen's Association has implemented its WESt Program that is designed to help landowners better understand their watersheds and stream functions through assessments and monitoring. The WESt Program brings landowners together along stream

reaches, and offers a series of workshops, conducted on a site specific basis, free of charge. The workshops include riparian ecology, setting goals and objectives, Proper Functioning Condition (PFC), data collection and monitoring. Over 25 workshops have been held, with attendance ranging from 5 to 30 landowners per workshop. The WESt Program is sponsored by the Oregon Cattlemen's Association, DEQ, Oregon State University, and GWEB.

(G) Within the Tillamook State Forest road network 1,902 culverts have been replaced or added to improve road drainage and to disconnect storm water runoff from roads reducing stream sediment impacts. Additionally, some of these culverts also improved fish passage at stream crossings. In this process, ODF has also replaced six culverts with bridges improving fish passage to approximately four miles of stream. The Tillamook State Forest in conjunction with many partners, such as the Association of Northwest Steelheaders, GWEB, Simpson Timber Company, Tillamook County, the FishAmerica Foundation, Hardrock Construction Company, the Oregon Wildlife Heritage Foundation, the F&WS, the Oregon Youth Conservation Corps, Columbia Helicopters and Terra Helicopters, has also recently completed instream placement of over 400 rootwads, trees and boulders at a cost of $300,000 for habitat enhancement.

(3) Key Agency Efforts. Continuation and completion of the following state agency efforts is critical to the success of the Oregon Plan. State agencies will make continuation or completion (as appropriate) of the following efforts a high priority.

(a) The State of Oregon and the U.S. Department of Agriculture have entered into a Conservation Reserve Enhancement Program (CREP). This cost-share program, one of the first of its kind, will be used to reduce the impacts of agricultural practices through water quality and habitat improvement. The objectives of the CREP are to: (i) provide incentives for farmers and ranchers to establish riparian buffers; (ii) protect and restore at least 4,000 miles of stream habitat by providing up to 95,000 acres of riparian buffers; (iii) restore up to 5,000 acres of wetlands that will benefit salmonids; and (iv) provide a mechanism for farmers and ranchers to comply with Oregon's Senate Bill 1010 (1993 Or. Laws, ch. 263).

(b) ODF will work with non-industrial forest landowners to administer the Stewardship Incentive Program and the Forest Resources Trust programs to protect and restore riparian and wetland areas that benefit salmonids.

(c) The Oregon Board of Forestry will determine, with the assistance of an advisory committee, to what extent changes to forest practices are needed to meet state water quality standards and to protect and restore salmonids. A substantial body of information regarding the effectiveness of current practices is being developed. This information includes: (i) the IMST report regarding the role of forest practices and forest habitat in protecting and restoring salmonids; and (ii) a series of monitoring projects that include the Storms of 1996 study, a

riparian areas study, a stream temperature study, and a road drainage study. Using this information, as well as other available scientific information including scientific information from NMFS, the advisory committee will make recommendations to the Board at both site and watershed scales on threats to salmonid habitat relating to sediment, water temperature, freshwater habitat needs, roads and fish passage. Based on the advisory committee's recommendations and other scientific information, the Board will make every effort to make its determinations by June 1999. The Board may determine that the most effective means of achieving any necessary changes to forest practices is through regulatory changes, statutory changes or through other programs including programs to create incentives for forest landowners. In the event that the Board determines that legislative changes are necessary to carry out its determinations, the Board will transmit any recommendations for such changes to the Governor and to the Joint Committee at the earliest possible date.

(d) Consistent with administrative rule, and statutory and constitutional mandates for the management of state forests, ODF State Forest management plans will include an aquatic conservation strategy that has a high likelihood of protecting and restoring properly functioning aquatic habitat for salmonids on state forest lands.

(e) ODF will present to NMFS a Habitat Conservation Plan (HCP) under Section 10 of the federal ESA that includes the Clatsop and Tillamook State Forests. ODF has already completed scientific review and has public review underway for this draft HCP. The scientific and public review comments will be considered by ODF in completing the draft HCP. The draft HCP will be presented to NMFS by June 1999. An HCP for the Elliott State Forest was approved by the U.S. Fish & Wildlife Service in 1995. In October of 1997, ODF and DSL forwarded the Elliott State Forest HCP to NMFS with the request that it be reviewed to determine whether it has a high likelihood of protecting and restoring properly functioning aquatic habitat conditions on state forest lands necessary to protect and restore salmonids. Based on discussions surrounding the NMFS review, ODF and DSL will determine what revisions, if any, are required to the Elliott HCP and/or Forest Management Plan to ensure a high likelihood of protecting and restoring properly functioning aquatic habitat for salmonids.

(f) Before the OFWC adopts and implements fishery regulations that may result in taking of coho, ODFW will provide NMFS with all available scientific information and analyses pertinent to the proposed regulation where the harvest measures are not under the jurisdiction of the PFMC, including results of the Oregon Plan monitoring and evaluation program. This information, together with the proposed regulation and supporting analysis, will be provided at least two weeks prior to the OFWC's action, to give NMFS time to review and comment on the proposed regulations.

(g) ODFW will evaluate the effects of predation on salmonids, and will work with affected federal agencies to determine whether changes to programs and law relating to predation are warranted in order to protect and restore salmonids.

(h) Under Oregon Senate Bill 1010 (1993 Or. Laws, ch. 263), ODA will adopt Agricultural Water Quality Management Area Plans (AWQMAPs) for Tier I and Tier II watersheds by the end of 2002. The AWQMAPs will be designed and implemented to meet load allocations for agriculture needed to achieve state water quality standards. In addition, ODA will work with ODFW, DEQ, GWEB, SWCDs, federal agencies and watershed councils to determine to what extent additional measures related to achieving properly functioning riparian and aquatic habitat on agricultural lands are needed to protect and restore salmonids, giving attention first to priority areas identified in the Oregon Plan. In the event ODA is unable to reach a consensus regarding such measures, ODA will ask the IMST to review areas of substantive scientific disagreement and to make recommendations to ODA regarding how they should be resolved. In the event that legislative changes are needed to implement such measures, ODA will transmit any recommendations for such changes to the Governor and to the Joint Committee at the earliest possible date. In addition, any measures identified as needed by ODA will be implemented at the earliest practicable time.

(i) ODFW will expedite its applications for instream water rights and OWRD will process such applications promptly where flow deficits are identified as adversely affecting salmonids, and where such rights are not already in place. The Oregon Water Resources Department (OWRD) and the Oregon Water Resources Commission (OWRC) will also seek to facilitate flow restoration targeted to streams identified by OWRD and ODFW as posing the most critical low-flow barriers to salmonids. In addition, where necessary, OWRD will continue to work with the Oregon State Police to provide enforcement of water use. Where illegal water uses are identified, OWRD will ensure outcomes consistent with maintenance and restoration of flows.

(j) The Oregon Environmental Quality Commission (EQC) and DEQ will evaluate and will make every effort to utilize their authorities to continue to provide additional protection to priority areas (as determined under section 1(f) of this Executive Order), including in-stream flow protection under state law, and antidegradation policy under the federal Clean Water Act (including Outstanding Resource Waters designations and high quality waters designations).

(k) DSL has proposed to adopt changes to its Essential Salmonid Habitat rules that will provide additional protection for spawning and rearing areas of anadromous salmonids. In addition, ODFW and DSL will consult with the OWRC to determine where it is necessary to administratively close priority areas (including work under General Authorizations) to fill and removal activities in order to protect salmonids. DSL, ODFW, ODF and ODA also will work together to identify means of regulating the removal of organic material (such as large woody

debris) from streams where such removal would adversely affect salmonids and would not be contrary to other agency mandates.

(l) DSL will seek the advice of the IMST regarding whether gravel removal affects gravel and/or sediment budgets in a manner that adversely affects salmonids.

(m) The Department of Land Conservation and Development (DLCD), and the Land Conservation and Development Commission (LCDC) will evaluate and, to the extent feasible, speed implementation of existing Goal 5 requirements for riparian corridors.

(n) DLCD, DEQ, ODF, ODA, ODFW, and DSL and their respective boards and commissions will evaluate and implement programs to protect and restore riparian vegetation for the purposes of achieving statewide water quality standards and protecting and restoring aquatic habitat for salmonids.

(o) DLCD, with the assistance of DSL and ODFW, and in consultation with coastal cities and counties, shall review the requirements of Statewide Planning Goal 16 as they pertain to estuarine resources important to the restoration of salmonids, and shall, report its findings to LCDC for its consideration.

(p) The Oregon State Police will work to facilitate the existing cooperative relationship with the NMFS Office of Law Enforcement, as well as to maintain cooperation with other enforcement entities, in order to enhance law enforcement, public awareness and voluntary compliance related to harvest, habitat and other issues addressed in the Oregon Plan.

(q) The Oregon Parks and Recreation Department will continue to work to provide information and education to the public on salmon and steelhead needs through park programs and interpretive aids.

(r) The Oregon Marine Board will work to ensure fish friendly boating and to develop boating facilities that protect salmonids.

(s) State natural resource agencies will continue, to the extent feasible, to support watershed councils by providing technical assistance to develop watershed assessments, restoration plans and to develop watershed priorities to benefit salmonids. In addition, state natural resource agencies will work on a larger watershed scale to develop basin-wide restoration priorities.

(4) Future Modifications; Public Involvement for the Oregon Plan Generally. The GNRO will solicit public comments and input from participants in the Oregon Plan regarding whether there are refinements or changes to the Plan and/or the organizational framework for

implementing the Plan that are necessary or desirable based on the experience gained over the past three years, or resulting from the widespread listings and proposed listings of salmon and trout under the federal ESA. Based on this public involvement, the GNRO will provide a report and recommendations to the Governor and the Joint Committee regarding whether modifications are necessary to the Oregon Plan in order to protect and restore coho and other salmonids.

(5) Definitions. For purposes of this Executive Order:

(a) The "Oregon Plan" means the Oregon Coastal Salmon Recovery Initiative, dated March 1997, and the Steelhead Supplement, dated January 1998. "Oregon Plan," as used in this Order, is intended to be consistent with the definition of the Oregon Coastal Salmon Recovery Initiative in Oregon Senate Bill 924 (1997 Or. Laws, ch. 7), and to include the Healthy Streams Partnership (1993 Or. Laws, ch. 263).

(b) "Protect" has the meaning given in section (1)(d) of this Executive Order.

(c) "Restore" has the meaning given in section (1)(e) of this Executive Order. Restore necessarily includes actions to manage salmonids to provide for adequate escapement levels, and actions to increase the quantity and improve the quality of properly functioning habitat upon which salmonids depend.

(d) "Coho" means native wild coho salmon found in rivers and lakes along the Oregon Coast.

(e) "Salmonids" means native wild salmon, char and trout in the State of Oregon.

(6) Effective Date; Relation to Federal ESA. This Executive Order will take effect on the date that it is filed with the Secretary of State. The State of Oregon will continue to work with NMFS to determine the appropriate relationship between the Oregon Plan and NMFS's efforts under the federal ESA.

Done at Salem, Oregon, this 8th day of January, 1999.

/S/_____
John A. Kitzhaber, M.D.
GOVERNOR

ATTEST:

Office of the Governor
State of Oregon

/S/_____
Suzanne Townsend
DEPUTY SECRETARY OF STATE

CHARTER OF THE
FOREST PRACTICES ADVISORY COMMITTEE
ON SALMON AND WATERSHEDS

Background and Purpose

Executive Order 99-01 signed by Oregon Governor Kitzhaber directs the Board of Forestry with the assistance of an advisory committee to determine what, if any, changes to forest practices are necessary to meet water quality standards and to protect and restore salmonids.

The Forest Practices Advisory Committee on Salmon and Watersheds is the advisory committee described in the Executive Order that is charged with making recommendations to the Board. To the extent possible, the Committee should make specific recommendations to the Board of Forestry by June 1999.

The Committee includes representatives from environmental, forest industry, commercial fishing, sports fishing, logging, local government, labor, and small woodland owner interests. Department of Forestry staff, in collaboration with staff from the Oregon Departments of Fish and Wildlife and Environmental Quality, provides technical and policy assistance.

Parameters and Assumptions:

The Board recognizes that forest practice rules are important for protecting, and over time restoring fish populations, while voluntary measures and incentives are also important to help protect and restore fish populations. Consistent with ORS 527.765, to the maximum extent practicable, forest practice rules are to be designed to meet state water quality standards.

Recommendations may include regulatory or statutory changes, incentives and/or voluntary measures. To the extent possible, any recommendations for rule additions or revisions must consider and reflect the standards contained in of ORS 527.714 (attached).

The Committee will seek consensus about recommendations when possible and clearly articulate the range of views when consensus is not possible. Significant differences of opinion, if any, will be highlighted in the Committee's report to the Board.

The Board shall approve significant revisions to this Charter and the focus of the Committee's work.

Charge From Board:

Consistent with the Executive Order, and the mission and objectives of the Oregon Plan for Salmon and Watersheds, determine: (1) what, if any, changes to forest practices, both regulatory and voluntary, are necessary to meet water quality standards and to protect and restore salmonids and (2) make specific recommendations to the Board of Forestry.

The Committee will:

1. Determine the Committee's decision-making process, work plan, and meeting mechanics.

2. Develop a common understanding of issues and the relative importance of limiting factors, science, policy, and consideration for forestry operations and riparian conditions on non-federal lands.
3. Consider the best available information including relevant monitoring data; field evaluations, the IMST report, and scientific information, including information from state and federal government agencies, universities and private entities, to determine how well the forest practice rules meet water quality standards and protect and restore fish.
4. Building on the findings from the third charge, evaluate whether the relative combined contributions of the current forest practice rules and voluntary measures (and in consideration of the contributions provided by other land uses) will achieve the Oregon Salmon Plan recovery objectives. Where possible, evaluate the likelihood that the rules and measures will achieve the objectives.
5. Identify, if any, additional practices or programs that might be necessary to meet commitments to the Oregon Salmon Plan and the Executive Order
6. Evaluate the relative costs and benefits of additional practices that might further support the Oregon Salmon Plan recovery objectives. This evaluation would include an analysis of the relative impacts on landowners, the relative contributions of other land uses, consideration of alternatives including non-regulatory approaches and alternatives, which achieve the desired level of protection and are least burdensome to landowners.
7. Building on the work of the prior objectives, recommend a package that is necessary to meet commitments in the Oregon Salmon Plan and Executive Order. If rule changes are recommended, develop findings consistent with ORS 527.714. Identify limitations in data and recommend appropriate monitoring or research.
8. Complete evaluations and recommendations to the extent possible by June 1999 to present to the Board of Forestry.

Membership

Ron Cease, Chair (Public)
Geoff Pampush, (Oregon Trout)
Dan Newton, (Oregon Forest Industries Council)
Paul Ketcham (Portland Audubon)
Gary Springer (Oregon Small Woodlands Association)
Bill Arsenault (Oregon Small Woodlands Association)
Paul Heikkila (Commercial Fishing/OSU Sea Grant Extension)
Bill Street (Labor/ Machinist Union)
Liz Hamilton (Northwest Sportsfishing Industry Association)
Blake Rowe (Oregon Forest Industries Council)
Sue Cameron (Oregon Counties)
Tom Hirons (Associated Oregon Loggers)
Mary Scurlock (Pacific Rivers Council)

Roles and Responsibilities

Chair

Direct the development of agendas, run the meetings, ensures that the minutes are correct and approved by the Committee.

Facilitators
Conceptualize, design and implement a facilitated group process that will enable the Committee to complete effectively and efficiently its work as charged by the Board.

Committee Members
Determine committee workplan, analyze issues, network with others, provide input and guidance to staff, and make recommendations to the Board of Forestry.

Staff
Provide technical and policy information and advice, answer questions on technical, policy and legal issues, and offer issue presentations to aid committee deliberation. Identify scientists and others that have information of value to the Committee and invite these parties to present information to the Committee. Provide logistical support.

The following staff will sit at the table to provide support:
Policy Lead and Secretary to the Committee – Ann Hanus, Department of Forestry
Forest Practices Policy – Ted Lorensen and David Morman, Department of Forestry
Forest Practices Technical Issues – Jim Paul, Department of Forestry
Fish and Wildlife Issues – Jeff Boechler, Department of Fish and Wildlife
Water Quality Issues – Department of Environmental Quality
Administrative Support – Cassandra Webber, Department of Forestry

Other staff leads are:
Incentives Policy Lead – Dave Stere, Department of Forestry
Field Coordination – John Seward, Department of Forestry
State Forest Lands Program Liaison – Ross Holloway, Department of Forestry

Other State and Federal Agency Participants
Provide technical and policy information and advice upon request of the Committee and answer committee questions.

Citizen and Scientist Participants
Provide information and input to the Committee at specified times to be determined by the Committee.

Attachment 1 – ORS 527.714

Attachment 2 – **Draft Statement of Individual Commitment and Accountability; Working Guidelines**

Working guidelines are statements of behavior, which, if mutually understood, accepted, and supported by members of a group, or team, improve the flow of useful information and create a climate for increased effectiveness and enjoyment of work.

Members commit to participate actively and will strive to attend all meetings and field trips.

Members will foster collaborative discussion by:

- Listening actively and demonstrating that you understand.
- Making clear whether you are speaking for yourself or the group.
- Respecting the difference between fact and opinion.
- Avoiding jargon and "loaded" words.
- Remaining focused on the objectives of FORPAC and refraining from pursuing additional issues or objectives.

Members will be respectful of a diversity of opinion and allow for an open, constructive dialogue.

Members will be sensitive to time constraints and keep remarks concise and to the point.

Members will focus on interests/ideas not on positions and persons.

Members will strive for seeking a range of information sources, recognizing that good information makes for good decisions.

Members recognize that appropriate humor is important to enjoying the process and building a team and that inappropriate humor may have the opposite result.

Appendix 2

Key Committee Correspondence

Appendix 2 only includes key correspondence about the committee's purpose and process.

The committee received many comments during the course of its work. These were from a range of interests including state and federal agencies, scientists, and interested public. Due to the amount of materials, such correspondence is not included but is available upon request to the Department of Forestry.

+Pacific Rivers Council +Audubon Society of Portland+
+Oregon Trout +Northwest Sportfishing Industry Association+

30 April 1999

Governor John Kitzhaber
State Capitol
Salem, Oregon 97310-0370

Re: Solidifying Goals for Forest Practices Under the Oregon Plan

Dear Governor:

As members of the Board of Forestry's Citizen's Forest Practices Advisory Committee, we seek clarification regarding how the work products we are developing will be formally connected to federal policies and programs under the federal Endangered Species Act and the Clean Water Act.

It is our understanding, based on statements from both Department of Forestry staff and landowner members of our Advisory Committee that our work does not contemplate the establishment of federal assurances under the Endangered Species Act nor Clean Water Act. While it is clear that the National Marine Fisheries Service (NMFS) has indicated its intention to use the "Forestry Module" in Washington as the basis for a 4(d) Rule, and NMFS intends to develop a 4(d) rule in Oregon for listed salmonids, our Advisory Committee's goals do not contemplate development of rules which would procure such assurances.

It strikes us that our committee's charge should reach sufficiently far enough to serve as the basis for the development of a 4(d) rule under the Endangered Species Act and meet the standards of the Clean Water Act as appropriate for forest lands.

We ask you for your clarification on this important matter.

Sincerely,

Mary Scurlock
Pacific Rivers Council

Geoff Pampush
Oregon Trout

Paul Ketcham
Audubon Society of Portland

Liz Hamilton
Northwest Sportfishing Industry Association

cc: Members of the Citizen's Forest Practices Advisory Committee

JOHN A. KITZHABER, M.D.
GOVERNOR

May 18, 1999

Mary Scurlock
Pacific Rivers Council
921 SW Morrison STE 531
Portland OR 97205

Dear Mary:

The Oregon Plan for Salmon and Watersheds has as its goal the restoration of salmonid species across Oregon. As part of the state's integrated effort to achieve this end, I issued Executive Order 99-01, which contained a request that the Board of Forestry, with the assistance of the advisory committee on which you sit, identify changes that may be needed to the forest practices act to meet water quality standards and protect and restore salmonids.

I believe that the Forest Practices Advisory Committee should focus its efforts on understanding and evaluating the best science available on the topic. Once the committee has reached agreement on what changes in the condition of the state's watersheds are needed, the committee should consider the various tools at its disposal to effect these changes. Among these tools are incentives, voluntary measures, regulatory measures, legislation, Habitat Conservation Plans, a 4(d) rule, or any combination of these.

I believe the best use of the committee's time is to focus on <u>what</u> needs to occur on forest lands to restore salmonids, rather than <u>how</u> it will be done. In this way, the committee can provide the most useful contribution to our recovery efforts.

I do want to thank each of you for your dedication to this process. I realize that it has already taken longer than was anticipated originally, but I want to assure you that the work of the Forest Practices Advisory Committee is a critical component of Oregon's efforts to restore salmonids.

Best regards,

John A. Kitzhaber, M.D.

JAK/NR/sw

c: Ron Cease, Chair
Members of the Advisory Committee

JOHN A. KITZHABER, M.D.
GOVERNOR

September 22, 1999

Ron Cease
Oregon Forest Practices Advisory Committee
c/o Oregon Department of Forestry
2600 State Street
Salem OR 97310

Dear Ron:

I have received and reviewed the report of the Independent Multidisciplinary Science Team (IMST). I am pleased that this group of respected scientists has provided us with such a thorough discussion of the relationship of forest management and fish habitat.

As part of the state's integrated efforts to restore watersheds across the state, I issued an Executive Order requesting that the Board of Forestry, with assistance of your advisory committee, identify changes that are needed to protect and restore salmonids. I would like your committee to carefully consider the findings of the IMST as you seek to meet those objectives.

The IMST report has done an admirable job of describing what salmon species need. As you move from what fish need to what management practices would provide for those needs, your committee has a wide menu of options it may consider, including regulatory and incentive-based approaches. I ask you to favor approaches that work well for Oregonians while assuring the recovery of salmonid habitat.

Thank you for the time you and your committee continue to devote to this important effort.

Best regards,

John A. Kitzhaber, M.D.

JAK/NR/sm

Associated Oregon Loggers, Inc.

P.O. Box 12339 • Salem, Oregon 97309-0339 • (503) 364-1330 • Fax: (503) 364-0836

June 26, 2000

Ron Cease, Chair, Forest Practices Advisory Committee
Oregon Department of Forestry
2600 State St.
Salem, OR 97310 ATTN: Ann Hanus

Re: Riparian Option, Forest Practices Advisory Committee Recommendations

Dear Ron:

On behalf of the logging operators in the state of Oregon, I voted against adopting the compromise proposal on riparian management put forth by the sub-committee of FPAC at its final meeting June 9. Clarity of our position demands some explanation.

The fifth paragraph on the first page of the Charter of the Forest Practices Advisory Committee on Salmon and Watersheds says that FPAC recommendations may include incentives and or voluntary measures. Item number 6 on the second page of the charter call's for an evaluation of the costs and benefits of additional practices.

Loggers had hoped for a riparian package that they could support including the above mentioned items. Because current rules regulating riparian management are already confusing for landowners and operators we see the additional new regulations embodied in the compromise proposal as being even more confusing, thus being a disincentive rather than an incentive to engage in active management of riparian areas. In the future there will be more of a tendency to rope off riparian areas and stay out entirely. No stewardship is not good stewardship!

From the information presented during committee meetings, there is insufficient scientific basis for many of the actions taken in the compromise riparian proposal. The committee has failed in its charge to determine the costs to landowners and loggers, or the benefits to the public. Neither has the committee addressed the private and state costs to administer, nor the unintended consequences of excessively complex regulations. Because some on both sides of the political spectrum bad-mouth the proposal does not make it right, even though it might be politically expedient.

Operators are the ones who will have to make new rules work on the ground. They work at the direction of landowners and will be the ones who are in violation if these new rules are misunderstood. Despite all of these reservations, Associated Oregon Loggers in cooperation with the State Forester will make every effort to make sure that our members are fully acquainted with all recommended changes to the Oregon Forest Practices Act. Through the "Oregon Professional Logger" program, which requires continuing education in OFPA, we will strive to make sure that loggers and FPFs continue to be on the same page. AOL is convinced that only a cooperative effort will insure good stewardship of Oregon's forests. We look forward to working with ODF staff during the rulemaking process.

Sincerely,

Tom

Tom Hirons
Mad Creek Logging Co. / FPAC Committee Member

Appendix 2
Page 2-9

Pacific Rivers Council **Audubon Society of Portland**

26 July 2000

Ron Cease, Chair
Ad Hoc Forest Practices Advisory Committee on Salmon and Watersheds
Mark O. Hatfield School of Government
Box 751
Portland, OR 97212

Re: Rationale for Declination to Support FPAC Riparian Subcommittee Package

Dear Ron:

At the final meeting of the Forest Practices Advisory Committee on June 9, Pacific Rivers Council and the Audubon Society of Portland did not support the Riparian Subcommittee's "Points of Agreement" package. Our decision to take this position bears some explanation, provided below. Based on the committee's discussion at the last meeting, we understand this text will be included in the body of the Committee report. That is, it will either be incorporated fully in the text describing the subcommittee option, or incorporated by reference in this location and attached in full.

Our decision is based on our understanding of the applicable science, policy and law. In sum, we believe that the proposed measures are not compatible with the biological needs of salmon, the Committee's Charter, the stated goals of Executive Order 99-01, the Oregon Plan, the Endangered Species Act's prohibitions on "take" or the state's obligations under the Clean Water Act. Our goal from the inception of this process was to represent the needs of salmon and the aquatic ecosystem upon which they depend. It is our opinion that we most effectively represent this interest by abstaining from support of reforms that better reflect landowners' preferences than the needs of salmon survival and, ultimately, recovery. We concur with the admonishment of Oregon's Independent Multidisciplinary Science Team (IMST) that effective conservation measures cannot be "defined by management needs," but rather "in accordance with natural processes and the maintenance of riparian and biological physical functions." (IMST Report 99-1 at 19).

