Chapter 3

3. AFFECTED ENVIRONMENT AND ENVIRONMENTAL EFFECTS

3.1 INTRODUCTION

This chapter provides information concerning the affected environment and the environmental effects of the alternatives. The affected environment sections describe the current condition against which the significant environmental effects are evaluated. The following areas are discussed:

- Sediment (Section 3.2)
- Hydrology (Section 3.3)
- Riparian Habitats (Section 3.4)
- Wetlands (Section 3.5)
- Water Quality (Section 3.6)
- Fish (Section 3.7)
- Wildlife (Section 3.8)
- Fire (Section 3.9)
- Cultural Resources (Section 3.10)

The environmental effects related to each of the above resource areas are discussed immediately following the presentation of the affected environment for each resource. The environmental effects sections provide the scientific and analytical basis for the comparison of alternatives presented in Chapter 2. They present the expected effects on the natural and the built environments associated with implementation of the alternatives. All significant or potentially significant environmental consequences are disclosed, including the direct, indirect, and cumulative effects. Effects are quantified where possible, although qualitative discussions are often necessary. Cumulative effects are addressed in a separate section at the end of Chapter 3.

Direct environmental effects are those occurring at the same time and place as the initial cause or action. Indirect effects are those that occur later in time or are spatially removed from the activity but would be considered significant in the foreseeable future. Cumulative effects result from the incremental effects of actions when added to other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes such other actions.

3.1.1 Available Information

There is less than complete knowledge about many of the relationships and conditions of the resources and issue areas including fish and wildlife. The ecology, inventory, and management of a large forest area, whether local, subregional, or regional, is a complex and developing science. The biology of fish and wildlife species prompts questions about population dynamics and habitat relationships. In developing the affected environment and environmental effects sections of this EIS, the analysis team examined the data and relationships used to estimate the effects of the alternatives. The data and level of analysis used were commensurate with the importance of the possible effects. Much of the analysis was based on the geographic information system (GIS) databases of the DNR as they existed in late 1999.

When encountering a gap in information, the analysis team generally either collected the information or developed the information through modeling. In some cases however, the effort required to obtain the information was prohibitively expensive or required too long a period of time, relative to the value of the information. In these cases, the team concluded that the missing information would have added precision to estimates or better specified a relationship; however, the basic data and central relationships are sufficiently well established in the respective sciences that the new information would be unlikely to reverse or nullify understood relationships. Thus, new information would add precision, but was not considered essential to provide adequate information for the decision-makers to make a reasoned choice among the alternatives.

3.1.2 Evaluation Criteria and Relationships Among Sections

Evaluation criteria are defined for each of the resource areas within their individual sections in this chapter. The criteria are briefly defined in a subsection placed immediately before the detailed discussion of environmental effects in all of the sections. Many of the resource areas have a variety of individual potential effects and individually identified criteria that stand alone. For the following sections, however, the relationships among the criteria are more complicated and are interrelated:

- Sediment
- Hydrology
- Riparian Habitats
- Water Quality
- Fish

The evaluation criteria for these sections are defined in greater detail, along with a background literature review, in Appendix B.

The effects on the environmental components of these resource areas are closely related and these interrelationships are shown in Figure 3.1-1. This figure shows the interrelationship of management activities (e.g., timber harvest; road construction, use and maintenance; and pesticide use) with the individual environmental components or individual environmental systems (e.g., riparian system or hydrological system) they affect.

It also shows how effects on one environmental component cascade to other environmental components. For example, timber harvest can influence shade and all other components of the riparian system, and through that effect can influence the temperature and sediment components of water quality. These, in turn, can directly influence the habitat and physiology of fish. Fish can also be directly affected through riparian modifications such as changes in LWD production which can affect fish habitat.

3.1.3 Environmental Effects and Risk Statements

It is desirable to be able to summarize the environmental effects of the alternatives in terms of their potential for meeting the three environmental goals of the Forest Practices Board, namely:

- To provide compliance with the Endangered Species Act for aquatic and riparian-dependent species on non-federal forest lands;
- To restore and maintain riparian habitat on non-federal forest lands to support a harvestable supply of fish; and
- To meet the requirements of the Clean Water Act for water quality on non-federal forest lands.

The Forest Practices Board also has an economic goal that **they** must consider:

- To keep the timber industry economically viable in the state of Washington.

However, this EIS only considers how each element of the alternatives would meet the three environmental goals. The question as to whether each element would meet the environmental goals cannot be definitively answered with a yes or no.