We find that the Subcommitee's 14-point proposal offers advances in some key areas, including:

- The level of riparian protection for some non-fishbearing streams (large and medium streams) is proposed to be commensurate with that now provided for fish-bearing streams. This partially recognizes the body of science that supports tying protection levels to perenniality, rather than fish use, in order fully recognize the important role of these streams in contributing organic materials and regulating sediment movement to

downstream reaches. (*See e.g.* IMST 99-1; NMFS Oregon Proposal 1998; Forests and Fish Report EIS 2000; Spence et. al. 1996).

- Some small non-fishbearing perennial streams would receive new riparian protection for 500 feet from the junction with a fish-bearing stream. This measure combines with revised stream-typing criteria which would provide "fish-bearing" levels of protection to some streams now in the non-fishbearing category. (As it has not been determined how much stream would be protected through either change, we strongly encourage the Department to conduct GIS analysis of these changes as soon as possible).

- The extent of the protected riparian area would include the full extent of the Channel Migration Zone in areas where one exists, a step which would appropriately increase the size of the protected riparian area in unconstrained reaches – generally floodplain areas of high habitat value for salmonids.

- A new harvest limitation could better protect higher quality riparian conditions by restricting riparian harvest to 40% of existing conifer basal area, an approach that reduces allowable degradation of currently robust riparian forests and could, over time, reduce the importance of minimum "conifer basal area" measures. Under the current rules, uniform harvest down to a minimum floor is allowed on all sites. (It is not known how many riparian sites currently are well-stocked enough that the 40% cap would be reached before the basal area limitation).

- Vegetation retention requirements, as measured by "conifer basal area," would increase on some streams. They would be the same for <u>all</u> medium and large streams—equal to that currently required on large non-fish streams. A 25% lower retention requirement is applied on small fishbearing streams. A "tree basal area" measure applies within the partial buffer on the undetermined number of small non-fish streams (Type NT) now proposed to receive a riparian protection area.

- Half of the overall riparian management area is now designated a "no harvest" zone. This would increase the current zones by 5, 15, and 25 feet on small fishbearing streams, all medium, and all large streams, respectively.

- A large tree provision is added to the conifer basal area measure for all medium and large streams and small fish-bearing stream, such that ten of the largest twenty trees must be retained outside the no-cut area.

- The addition of a riparian specialist to ODF staff promises to provide needed technical support for rules compliance, particularly for smaller, landowners.

- The current requirement not to locate skid trails within 35 feet of Type F or D streams will be extended to all streams.

Even recognizing these increased restrictions on streamside logging, Pacific Rivers Council and the Audubon Society of Portland are unable to support the subcommittee's proposal for the same reasons we were unable to support earlier proposals: we do not find it consistent with the goals of maintaining and restoring salmon and water quality—the Committee's charge. Our support would perpetuate the scientifically unjustified assumption that the proposed riparian management limitations are capable of mitigating for logging-related watershed degradation. Our specific key concerns are:

- Streamside protection areas still are too narrow. The proposal does not re-define protected riparian areas on all stream sizes to correspond to an area which, if maintained in mature forest conditions, would be capable of providing near-fully functional inputs of large wood, thermal regulation (e.g. shade, microclimate), chronic and episodic sediment regulation and other functions. We note that the need for riparian protection areas approximating at least one "site potential tree height" to reach this objective is supported by extensive analysis associated with the Forests and Fish Report recently adopted in Washington state, the NMFS Oregon Proposal and with other work.

- The stated measurable objectives for maintaining desired riparian forest conditions permit too much vegetation removal in riparian areas because they do not approximate the conditions within ecologically mature forests of 200 or more years. The targets are instead based on arbitrarily chosen basal areas only loosely correlated with that of 120 year-old forests.

- Only an unknown fraction of all small, nonfish-bearing perennial streams will receive any riparian protection, and even this is inadequate to protect the function of these streams. We see at least five problems with the proposal.

  - First, the recommended protection does not extend the full length of qualified stream reaches. Rather, it extends an arbitrary distance of only 500 feet from the confluence with a "fishbearing" stream, even if more than half the stream remains unprotected, or the stream's sensitive initiation point is not encompassed by this distance;

  - Second, the 50 foot-wide search zone (each side of the stream) may not constitute an area of sufficient size to reflect the

ecologically defined riparian area – i.e. the area which most directly influences and is influenced by the stream itself;

> Third, the protection offered in these areas is nominal. Logging is not sufficiently restricted within the small riparian areas to ensure the development of functional mature forest conditions. The low vegetation retention standard applicable to the small riparian areas offered for "temperature" streams (4 square feet per 100 feet of stream) and the lesser standard for "debris torrent" streams (location of 2 in-unit leave trees per acre) bear no relationship to the density and composition of a mature forest. Furthermore, no evidence has been provided that the buffers are adequate to meet shade, sediment filtration, or large wood recruitment functions at levels that will lead to salmon recovery. In particular, the provision applicable to the "debris torrent" streams – location of the already mandatory 2 wildlife leave trees per acre – will have negligible benefits toward meeting the ecologically appropriate objective of maintaining the natural rate, timing and characteristics of shallow-rapid landslides. Additionally, no area is off limits to harvest, there is no "harvest cap," and there is no requirement that the largest trees be retained.

> Fourth, only a small subset of small non-fishbearing streams will receive the nominal protection, although these may constitute the majority of stream miles in a given basin. Only streams contributing 30% of streamflow to a fishbearing stream <u>and</u> meeting a minimum basin size qualify for the partial riparian protection afforded "temperature" streams. "Debris torrent" streams are defined as streams with drainage basins greater than 30 acres, in which more than 75% of the basin has been mapped by the State Forester as "high" or 50% as "extreme" debris flow hazard, and which have a high probability of delivering large wood in debris torrents. It appears that these arbitrary qualifications will reduce the protected class of streams to a small fraction of all Type N streams in most basins, under-recognizing the role of these areas in maintenance of the sediment regime and a desirable range of geomorphological characteristics of streams watershed-wide.

> Fifth, the debris flow channel identification methodology and maps that will be used to locate "debris torrent" streams have not been peer reviewed. (We also note that it is not clear how many such streams will be disqualified as deserving of vegetation retention due to the 30-acre basin size limitation. Such analysis should be part of any rules package that ultimately goes to the Board).

> In sum, the proposed protection for the smallest perennial streams undervalues the ecological significance of smaller streams to overall watershed health and the creation of functional salmon habitat. In the North Coast of Oregon, ODF analysis indicates that these small "Type N" streams comprise as much as 50% of all stream miles. (*See e.g.* Economic Analysis of Northwest State Lands Conservation Plan in Board of Forestry meeting packet, April 2000). We believe that the proposed level of protection will allow continued resource degradation which cannot be adequately mitigated by making these streams a monitoring priority;

- No part of the ephemeral network would receive either riparian protection (as recommended by the IMST) or certain protection via the prohibition of logging in portions of the network identified as being at a high risk of slope failure and which is likely to connect directly with an ephemeral channel.

- Although riparian areas would include at least the extent of the Channel Migration Zone (CMZ) where one exists, there is no assurance that this area itself will be buffered. Full recognition of this area as the functional equivalent of the edge of the stream channel requires that the riparian area be measured from the edge of the CMZ. Furthermore, the CMZ is incorrectly defined as an area where the stream could move in one rotation—in the judgement of the forest practices forester. We suggest that 100 years should be used as the relevant time period (perhaps where the channel has been in the last 100 years), and also that FPFs may not have the appropriate expertise to locate the CMZ under either definition.

- Overall, stream size and fish-bearing potential still is over-emphasized as a determinant of the riparian protection area, a model which focuses on specific habitat characteristics associated with in-stream wood to the exclusion of other important functions which depend on ecological processes associated with the existence of mature forest condition in the upper watershed, where seasonal and small perennial streams predominate.

- Especially given the relatively small size of the overall riparian protection areas, the proposed "half the RMA" formula to define the no-harvest area provides insufficient assurances of stream protection. While the no-cut area will more than double on large streams under this proposal, it will increase by only 5 and 15 feet, respectively on small and medium streams. There is no prohibition on harvest in any area of the partial buffer afforded some small nonfish streams. We note that in some areas it is possible to meet even the proposed minimum conifer retention requirements within the no-harvest area alone, so that the only protection provided in the

balance of the riparian area could derive from the minimal 10 of the 20 largest tree provision.

- The large tree provision actually should require that the largest trees be left—without qualification—and that more trees be retained. Even though the intent seems to be that trees nearest the stream be preferred over those farther away, we find that the greatest value would derive from the larger trees being retained, even at the outer portion of the riparian area. Given that these areas are within the height of a site-potential tree in virtually all instances, they are necessarily still within the area of immediate influence on the stream.

We remind the Committee and the Board that the current condition of aquatic and riparian habitats is dire. Recently published research by the Oregon Department of Fish and Wildlife (ODFW) found that a typical western Oregon stream was characterized by elevated fine sediment, low woody debris levels, a low frequency of deep pools and a low density of large riparian conifers – bad news for critical indicators of healthy fish habitat. (Thom, Jones and Flitcroft, "Stream Habitat Conditions in Western Oregon," Monitoring Program Report 1999-1 (1999).

Our views on the riparian package were further colored by the balance of the Committee's deliberations, which were unable to produce agreement regarding the need for vegetation retention and a presumption against roadbuilding on even the highest risk landslide-prone sites and their runout paths. Rather, a "menu" of possible management options for areas subject to debris-torrents is being advanced, an open-ended approach with an uncertain relationship to the goal of minimizing management-related increases over background landslide risks.

Furthermore, even with increased harvest limitations and extension of small partial buffers to some smaller streams, it seems unrealistic to expect these areas to mitigate for all the watershed-scale impacts that accompany intensive commercial forestry. Relatively small riparian protection areas (from one-half to one-quarter or less of a site-potential tree for most stream miles) are coupled with the dispersal of short-rotation clearcut logging activity over large areas of the landscape in patches of up to 120 acres per ownership, regardless of overall watershed condition and past logging history.

The continuous, dispersed, management disturbance created by logging does not emulate natural disturbance patterns—nor (as the IMST noted) do arbitrarily and sharply demarcated riparian buffers. Yet, the proposed riparian buffers – comprising only slightly more than the 2-9% of the landscape currently in buffer—are being expected to substitute for the conditions under which salmon evolved. In western Oregon, these conditions included at least 50-70% of the entire landscape (not just the riparian area) in old-growth forest. Today, as much as three-quarters of the private forested landscape may be in early seral stages. (*See e.g.* Analysis of Western Washington forests contained in DEIS for the Forests and Fish Report, March, 2000).

In light of the IMST's well-founded declaration that a riparian-protection approach cannot alone provide the basis for a successful recovery strategy, it seems that a more conservative set of riparian prescriptions is justified until such time as a true landscape approach can be designed. Nor is shoring up existing buffers enough to serve in lieu of key landscape-scale recovery actions, including: 1) greater certainty of protection for biological refugia, and 2) cumulative effects assessment to validate the effectiveness of generally-applied prescriptions in specific watersheds. As the IMST observed, a landscape approach to management actions could permit greater flexibility in riparian management, but would also likely include greater concentration of activity in certain areas with longer recovery periods. The timing and scope of management-related disturbance would then be designed to emulate historic disturbance patterns.

Until such a management program is designed, however, much more robust riparian protection than that proposed by the Riparian Subcommittee is needed to hold the line against further degradation of aquatic habitat and turn the trajectory toward recovery.

Sincerely yours,

Mary Scurlock
Pacific Rivers Council

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Cc: Governor John Kitzhaber
David Gilbert, Chair, Oregon Board of Forestry
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Appendix 3

Independent Multidisciplinary Science Team Report

INDEPENDENT MULTIDISCIPLINARY SCIENCE TEAM (IMST)

State of Oregon

John Buckhouse
Wayne Elmore
Stan Gregory
Kathleen Kavanagh
James Lichatowich
Logan Norris, Chair
William Pearcy

September 14, 1999

The Honorable John A. Kitzhaber
Governor of Oregon
State Capitol
Salem OR 97310

The Honorable Brady Adams
Oregon Senate President
State Capitol
Salem OR 97310

The Honorable Lynn Snodgrass
Oregon House Speaker
State Capitol
Salem OR 97310

Enclosed is Technical Report 1999-1 from the Independent Multidisciplinary Science Team on the forestry project that we just completed. The report contains 19 specific recommendations. Most are directed to the Oregon Department of Forestry (ODF), but there are also recommendations for Oregon Department of Fish and Wildlife (ODFW) and the Forest Research Laboratory (FRL).

This report focuses on topics involving the management of (a) riparian areas, (b) large wood (sometimes referred to as large woody debris), (c) sedimentation from roads and landslides and (d) fish passage at road-stream crossings. While there are other forestry issues that could impact the recovery of wild salmonids, we felt these were most important, and were within the scope of what the IMST could do given the rest of our responsibilities.

The geographic scope of our report is forested lands west of the Cascades and in the Siskiyous. We excluded forest lands on the east side in part because grazing and forestry are so strongly intermingled on these lands and in many instances it will be difficult to segregate the effects on aquatic habitat of one land use from the other. I anticipate that IMST will address this intermixed land use on the eastside and their different policies in a separate project. For now we note that the concepts articulated for the westside forestlands can likely be extended by ODF, ODFW and the FRL to the eastside forests.

Concerning this report, the IMST finds that some specific aspects the Oregon Forest Practices Rules and the Measures of the Oregon Plan need improvement in dealing with riparian buffers, large wood management,

sedimentation and fish passage at road-stream crossings. We believe these changes can all be accommodated within the existing policy framework. However, even with these changes, the current site-specific approach of regulation and voluntary actions is not sufficient to accomplish the recovery of wild salmonids. A landscape scale approach with flexible or adaptive management will be needed. Our report recommends this for forestlands (see recommendations I and 2), but we believe this will require a change in the forest policy framework of the State before it will be feasible, equitable and attractive. Given that salmonids extend across most of the lands of the State, I anticipate that in the future the IMST will conclude the landscape approach will need to extend across this larger landscape as well.

To conclude, as you study our report keep in mind there are two levels of resolution and two general time scales involved. One level of resolution is at the operational level involving changes to existing Rules and Measures and their implementation. This level of resolution can be accomplished in the near-term future. The second level of resolution is at the policy level, as reflected in recommendations I and 2. This issues involved at this level will require a longer period of time.

The IMST will discuss this report with the ODF Advisory Committee on Forest Practices on September 23. 1 will discuss this report with the Board of forestry on October 22.

The IMST remains committed to the mission of the Oregon Plan and hope our work is helpful. We would be pleased to discuss this report or any of our other work with you at your convenience.

Sincerely Yours,

Logan A. Norris, Chair
Independent Multidisciplinary Science Team

LAN:grs

cc: IMST
JLCSRSR

Recovery of Wild Salmonids in Western Oregon Forests:

Oregon Forest Practices Act Rules

and the Measures in the

Oregon Plan for Salmon and Watersheds

Technical Report 1999-1

Independent Multidisciplinary Science Team

September 8, 1999

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PREFACE

The recovery of wild salmonids in Oregon depends on many factors, including quality freshwater and estuarine habitats. Freshwater habitat extends across all the lands of the State, and includes lands in urban areas and lands devoted to agriculture, forestry, and other uses. Estuaries provide a transition between fresh water and the ocean, and are a critical part of the habitat of anadromous wild salmonids. The Independent Multidisciplinary Science Team (IMST) is evaluating the science behind the management practices and policies that affect all of these freshwater and estuarine habitats.

We have subdivided the work to focus on major types of land use (forestry, agriculture, and urban land uses). The subdivisions correspond to the different policy frameworks within which these lands are managed. Although the policies differ, these land uses interface and intermingle, and the aquatic environments on which the fish depend traverse and link them all. We emphasize that the boundaries we make between these areas in our reports are entirely artificial.

IMST is conducting its analysis of land-use practices within a framework made up of three fundamental concepts. Although not testable in a practical sense, we believe each concept is consistent with generally accepted scientific theory. The concepts are as follows:

1. ***Wild salmonids are a natural part of the ecosystem of the Pacific Northwest, and they have co-evolved with it.*** The contemporary geological landscape of the Pacific Northwest was established with the formation of the major river/stream basins of the region, approximately two to five million years ago. The modern salmonids of the region largely developed from that time (Lichatowich 1999). The abundance of these species at the time of Euro-American migration to Oregon is a reflection of more than 10,000 years of adaptation to the post-glacial environment and 4,000 to 5,000 years of adaptation to contemporary climatic and forest patterns. There is some indirect evidence from anthropological studies that salmon in Oregon's coastal streams may not have reached the high levels of abundance that the first Euro-Americans saw until about 1,000 to 2,000 years ago. The point is that the salmonid stocks of today evolved with the environment (co-evolved) over a relatively long period compared with the length of time since Euro-Americans entered this landscape.

2. ***High quality habitat for wild salmonids was the result of naturally occurring processes that operated across the landscape and over time***. These same processes occur today, but humans have altered their extent, frequency, and to some degree, their nature. Humans will continue to exert a dominant force on the landscape of the Pacific Northwest, but current ecosystems need to better reflect the range of historic conditions.

3. ***The environment and habitat of these species is dynamic, not static***. At any given ***location***, there were periods of time when habitat conditions were better and times when habitat conditions were worse. At any given ***time,*** there were locations where habitat was better and locations where it was worse. Over ***time*** the ***location*** of better habitat shifted. Salmonid habitat in the Pacific Northwest has been a continuously shifting mosaic of

disturbed and undisturbed habitats. One of the legacies of salmonid evolution in a highly fluctuating environment is the ability to colonize new or recovered habitat.

These concepts apply regardless of the land use, and are the basis for the evaluations in this report that focus on forestry, as they will be in subsequent reports on other patterns of land use as well.

Wild salmonid stocks historically accommodated changes in their environment through a combination of three strategies**. *Long-term adaptation*** produced the highly varied life-history forms of these species, providing the genetic diversity needed to accommodate a wide range of changing conditions. ***High fish abundance distributed in multiple locations (stocks)*** increased the likelihood that metapopulations and their gene pools would survive. ***Occupation of refugia*** (higher quality habitat) allowed for recolonization of poor habitat as its condition improved over time.

Since the mid 1850s, the rate and extent to which habitat conditions changed has sometimes exceeded the ability of these species to adapt; therefore, stock abundance currently is greatly reduced. Although refugia exist (at a reduced level) today, population levels of wild salmonid stocks are seriously depressed because of other factors (ocean conditions, fisheries and hatchery management, land-use patterns and practices), that limit the rate and extent to which recolonization can occur. In addition, some harvest and hatchery practices have diminished the genetic diversity of salmonids, limiting their ability to cope with climate fluctuations. It is the combination of these factors and their cumulative effects since 1850 that have produced the depressed stocks of today.

The historic range of ecological conditions in the Pacific Northwest, both of habitat and of salmonid stocks, is important because it provides a framework for developing policy and management plans for the future. The performance of salmonids under historic ecological conditions is evidence that these habitats were compatible with salmon reproduction and survival. Land uses resulting in non-historical ecological conditions may support productive salmonid populations, but the evidence for recovery of salmonids under these circumstances is neither extensive nor compelling.

Therefore, we conclude that the goal of management and policy should be to emulate (not duplicate) natural processes within their historic range. The recovery of wild salmonid stocks is an iterative process. Just as policy and management have changed in the past they will continue to change in the future, guided by what we learn from science and from experience.

Executive Summary

The forests of Oregon are an important part of the landscape used by wild salmonids. How these forests are managed is important in attaining the goals of the Oregon Plan for Salmon and Watersheds (Oregon Plan) and Oregon Executive Order 99-01. Agricultural, urban, and other environments are addressed in other projects of the Independent Multidisciplinary Science Team (IMST).

Forested landscapes include both aquatic and terrestrial components. The linkage between aquatic and terrestrial components has been recognized for a long time and has been prominent in the Oregon Forest Practices Act (OFPA) since its creation in 1972. The OFPA and its Administrative Rules were developed primarily to protect resource values, including water quality and, indirectly, habitat for salmonids. They were not specifically directed towards the recovery of wild salmonids, which is the mission of the Oregon Plan. However, it is through the Administrative Rules of OFPA and the Measures in the Oregon Plan that the mission of the Oregon Plan and Executive Order 99-01 are to be accomplished. The goals of the IMST forestry project are to

(a) articulate the scientific basis for the recovery of wild salmonids as it relates to the forests of Oregon, and
(b) recommend actions concerning the Rules and the Measures as they contribute to accomplishing the mission of the Oregon Plan.

The geographic scope of this Technical Report is the portion of Oregon forests that provide habitat for wild salmonids west of the crest of the Cascade Range and in the Siskiyou Mountains. However, it also provides the fundamental concepts and relevant science questions and findings for a much broader area. Topically, it covers riparian buffers, large wood, sedimentation, and fish passage at road-stream crossings because IMST believes these are the most important aspects for the recovery of wild salmonids. The Report focuses on broad scientific issues and concepts. It is not a review of each OFPA Administrative Rule or Measure of the Oregon Plan, although some are addressed primarily as examples. The scientific direction provided by this Report can guide ODF staff (working with other panels of experts as needed) in formulating rules for OFPA and measures for the Oregon Plan that are needed as part of accomplishing the recovery of depressed stocks of wild salmonids.

This is a long and complex report addressing some issues with broad policy implications that will take time to resolve, and some other issues that are more operational and can probably be dealt with more rapidly. The Report includes a preface in which the fundamental approach to recovery of wild salmonids is outlined. Briefly, the approach is emulation (not duplication) of the historic range of conditions across the landscape. This approach is appropriate for all lands, although the extent to which it is applied is a matter of policy, to be determined in part by the extent to which wild salmonid recovery is to be achieved. The report is divided into six sections with an appendix. The details of the organization of the report are in Section 1, The Introduction.

The report addresses three science questions:

Question 1. What is the scientific basis for maintaining fish habitat/water quality in forested ecosystems with respect to riparian buffers, large wood, sedimentation, and fish passage at road-stream crossings?

This question is applied to four broad subject areas:

Riparian Protection

Managing riparian areas differently than upslope areas as a strategy for protecting fish habitat is scientifically valid only if it is done with the goal of maintaining the dynamics of landscape structure and function. Sharp demarcations between riparian forest and upslope forest, and between fish-bearing and nonfish-bearing streams are not consistent with the historic pattern.

Large Wood Management

Large wood is a key structural and functional component of aquatic systems. Most models of large wood recruitment focus on riparian areas as the source, ignoring the important contributions made by upslope sources, especially from landslides. There is a critical need to restore the ecological processes that produce and deliver large wood to the streams from riparian as well as upslope areas.

Sedimentation

Sediment is a natural part of forest stream systems, as are the more coarse elements of stream structure, such as large wood, boulders, and gravel. Roads and landslides increase the amount of fine sediment in streams, but do not always add the more coarse elements. In addition, fine sediment production from roads is chronic rather than episodic. Management of sedimentation from roads and landslides at the watershed level is more difficult, and the scientific basis for it is less well developed, although the concepts are known and provide a basis for reasonable conjecture on how to proceed. In essence, the concept is to vary the extent and intensity of disturbance in a watershed over space and time, emulating the historical pattern of disturbance.

Fish Passage at Stream Crossings

The road-stream crossing guidelines developed by ODFW (ODFW 1996) are based on science, although often not the result of explicit experimentation. They provide a scientifically sound basis for management of such crossings, although better information should result from monitoring.

Question 2. Are current forest practice Rules and Measures with regard to riparian buffers, large wood, sedimentation, and fish passage at road-stream crossings adequate to achieve the mission of the Oregon Plan?

IMST concludes that current rules for riparian protection, large wood management, sedimentation, and fish passage are not adequate to reserve depressed stocks of wild salmonids. They are not adequate because they are dominated by site- and action-specific strategies. While these are important as an initial step in accomplishing the mission of the Oregon Plan, they are not sufficient for the recovery of critical habitat for wild salmonids.

Question 3. What strategies are needed in the management of forest resources to achieve the mission of the Oregon Plan?

Recovery of wild salmonids requires, among other things, habitat that is functional across the landscape. This means that policy, management, regulation, and voluntary actions must also work across the landscape. Current State forest policy focuses on specific actions occurring within defined periods of time at specific sites. As an example, the rules provide for riparian protection on a site-by-site basis, rather than at the landscape level. Sharp distinctions in the management of riparian zones (as compared to upslope forests), based on the size of the stream and the presence or absence of fish, will result in a failure to maintain the dynamics of structure and function of riparian zones across the landscape. In other cases, hazardous sites on forest roads and railroad grades are exempt from current OFPA Rules because the actions occurred before the Rules were in effect. Mechanisms are needed to solve these problems on critical sites that are exempted from current rules. Similar examples can be drawn from conclusions about the recruitment of large wood and the management of sediment and fish passage. A policy framework that incorporates landscape perspectives and makes regulation, management, and voluntary actions possible at this scale is needed.

There are three major areas in which shifts in policy are needed:

1. Incorporate the objectives of the Oregon Plan and Executive Order 99-01 into the OFPA. This will place an emphasis of regulation on the protection and enhancement of habitat needed for the recovery of wild salmonids.
2. Develop policy that extends the management of forest resources to the landscape level. This does not delete the site-specific aspects of current rules, but applies them in a different context. It will entail a shift from prescriptive rules applied uniformly across the landscape to site-by-site regulations that take into account cumulative disturbance in the watershed, landscape features, and climatic variation.
3. Develop policy that brings roads not constructed to current standards and other hazardous settings in critical locations into compliance with current standards. This means having the current OFPA Rules applied to actions taken before the current Rules were in force. In many cases, the operator acted in good faith and within the rules of the day, but the outcome is not scientifically consistent with the mission of the Oregon Plan; thus, a provision by which remediation is accomplished is needed.