Existing knowledge about most of the relationships that define aquatic and riparian systems is incomplete. The ecology and management of aquatic and riparian habitats within forest ecosystems is a complex and developing science. Therefore, the major conclusions of this EIS relative to meeting the environmental goals of the Forest Practices Board are necessarily expressed in terms of risk. Ideally, risk statements should be quantified. However, because the physical and biological relationships of aquatic and riparian systems are imprecisely defined, and because quantitative measures do not exist for many aspects of the alternatives, the risk statements are given in qualitative terms.

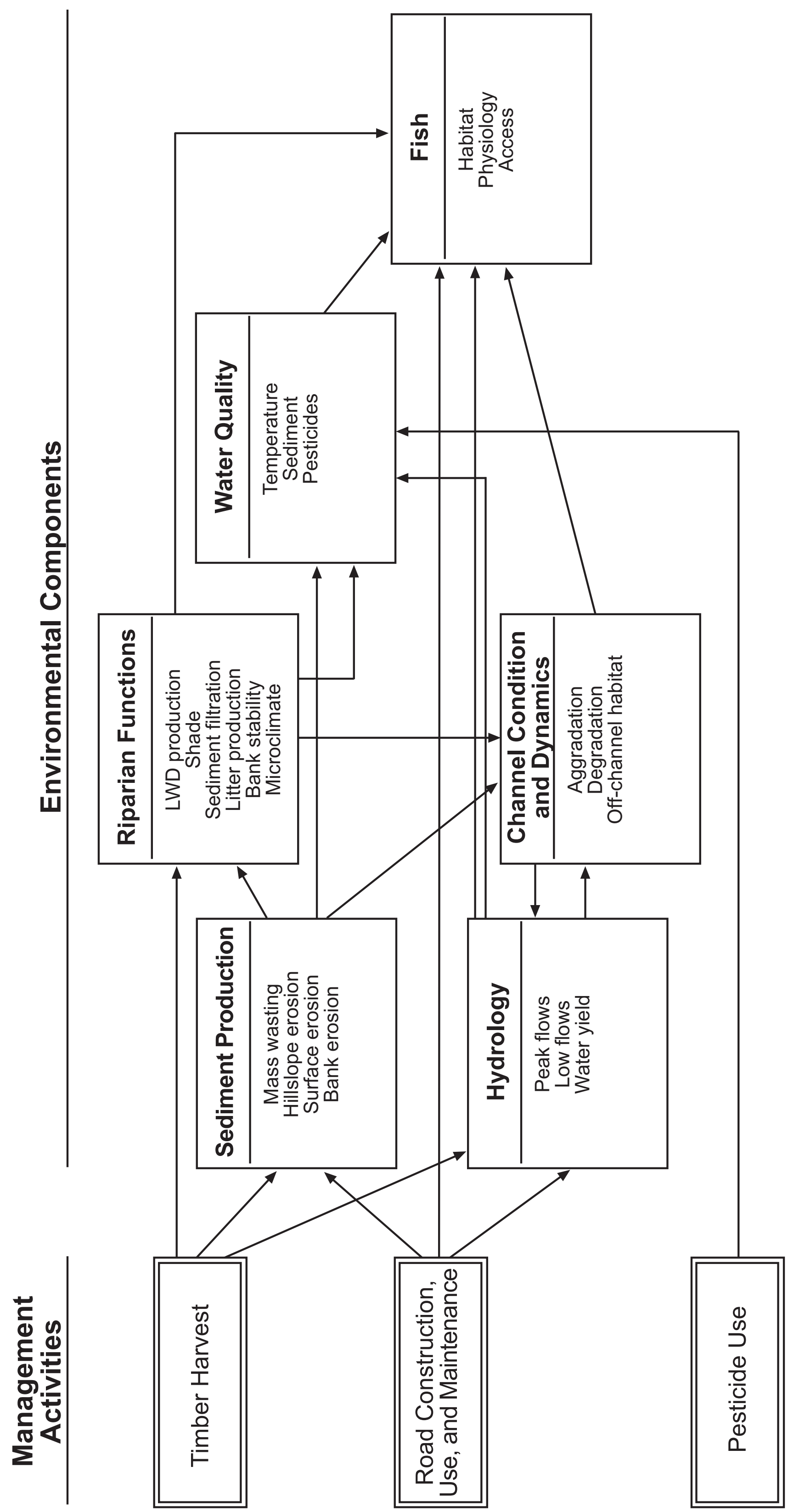
Risk is defined in this EIS as the likelihood that a specific factor will not support the achievement of one or more of the environmental goals. These risk statements assume that other factors (e.g., non-forest practices, ocean conditions, harvest, etc.) do not prevent the goals from being met.