Evaluating policy options within the complexity of contemporary forestry is a challenge. Extending these options to the landscape level and over time makes the job enormously more difficult. Fortunately, there are analytical approaches and models that can help. Examples of these are in the CLAMS research project, the Umpqua Land Exchange Project, and others.

The following are the specific recommendations of IMST. The first two recommendations will be difficult or impossible to implement within the existing policy framework. These we identify as Recommendations that May Require a Modified Policy Framework. Although these recommendations will take a longer period of time to implement, work on the revised policy framework should begin immediately. The other 17 recommendations can be accommodated within the existing policy framework of the Oregon Forest Practices Act or the Oregon Plan.

These we identify as Recommendations Consistent with the Existing Policy Framework, and we believe they can be addressed in the near future. In aggregate, our recommendations are intended to both reinforce and enhance the site-specific Rules of the OFPA and Measures of the Oregon Plan and provide a bridge to management that incorporates a landscape perspective.

Recommendations for ODF

Recommendations that May Require a Modified Policy Framework

Recommendation 1. Explicitly incorporate the policy objective of the Oregon Plan and Executive Order 99-01 into OFPA.

Recommendation 2. ODF should develop a policy framework to encompass landscape (large watershed) level planning and operations on forests within the range of wild salmonids in Oregon.

IMST recommends that the following elements be included in this modified forest policy framework:

Long-term landscape level assessment of the upslope and riparian forest and associated aquatic systems to ensure that the desired condition is maintained across the landscape and through time.

Identified goals for the characteristics of aquatic systems and riparian and upslope forests across the landscape to ensure the integrity of salmonid habitat.

Monitoring that will provide the information needed to evaluate the aggregated outcomes of management at the landscape level.

Coordination among agencies and watershed councils to facilitate landscape level planning and management at scales that extend beyond the forest.

Recommendations Consistent with the Existing Forest Policy Framework

Recommendation 3. Treat non-fish-bearing streams the same as small, medium, and large fish-bearing streams when determining buffer-width protection.

Recommendation 4. Provide increased riparian protection for the 100-year floodplains and islands.

Recommendation 5. Increase the conifer basal-area requirement and the number-of-trees requirement for RMAs, with increases in these requirements for medium and small streams regardless of fish presence.

Recommendation 6. Complete the study of the effectiveness of the OFPA rules in providing large wood for the short- and long-term.

Recommendation 7. Provide enhanced certainty of protection for “core areas”.

Recommendation 8. Develop and implement standards or guidelines that reduce the length of roadside drainage ditches that discharge into channels.

Recommendation 9. Implement the standards and guidelines for the length of roadside drainage ditch between cross-drainage structures, especially on steep-gradient roads.

Recommendation 10. Require the flow capacity of cross-drainage structures and stream-crossing structures and culverts to meet current design standards.

Recommendation 11. Provide for the stabilization of roads not constructed to current standards (including "old roads and railroad grades") in critical locations. Stabilization means reduction or elimination of the potential for failure. It includes a variety of strategies ranging from removal to abandonment, entirely or of sections, by which specific roads and railroad grades become a much less important source of sediment.

Recommendation 12. Require durable surfacing on wet-season haul roads and require that hauling cease before surfaces become soft or "pump" sediment to the surface.

Recommendation 13. Retain trees on "high risk slopes" and in likely debris torrent tracks to increase the likelihood that large wood will be transported to streams when landslides and debris torrents occur.

Recommendation 14. Continue to apply the current best management practices (BMP) approach to the management of forest lands with significant landslide potential, and develop a better case history basis for evaluating the effectiveness of BMP in this area.

Recommendation 15. Modify culverts and other structures to permit the passage of juvenile and adult salmonids upstream and downstream at forest road-stream crossings.

Recommendations for or with other agencies

Recommendation 16. ODFW and ODF should develop a collaborative program of monitoring to quantify the linkages between parameters of ecosystem condition and wild salmonid recovery.

Recommendation 17. ODFW should complete "core area" designation for all wild salmonids in Oregon and identify high priority protection/restoration areas that are not covered by current "core area" designations. ODFW should work with the Oregon Plan Implementation Team in prioritizing habitat for enhanced levels of protection and/or restoration.

Recommendation 18. ODFW should include consideration of practices (forestry, agriculture, urban, other land uses) above and below core areas, as these may affect the conditions and processes critical to maintenance of core area function in forestry areas.

Recommendation 19. The Oregon Forest Research Laboratory (FRL), in collaboration with ODFW, should develop forest road-stream crossing strategies that facilitate the passage of large wood at road-stream crossings.

SECTION 1
INTRODUCTION

The forest lands in Oregon are an important part of the landscape used by wild salmonids. How these lands are managed is important in accomplishing the mission of the Oregon Plan for Salmon and Watersheds (Oregon Plan) and the goals of Oregon Executive Order 99-01. This Technical Report of the Independent Multidisciplinary Science Team (IMST) focuses on western Oregon forests and their management while noting, however, that all of the habitats used by wild salmonids are important. Non-forested environments are addressed in other projects of IMST.

Forested landscapes include both aquatic and terrestrial components. The aquatic components are critical to the survival of salmonids in Oregon, and they are strongly linked to the terrestrial components of these landscapes. This linkage has been recognized for a long time and has been prominent in the Oregon Forest Practices Act since its creation in 1972. The Oregon Forest Practices Act and its Administrative Rules were developed primarily to protect resource values, including water quality and, indirectly, habitat for salmonids. They were not specifically directed towards the recovery of wild salmonids, which is the mission of the Oregon Plan and the goal of Executive Order 99-01.

The Oregon Plan includes two approaches in forestry that together are intended to contribute to the mission of the Plan. These are the application of the Administrative Rules of the Oregon Forest Practices Act and the Measures related to forestry in the Oregon Plan. The focus of IMST on the forestry project is two-fold:

1. The scientific basis for the recovery of wild salmonids as it relates to the forests of Oregon, and

2. The Administrative Rules and the Measures in the Oregon Plan as they contribute to accomplishing the mission of the Oregon Plan.

History and Scope of the Project

The 1997 Memorandum of Agreement (MOA) between the National Marine Fisheries Service (NMFS) and the State of Oregon contemplated that Oregon forest practices would be adjusted to provide a high probability that aquatic habitat on Oregon forest lands would be protected and restored. Such adjustments were to be considered through a cooperative process with the Oregon Board of Forestry. Towards this end, the Oregon Department of Forestry (ODF) formed the MOA Committee to develop recommendations to the Board of Forestry by late fall of 1998. As part of this process, NMFS produced a draft proposal on February 17, 1998, concerning Oregon forest practices (NMFS 1998).

The IMST initiated the design of a review of forest practices (the forestry report) in the spring of 1998, with the intention of completing the project about the time the MOA Committee completed their work. Because of the legal challenges to the NMFS decision not to list the north coast coho, the work of the MOA committee was suspended. IMST also suspended work on the forestry report in order to complete work on the IMST predation and hatcheries projects.

Executive Order 99-01 redirected work to be done on Oregon's Forest Practices Act Rules, with recommendations for changes to be made to the Board of Forestry. IMST reestablished its forestry project in January 1999, adjusting it to the State's new relationship to NMFS and the expanded scope of the Oregon Plan.

The geographic scope of this Technical Report is the portion of Oregon forests that provide habitat for wild salmonids west of the crest of the Cascade Range and in the Siskiyou Mountains. Yet it also provides the fundamental concepts and relevant science questions and findings for a much broader area. Topically, the scope of the Report deals with riparian buffers, large wood, sedimentation from roads and landslides (but not harvesting or reforestation), and fish passage at road-stream crossings. Although other topics could be included, IMST considered these the most important to the recovery of wild salmonids.

This Report addresses some issues that are quite broad and involve substantial changes in policy. We expect these will take longer to resolve and the recommendations associated with them will take longer to implement. Some other issues are quite operational in scale and can be dealt with within current policy. The recommendations related to these issues may be more rapidly addressed.

This Report focuses on broad scientific issues and concepts. It is not a review of each of the individual administrative rules that are part of the Oregon Forest Practices Act (OFPA), or the measures that are part of the Oregon Plan. In some cases it does focus on specific rules or measures, but these are used primarily to illustrate examples. Lack of inclusion of a specific rule or measure does not imply either approval or rejection of it by IMST. The scientific direction provided by this Report can guide ODF staff (working with other panels of experts as needed) in formulating administrative rules for OFPA and measures for the Oregon Plan that are needed as part of accomplishing the recovery of depressed stocks of wild salmonids.

Organization of This Report

This is a long and complex report, reflecting the breadth and complexity of the issues involved. It is divided into six sections with an appendix. The following explanation of its organization is to help readers direct their attention to the elements that are of greatest interest. Figure 1 is a schematic representation of the report's organization.

Figure 1. Report Organization Flow Chart

Preface

↓

Introduction

↓

Concepts for the Recovery of Stocks of Wild Salmonids in Oregon that Involve Forests and Forestry

- Changing Views of Salmonids and Habitat
- Landscape Ecology

↓

Science Questions and Answers

1. What is the scientific basis for maintaining fish habitat/water quality in forested ecosystems with respect to riparian buffers, large wood, sedimentation, and fish passage at road-stream crossings?
2. Are current forest practices Rules and Measures with regard to riparian buffers, large wood, sedimentation, and fish passage adequate to achieve the mission of the Oregon Plan?
3. What strategies are needed in the management of forest resources to achieve the mission of the Oregon Plan?

↓

Conclusions and Implications for Policy

↓

Recommendations

- Recommendations for ODF
- Recommendations for other Agencies

Section I. Introduction

∃ The introduction provides the history and context for the report, and identifies the major science questions addressed by the report.

Section II. Concepts for the Recovery of Stocks of Wild Salmonids in Oregon that involve Forests and Forestry

∃ The recovery of wild salmonids in Oregon depends on more than the forested portion of the landscape of the state. The purpose of this section, however, is to address the specifics of recovery that are particularly relevant to forests and how they are managed.

∃ Landscape ecology — basic concepts. This is a review of fundamental concepts of ecology as they operate at the large landscape level. These concepts are central to the recovery of depressed stocks of salmonids in Oregon, regardless of the type of landscape. In this section, we focus on concepts in forest settings.

Section III. Science Questions and Answers

∃ This section includes the specific questions IMST addresses, and our answers to them.

Section IV. Conclusions and Implications for Policy

∃ This section draws the major conclusions from the answers to the science questions and addresses them in the context of their implications for policy. This section is at the interface between science and policy. It is meant to help those addressing policy to do so in ways that are as consistent as possible with what is known from science.

Section V. Recommendations

∃ These are the specific recommendations of the IMST.

Section VI. References

Appendix. Summary of the State of Knowledge

∃ Interactions between forests and forest practices as they affect water quality and aquatic habitat. This is a review of much (but not all) of the knowledge from the literature as it relates to the topic. This section is organized around four topics: salmonid habitat, riparian management, large wood, and sedimentation. It provides the technical background and many of the references for the answers to the science questions.

Science Questions

There are a great many science questions that could be part of this project. From these, we selected three broad questions, which IMST considers to be most important in accomplishing the mission of the Oregon Plan. These questions contain sub-elements in which more specific issues are addressed. We include the three broad questions here to provide direction in reading the balance of this report:

1. What is the scientific basis for maintaining fish habitat/water quality in forested ecosystems with respect to riparian buffers, large wood, sedimentation, and fish passage at road-stream crossings?

2. Are current forest practices Rules and Measures with regard to riparian buffers, large wood, sedimentation, and fish passage adequate to achieve the mission of the Oregon Plan?

3. What strategies are needed in the management of forest resources to achieve the mission of the Oregon Plan?

Resource Materials

The forestry area is challenging because of the large number of summary and analytical documents relevant to Oregon forests and forestry. These are the result of the regulatory framework and history of the State of Oregon, the development of the Northwest Forest Plan for federal forest properties (FEMAT 1993), and the proposal developed by NMFS (NMFS 1998) concerning modifications of the Oregon Forest Practices Act Administrative Rules.

Both Washington and California have been reviewing their forest practices in attempts to accomplish the recovery of salmonid stocks. These efforts produced two major reports in 1999 (California [SRP 1999] and Washington [DNR 1999]). While differing in terminology and specifics, both reports cover many of the same issues addressed in this report of the IMST.

In aggregate, the documents from these various efforts are voluminous. IMST was not able to review and comment on these documents in detail. In some cases, we comment on their particular findings, but note that our doing so is not the result of a thorough evaluation. Although these documents have both strengths and weaknesses, they generally provide a reasonable basis for considering the technical issues involved.

We have included additional documents in the reference section of this report (identified with an asterisk) which were not cited in the report. These documents, along with the cited material, provide the technical basis for guidance in matters relating to changes in forest practices as they affect salmonid habitat.

SECTION II
CONCEPTS FOR THE RECOVERY OF STOCKS OF WILD SALMONIDS IN OREGON THAT INVOLVE FORESTS AND FORESTRY

CHANGING VIEWS OF SALMONIDS AND HABITAT

Our understanding of what constitutes aquatic habitat for salmonids has changed considerably with time, as have the conditions of streams in the Pacific Northwest over the past 150 years. From early descriptions found in Army journals, diaries, and some technical reports, we can reconstruct a description of salmon habitat in streams before the mid-1850s. It is to these conditions that salmonids are adapted and to which their spatial-temporal patterns of habitat use have evolved (Sedell and Luchessa 1981). A review of the sources of historical information clearly demonstrates that most stream channels and salmon habitat were more complex than they are today (Sedell and Luchessa 1981; Sedell et al. 1988; Brenner 1991). Salmonid habitat is associated with structural elements such as large wood, which create complex channels with a diversity of micro and macro habitats from headwaters to the ocean (Swanson et al. 1976; Sedell et al. 1988). Large wood is an important part of the structure of the stream channel. It creates pools, regulates sediment storage and distribution, provides nutrients and substrate for aquatic insects, and creates pockets of cooler water (thermal refugia) in warm streams (Gregory et al. 1991; Sedell and Swanson 1984; Sedell et al. 1988; Bilby and Bisson 1998). But healthy salmon habitat is more than the physical presence of those structural elements at a given spot. Salmon habitat is also the processes that create, alter, and maintain those elements across whole watersheds (Naiman 1992).

Major changes in salmonid habitat began with the arrival of large numbers of Euro-American settlers to the Pacific Northwest during the mid-nineteenth century. To accommodate the economic growth of their communities through trade and other means, settlers began to significantly alter streams. Obstructions were removed from channels to facilitate the passage of boats (Sedell and Luchessa 1981). Large logs and root wads were also removed from rivers to accommodate the gillnet fishery for salmon.

Timber harvest intensified the impacts of development on stream channels. By the end of the 1880s, every river that could float a log during high flows was being used to transport them downstream to the mills (Cox 1974). In 1884, the first splash dams were built to augment the natural flow of rivers and permit log transport through most of the year (Beckman 1970). Before logs could be moved downstream from a dam, however, the main channel had to be cleared of all obstructions, including large wood and boulders, and all side channels and backwaters had to be blocked to keep the logs in the main stem. After the rivers were cleared of debris, continued logging from riparian zones removed trees that might eventually have replaced the large structural elements lost from streams.

By the turn of the century, many river channels had already been converted from their natural state of complex tangles of logs, side channels, and surrounding wetlands to unobstructed highways for boats, gillnets, and logs. Thus, when biologists began making the first habitat surveys in the 1920s and 1930s, they believed that channel complexity, including large pieces of wood or any kind of roughness in the stream channel, was not part of salmon habitat. This belief

stemmed partly from the highly altered state of rivers that existed at that time. When biologists began to focus their attention on stream habitat, this altered condition was viewed as the norm. In fact, some biologists equated streams to highways: “Just as automobiles need smooth roads to operate on, fish need clean unobstructed rivers and streams if they are to live, move and propagate” (Schoettler 1953). Although the removal of large logjams that completely blocked the migration of fishes was justified, the vision of a clean unobstructed stream led biologists to support the aggressive removal of large wood from the stream channel and the destruction of important structural elements of habitat.

The vision of clean, unobstructed river channels and simplified habitat that prevailed before 1970 was matched by an equally simplified view of how salmon used that habitat. This view was based on an overly simplified perception of the life history of salmonids—generic patterns of migration, spawning, and rearing that were assigned to salmon species and races. The main stem and lower reaches of watersheds, which had already been cleared for splash damming and transportation, were viewed as merely conduits to carry salmon smolts to the sea. In their degraded state that was probably the only function these streams were capable of carrying out.

Our understanding of what constitutes aquatic habitat for salmonids has changed considerably in the past 25 years. We now recognize that stream habitat for salmonids resemble those pre-1800 stream conditions and not the unobstructed “highways". Just as our concept of what constitutes healthy aquatic habitat has changed, so has our understanding of how the salmonids used that habitat. W. F. Thompson (1959) visualized salmon habitat as “a chain of favorable environments connected within a definite season and place, in such a way as to provide maximum survival.” He went on to state that a given watershed and population of salmon would be composed of bundles of several of these chains of favorable places.

Thompson’s model introduced three new ideas that have subsequently been elaborated on by others: First, healthy stream habitat is complex and diverse. Salmon, due to their extensive migration throughout the various stages of their life histories, utilize multiple segments of the stream, selecting differing habitat types during each life history stage. Therefore, there are several possible chains of favorable places or life history pathways (habitat types/location combinations for any particular species/stock) from headwaters to the ocean. A healthy population is capable of using multiple pathways through the freshwater habitat when available. Salmon have evolved diverse life histories in response to habitat diversity and complexity. Life history diversity has been identified in chinook salmon (Reimers 1973; Schluchter and Lichatowich 1977; Carl and Healey 1984), in pink salmon (Gharrett and Smoker 1993), and in coho salmon (Lestelle et al. 1993).

Second, the interaction between salmonids and their habitat has a space and time dimension. The same habitat may be used by successive waves of salmonids at different times or seasons or for different purposes (Mobrand et al. 1997). Third, salmonids and their habitat comprise a single coevolved unit that cannot be separated for management purposes. We cannot meaningfully think of salmonid life histories without considering the habitats those life histories require. Conversely, we cannot think of salmonid habitat without considering the life histories that make use of it. The fundamental management unit is the fish and its habitat (Healey and Prince 1995).

Each species and its resulting populations have evolved additional diversity in response to the diversity and complexity in the local habitat they encounter (Healey and Prince 1995).

The recovery of life history diversity is important to long-term productivity and persistence of a species. The salmonids' environment is continually fluctuating: droughts, floods, fires, and changing ocean conditions are continually testing the resiliency of each species. Life history diversity is the strategy salmonids have evolved for survival in a fluctuating environment (Thorpe 1994). This strategy is successful because it spreads the risk of mortality in a changing environment (Den Boer 1968). Wild salmonid restoration requires the restoration of habitat complexity to allow the expression of life history diversity (Healey and Prince 1995). This approach requires at a minimum a watershed scale mapping of life history on habitat and reconnection of the "chains" of habitats and life histories from headwaters to the ocean.

Our understanding of what constitutes salmonid habitat is still evolving. It is currently shifting from site-specific structures and ecological functions to landscape-scale processes that shape and maintain salmonid habitat. These changes in what we consider stream habitat and how salmonid use that habitat have important and sometimes overlooked implications. Restoration of habitat must consider the whole watershed and its ecological processes and it must consider the entire chain of habitats required for salmonid to complete their life histories. For example, habitat restoration that focuses on public land in the upper watersheds will only permit the restoration of a limited range of life histories. Habitats through the entire watershed must be addressed if salmonid are to recover their full range of life history diversity. To accommodate our increased understanding of salmon habitat, land-use practices including forestry, agriculture, and urban and industrial development must all be evaluated and examined from the perspective of the entire landscape.

LANDSCAPE ECOLOGY: BASIC CONCEPTS

> *The study of landscapes as a system expands the focus from predictions about exact future states to predictions about the relationships between large-scale properties of landscapes (i.e., climat,e topography, and channel networks) and the long-term behavior of aquatic systems.* Benda et al.1998, p. 261.

Salmonids have evolved to depend on many interrelated components of the terrestrial landscape during several phases in their life histories. Since streams are tightly linked to the terrestrial landscape they flow through, when reviewing land-use practices and their effects on salmonid habitat, it is necessary to analyze impacts on both adjacent and distant components of the landscape. Analysis and adjustment of management practices in riparian forests has received a lot of attention. However, considering the interrelated components of the entire landscape, a similar analysis and adjustment in management practices must occur in upslope forests throughout the watershed. As outlined by Schlosser (1991), the science of landscape ecology (Forman and Godron 1986) offers an opportunity for this type of analysis by using landscape dynamics to analyze impacts of land-use and strengthen land-use decisions.

Taking only a site-specific approach to regulate landscape-level processes can be counter-productive and in some cases catastrophic. For example, fire suppression has been very successful in reducing the number of wildfires per year, but the subsequent accumulation of fuels and changing forest structure have increased the risk of severe or catastrophic fires and/or insect and pathogen outbreaks. From a landscape perspective, periodic fires that burn the forest understory (underburns) are critical to reducing fuel loads and stand density. Without these more frequent—but less intense—burns, the fire regime has switched to less frequent but more intense fires. This example is echoed in many land-use decisions. Failure to account for unintended consequences at specific sites often leads to unintended and therefore unplanned for results at the landscape level.

Structure, function, and change

The structure and functional interactions of the components in a landscape, along with their dynamic nature, form the conceptual basis for landscape ecology. Structural components include the physical habitat occupied by salmonids along with the materials that maintain the integrity of that habitat. Functional interactions include the flows of energy (food) and materials within the ecosystem. As with any living organism, landscapes are dynamic: both structure and function change across time and space. Even with change, stability is ensured as long as ecosystem structure and function are maintained within certain bounds and all required components remain within the landscape. By examining the landscape components and how they interact to provide good salmonid habitat, we can make better land-use decisions.

Landscape patterns

Landscapes form distinctive patterns influenced by geological, climatic, and hydrological processes, vegetative responses, and land-use history. Understanding landscape patterns and how they influence function (physical, chemical, and biological interactions of ecosystems) is important when evaluating impacts of management on aquatic habitat. As summarized in Naiman and Bilby (1998), the width of a forested riparian zone and the extent of the forest influence are related to stream size and morphology. Small upslope streams—the primary downstream conduit for water, sediment, organic material, and nutrients—are heavily influenced by upland forests with very limited riparian vegetation. The channels are generally steep and filled with unsorted sediments, boulders, and wood that exceed the streams' transport capabilities. In contrast, midslope streams typically have a distinctive band of riparian vegetation whose width is determined by geomorphology, long-term hydraulic forces, terrestrial disturbance, and successional patterns. The stream channels are characterized by moderate to steep gradients, substrates of boulders, gravel, and sands, and frequent large wood jams. Their connection with the upslope forests is buffered by the presence of riparian vegetation and more frequent, less intense, hydrological disturbance.

Landscape patterns result from the dynamic interaction between structure and function, and provide the heterogeneous habitats required by the numerous life-stages and species of salmonids. Establishing a quantitative link between fish habitat requirements and landscape patterns and processes is key to designing land-use practices that work within the range of forest conditions that encourage the recovery of salmonids. However, it should be recognized that

providing habitat similar to historical levels must be coupled with the spatial arrangement and landscape dynamics allowing for function (Wimberly et al., in press).

Disturbance

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 lightening-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.

Wild salmonids in relation to landscape ecology

The National Research Council's (1996) recommendation is to view salmon from the broader, metapopulation perspective, as well as by local populations. Metapopulations are groups of local populations that are distributed across a heterogeneous landscape and genetically linked by dispersal of individuals (Hanski 1991; Hanski and Gilpin 1991). Metapopulation theory has only recently been used to interpret salmonid population structure and ecology and to formulate management strategies (Reiman and McIntyre 1993, 1995; Gresswell et al. 1994; Li et al. 1995; Mundy et al. 1995; Schlosser and Angemeier 1995; National Research Council 1996; Independent Scientific Group 1996). Since it is relatively new, its application to salmonid populations should be viewed as a hypothesis that must be tested through effective monitoring and evaluation (Independent Scientific Group 1996).

Metapopulation theory directly links populations to the natural disturbance regimes that shape landscape structure and function. The linkage is the balance between the extinction of local populations after severe habitat disturbance and the subsequent recolonization of previously disturbed habitats as they recover. This extinction-colonization balance depends on the dispersal of individuals and the connectivity between habitats occupied by populations making up the

metapopulation. If the frequency of disturbance—whether human caused or natural—that degrades a species' habitat exceeds its ability to maintain a balance between extinction and recolonization, the individual populations and eventually the entire metapopulation will go extinct.

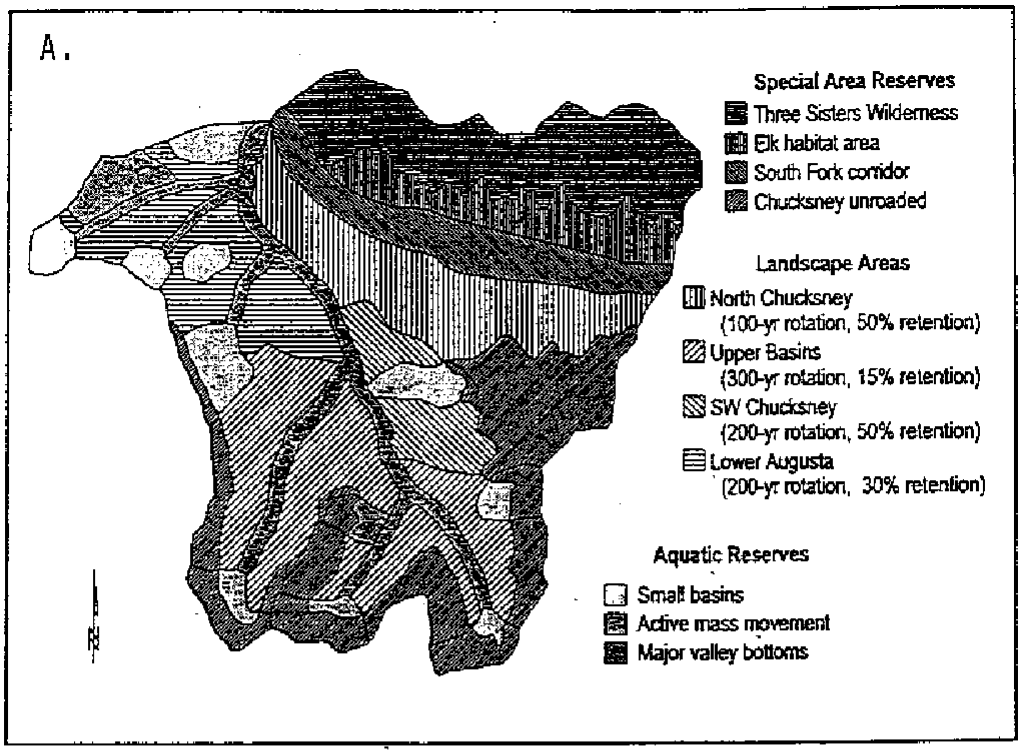
Several models of metapopulation structure have been presented (e.g., Schlosser and Angermeier 1995), but the core-satellite model appears to describe the structure of Pacific salmon metapopulations (Li et al. 1995; Schlosser and Angermeier 1995; Independent Science Group 1996). Core populations are large, usually occupying extensive and productive habitats; under natural conditions, the core population is expected to persist indefinitely. Satellite populations often occupy marginal habitat. Their abundance may fluctuate widely in response to changes in climate, and they may go extinct after severe disturbance events. Dispersal of salmon from a large core population will colonize vacant habitat, reestablishing satellite populations and generally minimizing the possibility of total extinction of the metapopulation (Harrison 1994). If core areas identified in the Oregon Plan were associated with core populations, then it would be critical to protect those habitats to prevent the extinction of the metapopulation and ensure the possibility of recovery.

A LANDSCAPE APPROACH

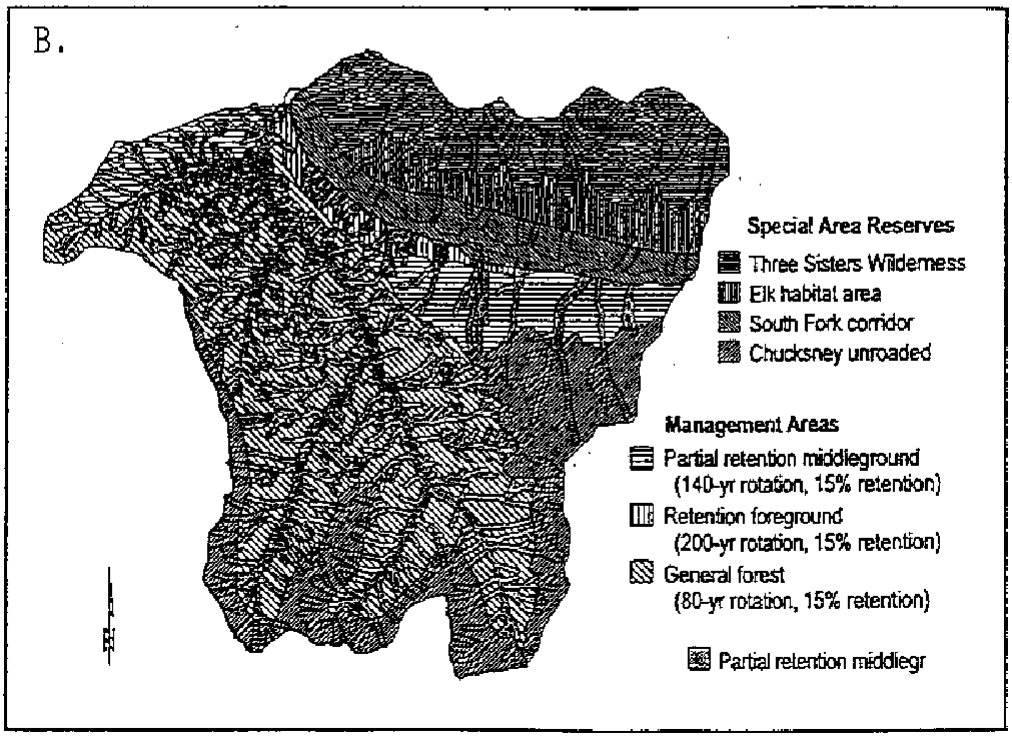
IMST believes the principles of landscape ecology should be used in managing salmonid habitat at both the site-specific and landscape level. When concepts of landscape ecology are applied to forest land-management decisions (throughout the forested watershed), the focus shifts from individual stream reaches or habitat components to the dynamics of landscape patterns and processes. Using historic patterns as a guide, a link between fish habitat requirements and landscape patterns and processes can be established. Currently, OFPA riparian buffer strategies are applied uniformly across the landscape. But a landscape strategy emulates disturbance patterns in both the upslope and riparian areas.

The Augustus Creek Study (Willamette National Forest) provides a useful example to illustrate what we mean by managing to better emulate natural disturbance patterns (Cissel et al. 1998). This study produced a landscape plan based on historical fire regimes. Figure 2 contrasts the land use allocations based on historic disturbance (A) and the Interim (Federal) Northwest Forest Plan (B). In (A), aquatic habitats include areas of both late-successional forest and younger forests, creating more diversity, resulting in higher productivity. In (B), use of a riparian reserve network provides for some functions, but it lacks the connection to the upslope forests, is homogenous, and does not emulate historic conditions.

At the larger landscape scale, there would be an aggregation of basins like the Augustus Creek study area. In the absence of a major natural disturbance, management would proceed as "planned" in all the basins. When a major disturbance (i.e., debris flow, fire) occurs in one of the basins and salmon habitat is negatively impacted, then management practices in an adjacent, less impacted basin may need to change.



Management categories for the Augusta Creek Landscape Plan.



Management areas for the Augusta Creek Interim Plan.

Figure 2. Contrasting land use allocations for the Augusta Creek Basin. A. represents landscape areas based on historic disturbances. B. represents management areas based on the interim (Federal) Northwest Forest Plan.

The landscape approach will be quite difficult to implement because it will require that we think and act in some different ways. It will require a level of collaboration that will be challenging

- *Philosophically* – Some of the "decision space" and accountability we have historically held closely will need to be shared more widely.
- *Legally* – Some existing laws and policies make collaboration at this level impossible, difficult or at least unattractive.
- *Practically* – How can it be done at the practical operational level?

The landscape approach is not something that can begin immediately, or be implemented uniformly, or that will yield results immediately.

- It will take time to (a) develop the policy framework that makes it possible and attractive, (b) improve the scientific base of understanding on which it rests, (c) refine the tools and techniques that are needed for assessment, planning, monitoring, and analysis, and (d) educate the various publics to the role this approach can play in natural resources management.
- Implementation will not be possible everywhere. For instance, there may be insurmountable policy barriers between actions at the private/state and federal levels, or there may be no feasible way to include many of the small woodland owners.
- It will take time for this approach to yield clearly discernable results in salmonid recovery because of the many factors (beyond the forest) that are involved, and the period of time it will take the landscape to respond and reflect these different approaches to practice. Monitoring of ecosystem and fish responses are essential.

Despite these challenges, IMST believes it is important to start, and do what can be done where it is possible. Smaller scale efforts (for instance in the ODF Northwest Forest Plan Area) may be a useful initial scale. This could be treated as a trial effort, in which techniques are developed and refined. While not a replicated experiment in the traditional sense, it is a life-scale case history experiment from which a great deal can be learned.

SECTION III
SCIENCE QUESTIONS AND ANSWERS

Question 1. What is the scientific basis for maintaining fish habitat/water quality in forested ecosystems with respect to riparian buffers, large wood, sedimentation, and fish passages at road-stream crossings?

A. Riparian Buffers

(1.) Riparian buffers as a strategy.

Limiting forest management practices adjacent to aquatic areas is the most common site-specific strategy applied on forested lands. There is a large body of scientific literature on the riparian buffer widths required to retain various aquatic functions. However, there is little discussion

about the scientific basis for riparian buffers as a landscape structure, particularly, their resiliency and role in maintaining landscape-level processes. Riparian vegetation often differs from upslope vegetation because its environmental conditions, disturbance histories, and successional patterns are distinctive, especially on low-gradient higher-order streams (Pabst and Spies 1998). When riparian protection strategies have been designed on the basis of buffer width, there has been little consideration of the interaction between riparian and upslope forests or the historic patterns created by riparian forests and their role in maintaining ecosystem heterogeneity. Although riparian buffer strips have been found to be sufficient for maintaining many physical structures and processes, this is not sufficient. Aquatic systems include a unique blend of both physical and biological components that interact with historic and current disturbance (Beschta 1997).

Recommended riparian buffer width should vary according to the ecosystem function under consideration, as well as the attributes of the ecosystem. For example, a relatively narrow strip of vegetation may provide shade, but maintaining relative humidity in the riparian area may require a buffer in excess of 100 m (Dong et al. 1998). Currently, most measurements of changing riparian and aquatic function, as influenced by buffer width, are made on forested buffers adjacent to cutover forests or young regenerating stands (Hibbs and Giordano 1996; Brosofske et al. 1997; Dong et al. 1998). This is quite different than comparing a riparian forest with an adjacent upslope forest of similar age or older.

Since the current riparian strategies on forested lands have not been in place long enough for long-term monitoring, a look at historic conditions is the best indication of future success in restoring stocks of wild salmonids. Historically, the Coast Range disturbance regime was dominated by frequent storms and infrequent but intense fires (Benda et al. 1998). From this we would expect to find a heterogeneous mix of riparian and upslope forests across a watershed. In a given basin, the riparian forests contrasted with upslope forests could be younger, older, or the same age, and could vary in their density.

The current regulatory framework has an implicit goal of maintaining older conifer forests with varying tree densities along the stream, surrounded by younger conifer forests in the upslope. In addition, current rules are based on the attainment of old forest structure, as represented by 120-year-old forests. The frequency of disturbance in riparian forests is highly variable. Fire return intervals of 300 years and/or 50-year flood events created a dynamic heterogenous mixture of young and very old forests. The remnants of these old conifer forests are represented by the large stumps found adjacent to many streams. The current strategy, although functional in the short-term, will not create a landscape pattern based on historic disturbance. Therefore, it would not be based on our best understanding of ecosystem structure and function. The riparian buffer approach creates a sinuous, sharply demarcated landscape pattern that has a limited historical basis.

Riparian management zones are thus being defined by management needs, and not in accordance with natural processes and the maintenance of riparian biological and physical functions. We conclude that in the long term, riparian buffer strategies, as a single landscape feature with sharp upslope demarcations, will not provide sufficient protection for the recovery of salmonids.

Riparian buffers as a strategy.

On the basis of scientific evidence, we conclude that managing riparian areas differently than upslope areas as a strategy for protecting fish habitat is scientifically valid only if done with the goal of maintaining the dynamics of landscape structure and function. Riparian buffer strategies, as a single landscape feature with sharp upslope demarcations are not consistent with historic pattern.

(2.) Riparian buffer management based on stream size.

As outlined in the appendix of this report, stream size impacts aquatic structure and function. Smaller streams in upper reaches transport material such as large wood down into lower, more productive reaches. Depending on the morphological conditions of the stream, transport is either in small steady flows or in large pulses associated with floods. Larger streams in lower gradient portions of the watershed are areas of deposition and organic material processing, making them some of the most productive reaches for some salmonids.

Floodplain development is also influenced by stream size. Floodplains are geomorphic surfaces created and shaped by alluvial processes during floods. These depositional surfaces are created by the stream and are part of the stream channel. These riverine surfaces then form the templates for floodplain forest development. Vegetated floodplains are stabilized by rooting and are lateral refuges of lower velocity and structural complexity for fish. When vegetated floodplain refuges are available, flood disturbances potentially provide many benefits, such as pool formation, riffle deposition, complex wood accumulation, sediment flushing from gravels, and exchange of food between terrestrial and aquatic ecosystems. Riparian protection for the floodplain is needed for it to perform these functions.

Given the distinctive differences between stream function based on size, we conclude it is scientifically sound to vary riparian widths with stream size. On a landscape basis, care should be taken to maintain a variety of forest types and ages on all stream reaches, including small and intermittent streams, and in the floodplain.

Riparian buffer management based on stream size.

Because stream size affects aquatic structure and function, it is scientifically sound to vary riparian widths with stream size. On a landscape basis, care should be taken to maintain a variety of forest types and ages on all stream reaches, including small and intermittent streams, and in the floodplain.

(3.) Riparian buffer management based on fish presence.

Non-game fish and other aquatic organisms play a role in the functioning of stream systems locally, and contribute to downstream processes. In addition, distribution of salmonids will change as populations adjust to dynamic landscape and ocean conditions. Therefore, unlike stream size, the presence or absence of game fish is not a scientifically sound basis for managing riparian buffers.

Riparian buffer management based on fish presence. There is not a scientifically sound basis for managing riparian buffers based on the presence or absence of game fish.

Conclusion

Overall, the current strategy of riparian buffers does not emulate historic conditions at the landscape level. Although some strategy of buffering is likely to be necessary, even with landscape level management, we believe it should be much different than the highly prescriptive approach reflected in current OFPA Rules.

B. Large Wood

The scientific literature on the importance of large wood to aquatic habitat is considerable and continues to expand (Spence et al. 1996; Bilby and Bisson 1998). It provides a clear scientific basis for the need to manage forest practices to ensure a continuous supply of large wood to the aquatic habitat. The specific level of large wood needed to bring about recovery of listed salmonids is still uncertain, however.

The scientific basis for the need to manage large wood and the current management strategies come from three sources. *Research* into recruitment and function of large wood in aquatic habitats has contributed to the development of management strategies. *Stream surveys* give the status of large wood in Oregon's streams relative to current benchmarks. Finally, *historical reconstruction* of aquatic habitats provides important information on the volume of wood in stream channels at the time of Euro-American settlement.

(1). Functions of large wood.

The literature on the importance of large wood on the structure of stream habitat was recently reviewed in Spence et al. (1996) and Bilby and Bisson (1998). Large wood accounts for much of the pool formation in streams draining forestland, and pools are the preferred rearing habitat for coho and other salmonids in Oregon's coastal streams (Nickelson et al. 1992). Other functions of large wood include (a) trapping and regulating the flow of sediment, (b) providing substrate and nutrients to the aquatic food web, (c) creating complex patterns of hydrologic flow, (d) keeping salmon carcasses in the stream (their nutrients can be an important part of the food web), and (e) providing thermal refugia.

Functions of large wood.

Large wood is critical to the proper functioning and condition of aquatic systems, and it is essential in the recovery of wild salmonids in areas where it existed historically.

(2.) The status of large wood in streams and the landscape.

Historical reconstruction of aquatic habitats clearly shows that large wood in the stream channel was a major feature of Oregon's watersheds. Prior to the early 1800s, Oregon's coastal rivers contained a large volume of wood that created complex habitat structure, including large pools, backwaters, and associated wetlands (Swanson et al. 1976, Sedell and Luchessa 1981, Sedell et al. 1988, Brenner 1991, Brenner and Sedell (1994). It was this condition—habitat and channel complexity imparted by significant volumes of large wood—to which salmonids adapted and to which their spatial and temporal patterns of habitat use evolved (Sedell and Luchessa 1981). In addition, portions of the forested landscape were dominated by extensive older forests, large snags, and the associated accumulation of large downed wood (Teensma et al. 1991).

Shortly after the arrival of the first Euro-American settlers to the Pacific Northwest, stream channels were radically altered. Not only was large wood removed from the channel to facilitate the use of rivers for transportation, potential wood replacements were harvested from riparian and upslope forests. This altered state of inner channels was maintained by continued logging in the riparian zone and the problem was compounded by removal of wood from streams into the 1970s.

As part of the Oregon Plan and other efforts, extensive surveys of large wood in forest streams are being conducted in Oregon's coastal rivers. Surveys of about 2,000 stream- miles on non-Federal lands show there are fewer pieces of large wood in the stream channels than specified in the current Oregon benchmarks. About 40 percent of the stream-miles surveyed are considered adequate or good with regard to the presence of large wood, but 60 percent are considered poor. Probably more important to the long-term recovery of wild salmonids is the finding that 94 percent of the riparian areas (a potential source of future large wood in streams) are themselves ranked as poor with regard to the presence of large conifers (ODF 1999).

We conclude that Oregon streams and adjacent forests currently contain much lower levels of larger wood than they did historically, and under the current management practices, the potential for recruitment will not result in its replenishment.

The status of large wood in streams and the landscape.

Oregon streams currently contain much lower levels of larger wood than they did historically.

(3.) Managing for recruitment of large wood.

The riparian zone is an important source for large wood. The trees that fall into the stream from the riparian zone come predominantly from within 98 feet of the channel edge. However, large wood can also be recruited from as far as 165 feet from the stream bank. A riparian buffer consisting of taller older trees contributes large wood from greater distances than do younger forests with shorter trees (McDade et al. 1990; Van Sickle and Gregory 1990; Fetherston et al. 1995). In unconstrained stream reaches, large wood from the floodplain also can eventually reach the stream because of floods or lateral migration of the stream channel (Bilby and Bisson 1998).

Upslope areas adjacent to headwater streams are also an important source of large wood. In intermediate-sized stream channels, large wood may originate on the slope above a headwater tributary and be delivered to the lower stream reaches through a debris torrent. First- and second-order headwater streams provide a large amount of the wood that forms habitat in larger channels downstream (Prichard et al. 1998).

We conclude that both riparian management areas and unstable upslope areas are important for the recruitment of large wood to streams in the future. While harvesting has reduced the amount of large wood available for recruitment, it must also be recognized that the level of mortality in forested systems has also been reduced. Fire suppression, limitations on pathogens, and thinning have reduced the production of snags on the landscape. Therefore, even if old forests are allowed to develop, management will have to also facilitate the recruitment of snags.

Managing for recruitment of large wood.

Both riparian management areas and unstable upslope areas are important for the recruitment of large wood to streams.

Conclusion

The current status of large wood in Oregon streams is far outside the historic range and we believe this is seriously hindering the recovery of wild salmonids. Management strategies that more nearly emulate the historic range of condition are possible and can contribute to the attainment of the mission of the Oregon Plan.

C. Sedimentation

Sediment occurs naturally in forested stream systems. Although this is part of the natural disturbance regime for this region, the processes of erosion have accelerated with the increase in forest management activities.

Fine sediment is a natural part of stream systems, as are the coarser elements of stream structure, such as large wood, boulders, and gravel. The trick in achieving quality habitat for salmonids is to keep these various elements in balance with one another. There is no definitive scientifically

based "tolerance" for fine sediments, but in the absence of introductions of boulders, large wood, and gravel, it is prudent to minimize the introduction of fine sediment.

(1.) Managing chronic sedimentation from roads at the site level.

Scientific investigation and analysis have produced a sound scientific basis for site-level management of the production of road-related sediment and its movement to streams. The volume of literature is such that a point-by-point analysis of it by IMST is impractical, and can be done by ODF staff. Briefly:
Fine sediment production increases with road construction, use, and maintenance. The scientific principles that govern sedimentation are well documented in the literature:

- Actions that decrease the size of soil particles increase the amount of fine material available for water transport. An example is the production of fine particles from the mechanical action of vehicular traffic on forest roads.
- Actions that expose the soil surface or disturb road or ditch surfaces increase erosion potential. Some examples include excavating road cuts, clearing vegetation from roadsides and ditches, and scraping road surfaces with road graders or other bladed vehicles.

Once fine particles have been produced, they are available for transport to streams where they can impact the quality of salmonid habitat. The key issues concern the effectiveness of road-drainage systems and the dispersal of ditch-drain water.

We accept that drainage from road ditches into streams cannot be completely eliminated, but we believe that it can be greatly reduced. Dispersing road drainage water onto stable slopes rather than into channels will minimize the movement of sediment from roads to streams. Science has shown that undisturbed forest floor has a high infiltration capacity. Although it has not been explicitly tested, logic indicates that sediment transported to such areas will be trapped in the soil profile and will be less likely to enter the stream.

The volume and velocity of the water determine its erosive and sediment transport power. Crossroad drainage culverts are used to limit the distance over which the volume of road-drainage water can accumulate. On steeper roads, the distance between crossroad drainage culverts is decreased to prevent the accumulation of large volumes of rapidly flowing water. Empirically derived guidelines for crossroad drainage systems have been part of the literature for many years, but often have not been rigorously followed. Systematic validation of these guidelines should be incorporated into the monitoring program to determine their adequacy. In the meantime, however, implementation of the guidelines should reduce the introduction of chronic sediment from roads.

Managing chronic sedimentation from roads at the site level.

Fine sediment production increases with road construction, use and maintenance. There is a strong, scientifically sound basis for site-level management of sediment production and movement to streams.

Some reports argue that chronic sediment particles from roads are too small to be entrained in gravel, and therefore have little impact on salmonid production. Although this is likely true in the sense of salmonid egg survival and emergence of fry, we find this view too narrow. More suspended sediment will deposited in areas where water velocity is slower, and chronic sediment production and transport will occur even during periods of lower stream flow. The result will be increased sediment deposition in pools, backwaters, and other areas critical for rearing. In addition, suspended sediment reduces the transmission of light, which reduces the primary productivity of the stream. Suspended sediment also decreases visibility, which may alter foraging and territoriality behaviors and perhaps the ability to evade predation.

We conclude that chronic sediment production can be managed and mitigated and that there is a scientifically valid basis for doing so. The technical literature (some of which is reviewed in the appendix) provides the scientific basis for this. Examples include the use of rock to armor a road surface, reduced tire pressure, revegetation of exposed soil surfaces, and retention of vegetation on roadsides. Technical specialists can use the literature to develop specific practices for reducing chronic sediment production from roads. Minimizing the amount of road drainage water that flows directly into streams and channels can reduce the movement of fine sediment from roads to streams. This can be accomplished by decreasing the distance between crossroad drainage structure and by diverting more road drainage water onto stable slopes.

(2.) Managing chronic sedimentation from roads at the landscape level.

There is a sound scientific basis for the management of chronic sediment production and transport to streams at the site level, but there has been less analysis at the landscape level. There are relationships in the literature showing the quantity of sediment production as a function of the number of roads in a watershed. In general these relationships suggest that sedimentation increases with road density, but as a practical matter these are empirical or intuitive relationships and are not the result of critical experimentation. There are many site-specific factors that influence these relationships and their empirical nature makes it difficult to apply them (quantitatively) to other areas.

We conclude 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.

Managing chronic sedimentation from roads at the landscape level.

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.

(3.) Managing episodic road failure.

The literature on sedimentation from roads is dominated by the impact of catastrophic road failures. The topic is complicated by the episodic nature of storms and changing road construction and maintenance standards. Among the various operations that occur on forest

lands, the scientific base of knowledge and experience over the past two decades have increased the most with respect to road construction and maintenance. This increase in knowledge provides a sound basis for the development of guidelines and standards that will greatly reduce sedimentation from road failures. The base of information has been summarized effectively in presentations to ODF and in the issue-analysis documents prepared by the Department. Technical staff (in the Department and elsewhere) can use this information and these documents in refining rules and measures to help accomplish the mission of the Oregon Plan.

Road-failure related sedimentation is best addressed in three parts: 1) location, 2) design and construction, and 3) maintenance and abandonment.

Road Location

Our knowledge of the relationships between geology, soils, topography, and climate is well developed and scientifically sound. Much of the improvement in road location standards over the past few decades have come from this knowledge. Continued adherence to these best management practices (BMP) will result in a markedly fewer failures of new roads than of so-called "legacy" or "old" roads (meaning roads not covered by OFPA, often those constructed before current rules were in force). The literature and experience support the value of using BMP to locate roads such that they

- minimize stream and channel crossings
- do not cross wetlands or areas with a high likelihood of slope failure

Road design and construction methods

Current road design and construction methods are well documented in the literature and are well reflected in ODF documents. The scientific and engineering principles on which they rest are sound.

Road Maintenance and Retirement

Road location, design, and construction establish the limits of the potential impact of a road on salmonid habitat. Maintenance (short- and long-term) often determines the degree to which the potential impact (for protection or damage) is achieved. Scientific and technical analyses show that roads not constructed to current standards are involved in a disproportionately large number of road-related slope failures. We believe that a systematic program of road retirement and stabilization of hazardous sites can minimize both the catastrophic and chronic sources of sediment from roads no longer in active use.

The strategies for road retirement and stabilization have evolved from experience and from adaptation of the principles associated with road maintenance. Specifically:

- remove culverts and stream crossings that are more susceptible to catastrophic failure during heavy storms
- prevent channelization on road surfaces
- stabilize fills
- limit access
- encourage revegetation

These strategies have not been scientifically tested for effectiveness, but they have a sound theoretical basis. A more systematic basis for judging the effectiveness of various road retirement strategies can be developed through case history analysis and monitoring.

We conclude that the scientific and technical basis for what is needed in road maintenance and retirement is well developed and known. Refinements in this knowledge can occur through the monitoring and event analysis programs that are already part of ODF programs.