The scientists who conducted the analysis for this EIS developed risk statements based on best professional judgment after weighing all of the quantitative evaluation criteria that were developed, as well as their review of the scientific literature. They also considered the performance targets identified in Schedule L1 of the Forests and Fish Report and the likelihood that they would be achieved. Further, they considered the fact that each alternative incorporates a level of adaptive management, which allows for change in the rules over the long-term, based on feedback from research and monitoring activities. In giving consideration to adaptive management, the efficiency and timelag involved for each adaptive management program was also evaluated.

Finally, the issue of uncertainty was also considered. Because of the lack of information available to make definitive statements regarding risk, each of the risk statements given has a certain amount of uncertainty associated with it. In a few cases, the amount of uncertainty associated with the risk statement is quite high; in these cases, the high uncertainty is noted along with the risk statement.

As described in Chapter 2, the Forest and Fish Report has the potential to be developed into a Habitat Conservation Plan that could be in place for up to 50 years. Consequently, the effects analysis in the EIS generally considers “long-term” to mean approximately a 50-year period, but in some circumstances could be a longer time period. Given the definition of “long-term,” a “short-term” period is considered approximately 10 years.

Figure 3.1-1. Generalized Relationships among Management Activities and Environmental Components of the Aquatic Ecosystem



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3.2 SEDIMENT

3.2.1 Introduction

Sediment transported from upslope areas into stream channels can adversely affect the hydrologic system and its beneficial uses, such as fish habitat and water quality. In addition, sediment transport in the form of landslides can adversely affect public safety. Sediment enters water through various processes including surface erosion, channel erosion, and mass movements, and these inputs can be either chronic or episodic. This section discusses the management-related impacts that can influence sediment delivery to streams.

3.2.2 Affected Environment

Sediment delivery rates are controlled by watershed characteristics such as geology, topography, vegetation, and hydrology. As a result there is equilibrium between sediment input and sediment routing that must be maintained to have a healthy stream system (Everest et al., 1987). Sediment inputs are a combination of fine sediment, coarse sediment, and larger elements of instream structures, such as boulders and large wood. In undisturbed basins, most natural sediment production occurs from streambank erosion, debris slides followed by debris flows, tree blowdown, and animal burrows. Forest practices, through the alteration of soil structure, vegetation, and hydrology, can significantly alter the delivery of fine and coarse sediment to streams, thereby potentially adversely affecting the beneficial uses of the stream network. The primary management-related sources of sediment are surface erosion and mass wasting from timber harvest activities and roads.

To effectively discuss the effects of forest practices on sediment production in forested environments, it is important to have an understanding of the major management activities that contribute sediment to the drainage network.

3.2.2.1 Road-related Sediment

Surface Erosion

Road-related surface erosion is a function of sediment available for movement and the power of water available to move it. Road construction, use, maintenance, abandonment, and drainage all play important roles in the production and delivery of sediment. Surface erosion from roads tends to be a chronic source of fine sediment to the drainage network. Chronic sources of fine sediment can adversely impact the physical habitat of the aquatic system and certain lifestages of fish and amphibians, and also degrade water quality. Delivery of fine sediment to streams from roads is a major concern because of the thousands of miles of forest roads that exist to transport harvested timber in forested regions of the state. Appendix F, Forest Roads evaluates the specific best management practices (BMPs) of each alternative and should be consulted for further details.

Road-Related Landslides

Landslides are episodic sources of fine and course sediment to the aquatic system. A landslide is the mass movement of soil, rock, and debris downslope; it occurs most frequently after heavy winter rains. Landslide activity can be greatly accelerated by road management practices. Many studies have shown that on a unit area basis, roads have the greatest effect on slope stability of all activities on forestlands (Sidle et al., 1985). However, some recent research suggests that harvest-related landslides occur with roughly equal frequency as road-related landslides (Montgomery et al., 1998).

Road location, drainage, design, construction, and maintenance are all-important factors in effective road design, but can be contributing factors to road-related failure. Newer road construction and engineering design has reduced road-related landslides relative to roads constructed more than 15 to 20 years ago (Toth, 1991; Robison et al., 1999). Road-related landslides can become debris torrents and impact stream channels.

Orphan Roads

For the purpose of this analysis, orphan roads are roads constructed prior to 1974 that have not been used for forest practices since that time. Such roads are typically not maintained and many were constructed without a requirement to consider public resource and channel impacts. The mileage of orphan roads in the state is unknown; however, the associated hazards have been identified. The concern with orphan roads is the potential for failure and initiation of debris flows and torrents.

3.2.2.2 Sediment Related to Timber Harvest

Timber harvest-related sediment can be delivered to the aquatic system as short-term surface erosion (fine sediment) generated from harvest units and skid trails, or it can be episodic from landslides initiated in harvested areas on unstable slopes. Timber harvest activities often alter watershed conditions by changing the quantity and size distribution of sediment that can lead to stream channel instability, pool filling by coarse sediment, or introduction of fine sediment to spawning gravels.

Surface Erosion

Surface erosion is dependent on many variables. The primary variables are slope, soil texture, and vegetation cover (Benda et al., 1995). Harvest activities such as ground skidding or cable yarding can cause some degree of soil disturbance. Typically, ground-based systems compact and disturb more soils than non ground-based harvest systems (Graham et al., 1990). The harvest systems most likely to cause greater levels of disturbance (from greatest to lowest) are ground-based systems, cable yarding, and aerial systems (Beschta, 1995). Clearcuts tend to create the greatest area of soil disturbance (Hermann, 1978); however, disturbance from felling, yarding, and skid trails in partial cuts can also cause ground disturbance and compaction. Cromack et al. (1978) found levels of soil disturbance in clearcut and partial cut areas to be comparable because of the need for equivalent access through a harvest unit. Accelerated rates of erosion are generally not prolonged for more than several years as areas revegetate (Beschta et al., 1995). Fine sediment that is transported overland can be significantly reduced by streamside buffer strips. The ability of riparian buffer strips to control sediment inputs from surface erosion depends on several site characteristics including the presence of vegetation or organic litter, slope, soil type, and drainage characteristics. Additionally, the filtering capacity is affected by timber harvest activities within the buffer. Although soil disturbance generally increases the sediment delivery potential, the addition of obstructions on the forest floor from tree limbs and boles associated with partial logging can offset diminished filtration (Burroughs and King, 1989; Benoit, 1979).

Mass Wasting

Landslides

Landslides tend to be the dominant natural erosion mechanism in areas with steep slopes throughout the Pacific Northwest (Swanson et al., 1987). Landslides are an important disturbance mechanism to riparian areas and are episodic sources of predominantly coarse and fine sediment to the drainage network of a watershed. Generally, less than 2 percent of the land is directly affected by landslides at any given time (Ketcheson and Froelich, 1978; Ice, 1985). Debris slides are the most common landslides on steep forest lands. Major storms increase the rate and intensity of landslides. Sidle et al. (1985) summarized several studies (Swanston, 1970, 1974; O'Loughlin, 1974; Ziemer and Swanston, 1977; Burroughs and Thomas, 1977; Gray and Megahan, 1981; Ziemer, 1982) indicating that stability depends partly on reinforcement from tree roots, especially when soils are partly or completely saturated.

DEBRIS TORRENTS

Landslides can turn into debris torrents, which are classified as debris flows (approximately 80 percent solid and 20 percent water) or hyperconcentrated floods (about 80 percent water and 20 percent solid), depending on site characteristics and conditions at the time. Debris flows usually transport more material than the initiating event, due to scouring action on the slope or in the channel. Debris flows stop moving when the slope gradient of the channel decreases or when the flow encounters a sharp bend in the channel. Debris torrents contain significant amounts of wood and can travel varying distances, which can result in variable degrees of impact depending upon channel gradient, confinement, layout of the channel network, and other characteristics (Fannin and Rollerson, 1993). Debris torrents and debris flows can have significant, long-lasting effects on stream channels. The channel location and cross-section can be radically altered in such a way that normal flows and normal peak flows cannot reconfigure the channel easily (Lamberti et al., 1991). This is important because even though landslides in general may affect only one percent of a watershed, debris flows and torrents can affect 10 percent of the stream system because of their mobility (Swanson et al., 1987). In addition to having significant impacts on the stream channel, debris torrents can also affect riparian buffer functions and streamside forests when bank scour is so great that streamside vegetation is removed (see discussion on streambank stability).

STREAM BANK STABILITY

The roots of riparian vegetation help bind soil together, which make stream banks less susceptible to erosion. The stability of stream banks is largely determined by the size, type and cohesion of bank material, vegetation cover, and the amount of bedload carried by the channel (Sullivan et al., 1987). Riparian vegetation can also provide hydraulic roughness elements that dissipate stream energy during high or overbank flows, which further reduces bank erosion. In most cases, vegetation immediately adjacent to a stream channel is most important in maintaining bank integrity (FEMAT, 1993); however, in wide valleys with shifting stream channels, vegetation throughout the floodplain or CMZ may be important over longer time periods.