Managing episodic road failure.

The scientific and technical basis for what is needed in road maintenance and retirement is well developed and known. Refinements can occur through the monitoring and event analysis programs that are already part of ODF programs.

(4.) Managing slope failure and the movement of material to the stream system.

Landslides occur in both disturbed and relatively undisturbed forests. Available evidence from central and northwestern Oregon indicates that forest management activities increase the frequency of landslides within a period of one to two decades after disturbance. Results from the ODF study (ODF 1998b) are consistent with the suggestion that harvesting may shift the timing of occurrence of slope failure and concentrate it within the two decades after harvest. Although a provocative idea, we do not consider this a rigorous test, and caution against adoption of this as a paradigm without further testing. We do not consider it an adequate technical basis for policy formulation.

Slope stability problems need to be considered at the site and the landscape level. The logic for managing slope failure is (a) to identify sites where significantly elevated risks of slope failure exist, and (b) to moderate or limit management activities believed to increase the occurrence of slope failure. The ability to characterize (or predict) the risk of slope failure is not uniform across the scale of risk. At the extremes of the risk of slope failure, the ability to predict accurately is greater, e.g., for a given set of geological soil and climatic conditions, shallow slopes are unlikely to fail but very steep slopes are more likely to fail. Prediction of slope failure must be done in the face of uncertainty about weather patterns over the first two decades after disturbance.

The ability to predict slope failure is limited by

- the difficulty of accurately predicting inherent slope stability, except at the extremes of condition (including steepness)
- limited knowledge of how a given management tactic might interact to increase or decrease inherent slope stability, and
- inability to predict pattern of extreme weather events over a subsequent period of one or two decades.

These points apply at both the site and the landscape level, but some degree of averaging occurs at larger scales, with an increase in the accuracy with which slope failure can be predicted (at the

landscape level). The consequence is a greater ability to "manage" in the face of slope failure at the landscape level. The concepts for this are illustrated in Figures 3 and 4 (Benda et al. 1998).

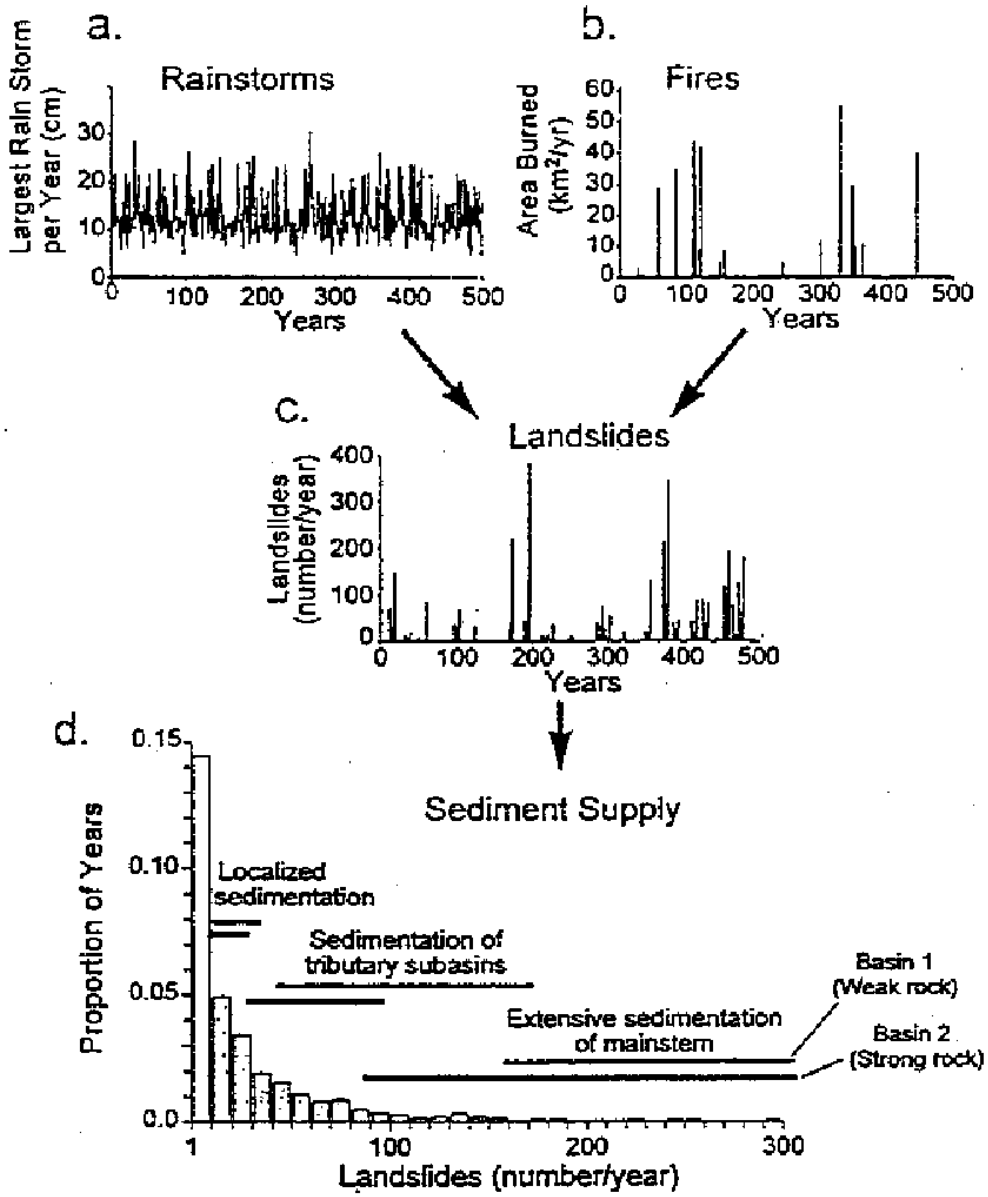


Figure 3. A sequence of rainstorms (a) and fires (b) generates a sequence of landscapes within a basin (c) which results in an intermittent sequence of sediment delivery to the channel system. The time sequence of sediment supply is represented as a distribution (d) indicating how likely various magnitudes of sedimentation occur. Channel response depends on the size distribution and durability of the sediment delivered. (From Benda et al. 1998, p. 275.)

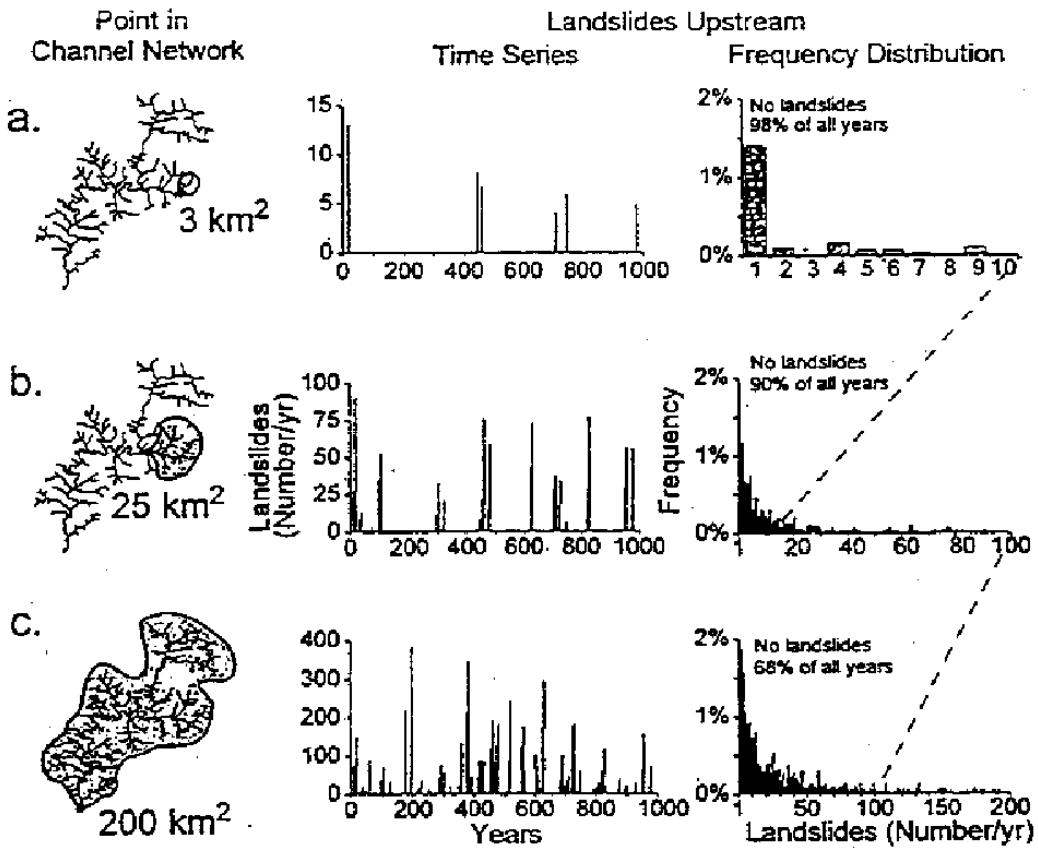


Figure 4. A 1000-year simulation of landslides in a 200-km^2 basin in the Oregon Coast Range indicates that the likelihood of landslides and associated sediment and wood delivery to the channel system increases with increasing basin area. (a) a 3-km^2 headwater basin experiences infrequent landslides. (b) a 25-km^2 tributary subbasin contains a greater total number of potential landslide sites and is more likely to include a fire: hence, landslides occur more frequently and in greater numbers within this larger area. (c) Numerous subbasins and a vary large number of potential landslide sites are contained within the entire 200 km^2 basin. Landslides occur somewhere within the basin a third of all years. On rare occasions, when large fires are followed by intense storms, well over 100 landslides can occur within the basin in a single year. (From Benda et al. 1998, p. 278.)

Although the ideas in these figures are conceptually strong, they must be validated through monitoring and analysis based on the continued use of BMP. There is some risk in continuing the present approach (because in some cases slope failures will be underestimated), but the long-term gain in benefit for management across large areas may be worth the risk. This is a policy question.

Not all landslides result in transport of material (debris torrents) to streams. When they do, the consequences vary. In some cases, stream channels and riparian zones have been completely scoured, leaving the system in a highly unproductive state, at least over the near future. In other cases, landslides have significantly enhanced fish habitat by adding structural complexity and

spawning materials or creating off-channel refugia. As with most other elements of resource management, there is no single simple solution.
Although specific evidence is limited, we believe that functional riparian zones may be an important factor in diminishing the adverse effects of debris torrents. Riparian zones can contribute large wood and other debris to the torrent, maintaining some balance between the amounts of sediment, gravel, boulders, and large wood. This idea requires validation through monitoring and analysis of BMP. It may be premature as a basis for policy formulation, but we believe it is conceptually correct.

We conclude that the geology, engineering, and geotechnical concepts for addressing slope failure are reasonably well developed and are described in Benda et al. (1998), Swanson et al. (1987), and in ODF (1998b). We conclude, however, that except where inherent slope stability is at its extremes (either very great or very low), regulatory or voluntary measures have little certainty of reducing sedimentation from non-road-related slope failure at the site level.

Managing slope failures and the movement of material to 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.

D. Fish Passage at Road-Stream Crossings

Road/stream crossings impact salmonids through blockage of access to upstream habitat, as sources of chronic sediment input, and as sites of catastrophic failure and subsequent debris torrents. Fish passage at forest road crossings is reported to be a major factor in loss of habitat suitable for fish (ODF 1998a). Studies in Washington documented loss of coho summer rearing habitat from culverts at 13 percent of the total decrease in habitat. This decrease was considered to be greater than the combined effect of all other forest management activity related causes (ODF 1998a). Conroy (1997), noted that as many as 75 percent of culverts in given forested drainages in Washington were either outright blockages or impediments to fish passage. The technical basis for solution of this aspect of the habitat problem is well established. Strategies include minimizing the numbers of such crossings, reducing the erodability of exposed soil surfaces, making them stable during periods of high water, and providing for upstream and downstream fish passage.

Specific best management practices must be adopted on a site-by-site basis. A set of road-stream crossing guidelines have been developed by ODFW (ODFW 1996). The guidelines were adopted in 1996–1997 by memorandum of agreement among several state agencies, including ODF and ODFW. These are based on science, although specific design elements are the result of extrapolation from scientific principles and often are not the result of explicit experimentation.

Fish Passage at Road-Stream Crossings

The ODFW guidelines are believed to be scientifically sound (although not thoroughly tested) and provide an adequate basis for managing fish passage at road-stream crossings.

Question 2. Are current forest practices Rules and Measures with regard to riparian buffers, large wood, sedimentation, and fish passage adequate to achieve the mission of the Oregon Plan?

The current OFPA Rules and Measures in the Oregon Plan are predominantly prescriptive and site specific, and deal with specific actions. Our analysis of the scientific basis for management (see question 1) provides the basis for an analysis of the adequacy of the Rules and Measures. While this report is not a review of the Rules and Measures, we provide the following evaluation of adequacy to highlight some examples.

Riparian Buffers as a Strategy

The current Rules will result in buffers with characteristics that are quite different from adjacent upslope forests, resulting in sharp demarcations and a landscape condition that does not emulate the historic range of conditions.

Riparian buffer management based on stream size

Current OFPA rules correctly allow for varying buffer width and stand density based on stream size, with smaller streams receiving less protection compared to larger streams.

Riparian buffer management based on fish presence

The OFPA Rules and the Measures outlined in the Oregon Plan are not scientifically sound for the recovery of wild salmonids because they only consider game fish and do not adequately address the contribution of non-fish bearing streams to many downstream processes.

Riparian buffers on floodplains

OFPA rules for riparian management provide no protection for floodplains outside the RMA. This means that floods in floodplain reaches may extend beyond the RMA and increase the risk of erosion and channel change on the outer margins of floodplains. These areas will not provide the ecological functions associated with stream riparian systems.

Functions of large wood

OFPA Rules and the Measures of the Oregon Plan acknowledge the importance of large wood in aquatic systems.

Managing for the recruitment of large wood

Within existing RMAs, the width is adequate for recruitment of large wood but the density of large conifers is not, especially on small streams. RMA protection must be extended to stream reaches not currently included and trees must be retained on unstable upslope to increase the potential for large wood recruitment.

Managing chronic sedimentation from roads

OFPA Rules provide an adequate basis for addressing several of the chronic sources of sediment from roads at the site level. Specific attention in implementation needs to be given to enforcement with respect to road drainage directly into channels, cross-road drainage frequency, road surfacing, tire pressure, wet season operations, revegetation of exposed surfaces, and vegetation retention on roadsides. The Rules do little to address roads at the landscape level except to encourage strategies that reduce the construction of new roads.

Managing episodic road failure

Current road design and construction methods are scientifically sound and well documented in the technical and operational literature, providing a sound basis for OFPA Rules and Measures in the Oregon Plan. The Rules and Measures are adequate in this regard, with attention to implementation.

Managing road maintenance and abandonment

OFPA Rules provide an adequate basis for regulation of road maintenance. In the implementation of the Rules, it is important to retain culvert design discharge capacity. OFPA Rules require that culvert replacements conform to current standards, including providing for passage of 50-year flow events. However, this requires complex judgements on the part of operators and landowners, often under emergency conditions. The challenge is to ensure the information necessary for making the right decision is readily available, and that appropriate regulatory oversight is provided.

Managing slope failure and the movement of material to the stream system

Continued use of BMP as permitted under the Rules is appropriate, but it needs to be combined with monitoring and case history analysis to provide a better basis for management of slope failure in the future.

Fish passage at road-stream crossings

Pending better information and the results of monitoring, the ODFW guidelines provide a sound basis for managing fish passages at road-stream crossings.

The changes noted above, combined with their effective implementation, will improve the effectiveness of site-specific Rules and Measures. We conclude, however, that site specific rules alone, even with these changes, will not result in the emulation of the range of historic condition

at the landscape level needed for salmonid recovery. The problems with site specific rules include the following:

A. Each site or action is treated as if it is independent of any other. This ignores cumulative effects and it ignores other related processes occurring in other parts of the landscape.

Cumulative effects are often difficult to explicitly measure at the landscape level, but they are consistent with logic. For example, roads produce fine sediment and culverts and stream crossings modify the movement of water, sediment, and large wood. Although difficult to demonstrate at the watershed level, logically, the production of fine sediment increases with the length of a road system and number of stream crossings, and the movement of water, sediment, and large wood is increasingly influenced as the number of culverts and stream crossings increase.

The relationships between riparian and upslope areas provide examples where current rules ignore related processes occurring in other portions of the landscape. As an example, current OFPA riparian rules relating to large wood recruitment are based on achieving 58 to 92 percent of the large wood that results from a mature forest riparian zone. Relying primarily on recruitment from riparian buffers, watersheds that historically had significant contributions of large wood from upslope positions have much lower levels of large wood recruitment than the historic range of condition. ODF acknowledges that currently the rules do not address the issue of potential large wood inputs from upslope sources.

As a second example, the riparian forest is treated as distinct from the upslope forest. The result of current riparian protection is a strip of mature forest between the upslope forest and the stream. Since the upslope forest is managed primarily for harvest of trees, and the riparian forest is managed to develop into mature forest for stream protection, larger demarcations between the two forest types could/will develop. This will almost certainly result in a riparian forest structure and function (perhaps an upslope as well) that is different from historic conditions (Murphy 1995). Landscape level goals for riparian and upslope conditions must be developed and implemented to allow for the full complement of physical and biological structures and functions, while minimizing risk to the aquatic system. We believe the key is emulation of the historic range of condition.

B. Application of uniform riparian rules results in a relatively uniform outcome throughout a landscape. A principle outlined in the Preface is that heterogeneity of ecosystem conditions across time and space is the pattern to which wild salmonids adapted. The application of uniform rules tends to reduce the heterogeneity.

As an example, the current riparian management rules require specific widths and basal area retention for streams of specific sizes. Over time the result will be an increasingly uniform condition in the riparian zones of a landscape. There will be little variation in the entry of sunlight, organic material, nutrients, insects, large wood, and other materials to the aquatic system. This will poorly emulate the historic range of condition.

We conclude that the current site-specific Rules and Measures contribute to achieving the mission of the Oregon Plan, but they are insufficient. In the short run, they must be incorporated into a landscape approach. Over the long run, the site-specific Rules and Measures may be able to be simplified and become less prescriptive as management, policy, regulation, and voluntary measures are developed at the landscape level.

Adequacy of site-specific strategies for achieving the mission of the Oregon Plan.

The current site-specific Rules and Measures contribute to achieving the mission of the Oregon Plan, but they are insufficient. They must be incorporated into a landscape approach.

Question 3. What strategies are needed in the management of forest resources to achieve the mission of the Oregon Plan?

Based on our understanding of the science, we believe a landscape approach to policy, resource management, regulation, and voluntary actions is needed to accomplish the mission of the Oregon Plan. The current approach is primarily a site- and action-specific prescriptive approach. Other approaches are at the conceptual or landscape level only. It is likely that a blend of these approaches is best.

A. Prescriptive Approaches

Prescriptive approaches are the dominant strategy for the regulation of practices on forestlands. They typically specify the actions that should (or should not) occur at any given site. An example is to leave a buffer strip of some specific width (or widths) along streams. The Oregon Forest Practices Act, the federal Northwest Forest Plan, and the Forest Practices Rules in Washington and other states are all prescriptive in their approach.

As outlined in the Preface to this report, we believe emulation of the historic range and distribution of conditions at the landscape level is essential to accomplishing the mission of the Oregon Plan. This is the criterion we apply in our analysis of the capacity of several prescriptive approaches to this goal.

(1.) Oregon Forest Practices Act and Administrative Rules

The contemporary version of the Oregon Forest Practices Act was enacted in 1972, with substantive revisions in 1987 and 1994, and the latest modifications in 1998. The OFPA Rules regulate forestry activities, and were developed to protect forest-related resource values, including waters of the state. They provide benefit to salmonids through protection of water quality and habitat, but they do not include the recovery of wild salmonids.

The OFPA rules focus on specific activities as they occur on specific sites. Examples include timber harvest, use of pesticides and other chemicals, reforestation, and the design, construction, and maintenance of roads. They incorporate a landscape perspective with respect to some aspects

of timber harvest (for instance by limiting the size and adjacency of clearcut harvest units) and some aspects of roads (encouraging the use of existing roads rather than building new roads where practical).

The OFPA rules include Water Protection Rules, which include specifics for Riparian Management Areas (RMAs). Vegetation retention along streams follows a protocol that is designed to meet criteria for "desired future conditions". The purpose of these requirements is to provide for the establishment or re-establishment of functioning riparian habitat along streams, which will benefit water quality of fish habitat. These rules are designed to minimize or avoid adverse effects to the waters of the state, but are action and site specific. They do not include a landscape perspective.

(2.) The (federal) Northwest Forest Plan

The Forest Ecosystem Management Assessment Team (FEMAT) developed the Northwest Forest Plan (ROD). It is based on the analysis of 10 options for management of federal forests within the range of the northern spotted owl, and it focuses on wildlife species that are associated with late-successional and old-growth forests. Allocation of land to a system of “reserves” interspersed with lands where timber harvest can occur and Adaptive Management Areas (where new approaches to management can be tried) is central to the Northwest Forest Plan. Specific Standards and Guidelines for Management provide prescriptive elements.

Key watersheds were also identified and prioritized within each land allocation. The Aquatic Conservation Strategy, under the Northwest Forest Plan, was designed to protect and restore salmon and steelhead habitat by maintaining and restoring ecosystem health at the watershed scale. This includes watershed analysis. The current measures are conservative, and may be changed as additional information providing a better basis for management options becomes available.

The Northwest Forest Plan includes both a site-specific and a landscape perspective, although it does little to include lands outside of federal ownership, even when they are key parts of the landscape to be managed. A variety of policies and laws (some of which are conflicting) have made it difficult to achieve the full array of federal management objectives or the elements of adaptive management that are a critical part of the Northwest Forest Plan.

(3.) Washington Forest Practices Act and Rules

The State of Washington has regulated forestry activities on state and private lands since 1974 through the Washington Forest Practices Act. Under the Act, the Washington Forest Practices Board (WFPB) issues Rules (WFPB 1995) and a Board Manual as guidance for regulation of forestry activities. The rules have gone through many changes, with the most current legislation directing futures rules to be based on the April 1999 “Forest and Fish Report” (DNR, 1999).

The Forest Fish Report articulates four goals:

- Provide compliance with the Endangered Species Act for aquatic and riparian-dependent species on non-federal forest lands.

- Restore and maintain riparian habitat on non-federal forest lands to support a harvestable supply of fish.
- Meet the requirements of the Clean Water Act for water quality on non-federal forest lands.
- Keep the timber industry economically viable in the State of Washington.

Priorities include riparian protection (buffer zones with regional variations) for fish and non-fish habitat, road maintenance and construction and protection for unstable slopes, adaptive management, watershed analysis, and other issues. The approach includes prescriptions designed to achieve desired future conditions, based on scientific criteria that are believed will provide appropriate ecological functions required for water quality and stream habitat.

The Washington State approach is similar in many respects to the OFPA approach, although it incorporates more contemporary, strategies including watershed analysis and a landscape based approach. However, as with OFPA, the Washington State strategies do not adequately incorporate the landscape perspective needed to accomplish the mission of the Oregon Plan.

We find that regulatory frameworks for managing natural resources are often focused on single factors and present a simplified view of complex ecosystem interactions. The goal of regulation may be multifaceted (i.e., water quality), but the rule designed to obtain the goal is often singular (i.e., a 100-ft riparian management zone). A "one-size-fits-all" approach, while an attractive regulatory framework, is not capable of reflecting the dynamic nature of landscape structure and function. In addition, by limiting the application of scientific concepts, managers are often discouraged from adapting the regulatory framework to coincide with changing ecological conditions.

We do not consider the prescriptive approaches included in the Oregon and Washington forest practices rules to be consistent with the direction provided by science for the recovery of Oregon's wild salmonids. To meet the objective of long-term ecosystem function, a conceptual-based management approach may be more successful.

B. Conceptual Approaches

The science of landscape ecology forms a good conceptual basis for meeting the goal of enhancing and maintaining salmonid habitat (Schlosser 1991). By developing a policy framework that encourages landscape patterns that reflect the historic conditions under which salmonids evolved, the entire landscape can play a role in achieving properly functioning aquatic conditions. A mosaic of conditions across the landscape was once achieved through natural disturbances. Although we can never recreate the same dynamic system on our current landscape, we can use our current understanding and monitoring of results to better tailor our management activities towards the same end.

There are difficulties inherent in applying a landscape-based management strategy. The lack of large-scale quantitative relationships makes it hard to predict the impact of management decisions on desired outcomes. There are models available that simulate disturbance history (Benda et al. 1998), sediment transport (Benda and Dunne 1997a, b), and large wood recruitment (Meleason and Gregory 1999); however, these models remain to be validated across larger

landscape scales. In addition, the regulatory framework of such a complex approach would be difficult to monitor, although satellite imagery and projects such as the Coastal Landscape Analysis and Modeling Study (CLAMS) indicate that the required technology is rapidly becoming available.

We conclude that the science of landscape ecology provides the appropriate concepts for landscape level management, but it is not sufficiently well developed and tested to permit its widespread use now. In addition, the policy framework (a combination of regulation, voluntary action, incentives and other approaches) required to make it workable has not been developed.

C. A Blended Approach

The Oregon Department of Forestry is preparing a management plan for over 600,000 acres in northwestern Oregon. The plan is a blend of the prescriptive approach (because it does not violate the OFPA rules) and a conceptual approach (because it uses principles of landscape management).