3.2.2.3 History of Forest Practices Affecting Sediment Production

Prior to the adoption of the Washington Forest Practices Act in 1974, there were few rules or regulations that governed timber management activities on state and private forest lands. In early years, streams were used to move logs downstream to accumulation sites. Most streams of sufficient size in western Oregon and Washington were cleared of obstructions for log drives during high water (Sedell et al., 1991). On streams too small for log drives, splash dams of log cribbing were used to raise a head of water for sluicing logs (Sedell and Luchessa, 1982). By about 1900, over 300 major splash dams and many undocumented smaller dams operated in Oregon and Washington.

Railroads were built along the mainstems of the larger drainages, and logs were yarded down the smaller tributaries to the rail bed. In this way, impacts extended to intermittent channels. Whole watersheds were logged as convenience dictated beginning in the lower watershed and progressing upstream until all valuable timber was taken. Logs were yarded downhill, scraping debris and sediment into stream channels. Streams were protected from being used for yarding beginning in the 1950s. Clearcutting to the streambank, however, was normal practice until the 1980s.

Timber harvest and associated road building can lead to increased rates of erosion into stream channels, which can alter substrate composition within the channels. Channel disruption, decreased rooting strength, removal of debris from channels, and elevated sediment loading decrease the stability of channel morphology and the stream substrates (Gregory et al., 1987). Roads were constructed on unstable slopes with substandard construction techniques compared to today's practices. The result is a legacy of roads that continue to be sources of chronic and episodic sediment into the drainage network. In addition, there were few restrictions on harvest unit size. The proportion of sediment contributed from different timber harvest activities varies between areas. Some studies have shown that landslides related to timber harvest contribute more sediment on a watershed basis, than landslides associated with roads (e.g., Paulson, 1997), while other studies indicate that roads contribute more sediment, through both landslides and surface erosion (Ice, 1985). Differences in lithology, soils, style of timber harvest, and road age may be responsible for this variation.

Furthermore, the effects of debris torrents and debris flows originating from harvested areas may be more damaging than such landslides originating from mature forest. Reynolds and Paulson (1997) documented that the run-out along stream channels of debris flows which originated in harvested areas, was twice as long as those landslides originating in mature forest. Buffers intended to minimize landsliding and provide a fencing effect may be compromised by short-term losses to wind; therefore, the ability of a buffer to withstand blowdown is an important aspect of its effectiveness. In a detailed study of four dam-break floods, Johnson (1991) found that the width of damage to riparian stands averaged 75 feet and ranged from less than 33 feet to 197 feet (depending on channel slope and valley width.

The legacy of these past practices can be observed on the hillslopes of many managed-forested areas. Road construction associated with timber harvest activities began before 1950, with many areas thoroughly harvested prior to that time. Many of the roads used before the advent of forest practices rules were no longer in use by 1974. These old roads, called orphan roads, have been recognized as potential hazards to public resources and public safety (Brunengo and Bernath, 1990). Since the establishment of forest practices rules and the requirements of the Clean Water Act, rules and BMPs were implemented to guide timber harvest methods and new road construction.

3.2.2.4 Existing Conditions Related to Sediment Production

In a DNR unpublished draft document on forest roads (DNR, unpublished draft report, 1999), significant amounts of sediment entering the drainage network were documented in 70 percent of the sub-basins reviewed. The survey was conducted on 380 miles of forest roads on 113 square miles of various private and public lands on 23 westside sites and 11 eastside sites. Maintenance issues and rule language that does not address sediment delivery during road construction and maintenance were concluded to be the major factors contributing to the current state of road surface erosion and road-related mass wasting in Washington. The findings of the DNR survey include:

- Landslides were identified in half of the survey areas, with some areas delivering large amounts of sediment to perennial streams.
- Approximately 65 percent of the survey areas had direct delivery of sediment from roads to streams.
- Culverts were a problem in 90 percent of the sub-basins.
- Individual roads can exceed natural sediment input levels by 40 times.
- Road drainage ditches were a problem in 66 percent of the sub-basins.
- Commonly used road maintenance techniques are inadequate.
- Watershed analysis and road maintenance plans assist landowners in identifying and correcting resource issue.

The forested environment includes steep slopes or specific landforms that have a greater potential to fail, especially if disturbed by management activities. High and moderate hazard unstable slopes are defined as areas that have the greatest potential for mass wasting. Approximately 9 percent of the eastside and 18 percent of the westside consist of unstable slopes with a high or moderate potential to deliver sediment to streams (see Appendix E for more information).

3.2.3 Environmental Effects

In describing the environmental effects of sediment, it is best to separate the discussion according to the primary sources of management-related sediment -- roads and timber harvest. This discussion is presented in the following sections.

3.2.3.1 Evaluation Criteria

A number of evaluation criteria have been identified to evaluate the degree of protection from sediment impacts offered by each of the alternatives. Both quantitative and qualitative criteria are necessarily included. These criteria are defined in greater detail in Appendix B. Quantitative analysis of many of these criteria are provided in Appendix D (Riparian Habitat Analyses), Appendix E (Slope Stability Analysis), and Appendix F (Forest Roads).

Road Surface Erosion

As described in Section 3.2.2, road surface erosion is affected by road construction methods, road use, road maintenance, road abandonment, and drainage. The criterion for evaluating this chronic source of sediment impacts is how the forest practices rules that define road management (i.e., planning, construction, use, maintenance, drainage, and abandonment) under each alternative, control road-related sediment production and delivery to streams (see Appendix F).

Road-related Landslides

The potential for road-related landslides depends on both the location of roads in relation to unstable areas and on how the roads are designed, built, and maintained. Therefore, the evaluation criteria for this episodic source of sediment impacts are: (1) the degree that unstable slopes would be avoided under each alternative; and (2) the degree of protection from road-related landslides provided by the forest practices rules (see Appendices E and F).

Hillslope Erosion Related to Timber Harvest

The disturbance of soil on hillslopes from timber harvest activities can result in short-term surface erosion that can be generated until vegetation is reestablished. The potential for delivery of fine sediment to streams is dependent upon the amount of ground disturbance and the interception of potential overland flow. The evaluation criteria for harvest-related sediment is the amount of harvest and hillslope-related surface erosion that reaches stream channels through riparian buffers. In Section 3.2.3.2, the width of RMZs is compared to a buffer width of 30 feet. Then the activity allowed in the RMZ is evaluated by using the results of the equivalent buffer area index (EBAI) for sediment (see Appendix D) and by assessing BMPs within the RMZ.

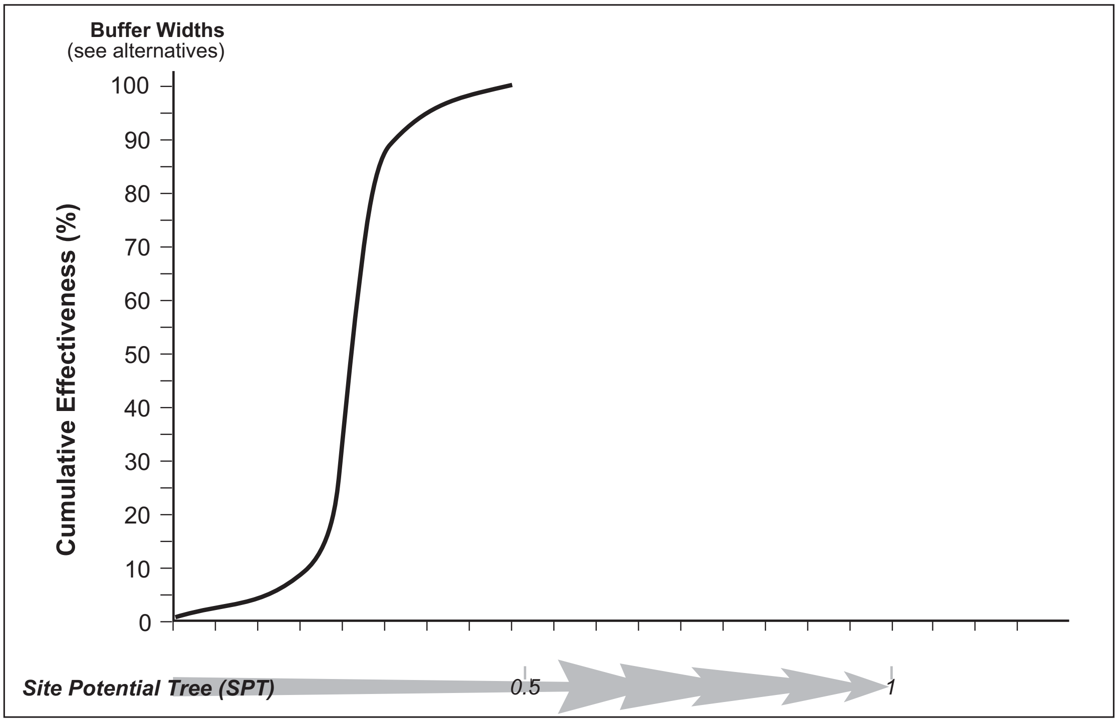
Landslides Related to Timber Harvest

Harvest-related mass wasting is most likely to occur on steep slopes and specific landforms that are highly susceptible to mass failure. The initiation of failures from management activities can occur near streams within riparian areas and upslope areas. Buffers intended to protect slope stability (in addition to other functions) and provide a fencing effect may be compromised by short-term losses to wind; therefore, the ability of a buffer to withstand blowdown is an important aspect of its effectiveness. The evaluation criteria for harvest-related landslides is the degree of protection provided to unstable areas by forest practices rules. These criteria include protection of unstable slopes upslope from RMZs that may buffer upslope landslides, landslides that may occur in RMZs, and debris torrent initiation areas that are likely to deliver sediment to the channel, and buffer effectiveness (see Appendix E).