This plan has the goal of maintaining properly functioning conditions in both terrestrial and aquatic systems, including a variety of habitats and forest conditions across the landscape and over time. Aquatic systems are further considered with a goal to provide stands that are diverse in size, type, and arrangement, both adjacent to riparian areas and across the landscape. In addition to these landscape-based goals, the plan will be implemented under the current regulatory framework established by the Oregon Forest Practices Rules. The aquatic strategies outlined in the plan attempt to take a blended approach by including both an overall landscape management element, as well as more specific prescriptive elements, to be applied when different forest activities are conducted.

In a review by several scientists (Hayes 1998), the plan was recognized for having a strong conceptual basis rooted in science. However, the scientists agreed that individual management approaches (such as riparian buffer widths) were not well supported with scientific data.

D. Emulating Historic Patterns — A Challenge

Designing a management strategy that emulates historic patterns of disturbance at the landscape level is a useful framework, but we need to recognize that we are managing from current conditions, and these do not fully reflect historic landscape patterns. Historically, the major disturbances in the forests of western Oregon included fires and hydrological (i.e., landslides, debris flows, floods), climatic (i.e., drought, wind), and pathogenic (i.e., insects and disease) events. Although they are often discussed as separate incidents, it should be recognized that these disturbances are interrelated and often have synergistic effects on terrestrial and aquatic systems.

These disturbances and their interactions change aquatic systems and add to their spatial and temporal heterogeneity. The degree of change depends on the frequency extensiveness, and intensity of the disturbance and the condition of the ecosystem. For example, a severe fire, followed by a 50-year storm will provide the aquatic system with sediment, rock, and large wood at a time when the hydrologic forces are present to transport and deposit it (Benda et al. 1998). The effects of fire also interact with the age class of the forest. For example, in younger stands,

fire may kill many trees because their bark is relatively thin; smaller material is also more likely to burn completely, leaving less wood to be transported into streams. The frequency or return interval of a disturbance can have major impacts on forest composition and density. For example, frequent disturbances that provide light and an adequate seedbed would favor short-lived species such as red alder, whereas less frequent gap-formation events (such as root rot or patchy blow-down) would favor shade-tolerant conifers. Maintaining the riparian forest heterogeneity based on historic patterns should be considered when designing riparian protection strategies.

Conclusion

We conclude that the current OFPA Administrative Rules and the Measures of the Oregon Plan are designed to meet our forest management goals, but are not adequate for accomplishing the mission of the Oregon Plan. To better meet the goal of properly functioning aquatic systems, we believe an approach that retains prescriptive elements but incorporates landscape level perspectives is needed. The blended approach taken by Oregon Department of Forestry in their Northwest Management Plan with a few modifications is an example. The modifications include 1) the immediate protection of all existing core habitat while implementation occurs; 2) taking a broader perspective to include adjacent private lands; and 3) the implementation of a scientifically valid monitoring program.

Strategies needed in the management of forest resources to achieve the mission of The Oregon Plan.

The current OFPA Administrative Rules and the Measures of the Oregon Plan are designed to meet our forest management goals, but are not adequate for accomplishing the mission of the Oregon Plan.

To better meet the goal of properly functioning aquatic systems, a blended approach that retains prescriptive elements but incorporates landscape-level perspectives is needed. The blended approach taken by Oregon Department of Forestry in their Northwest Management Plan with a few modifications is an example. The modifications include the immediate protection of all existing core habitat while implementation occurs, and taking a broader perspective to include adjacent private lands, and the implementation of a scientifically valid monitoring program.

SECTION IV
CONCLUSIONS AND IMPLICATIONS FOR POLICY

The science-based conclusions and implications for policy are drawn from our answers to the science questions and are grouped in four areas: riparian protection, large wood management, sedimentation, and fish passage at stream crossings.

Conclusions

Riparian Protection

Managing riparian areas as a strategy for protecting fish habitat is scientifically valid only if it is done with the goal of maintaining the dynamics structure and function across the landscape. Sharp demarcations between riparian forest and upslope forest, and between game-fish-bearing and non-bearing streams, are not consistent with the historic pattern.

Large Wood Management

The current status of large wood in western Oregon streams and the future recruitment potential for large wood are not adequate to ensure recovery of depressed stocks of wild salmonids. Most models of large wood recruitment focus on riparian areas as the source, ignoring the important contributions made by upslope sources, especially from landslides. There is a critical need to restore the ecological processes that produce and deliver large wood to the streams (riparian as well as upslope). Correcting this problem will take a long time, several decades. We do not believe the current OFPA rules will achieve the desired levels of large wood in the stream channels and in the forested riparian zones. A rigorous coast-wide monitoring and evaluation program and an adaptive management process is needed to detect and solve problems.

Sedimentation

Forestry operations increase the amount of chronic and episodic production of fine sediments. Disproportionately high amounts of fine sediment, compared with the coarser elements of stream structure (large wood, boulders, gravel, and cobble), diminish the quality of habitat for wild salmonids. In many instances, excess fire sediment can be reduced or the balance between finer and coarser material improved through actions at the site, using existing knowledge. Examples include designing, locating, constructing, and maintaining roads to minimize failure and to prevent road drainage from entering streams; maintaining trees on areas with a high risk of slope failure; and maintaining fully functional riparian zones to reduce the extent of disturbance of debris torrents.

Management of sedimentation at the watershed level is more difficult, and the scientific basis for it is less well developed, although the concepts are known and provide a basis for reasonable conjecture on how to proceed. In essence, the approach is to vary the extent and intensity of disturbance in a watershed over space and time, emulating the historical pattern of disturbance.

Fish passage at stream crossings

The stream-road crossing guidelines developed by ODFW (ODFW 1996) are based on science, although often not the result of explicit experimentation. They provide a scientifically sound basis for management of such crossings, although better information should result from monitoring.

Implications for Policy

Current forest policy for the state of Oregon focuses on forest management and environmental protection, but not the recovery of wild salmonids. The Rules and Measures by which current

policy objectives are sought focus on specific actions occurring within defined periods of time at specific sites. It is precriptive: the rules provide for protection on a site-by-site basis, rather than at the landscape level. The rules make sharp distinctions in how riparian zones are managed, which may result in a failure to maintain the dynamics of structure and function of riparian and aquatic zones across the landscape. In other cases, hazardous sites on forest roads and railroad grades are exempt from current rules because the actions occurred before the rules were in effect. Mechanisms are needed to solve these problems on critical sites that are exempted from current rules. Similar examples can be drawn from conclusions about the recruitment of large wood and the management of sediment and fish passage.

There are three major areas in which shifts in policy are needed to achieve scientific consistency with the mission of The Oregon Plan.

- Incorporate the objectives of the Oregon Plan and Executive order 99-01 into the OFPA. This will place an emphasis of regulation on the protection and enhancement of habitat needed for the recovery of wild salmonids.
- Develop policy that extends the management of forest resources to the landscape level. This does not delete the site-specific aspects of current rules, but applies them in a different context. It will allow a shift from the current more prescriptive rules applied uniformly across the landscape to site-by-site regulations that take into account cumulative disturbance in the watershed, landscape features, and climatic variation.
- Develop policy that identifies, prioritizes and brings roads not built to current standards and other hazardous settings in critical locations into compliance with current standards. This means having the current rules applied to actions taken before the current rules were in force. It is remediation of particularly hazardous situations. In many cases the operator acted in good faith and within the rules of the day, but the outcome is not scientifically consistent with the mission of the Oregon plan; thus, a provision by which remediation is accomplished is needed.

Evaluating Policy

Evaluating policy options within the complexity that characterizes contemporary forestry is a challenge. Extending these options to the landscape level and over time makes the job enormously more difficult. Fortunately, there are analytical approaches and models that can be useful. Although it is not as simple as just “getting and running the model”, these approaches from research can help. Examples of these are currently in use in the CLAMS research project and the Umpqua Land Exchange Project, both in western Oregon. Another example is illustrated by the work of Bettinger et al. (1998), who analyzed policy options involving aquatic habitat and timber production over time in a 15,000-acre watershed in eastern Oregon.

During the policy transition, regulatory actions will have to be treated as hypotheses that must be tested through adequate monitoring and evaluation. ODF will need to respond rapidly to new information obtained through the monitoring and evaluation program.

SECTION V.

RECOMMENDATIONS

This Report focuses on broad scientific issues and concepts. It is not a review of each of the individual Administrative Rules that are part of the Oregon Forest Practices Act or the Measures that are part of the Oregon Plan. In some cases it does focus on specific Rules or Measures, but these are used primarily to illustrate examples. Lack of inclusion of a specific Rule or Measure does not imply either approval or rejection of it by IMST. The scientific direction provided by this Report can guide ODF staff (working with other panels of experts as needed) in formulating Administrative Rules for OFPA and Measures for the Oregon Plan that are needed as part of accomplishing the recovery of depressed stocks of wild salmonids.

The following are the specific recommendations of the IMST. Some of our recommendations can be accommodated within the existing policy framework of the Oregon Forest Practices Act or the Oregon Plan. These are identified as Recommendations Consistent with the Existing Policy Framework, and we believe they can be addressed in the near future. Some other recommendations will be difficult or impossible to implement within the existing policy framework. These we identify as Recommendations that May Require a Modified Policy Framework. Although these recommendations will take a longer period of time to implement, work on the revised policy framework should begin now. In aggregate, our recommendations are intended to both reinforce and enhance the site-specific Rules of OFPA and Measures of the Oregon Plan and provide a bridge to management that incorporates a landscape perspective.

Recommendations for ODF

Recommendations that May Require a Modified Policy Framework

Recommendation 1. Explicitly incorporate the policy objective of the Oregon Plan and Executive Order 99-01 into OFPA.

The policy objective of OFPA includes (among other things), the protection of water quality and aquatic habitat. Site-specific rules that protect aquatic habitat and water quality are necessary to achieve the policy objectives of the Oregon Plan. However, they are not sufficient because they do not specifically address the recovery of the depressed stocks of wild salmonids covered by the Oregon Plan and Executive Order 99-01. The objectives of the Oregon Plan and Executive Order 99-01 should be a specific objective of the OFPA if OFPA is to be scientifically consistent with them.

Recommendation 2. ODF should develop a policy framework to encompass landscape (large watershed) level planning and operations on forests within the range of wild salmonids in Oregon.

The current forest policy framework focuses on individual actions at specific sites. Although this is critical to accomplishing the mission of the Oregon Plan, IMST does not find that it is sufficient. There is a strong scientific basis for believing that achieving the mission of the Oregon Plan requires management of habitat for wild salmonids at the landscape (large watershed) level.

Large watersheds (such as the Willamette River, Alsea River, and others), include both forested and non-forested lands. Given that forests tend to predominate in the upper reaches of watershed areas, it is logical to provide for landscape (watershed level) management of forestlands within the framework of OFPA. Other policy frameworks will need adjustment to accomplish this same recommendation on other lands. The landscape level approach that is recommended for forestry will be prominent in IMST reports on other land uses as well.

IMST recommends that the following elements be included in this modified forest policy framework:

Long-term landscape (watershed) level assessment. Watershed level assessments of the conditions of upslope and riparian forest and associated aquatic systems are needed to determine the changes necessary to achieve the desired future conditions. This is believed to be an important mechanism for decisions and planning for management on the landscape scale. Remote sensing, digital elevation models, and a variety of modeling and analytical tools are available for this purpose. (Examples particularly relevant to forestry are found in the CLAMS project and the Umpqua Land Exchange Project.)

Identified goals. Goals that ensure the integrity of salmonid habitat should be identified for the characteristics of aquatic systems and riparian and upslope forests across the landscape. An important part of this is establishing quantitative links between fish habitat requirements and landscape patterns/processes. The ODF Northwest Forest plan is an example of one approach to this, although the goals of this plan are more explicit to forest stand structure than they are to aquatic and riparian system characteristics.

Monitoring. Monitoring is necessary to provide the information needed to evaluate the aggregated outcomes of management at the landscape level. Accomplishing monitoring from the landscape perspective will require additional monitoring, or perhaps can be accomplished with better coordination of monitoring and analysis of data across agencies to include the landscape perspective. There is a specific need for collaboration between ODFW and ODF to explicitly examine and evaluate the links and relationships between fish and ecosystem conditions (see Recommendation 16).

Coordination. Coordination among agencies and watershed councils is needed to facilitate the expansion of landscape level planning and management at scales that extend beyond the forest. The purpose of this element is to improve the coordination of forest lands with other lands.

We believe landscape analysis can be used in designing forestry practices that result in an emulation of the historic patterns of landscape disturbance on the current landscape. Among strategies that may be effective and advantageous from several perspectives are the following:

- defining the number stream crossings in a given basin
- defining the length of road system in a given basin
- defining the amount and distribution of stand age-classes in a given basin.

Utilization of such strategies may, among other things,

- permit a shift from the current, rigid buffer-width strategy to a more flexible one providing the historic array of condition at the landscape level
- provide the ability to achieve water temperature goals through control of the proportion of the landscape in various forested conditions
- provide greater flexibility in scheduling the extent and frequency of management related disturbance (i.e., concentrate clearcut timber harvest in a sub-basin and then provide longer periods for the watershed to stabilize and recover).

Recommendations Consistent with the Existing Forest Policy Framework

Recommendation 3. Treat non-fish-bearing streams the same as small, medium, and large fish-bearing streams when determining buffer-width protection.
Current rules reduce buffer-width requirements if game fish are not present. It is recommended that all large, medium, and small streams, regardless of fish presence, receive a riparian management area (RMA) of 100, 70, and 50 feet, respectively. Currently, there is no lower size limit for what constitutes a small stream. Given the increased level of protection, a lower limit to define a small stream should be developed. The lower limit should allow for a sufficient level of aquatic protection, paying particular attention to the role small streams play in wood delivery and carbon inputs during storms. On a landscape basis, a portion of intermittent or ephemeral streams will require the 50- foot buffer in order to retain aquatic function.

Table 1. Summary table based on ODF Rules regarding current requirements for minimum retention of streamside trees. Requirements are for numbers and basal area (BA) of conifer trees (exceptions are allowed under certain circumstances to substitute appropriate hardwoods for conifers) in riparian management areas (RMA) for clearcuts in Coast Range and South Coast geographic regions. Required minimum diameter at breast height of trees retained in the RMA for both Type F and Type N streams is 11 inches for large streams and 8 inches for medium streams.

		Number of conifers		Standard target		Active management target	
Stream type/size	RMA width (ft)	Trees/1000-ft stream length	Trees/acre	BA/1000-ft stream length	BA/acre	BA/1000-ft stream length	BA/acre
Type F (fish)							
Large	100	40	17	230	100	170	74
Medium	70	30	19	120	75	90	56
Small	50	0	0	40	35	20	17
Type N (non-fish)							

Large	70	30	19	90	56	—	—
Medium	50	10	9	50	44	—	—
Small	0	0	0	0	0	—	—

Recommendation 4. Provide increased riparian protection for the 100-year floodplains and islands.

Floodplains are low-gradient, unconstrained stream reaches where a strong connectivity exists between the aquatic and terrestrial ecosystems. To maintain this important landscape function, the 100-year floodplain should receive increased protection over that provided by current OFPA Rules or Measures in the Oregon Plan. The goal of this protection is to create the same type of mature forest condition that is the goal of current RMA management.

The entire 100-year floodplain should be included (including on islands). This would include the RMA and the areas beyond it to the edge of the floodplain. This may result in a larger zone of protection on one side of the stream. For example, if a stream is currently against the east side of a floodplain, the protection zone to the east may extend only as far as the upslope edge of the RMA, but on the west side, the protection may be 250 feet or more, depending on the floodplain width. The only time the floodplain protection zone should be equal on each side is if the stream is in the center of the floodplain.

Recommendation 5. Increase the conifer basal-area requirement and the number-of-trees requirement for RMAs, with increases in these requirements for medium and small streams regardless of fish presence.

This recommendation is based on the expected volume and number of trees in the riparian forest under current rules. In the Coast Range, current OFPA rules have *active* management basal area targets in the RMA on "Type 2 or 3" harvest units of 56 ft^2/acre and 17 ft^2/acre for medium and small streams, respectively. Standard targets are 75 ft^2/acre and 34.7 ft^2/acre for fish-bearing medium and small streams, respectively. These targets are too low and should be increased to at least the level required for large streams. In addition, these rules should be applied to all streams regardless of fish presence. The current required minimum trees-per-acre should also be increased on medium and small streams to meet the levels required on large fish-bearing streams. As in Recommendation 3, the lower limit defining small streams must be developed, with attention given to a similar level of protection for a portion of intermittent or ephemeral streams.

Recommendation 6. Complete the study of the effectiveness of the OFPA Rules in providing large wood for the short and long term.

One of the goals of riparian management is to generate a supply of large wood of diverse character and size to meet several different functions in the stream. Oregon Plan measure ODF 11S is to determine the effectiveness of the 1994 forest practices rules in providing for short-term and long-term sources of large wood. According to Measure 11, "If this monitoring effort identifies that the Water Protection Rules are not achieving the protection or LWD recruitment

goals, the department will recommend rule changes." The depleted status of large wood throughout Coast Range watersheds makes completion of measure ODF 11S critically important.

There are several important questions this ODF study will be able to address. For example, what role will thinning of conifers in the riparian zone contribute to achieving a mature riparian forest condition sooner? When, where, and how should active management of hardwood-dominated riparian zones be done? Are basal area credits (in RMAs) for large wood placement in streams a useful and appropriate strategy for achieving large wood goals?

Recommendation 7. Provide enhanced levels of certainty of protection for "core areas".

The term "core area" was used by ODFW in identifying specific areas critically important to the recovery of coho in the original Oregon Plan. This term may be replaced in the future. It is our intention that, regardless of the term used, this recommendation be applied to areas specifically designated by ODFW as critical to achieving the mission of the Oregon Plan and the intention of Executive Order 99-01.

The OFPA Rules should be changed to eliminate language that equivocates on resource protection in favor of forest operations. This equivocation inappropriately puts the risk of operations in core salmonid areas on the habitat. Examples of such language are found in the Road Location rules, 629-625-200 (3) "where *viable alternative exist"*, (5) "*where practical*", and "*investigate options*", in Road Maintenance rules 629-625-600 (8)(b) "*As reasonably practicable*".

These equivocal statements and similar types of statements in other rules should be replaced with language that clearly gives priority to the protection of core areas.

Recommendation 8. Develop and implement standards or guidelines that reduce the length of roadside drainage ditches that discharge into channels.

Surveys of road systems find that 30 to 70 percent of road drainage points discharge water and entrained sediment into channels. Although it is impractical to eliminate such drainage points, the amount of sediment discharged can be reduced by reducing the length of the segments of roadside drainage ditches that feed into channel discharge points. The shorter the distance of such channels, the less sediment that will be come entrained in the flowing water. This recommendation should be implemented for all new road construction and any road reconstruction covered by the OFPA Rules.

Recommendation 9. Implement the standards and guidelines for the length of roadside drainage ditch between cross-drainage structures, especially on steep gradient roads.

Surveys of road systems find that the distance between cross-drainage structures usually exceeds established guidelines. Decreasing the distance between such structures will reduce the volume of water discharged to the slope and will reduce the amount of sediment that becomes entrained in the discharge flow. The consequence of these changes will be a reduced likelihood of

discharge-related slope or road failure and a reduced level of road-related sediment entering stream systems.

Recommendation 10. Require the flow capacity of cross-drainage structures and stream-crossing structures and culverts to meet current design standards.

This recommendation addresses two issues: maintaining the flow capacity of cross-drainage structures and culverts during maintenance, and emergency culvert replacement.

Maintaining flow capacity. ODF surveys show that a large percentage of ditch-relief culverts have reduced flow capacity because the ends of the culverts are damaged and/or the culverts are obstructed with debris. These culverts may cause water to be diverted, increasing the potential for catastrophic road failure. An effective program of drainage system maintenance will reduce the potential for road failure from this source. As part of this system of maintenance, equipment operators should be trained to prevent damage to the ends of culverts.

Emergency culvert replacement. OFPA rules require that culverts replaced during a road "reconstruction" meet current standards, i.e., the 50-year rule. Unfortunately, culverts that are undersized by current standards may fail and need to be replaced on an emergency basis during intense storms. Operators may not have the level of knowledge needed to determine the correct culvert size for this reconstruction. ODF needs to develop a program to predetermine appropriate culvert size for critical sites to ensure that this information is readily available to operators.

Recommendation 11. Provide for the stabilization of roads not constructed to current standards (including "old roads and railroad grades") in critical locations. Stabilization means reduction or elimination of the potential for failure. It includes a variety of strategies ranging from removal to abandonment, entirely or of sections, by which specific roads and railroad grades become a much less important source of sediment.

Analysis of road failures shows that roads not built to current standards dominate road-failure statistics in sensitive locations. IMST finds compelling evidence that road failures present sedimentation risks that are inconsistent with achieving the recovery of wild salmonids. OFPA rules can require that roads being used for forestry purposes be stabilized. We believe this rule should be vigorously enforced, with highest priority attention given to roads in core areas identified by ODFW, but with attention to forest roads at all locations over time.

"Old roads and railroad grades" on forestlands, sometimes called legacy roads, are not covered by the OFPA rules unless they are reactivated for a current forestry operation or purposes. IMST believes the lack of a mechanism to address the risks presented by such roads is a serious impediment to achieving the goals of the Oregon Plan. A process that will result in the stabilization of such roads is needed, with highest priority attention to roads in core areas, but with attention to such roads and railroad grades at all locations on forestlands over time.

As part of the Oregon Plan, voluntary efforts by forest industry are underway in northwestern Oregon to identify and stabilize or reduce the risk of failure on "old roads". ODF should

document and report on the progress of this effort, and should extend it to other forest areas where wild salmonid habitat exists. Highest priority should be given to core areas identified by ODFW.

Recommendation 12. Require durable surfacing on wet-season haul roads and require that hauling cease before surfaces become soft or "pump" sediment to the surface.

Road surfaces are a source of fine sediment when they are used for hauling during the wet season. The surfacing characteristics of the road and the intensity of use influence the production of these sediments. Research has shown that a durable surface, such as rock of sufficient hardness and depth, will markedly reduce the production of sediment. In some cases the road surface or base may be soft, or traffic may cause a pumping action that causes sediment to move to the surface, where it can be transported to streams. A cessation of hauling will reduce sediment production from this source.

Recommendation 13. Retain trees on "high risk slopes" and in likely debris torrent tracks to increase the likelihood that large wood will be transported to streams when landslides and debris torrents occur.

Landslides and debris torrents may be an important mechanism by which portions of the aquatic system are revitalized. Landslides and debris torrents that emulate the historical quality and quantity of debris delivered to the stream system are believed to be most effective. The key elements of landslides and debris torrents are their composition (wood, rock, and sediment) and the size of material (large wood, boulders, cobble, gravel). The composition and size of rock and sediment is largely defined by the characteristics of the site, but the presence of trees to serve as a source of large wood is largely determined by management decisions.

IMST concludes that retention of trees on high risk slopes and in likely debris torrent tracks will provide an important source of large wood for stream systems that drain these areas. Science does not provide guidance on the density of tree retention in such areas. The "Benda wood accumulation model" and the debris "run-out model" provide scientifically sound guidance. We suggest an adaptive management approach, using monitoring of landslides and debris torrents to identify the tree retention density that will be effective.

Recommendation 14. Continue to apply the current best management practices (BMP) approach to the management of forest lands with significant landslide potential, and develop a better case history basis for evaluating the effectiveness of BMP in these areas.
Recent research experience and ODF's documentation and analysis of landslides provide an initial basis for management of areas with significant landslide potential. A continuation of these efforts and the periodic analysis of findings offer a scientifically sound approach to identifying management strategies that will be consistent with the mission of the Oregon Plan.

Recommendation 15. Modify culverts and other structures to permit the passage of juvenile and adult salmonids upstream and downstream at forest road-stream crossings.

Surveys of forest road-stream crossings show that a significant number of sites have culverts or other structures that prevent the passage of adult and/or juvenile salmonids. This prevents the full use of potentially productive salmonid habitat. OFPA Rules (629-625-600 (8)(a) provide for fish passage for roads constructed after September 1994, however a significant number of fish passage barriers exist on roads not covered by this rule. Voluntary efforts to solve this problem are being conducted on other roads in northwestern Oregon by forest industries, as part of the Oregon Plan. ODF should document progress on the voluntary efforts to solve this problem, and implement voluntary or regulatory programs on other lands to achieve the goals of the Oregon Plan. If there are situations on forest lands where OFPA Rules or Oregon Plan measures do not address fish passage problems, ODF should notify the Manager, Oregon Plan, so that remediation may be implemented by the appropriate agency.

Recommendations for or with other Agencies

Recommendation 16. ODFW and ODF should develop a collaborative program of monitoring to quantify the linkages between parameters of ecosystem condition and wild salmonid recovery.

Validation of the effectiveness of various strategies of both site specific and landscape level management on the recovery of wild salmonids can only come through effective monitoring. Both ODF and ODFW conduct monitoring that are or can be useful for this purpose. In some cases, modification or expansion of programs may be needed. A collaborative effort between the Departments in the design, conduct, and analysis of monitoring programs is a critical step in quantifying the links between forest condition and the welfare of the fish. Historically these links have been very difficult to establish but are needed for future policy and planning activities. ISMT believes well designed, adequately funded, and carefully coordinated monitoring efforts involving both Departments are essential for this purpose.

Recommendation 17. ODFW should complete "core area" designation for all wild salmonids in Oregon and identify high priority protection/restoration areas that are not covered by current "core area" designations. ODFW should work with the Oregon Plan Implementation Team in prioritizing habitat for enhanced levels of protection and/or restoration.

The term "core area" was used by ODFW to identify specific areas critically important to the recovery of coho in the original Oregon Plan. This term may be replaced in the future. It is our intention that, regardless of the term used, this recommendation be applied to areas specifically designated by ODFW as critical to achieving the mission of the Oregon Plan and the intention of Executive Order 99-01.

Core area designations are incomplete for winter steelhead and are completely lacking for sea-run cutthroat trout and other salmonids covered by the Oregon Plan and Executive order 99-01. Core areas for other species may need revision in light of new information obtained since completion of the first core area designations.

Recommendation 18. ODFW should include consideration of practices (forestry, agriculture, urban, other land uses) above and below core areas, as these may affect the conditions and processes critical to maintenance of core area function in forestry areas.

The concept of a core area needs to extend beyond the specific location of a core area. A core area cannot continue to function in the recovery of wild salmonids unless upstream and downstream portions of the system are also functioning effectively. For forested portions of the landscape, this means explicitly considering the effects of forest practices under OFPA, as they may influence the core area. The same concept must be applied to non-forested portions of the landscape for the same reason. For instance, the functionality of core areas in the forested portion of the landscape will be reduced if water quality and habitat conditions in downstream agricultural or urban areas are not conducive to salmonid recovery.

Recommendation 19. The Oregon Forest Research Laboratory (FRL), in collaboration with ODFW, should develop forest road-stream crossing strategies that facilitate the passage of large wood at road-stream crossings.

Stream crossings, especially in upper reaches of stream systems, can provide significant impediments to the downstream passage of large wood and other elements of habitat structure. Alternatives to bridges or culverts may be more effective, and in some instances, perhaps less expensive. Forest managers currently have few options to consider in the design of stream crossings. The development and testing of additional alternatives may provide a better mixture of solutions to stream crossing problems. An initial step in this could be a jointly sponsored (FRL and ODFW) workshop to establish key design parameters and performance criteria.

SECTION VI
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APPENDIX. SUMMARY OF THE STATE OF KNOWLEDGE

The following section provides a summary of the state of knowledge and an entree to the literature dealing with key areas of this report: relationships between forests and aquatic habitat, forest practices, and water quality**.**

ATTRIBUTES OF SALMONID HABITAT

Ecological processes influencing the quality of habitat attributes and their relationship to forest practices are discussed in various sections of this report. This discussion of the attributes of salmonid habitat has been adapted from Bjornn and Reiser (1991) unless noted otherwise.

Salmonid Life Histories

Pacific salmon need chains of favorable places connected at the appropriate season to complete their life histories. To be considered favorable, those places must include attributes that match the environmental requirements of the fish and the aquatic community at the appropriate time. The importance, quality, and location of critical attributes of salmonid habitat may vary through the life stages of migration, spawning, incubation, and rearing.

Migration. For anadromous species such as salmonids, the stream channel must be free of barriers from the estuary up to the spawning areas (adult upstream migration) or from rearing areas down to the estuary (juvenile downstream migration). The most obvious necessity of the migration corridor is appropriate stream flow. Low flows can block or delay movement of fish, as can excessive flows or conditions that create high velocities. Other physical barriers such as excessive debris can also block migration. High turbidity may delay or block migration entirely. Physiological barriers can also impede migration. For example, excessive temperatures or low concentrations of dissolved oxygen can also effectively block migration.

Spawning. Each salmonid species requires gravel of the appropriate size for spawning (substrate), as well as stream flow at a depth and velocity that are within the preferred range. Temperatures at the time of spawning can be a key habitat attribute. In adapting to its local environment, each salmonid population has evolved a unique time and temperature for spawning that maximizes the survival of the offspring (Miller and Brannon 1982; Bjornn and Reiser 1991).

Incubation. Because the incubating eggs are immobile, they are particularly vulnerable to changes in habitat. For example, the eggs need continuous flows of well-oxygenated water to thrive. Although eggs may survive in water with oxygen concentrations that are below saturation, they may develop abnormally. Heavy siltation during incubation can smother the eggs. High levels of fine sediment can fill in the interstitial spaces in the gravel cutting off the supply of oxygenated water. As indicated for spawning, natural temperature regimens are important regulators of salmonid life histories. That is especially true for the incubating egg, because the length of incubation is directly related to water temperature.

Rearing. Attributes associated with rearing habitat of salmonids are complex. In addition to flow, temperature, substrate, and dissolved oxygen, juveniles need to be able to move between

habitat types. Cover that allows them to avoid predators is a critical habitat attribute from the time the juveniles emerge from the gravel until their migration to sea. Cover can take several forms including deep pools, undercut banks, boulders, large wood, and root wads. Productivity (food base for salmonids) is an important attribute of rearing habitat and is determined largely by nutrients and energy available to the stream community.

RIPARIAN FORESTS AS A KEY FACTOR INFLUENCING SALMONID HABITAT

Role of Riparian Forests in Regulating (Influencing) Stream Temperature

Where riparian vegetation intercepts solar radiation it serves a role in moderating the quantity and quality of light reaching the stream (Beschta et al. 1987). In well-stocked forests, depending on aspect and slope, the amount of solar radiation reaching a forested stream channel is 1 to 3 percent of the total incoming radiation for small streams and 10 to 25 percent for mid-size streams (Naiman 1992). Removal of trees near a stream causes increases in water temperatures and daily temperature fluctuations (Hetrick et al. 1998; Beschta et al. 1987; Hall and Lantz 1969; Brown and Krygier, 1970; Brown, 1980; Hall et al. 1987). Newton and Cole (1998) report interesting research suggesting that retention of vegetation cover on the south side of streams was adequate to maintain temperature in the situation they studied. However, depending on ambient climatic and down-stream conditions, the increase may only be temporary (Hetrick et al. 1998; Caldwell et al. 1992). The work of Brown (1970) provides a scientific basis for predicting stream temperature based on an energy balance model.

On a landscape basis, the relationship between stream temperature and riparian vegetation is complex and highly variable. By understanding the processes influencing the amount of radiation intercepted by the riparian forest canopy along with the interaction with disturbance, stand development and geomorphology we can begin to answer the questions concerning the role of forest vegetation in influencing stream temperature. The amount of solar radiation intercepted by a forest canopy is a function of the cumulative leaf area and an extinction coefficient that is determined by the foliar arrangement and reflective properties (Beer-Lambert law as cited in Waring and Schlesinger 1985). Leaf area for deciduous species is often one third of the values for conifer stands (Waring and Schlesinger 1985). Therefore any natural and human-caused factor that reduces riparian leaf area and/or changes species composition can increase the amount of radiation reaching the stream surface and therefore increase stream temperatures. For example, in stands with few remaining evergreens and a high percentage of deciduous trees, more radiation will reach the stream surface when the deciduous trees lose their leaves.

Along with obvious losses in leaf area after timber harvest, there are also changes in forest successional processes. These alter the quantity and arrangement of leaf area in riparian forests. As alder forests decline with age, shrub-dominated communities with lower leaf area develop. As long-lived conifer stands mature, leaf area rapidly increases to about age 40, levels off, and then declines at a rate dependent on self-thinning and disturbance-related mortality (Gholz 1982). Therefore, as gaps in the forest form and stand densities are reduced, more radiation can be expected to reach the stream surface. Although dense conifer forests are often seen as a goal in managing forests to regulate stream temperature, historically, natural disturbance and

successional processes resulted in a forest with a variety of tree and shrub species, ages, and densities (Pabst and Spies 1998; Poage 1995; Avina 1999).

The impact of riparian vegetation on stream temperature depends on riparian landscape patterns, forest conditions, and stream channel characteristics as they influence interception of solar radiation. For example as stream width increases, the forest may no longer be capable of shading the entire stream or river corridor. Thus the potential role riparian vegetation plays in regulating temperatures declines. Aspect and slope may also influence the amount of radiation reaching the water surface. Radiation may increase or decrease depending on the geographic orientation of the stream and the angle of light reaching the basin.

Although forests play a key role in regulating stream temperature, the integration of stream temperature within a basin depends on vegetative and morphological factors that vary widely across the landscape and with time. To list and quantify all the factors involved in maintaining stream temperatures within the range of quality salmonid habitat would be an exceedingly complex undertaking. Because the required landscape variability and complexity are difficult to create through management, managers have defaulted to the use of riparian buffers to minimize impacts of forest management practices on stream temperature. One of the goals of the riparian buffer is to create conditions that will minimize the risk of increasing stream temperatures when the adjacent stand is harvested. There is general agreement that buffers of 100 to 150 feet are sufficient to protect water quality in most situations (Spence et al. 1996). Thus there are few studies that examine what percentage of the landscape must contain these intact riparian buffers and where they should be located to be most beneficial for maintaining quality salmonid habitat.

As an alternative to riparian buffers, maintaining a diverse set of forest conditions — by generating forest harvest patterns that "mimic" historic disturbance patterns (i.e., size, frequency, distribution) — within the landscape will allow natural processes to act in accordance with forest management to balance water temperature. When considering the impact of stand density, successional processes, species composition, and geomorphology on water temperature, the major emphasis shifts from buffer width requirements to the percentage of the landscape in various forested conditions required to maintain water quality. This means that instead of all buffers, there will be stands of different ages and harvest patterns along the stream.

Role of Forests in Influencing Nutrient Inputs and Flux

By understanding the fundamental processes involved in the deposition and processing of organic matter, we can examine how factors that vary across the landscape, such as forest stand age, stand density, tree species, stream size, percent slope, aspect, and stream morphology, influence the location and amount of habitat for salmonids. The deposition and processing of organic materials are major limiting factors in stream productivity. For salmonids, a productive stream has good physical habitat for spawning and the organic resources needed to produce the food required for fry to survive and grow. The stream obtains organic resources from two primary sources: 1) organic matter produced within the stream from photosynthetic algae and other aquatic plants; and 2) organic matter deposited by the terrestrial system, such as leaves, bark, and wood. In forested ecosystems, terrestrial sources provide streams with most of their

organic matter. In an eastern U.S. forest, 98 percent of the organic material in the stream came from terrestrial sources (Fisher and Likens 1973).

Deposition of organic materials. The size and morphology of the stream, as dictated by topography, greatly influence the deposition and processing of organic materials. Slope also influences the species composition of the forest, forest biomass production, and in some cases stream temperature. As a forest ages, litterfall increases with increasing biomass. Litter is deposited into small steep-gradient streams in densely forested areas high in a watershed. Steeper slopes with fast-moving streams are less likely to retain deposited organic material until it is decomposed. Thus these small (lower-order) streams are important to the productivity of larger (higher order) streams in lower reaches of the watershed because they are a major source of organic material. Leaves, bark, and wood deposited in these small streams can be rapidly transported downstream if there are no barriers, such as culverts, large wood, and boulders.

Forest age, composition, and season affect the quality, as well as the quantity, of leaf material deposited in streams. For example, alder leaves are noted for their relatively high nitrogen are readily decomposed. But before a leaf or needle is abscised (released and falls), the tree recaptures many of the nutrients; thus leaves deposited in the fall are not as nutrient rich as those deposited from a mid-summer windstorm. With their high lignin content, conifer needles are more difficult to break down and therefore release their organic material more slowly compared with deciduous foliage.

Decomposition of organic materials. After it is deposited in streams, organic material must be processed before it is available as a food source for salmonids. Forest stand age, density, and species composition, along with stream characteristics, such as size, percent slope, aspect, and morphology, all influence the decomposition of organic material.

In small (lower-order) streams on densely forested slopes, large wood can trap organic material, where it may be broken down before it is transported downstream with high flows. However, because many of the biological processes required to decompose organic material are temperature dependent, the process may be slower in cool streams within densely forested riparian zones (Beschta et al. 1987; Hawkins et al. 1982).

Decomposition of organic material occurs in several ways. Some organic compounds are leached from material in the stream. Shredding insects that feed primarily on leaves also process organic materials. Microorganisms colonize material that becomes trapped in the stream, breaking it down into constituents available for microbes and insects. Fine particles are carried downstream and deposited within the channel, becoming available to benthic (bottom) feeding organisms and rooted aquatic plants.

The morphology of the stream largely determines the decomposer species present. Functional groups of these animals correspond to orders of streams. These distinctive relationships are based on the relative availability of different substrates and are used for classification (Cummins 1973, 1974). Shredding insects rely on leaf material and are thus found primarily in small, lower-order (1st through 3rd) streams. Grazing insects rely on instream (primary production) algae attached to rocks and are therefore found primarily in larger, higher-order (5th and 6th) streams.

Fine-particulate collectors, which feed primarily on fecal material, are distributed across a wider range (1st through 6th) of stream orders. The ratio of shredders to grazers was found to be more than 100:1 in canopy-covered first-order streams with low incident light levels and was 1:14 in wide, eighth-order streams with high levels of sunlight (Triska et al. 1982).

Forest practices. Where forest practices change tree density and species composition, they will affect the input and processing of organic material. The degree of impact depends on prior stand conditions and the composition of adjacent stands. For example, frequent intense harvest in the presence of an alder seed source will result in a shift toward alder-dominated riparian areas. Low intensity thinning in riparian conifer stands will increase stand stability and the productivity of the remaining trees, while not opening up the stand enough for alder regeneration. Across the landscape, shifts in stand age and species composition will benefit the higher-order streams by providing a variety of materials at varying rates, thereby adding to habitat heterogeneity. The processes controlling the input and processing of organic material are better served by a heterogeneous landscape with varying amounts of forest cover, species composition, and age classes than by the creation of a single forest type across the landscape.

LARGE WOOD AS STRUCTURAL AND FUNCTIONAL ELEMENTS OF AQUATIC HABITAT

The most productive habitats for salmonid fish are small streams associated with mature and old-growth coniferous forests where large organic debris and fallen trees greatly influence the physical and biological characteristics of such streams. Sedell et al. 1988.

Functions of Large Wood in Streams

Large wood is often the primary structural element in the stream channel responsible for forming pools in smaller streams and side channels and backwaters in larger streams (Bilby and Bisson 1998). Both are critical habitats for coho salmon in Oregon's coastal streams (Nickelson et al. 1992). Over 80 percent of the pools in small streams in southwestern Washington, in the Idaho panhandle, and in northern California were associated with the presence of large wood (Bilby and Bisson 1998).

The function of large wood varies with the size of the stream. In smaller streams, large wood can generally span the channel. There it becomes an important structural element that increases the frequency and volume of pools, traps organic material and slowly releases nutrients to the stream, provides substrate and food for aquatic invertebrates, and traps fine sediments. The smaller stream channels are also the conduits that deliver much of the large wood to the channels lower in the watershed. Large wood increases channel complexity, obstructs and diversifies currents, and creates essential features of salmonid habitat, such as plunge (created by water flowing over logs), lateral (along the bank), and backwater pools (Spence et al. 1996).

Larger streams contain less wood, but the average size (diameter, length, or volume) of the wood is greater because these streams can transport larger materials. The nature of the pools formed by large wood changes from plunge pools in the smaller headwater streams to scour pools in mid-

sized streams (Bilby and Ward 1989). In larger channels, large wood tends to accumulate along the margins and on gravel bars or other obstructions. This creates variable depths and complex flow patterns, lateral migration of the channel, and backwaters along the stream margins (Spence et al. 1996).

In the larger low-gradient streams, large accumulations of wood can span the channel and create large pools, secondary channels, and backwaters (Bilby and Bisson 1998). Alcoves, side channels, and beaver ponds are important over-wintering habitat for coho salmon in Oregon's coastal streams, and it is the availability of this kind of habitat that constrains coho survival in coastal rivers (Nickelson et al. 1992). Large wood also prevents salmon carcasses from washing out to sea after spawning, which allows nutrients from the carcasses to be released to the watershed (Cederholm et al. 1989). Nutrients derived from salmon carcasses can be an important source of nitrogen and carbon for juvenile salmon and can influence their growth (Bilby et al. 1996).

Local temperature regimes may exert more influence on the evolution of life history patterns than do other environmental attributes of stream habitat (Miller and Brannon 1982). Structural roughness imparted by large wood, especially the creation of pools, can retard mixing of warm water and cool water from either tributaries or ground water and create local pockets of cool water refugia (Sedell and Swanson 1984). Studies in the Yakima River, Washington, have shown that adult chinook salmon can locate and will make use of these small thermal refugia (Berman and Quinn 1991).

Sources of Large Wood

The sources of large wood and the mechanisms for their delivery to the stream channel vary with the size of the stream, its gradient, and the surrounding landscape. First- and second-order headwater streams provide much of the large wood that can form habitat in larger channels (Prichard et al. 1998). Over time, fire, blowdown, natural mortality, and bank undercutting deliver wood to first- and second-order streams, where it easily spans the smaller channels. There it traps sediment, sometimes for very long periods of time, even centuries or more. The buildup of wood and sediment continues until it is delivered downstream, along with green wood, through a mass movement of the material. This type of movement is called a debris torrent. The sediment and wood are eventually incorporated into the channel structure of the larger stream where they become part of normal stream function (Prichard et al. 1998).

Trees that fall into streams usually come from within 30 m of the channel edge; 70 to 90 percent of the large wood in streams is derived from this distance. The riparian vegetation of an old-growth forest consists of taller trees, so the source of large wood is from greater distances than for younger forests with shorter trees, since more tall trees reach the stream when they fall (McDade et al. 1990; Van Sickle and Gregory 1990; Fetherston et al. 1995). In unconstrained stream reaches, large wood from anywhere in the flood plain can eventually reach the channel after floods or lateral migration of the stream channel (Bilby and Bisson 1998).

Both episodic and chronic events deliver large wood to the stream channel. Chronic events include natural tree mortality and natural undercutting of the stream banks. However, these events add relatively small amounts of large wood to the stream. Fires, floods, windthrow,

landslides, and debris torrents occur infrequently, but they are the source of large quantities of wood (Bilby and Bisson 1998; Benda et al. 1998).

Impact of Forest Practices on Large Wood

Recent surveys confirm that many of Oregon's coastal streams in managed forests are deficient in wood (State of Oregon 1998). The amount of wood in streams associated with managed forests has been evaluated by comparing it with two standards: 1) The average amount of wood in reference streams (streams with little or no forestry impacts); and 2) the target amount of wood identified in the Oregon habitat benchmarks (Oregon Plan 1997). Most of the reference streams were in the Cascade Range, with a few located in the Coast Range (State of Oregon 1998). In addition, the surveys reported the presence of wood in two ways: 1) pieces of wood greater than 0.15 m in diameter and 3.0 m in length; and 2) key pieces of wood greater than 0.6 m in diameter and 10.0 m in length. To account for regional differences in salmonid habitat in coastal rivers, the Oregon Coast was divided into five regions: north coast, mid-coast, mid-south coast, Umpqua, and south coast. The north coast and mid-coast stream reaches had slightly more pieces of wood than did the reference reaches. The mid-south coast, south coast, and Umpqua had lower levels of wood (number of pieces) than did the reference reaches. Over 75 percent of the stream length surveyed in the mid-south coast, south coast, Umpqua had fewer than 15 pieces of wood per 100 m of channel. The Oregon benchmark is >20 pieces of wood per 100 m stream length. It should be kept in mind that the benchmark is probably lower than the historical, undisturbed state, especially in the lower elevation stream reaches.

The number of pieces of wood includes smaller sizes that may not have a strong influence on channel process and habitat formation. The status of key (larger) pieces of wood is a better measure of wood that can form habitat in the coastal stream channels. Half of the stream lengths surveyed in all the coastal subregions had less than one key piece of wood per 100 m of channel (State of Oregon 1998). The benchmark is three key pieces of wood per 100 m of channel. Current levels of large wood in coastal rivers are less than the benchmark and far below historical levels.

The amount of large wood currently in stream channels of Oregon's coastal rivers has been depleted and in the near future, new recruitment is not likely to correct that condition. Over 30 percent of the stream lengths surveyed have no large conifers in the riparian zone. Large conifers are defined as trees >50 cm dbh (diameter at breast height) within 30 m of the stream (State of Oregon 1998). Seventy-five percent have fewer than 60 large conifers per 333 m of stream channel. This is far less than in the reference riparian areas, which had 240 large conifers per 333 m of stream channel.

Timber harvest has reduced the amount of wood in streams, consequently degrading the quality of habitat. For example, in an extensive survey of streams draining unharvested old-growth forests and streams within intensively and moderately logged forests in western Washington State, intensive harvest was associated with increased riffle area, reduced pool area, and reduced pool depth. The total amount of wood in the streams did not change with timber harvest, but the size of wood was reduced (Ralph et al. 1994). Since the size of wood in the channel is directly related to pool size (Bilby and Bisson 1998), this represented a direct loss of critical salmon habitat. Similar results—reduced amounts of large wood— were obtained in surveys of Oregon Coastal streams.

The loss of habitat caused by the decrease in large wood can cause a significant reduction in salmonid standing stocks (numbers of adults returning to spawn each year). Standing stocks in three sections of stream that had been previously cleared of all large wood were compared to four sections of stream that had been undisturbed for 40 years. Pool volume, sinuosity, width, and depth had all decreased in the stream sections from which the wood had been removed. These changes in habitat caused a fivefold reduction in salmonid standing stocks (Fausch and Northcote 1992).

Historically, the quantity and quality of large wood in stream channels reflected the age and species composition of the riparian forests and the occurrence of disturbance. Major disturbance events such as wildfire, catastrophic windthrow, and floods were natural features of watersheds that added massive amounts of large wood to the stream channels or redistributed it downstream within the watershed (Bilby and Bisson 1998). At any given time 15 to 25 percent of the central Oregon Coast Range may have been in early successional stages following disturbance (Reeves et al. 1995).

Even during those periods when the riparian forests were recovering, however, the amount of large wood in the stream would have remained high. That is not true of forests subjected to human-caused disturbance, such as logging, which reduces the quality and quantity of large wood delivered to the stream (Bilby and Bisson 1998). Reeves et al. (1995) identified four differences in natural and human-caused disturbance that affect the quality and quantity of large wood delivered to the stream channels:

1. Disturbance such as wildfire leaves a legacy of large wood that can eventually enter the stream, whereas timber harvest removes that source of wood.

2. The interval between major natural disturbances is usually longer than the harvest cycle—300 years for wildfire and 40 to 80 years for timber harvest.

3. The area disturbed differs. Historically, 15 to 25 percent of the central Oregon Coast Range at any given time may have been in an early successional stage because of wildfires, whereas timber harvest generally affects a larger total area.

4. Disturbance from timber harvest is widely dispersed over the landscape, whereas natural disturbance events may cover a larger area in a single event.

Hicks et al. (1991) reviewed studies that evaluated the effects of habitat change on salmonids and concluded that timber harvest has simplified salmonid habitats and the process of simplification was continuing. Although the loss of stream structure due to reduced levels of large wood has only recently been viewed as a problem, it has contributed to major habitat degradation (Hicks et al. 1991). Some changes in habitat, however, such as increased temperatures and increased fine sediment are more transient and less detrimental than originally believed. Based on their review, Hicks et al. (1991) formulated the following principles that should guide logging operations to protect aquatic habitat:

- *Protection of streamside zones by leaving streamside vegetation intact will help maintain the integrity of channels and preserve important terrestrial-aquatic interactions.*
- *Productivity of streams for salmonid populations tends to be enhanced under conditions of moderate temperatures, low to moderate sediment levels, high light levels, adequate nutrients, an abundance of cover, and a diversity of habitat and substrate types.*
- *Productive floodplain and side-channel habitats should be protected.*
- *Streams should be protected against frequent and extreme episodes of bed-load movement or sediment deposition through careful streamside management and through proper planning and engineering of roads and timber harvest systems.*
- *Management of streamside zones should include provisions for long-term recruitment of large woody debris into stream channels and for protection of existing stable large woody debris.*
- *The geology, geomorphology, and climate of a watershed mediate the response of fish populations to timber harvest. Site-specific management recommendations must consider regional landforms and climatic variation.* (Hicks et al. 1991, p. 518.

It should be noted that the last principle is consistent with a landscape approach to the regulations of timber harvest.

Most studies of the effects logging on salmonids have looked at specific stream reaches and target species. However, when aquatic habitat loses diversity and complexity as a result of timber harvest, there is a corresponding loss of diversity in fish assemblages at the basin scale. For instance, instead of having coho, chinook, and chum salmon in a watershed, as a result of homogenization of the habitat, it now supports only coho. This represents an important loss in biodiversity. In a study of 14 small to intermediate coastal basins in Oregon, Reeves et al. (1993) found lower diversity in fish assemblages in streams with high harvest levels than in streams with low harvest levels. Fish assemblage diversity in a watershed was most highly associated with the percent of the basin harvested. Reeves et al. (1993) attributed this in part to the more diverse habitats in the basin with low timber harvest levels. Streams in those basins had more pieces of wood and more pools than did streams from basins with high harvest levels. Reeves et al. (1993) concluded that basin-level evaluations are needed to fully assess the effects of timber harvest in a watershed. This conclusion is consistent with our recommendation that habitat management and protection should be approached from the landscape perspective.

SEDIMENTATION

Sedimentation is a natural process, occurring in both "unmanaged" and actively managed basins. Swanson et al. (1987) provide excellent overviews of sediment producing processes in forests of the Pacific Northwest. Their review emphasizes the high degree of variability that exists in sediment relationships, across landscapes and over time, and as these interact with natural and human-mediated events. Everest et al. (1987) provides a useful perspective about sedimentation. Their central theme is that sediment is a natural part of stream systems, and that there is an equilibrium between sediment input and sediment routing that needs to be maintained to have healthy stream systems. This means maintaining a balance between the amount of fine sediment, coarser bedload sediment and larger elements of in-stream structure (boulders, large wood). Both the production and routing of suspended sediment and bedload sediment are important.

Reid (1981) reported sediment yields ranging from 13 to 133 tons per square kilometer of basin area per year in systems not under active management (Table 2). Landslides and bank erosion are the dominant sources of sediment in these "unmanaged" systems.