Bank Stability

This evaluation is based on width of the respective RMZs and activities allowed within the buffer that may affect root strength and, thus, stream bank integrity. For this analysis, one-half of a tree crown diameter (or its equivalent 0.3 of a site-potential tree height [SPTH], based on 100 to 250 years) is assumed to provide complete protection of bank stability (Spence et al., 1996), though it is realized in certain channels, particularly bedrock controlled channels, a much narrower RMZ would be required to maintain bank stability. The full estimated relationship between bank stability protection and SPTH is shown in Figure 3.2-1.

Figure 3.2-1. Percent Effectiveness of Root Strength in Relation to the Distance from the Stream Channel



Source: FEMAT, 1993

Figure 3.2-1
The Percent Effectiveness of Root Strength in Relation to the Distance from the Stream Channel

3.2.3.2 Alternative Evaluation

Road Surface Erosion

ALTERNATIVE 1

> Alternative 1 would result in a high risk of fine sediment delivery to streams, primarily because the rules do not directly address the desired outcome; therefore, they lack the needed flexibility for site-specific situations. In addition, RMAPs are not generally required and rules and BMPs that address road drainage are inadequate. The risk of sediment delivery is substantially reduced with watershed analysis.

Under Alternative 1, the forest practices rules are intended to reduce the risk of sediment delivery to streams based on implementation of BMPs. As discussed in Appendix F, there is a high risk of sediment delivery to streams from roads, under Alternative 1. This was confirmed in a published study by Rashin et al. (1999) who evaluated the BMPs in the current forest practices rules. However, where watershed analysis had been applied, prescriptions were developed to reduce surface erosion for areas where there was a high vulnerability to a public resource, such as fisheries or water quality.

A road maintenance survey was conducted by the DNR on 379 miles of forest roads across the state. The unpublished draft document concluded that the rules under Alternative 1 are subjective and inadequate because they do not establish an acceptable limit on how much sediment delivery constitutes resource damage. The delivery of fine sediment from the road surfaces to streams are addressed by the rules with statements such as “minimize erosion” or “not conducive to accelerated erosion;” however, the rules do not directly address the desired outcome, which is to avoid resource damage. In addition, the rules do not offer a standard process for landowners and regulators to assess or identify successes and failures relating to resource protection which can lead to varying compliance expectations throughout the state for landowners, regulators, and the public. The draft report by the DNR on road maintenance concluded that the current rules emphasize the use of culverts and ditches as the primary means of addressing hydrologic issues, but do not adequately address sediment production. The results of the survey showed that approximately 65 percent of the survey areas had direct delivery of sediment from roads to streams (DNR, unpublished draft report, 1999).

In addition, the rules under Alternative 1 do not result in a landscape-level approach to sediment reduction. The rules do not encourage the reduction of road drainage into streams. Road maintenance and abandonment plans, which are more of a landscape-level assessment, are not mandatory unless DNR assessments indicate an ongoing problem; in this situation, road plans are required on a case-by-case basis. The rules under Alternative 1 do not have any specific guidelines or assessment tools in the Board Manual as to when these plans are required. The draft report by the DNR on road maintenance concluded that road maintenance and abandonment plans appear to assist landowners in identifying and addressing most issues that have the potential to cause resource damage and are effective at providing better protection for public resources; however, surface erosion appeared to be a problem in some areas that had a road maintenance and abandonment plan (RMAP) (DNR, unpublished draft report, 1999).

Alternative 2 would substantially reduce road-related sediment from delivering to streams due to: 1) improved BMPs and 2) implementation of RMAPs, and 3) an outcome-based and enforceable policy statement that requires resource protection. However, monitoring is necessary to verify the resource protection required by an outcome-based policy.

ALTERNATIVE 2

Under Alternative 2, the BMPs recommended in the Board Manual are expected to substantially reduce sediment delivery to streams relative to Alternative 1. Like Alternative 1, many of the BMP guidelines would be prescriptive; however, the revised outcome-based policy statements under Alternative 2, requires whatever measures are necessary to protect water quality and aquatic/riparian habitats (see Appendix F).