Table 2. Source of sediment in undisturbed 6th order basin

Source of sediment	Sediment production (m^3/ km^2/yr)
Bank erosion	29.0
Landslides	28.0
Debris flows	9.7
Tree throw	8.9
Animal burrows	4.0

Source: Reid, 1981.

The effect of active forest management on sedimentation is a central issue. Benda et al. (1998) summarize the interaction between land management, sedimentation and fish habitat. Numerous efforts have been made to study sedimentation in connection with forest management. As an example, Beschta (1978) reporting on the Alsea watershed studies in the Oregon Coast Range found increases in suspended sediment discharge from two small watersheds occurring over an 8-year post disturbance period. The increase in discharge was episodic, and the author associates periods of elevated discharge with disturbance. In a 25-percent patch-cut watershed, sediment production was elevated for three years, with the elevations dominated by two road failure related events. In the other five years, the level of sediment discharge resembled the pre-treatment pattern. In the second watershed, 82 percent of the areas was clearcut, and slash burned with no stream protection. The highest sediment discharge occurred after burning, with annual reductions in discharge occurring over the next six years until pretreatment levels were attained. Beschta attributes the pattern of the response in this watershed to the degree of vegetative cover, but is not able to determine the influence of soil disturbance close to the stream on the effects measured.

It has been much more difficult to quantify the effects of management on in-stream sediment condition over landscapes larger than those included in the Alsea study. In an analysis of stream

gravel composition, Duncan and Ward (1985) surveyed 12 watersheds in SW Washington. They found no statistically significant relationship between the amount of fine sediment in stream gravel and any variable except bedrock geology. Streams draining watersheds dominated by sedimentary rock had a higher level (11.6%) of fine sediment (< 2 mm) than watersheds dominated by volcanic rock (10%). However, they note that when only two variables are considered (and sediment finer than 0.63 mm is addressed), the frequency of road drainage points into streams is a statistically significant factor. Everest et al. (1987) note that studies of the impacts of forest management on fish have generally failed to isolate the effects of fine sediments from the effects caused by other habitat changes, making it impossible to segregate the effects.

Reid (1981) calculated the sediment production from road-related and natural process in two hypothetical sub-basins of the Clearwater basin in northwestern Washington (Table 3). They found that roads accounted for about 75 percent of total sediments, and 82 percent of the sediment that was less than 0.2 mm in size.

Table 3. Calculated road-related and natural process sediment production (assumes no other management actions) in two hypothetical sub-basins of the Clearwater basin.

Source of Sediment	Sediment Production, tons/km^2/year			
	NW Basin		SW Basin	
	Total	< 2 mm	Total	< 2 mm
Road-related, all sources	190	99	308	130
Natural processes, all sources	79	28	79	21
Total, both sources	269	127	387	151

Source: Reid, 1981.

Major storms increase the rate and intensity of landslides and road failures. Initiating landslides may turn into debris flows (movement of material beyond initiation area, on the slope but outside of a channel) or debris torrents (movement of material down a channel), depending on site characteristics and conditions at the time. Debris flows and debris torrents commonly transport much more sediment than the initiating event, due to the scouring action of the movement of the debris on the slope or in the channel. Debris flows stop moving when the slope gradient of the channel decreases. Debris torrents also tend to stop and become debris jams when channels merge, especially where the debris torrent is in a channel that enters another channel at a steep angle. Predictive models (Benda and Cundy, 1990) are useful in analysis and management of such events.

Several investigations of storm-related landslides have been conducted. Following a major storm event in 1975, Gresswell et al. (1979) analyzed mass soil movements associated with roads and clearcuts on the Mapleton District of the Siuslaw National Forest in the central Oregon Coast Range. Their findings indicate slides in harvest units accounted for over three-quarters of the failures and about two-thirds of the landslide volume; however, the average volume associated with road failures was twice as large as in-unit failures. The study results provide guidance on characteristics associated with the failures. Swanson et al. (1977) working in the same general

area reported the frequency of landslides was 1.9 to 4.0 times greater in clearcuts than it was in similar areas of unharvested forest. In a study of small unroaded areas, Ketcheson and Froehlich (1978) found a frequency of land sliding that was 3.7 times greater in clearcuts than in undisturbed forest.

ODF conducted an extensive evaluation of storm-related landslides following the 1995-1996 season. ODF concluded that the incidence of road-related failures was smaller and slide volumes were smaller than in past studies, suggesting that the changes in road practices since 1972 is reducing road-related slope failures.

Swanson et al. (1987) summarized data on land sliding and sedimentation from the various watershed level studies of the region, but note serious limitations with them:

- The forest management and harvest strategies used in the study are not necessarily relevant today.
- The results only reflect the complex of weather as it occurred at the time of the study.

The problem is that the interrelationships between treatments, site characteristics, and weather are unique, making each study a case history. There is limited ability to compare the results among such major efforts. This is not suggesting we can't learn from them ? but the uniqueness of what is learned from each study must be appreciated.

In summary, roads, landslides, and bank erosion are believed to be the dominant sources of sediment in managed systems, and there is a strong interaction with storms. Given riparian protection, landslides and roads become the dominant source likely to be influenced by management action.

Roads as a Source of Sediment

According to Luce and Black (1999) road-related erosion is the result of the interaction between how much sediment is available for transport and the power of water to move it. They provide an analytical framework for dealing with both factors, providing a reasonable scientific basis for both evaluating the potential for movement of road-related sediments to the stream, and prioritizing the protective measures that might be taken to address them. Surface-related erosion from roads appears to be concentrated in the first few years after construction, landslide-related erosion and sediment production could occur many years later, and is highly episodic.

Based on their findings, Luce and Black (1999) conclude that substantial amounts of sediment can come from relatively standard roads with little use, and that it is possible to substantially reduce road erosion by targeting those sections with the greatest sediment production. Their paper addresses the sources of variability, which may be able to be incorporated into management guidelines or standards. This study is significant because of its location in the Oregon Coast Range, and the fact it began in November 1995 and ran through the February 1996 storm.

Reid and Dunne (1984) conducted an important study in the Clearwater drainage of the Olympic Mountains in western Washington. Their study of 10 road segments provides helpful relationships between road surfacing materials, intensity of use, and rainfall and its related hydrograph. Their results quantify what logic suggests, i.e.,

- Sediment concentration increases with culvert discharge for active roads, but showed no increase for an abandoned road.
- Sediment concentration is higher during periods of heavy road use compared to periods of light use.
- Sediment yield increased with the amount of rainfall in a storm, and was higher for roads with a higher intensity of use.

Using the relationships developed in their study, they calculated the average annual sediment yield from various types of roads in the study basin. They also estimated the proportion of road miles in various level-of-use categories for a 40 percent clearcut basin being managed on a 60-80 year cutting cycle (Table 4).

Table 4. Sediment yield per kilometer of road, and proportion of the length of unpaved roads in a given level of use category, Clearwater Basin, Olympic Mountains, Washington.

Road type	Average sediment yield (tons/km/yr)	Basin roads in a road type (% of km)
Rock, heavy use (>4 loaded trucks/day)	500	6
Rock, temporary non-use (Heavy-use road not used for 2 days)	66	Not applicable
Rock, moderate use (1-4 loaded trucks/day)	42	5
Rock, light use (no loaded trucks, but some light vehicles)	3.8	39
Paved	2.0	Not applicable
Abandoned	0.5	50

Source: Reid and Dunne, 1984.

The data in this table are the sediment yield at the culvert. How much of this enters the stream system varies with the proportion of road runoff that is diverted to streams. Estimates for this are highly variable, ranging from 75 percent (Reid and Dunne, 1984), to about 33-34 percent (Bilby et al. 1989) and (Wemple et al. 1996).

Based on the data for paved roads, Reid and Dunne (1984) suggest 1.8 tons of sediment per km of road per year comes from cut slopes and ditches, considerably less than might have been anticipated. They note that the armoring of the surfaces that occurs with time since disturbance is a key factor in this process.

The key point from Table 4 is to show the difference in sediment production from roads that are in various levels of use, and paved or unpaved. We do not suggest these are the values to be extended to many other areas, but only show that there is a basis on which estimates can be constructed and decisions made which will influence the sediment production from road systems and road surfaces.

Bilby et al. (1989) followed the generation and fate of sediments from gravel road surfaces in southwestern Washington. Their study shows smallest sizes of sediment (<0.004 mm) comprised about 80 percent of the sediment yield from both the two mainline road sites and the two spur road sites. A settling pond that received runoff from the mainline road was effective in reducing sediment load in the ditch flow during periods when the concentration of sediment was high, and the rate of water discharge was moderate to low. While trapping perhaps only 20 percent of the sediment, the settling pond accumulated more than 1 ton of sediment over the course of the study period. Perhaps significantly in terms of potential impact on aquatic habitat, the settling pond trapped about 97 percent of the sand-sized sediment. This larger sized sediment is more likely to be deposited in streams as stream velocity decreases. The settling pond had no influence on the smallest sized sediment (<0.004 mm) or turbidity. They note this sized material is much less likely than sand-sized sediment to be deposited in spawning substrates in the stream system. Settling ponds may provide some short-term relief, but eventually they will fill, and either no longer be able to serve as a sediment trap, or may require maintenance and disposal of the sediment to a location where it will not erode to streams

The Bilby et al. (1989) study sites differed in the nature of the road base and the rock used as a surface for it. Their article suggests that the depth of the ballast (and the nature of the surfacing materials) was different at the two sites, but they provide no quantitative data on this point. The mainline road was on relatively flat terrain (no cut slopes), while the spur road was much steeper and had cut slopes.

They provide regression equations to illustrate the relationship between intensity of road use (axles per day) and sediment production over the course of a storm. Although this factor alone accounts for (explains) 60 to 70 percent of the variation in sediment production on the spur road, it accounts for very little (<3%) of the sediment production on the mainline road. When the same data set is analyzed on an hour-by-hour basis, however, intensity of use appears to be the dominant factor on the mainline road as well. The regression equation and relationships for only one site are provided in the paper (presumably the equations and relationships for the other sites can be obtained from the authors). For the site illustrated, the combination of axles per hour and accumulated number of axles explain nearly 60 percent of the response (concentration of sediment in runoff from the road system).

Bilby (1985) studied the input of sediment from a mainline haul road in southwestern Washington for one year. He found that at a point 50 meters below the point of road runoff, 21 percent of the total sediment load of the stream at that point was road-related. By weight, 80 percent of the sediment introduced from the road was <0.004 mm in size, and 79 percent was entering the study reach from upstream. In contrast, he reports, that more than 80 percent of the "fine sediments" in the stream bed gravel were from 0.25 to 2.0 mm in size. Analysis of

sediment cores from above and below the study sites showed no difference in the proportion of fine sediments (<2 mm) by weight. Bilby concludes that in this case study that the road surface sediment did not make an appreciable contribution to sediment stored in the channel, although this is a reflection of the particular site under study (1% slope, vegetated ditches, deep road prism), and cannot be widely extrapolated. The transport of sediment is clearly influenced by the energy of the water flow, as illustrated by the increasing degree with which sand-sized sediment (0.63-2.0 mm) was transported with increasing steepness of the road gradient. Road gradient accounted for 97 percent of the variation in the data they collected at these five sites (2 mainline, relatively flat road gradients of 2% and 2.5%; and 3 secondary roads with gradients between 3.1% and 14.4%).

Burroughs and King (1989) summarized extensive research on sediment production and control on forest roads in Idaho. They also summarize relevant research findings from other parts of the United States. While the weather patterns and soil properties are remarkably different in many cases from those of the Oregon coast range, the qualitative aspects of the relationships they report are useful. Examples of their findings include the following:

- Heavy vehicle traffic on unsurfaced, rutted roads doubles sediment production.
- 6 inches of crushed rock reduces sediment production by 70 percent, and when combined with grass at the margins of the travel-way, 84 percent (2 inches of rock did not reduce sediment production).
- Bituminous coverings (asphalt) and road oils reduced sediment production by 97 and 85 percent respectively.
- Sediment production from unconsolidated fill slopes is high, but decreases exponentially with time.

Several strategies have been evaluated to quantify their effectiveness in reducing sediment production from both cut and fill slopes. Interestingly logging debris placed parallel to the contour decreased sediment production by 75 percent, suggesting this may be a useful strategy around landings and perhaps skid roads. Seeding alone does little until vegetation is established, and prior to establishment seed is subject to loss from the site with soil from erosion. Although a study in the Oregon Cascades on a 100 percent slope cut-bank showed seeding reduced sediment production by 36 percent.

There are quantitative relationships for the transport of eroded sediment from fill slopes to streams. Although these would need to be evaluated for use in the Coast Range, such characterization would be helpful because it will show the distance over which protective strategies are needed near streams. The specific data reported for an erosive soil in northern Idaho suggests distances of 100 feet or less were relevant. This suggests there is a basis on which protective strategies can be developed for Oregon — and with monitoring, their effectiveness evaluated.

Burroughs and King (1989) show interesting relationships among the various sources of sediment from a road study site in Idaho, where artificial rain was used. Although the quantitative aspects of the relationships probably do not apply in the Oregon Coast Range, qualitatively the relationships may well be valid, and can provide a basis for providing for

sediment production management. These relationships are shown in Figure 14 of Burroughs and King (1989).

Many of the ideas developed in Burroughs and King (1989) are evaluated in Luce and Black (1999) in connection with their study of sediment production from forest roads in western Oregon. They established important relationships between sediment production and such parameters as distanced between culverts, road slope, soil texture, and cut slope height. The study appears scientifically sound. Their findings can be summarized as follows:

- Sediment production was a function of road-segment length and slope.
- Rocked roads on silty clay loam produced nine times the sediment as rocked road on a gravelly loam.
- Sediment production was not correlated with the height of the cut-slope.
- Road segments with vegetation cleared from cut-slope and ditch produced seven times the sediment as road segments where the vegetation was retained.

In summary, we conclude that there is significant scientific evidence to show that management actions can influence chronic sediment production from roads. This evidence is well documented and is known to ODF, based on its citation in their reports.

Road Drainage

Road drainage is the process by which road-related sediment might be moved to stream systems. Road drainage issues include (a) spacing between cross road drainage culverts, (b) the effectiveness with which these culverts operate, and (c) the location at which discharge from drainage culverts occur.

ODF (1996) monitoring data show that about one-third of the road systems on State and private forest lands in western Oregon can deliver sediment to streams by ditch delivery. West of the crest of the Cascades in Oregon and Washington, other estimates of road drainage discharged to streams or gullies range from 33 percent (Wemple et al. 1996) to 34 percent (Bilby et al. 1989) to 75 percent (Reid and Dunne, 1984). Paul (1998) reports that road drainage points are associated with about one-third of the road-related landslides, based on surveys in western Washington (Toth 1991) and western Oregon (Mills 1991). Irvin and Sullivan (cited as an unpublished report by Duncan et al. 1987) looking at three watersheds in western Washington and Oregon, note 20 percent of road runoff points discharged onto the forest floor and 80 percent emptied directly into drainage systems (70% emptied into first- or second-order channels). The balance emptied into permanent watercourses. These data show the importance of road drainage systems, and the impact of their discharge of sediment entrained in water on water quality.

We conclude that reducing the amount of road drainage water that flows into channels can reduce sediment delivery to streams. Although it may not be possible to reduce the number of points at which entry occurs, the volume of road drainage water at these points can be reduced by more frequent cross-road drainage. The key is to reduce the length of the road drainage ditch that leads directly to the point where it discharges to the channel. This can be accomplished by

installation of a cross-road drainage structure a relatively short distance "uproad" from the channel entry point.

Piehl et al. (1988) studied ditch-relief culverts and low-volume roads in the Oregon Coast Range. As part of their paper they summarized relevant research from two other related efforts, as follows: after the major storms of December 1964 and January 1965, the Forest Service conducted an analysis of storm-related road failures in the Pacific Northwest. They concluded that the failure of road-drainage facilities caused nearly all road damage and those plugged ditch-relief culverts contributed significantly to the problem (Dyson et al. 1966). In the second effort by Krag et al. (1986), the authors reported on an analysis of 31 slope failures on the Queen Charlotte Islands in Canada. Most of the road-associated failures were traced to problems of road drainage (i.e., ditches - absence of ditches or ditches formed from road ballast; or culverts - spaced too far apart, too small, or poorly located).

In their Oregon Coast Range study, Piehl et al. (1988) found ditch-relief culverts spaced on average from 30 to 170 percent greater than the guidelines developed for such drainage by Arnold (1957). The average culvert spacing on Forest Service and BLM roads was closest to the guideline. The greatest average spacing was on private lands (although the sample of sites studied on state and private lands was quite small in comparison to the size of the sample on federal proprieties). Culvert inlet condition was also studied. On average, the cross-sectional opening of culverts averaged 81 percent of original, due to a combination of siltation, debris, denting and slumping of cut banks. This suggests that the ability of the culvert to pass water and material entrained in it was reduced by 19 percent over that envisioned in the design.

Erosion at the outlets of culverts was measurable in 38 percent of the cases studied. Outlet discharge volume increased with increased spacing between ditch-relief culverts. When spacing between culverts exceeded the "Arnold" standards by more than 100 percent, the erosion volume was 3 times as great as it was when the spacing standard was exceeded by less than 100 percent.

The stability of fill slopes below ditch-relief culverts showed some relationship to the degree to which spacing exceeded the Arnold guidelines, but the variability was high, suggesting the importance of a site-specific evaluation. Although the predictive power of the relationship may be low, it shows the correctness of the logic that the specifics of the location of drainage discharge points, and the volume of water they handle, will influence fill-slope stability.

The Arnold spacing guidelines have served as a guideline in this region for more than 30 years, but we caution that they should not be viewed as a standard. The guidelines appeared in a 1957 summary publication on soils of the Douglas-fir region. As nearly as we can determine, the guidelines are based on an unpublished report by Arnold of "studies" of culvert spacing. Piehl et al. (1988) note that the guidelines have not been systematically evaluated.

In absence of better information, we suggest the "Arnold guidelines" continue to be used because they provide a systematic basis for design of ditch-relief culvert drainage patterns. Monitoring culvert/drainage system function over time will provide the basis for refinement of these guidelines.

A difficult issue to manage is low-level sediment production over an extensive area, contrasted with high-level sediment production concentrated in a few areas. For instance, Piehl et al. (1988) in the central Oregon Coast Range evaluated 515 crossroad culverts. There were two such crossings where landslides occurred. These accounted for 72 percent of the sediment production from all 515 crossings. Although it is important to reduce or eliminate such large sources of sediment, the average sediment production at all of the other sites averaged 0.7 cubic meters of erosion per site, for 28 percent of the total.

ODF surveys have found that many landslides are the result of the failure of roads not constructed to current standards. These are roads constructed befosre the current OFPA rules were in place. These so-called "legacy roads" continue to be sources of sediment long after they were constructed, due to their inherently higher rate of failure.

Road Maintenance and Abandonment

Roads with any vehicular use since 1972 are required to meet OFPA maintenance requirements, regardless of when the road was constructed. Effective maintenance is required both for stability of the road, and for its efficient use, however. Maintenance as an activity both produces and influences sediment production.

Luce and Black (1999) comment on the issue of cleaning road drainage ditches. They found that sediment yield on older roads with undisturbed ditch lines is small compared to newer roads, or roads with disturbed ditches (unless the cut-slope is producing a great deal of sediment. They suggest that road surfacing (use of aggregate) and control of the level of traffic could be equally as effective in influencing sediment production. In a further study by Black and Luce (1999), in the same location in the Oregon Coast Range, they monitored sediment production over two years, 1995-1997, following blading of a rocked road surface. They found a 76 percent reduction in sediment yield the second year, which they attribute to revegetation of the cut-slope and ditch, and the armoring of the road surface once the fines exposed due to the blading were removed. Revegetation was thought to play a significant part in the erosion reduction.

Reduced tire pressure (reduced from 620 kPa to 340 kPa) on logging trucks has been shown to reduce sediment production from 45 to 80 percent operated over low quality aggregate (Foltz 1996; Foltz and Elliot 1997), as reported in Luce and Black (1999).

We conclude that when roads are newly constructed or are in use, policies that address road surface composition, tire pressure, and frequency, distribution, and characteristics of cross-road drainage and the maintenance of these systems can influence sediment production and delivery to streams. Limiting maintenance of ditches and roadside vegetation during periods of low road use will reduce chronic sediment production, allowing the system to “armor up”. However, this must be coupled with road design and construction strategies that produce an “inherently stable” road. There are no formulas to completely ensure success in this. However, there is a strong engineering and science conceptual base for it. This makes best management practices (BMP), reinforced with experience, a sound approach. The Luce and Black (1999) and Black and Luce (1999) papers are rich in guidance for scientifically-based approaches to road sediment management in the Oregon Coast Range.

Abandonment (including stabilization) of roads can help reduce road-related sedimentation problems, both chronic and episodic. Weaver and Hagans (undated) provide useful discussion and perspectives for road abandonment. Although much of their perspective is influenced by experience with the redwood region of northern coastal California, the concepts and practices they discuss are useful in Oregon. The many practices they discuss are likely to be helpful, but it is difficult to elect the more cost-effective strategies. The costs of various approaches are outlined in Table 1 of their report. Prioritization of road abandonment strategies at any given location, and the prioritization of general areas in which abandonment strategies should be exercised, is needed.

Harr and Nichols (1993) evaluated decommissioning roads in one case study in Canyon Creek (tributary of the Nooksak River in northwestern Washington). They reported that 17 road-related landslides deposited 191,000 cubic meters of sediment into streams during four periods of rain-on-snow events with recurrence intervals of 2 to 5 years. After decommissioning work, only a single road-related landslide occurred during a record rain-on-snow runoff event of 1989-90, and none of its sediment reached the stream. Decommissioning involved stabilization of fills, removal of stream crossings, recontouring slope, and reestablishing drainage patterns to reduce landslide hazards. Note this is an unreplicated case study, but it suggests decommissioning may be a useful strategy in some cases. Segment decommissioning costs ranged from $1615 per km to $6625 per km. Sixty-six percent of the length cost less than $1615 per km for decommissioning. The average cost for road abandonment was $3500 per km.

Non-road-related Landslides

Slope failure rates are highly variable across the landscape and over time. This is a fundamental problem in the analysis of these events. When superimposed on the question of human-related actions as changing the rate or magnitude of disturbance, relative to historic patterns, it is difficult to make this comparison.

ODF began monitoring landslides in 1988 (ODF 1997). Their findings included the following:

- Very few landslides occurred on areas the Department had determined to be high risk sites.
- Landslides associated with roads (especially those constructed prior to 1983) dominate the statistics.
- Approximately one-third of the landslides investigated were classified as in harvest units (as opposed to related to roads or landings).

Following the major storms of 1995-1996, ODF (1998b) conducted an extensive survey of landslides. ODF stratified the landslide data according to length of time between harvest and slope failure. Although there is variation, the general pattern is that the rate of land sliding was highest in stands 0-9 years post harvest, and lowest in stands 10 to 30 years, and then increased with stand age. Probably of greater importance is the landslide erosion rate (how much sediment is moved). When the same data set is analyzed with respect to soil moved (yd^3/acre) the pattern is similar to that for rate of land sliding, but the variation is higher. As a generalization, the

erosion rate is higher in areas shortly after harvest, and then it decreases with stand age. In three of four cases, the erosion rate is lowest in stands more than 100 years of age.

The ODF study provides a clear picture concerning the association of land form and slope steepness with the rate of occurrence of landslides (Table 5). There were no landslides that entered channels where slopes were less than 40 percent.

Table 5. Slope steepness is critical.

Slope class, %	Landslide frequency, % of total	Cumulative landslide frequency, % of total
0 – 60	8	8
60-70	15	23
70 – 90	49	72
90 +	28	100

Landform also appears to be a useful indicator of landslide erosion risk. In those study areas in which more than 20 landslides occurred, uniform slopes and, in all but one case, concave slopes had the greatest incidence of landslides. Convex slopes and irregular slopes were lower. Landslide inventories show that from one-third to one-half of all landslides in the Oregon Coast Range originate in headwall areas. This relationship suggests a higher level of predictability on a site-by-site basis than exists.

The COPE analysis of headwall leave areas in the central Oregon Coast Range (Mapleton Ranger District) showed the Mapleton Risk Rating System is a useful guide in assessing the risk of slope failure in headwall areas (Martin 1997; Skaugset et al. 1993). This is a semi-quantitative checklist system in which field observers assign numerical values to various characteristics of headwall areas. These are based on the degree to which they are believed to contribute to headwall stability. Although this rating system loses predictive power at higher risk rating levels, it remains useful in instances where the goal is to reduce the risk of erosion from slope failure in headwalls. This risk assessment system has not been tested outside of the Central Oregon Coast Range (highly dissected marine sandstone and siltstone). Such testing is needed and can be incorporated into monitoring and adaptive management strategies.

Re-analysis of headwall inventory data in the central Oregon Coast Range showed no statistically significant difference in slope failure rate in clearcut, forested and headwall leave areas. However, this is not a random test of the variables, and the sample size is quite small. We do not consider it a critical test of the hypothesis, and caution against the use of the general findings as indicating that headwall leave areas are ineffective in preventing or reducing slope failures.

Important quantitative relationships between landslide initiation and subsequent behavior were reported by Fannin and Rollerson (1993) following their analysis of 449 debris flows in the Queen Charlotte Islands of British Columbia.

In general, we conclude that, on average, the relationship between slope characteristics (and other factors) and slope failure are helpful for management of the risk of landslide-caused sedimentation on actively managed forest properties, but the variation exhibited on a site-by-site basis is very large. We should not be surprised by this site-to-site variation. If it were not the case, then all steep headwall sites would have failed long ago. Refinements in our understanding of the interaction among site factors and our technical ability to characterize them are needed to permit more accurate predictions of slope failure potential.

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