The approach of the rules under Alternative 2 is specifically designed to reduce road-generated sediment. For new roads, all ditch relief culverts would be required to empty onto the forest floor in such a way that no sediment reaches a stream. Research has shown (Duncan et. al, 1987) that outfall sediment can travel overland for 100 feet (or more) under certain conditions. Therefore, Alternative 2's requirement for ditch relief culverts will result in placement of the culvert at least 100 feet from any stream. Other conditions, such as slope and soil texture, could make the culvert-to-stream distance even greater. Road maintenance and abandonment plans would be required by 2005 of landowners with more than 500 acres of forest land. They would require the inventory and assessment of all forest roads, including orphan roads. Further, the rules under Alternative 2 specify that all upgrades to roads must be completed, and new maintenance standards applied to all roads built after 1974 by the end of 2015. Priorities in the rules place activities and locations with the highest potential benefit to fish and water quality early in the maintenance and abandonment schedule. The DNR provides guidance and tools necessary for landowners to complete the road maintenance and abandonment plans.

The road maintenance and abandonment plan represents a landscape-level approach that includes prioritization of problem sediment areas and temporal components for completion that would reduce the delivery of chronic sediment to streams. Abandonment plans would prioritize roads for abandonment that would exempt them from future maintenance. This would also result in further reduction of surface erosion sediment delivery to streams.

The road policy to protect water quality and aquatic riparian habitats does not explicitly include or recommend tools such as monitoring to measure the effects of roads on the resources. As a result, there is no systematic way to determine whether the policy or goals will be attained in a given watershed under Alternative 2. However, general effectiveness monitoring will occur through the adaptive management program and the proposed rules require annual reviews of road plans and meetings with landowners which are likely to include an assessment of the plan's effectiveness.

There is great difficulty associated with implementing a cost- and time-efficient monitoring plan that can verify the attainment of resource goals (e.g., in order to verify that new ditch relief culverts do not deliver any sediment to streams, intensive monitoring may need to be conducted during rainy periods). Consequently, the adaptive management program intends to focus effectiveness monitoring within representative watersheds to obtain a higher likelihood of collecting meaningful data rather than a lower level of monitoring dispersed over a wider area (M. Hunter, WDFW, personal communication, January 19, 2001) .

Alternative 3 would produce a low risk of road-generated sediment from entering streams over the short-term, as well as over the long-term, because of the restriction on increasing road densities and the shorter timeframe for completion of RMAPs; otherwise, it would be similar to Alternative 2.

ALTERNATIVE 3

Alternative 3 would substantially reduce road sediment delivery to streams relative to Alternative 1. There would also be a reduced risk of road sediment delivery to streams under Alternative 3 compared to Alternative 2. This is primarily due to the requirement of no net increase in forest road densities on state and private timberlands. In addition, Alternative 3 would require orphan roads to be maintained or abandoned and would eliminate sources of chronic sediment where these roads deliver sediment to streams. In addition, the time frame for road maintenance and abandonment plan completion by 2010 would be 5 years shorter than under Alternative 2. Road upgrades and road abandonment in a shorter time period would reduce the total quantity of sediment generated by surface erosion compared to Alternative 2.

Road-related Landslides

ALTERNATIVE 1

Alternative 1 would result in a continued moderate risk of road-related landslides because:

1) the unstable slope screening process does not identify some unstable areas;

2) the rules and BMPs that address road drainage are inadequate; and

3) there are generally no requirements for RMAPs.

Under Alternative 1, road-related landslides would continue to occur at their current rate and deliver episodic quantities of sediment to streams. The construction of roads on potentially unstable slopes increases the risk of road-related failures (as mentioned above). Landforms with a high potential for mass wasting would most likely be identified in forest practices applications (FPAs) and classified as Class IV-special. A Class IV-special forest practices application covers practices where there is a potential for substantial impact to the environment such as aquatic habitat, water quality, and cultural resources (see Section 1.4.1). Because of the rudimentary screening tools used to identify unstable areas, there is a greater likelihood that potentially unstable areas may be missed in the application process.

The current rules also have few specific guidelines that directly address road-related mass wasting issues such as road drainage. Road-related landslides can be caused by road drainage problems such as plugged culverts and inadequately spaced cross drains and/or roads construction on potentially unstable slopes. Problems can result from inadequate construction and maintenance. The rules under Alternative 1 require culverts and bridges that cross streams to pass a 50-year flow event. Cross drains are only required every 600 to 1,000 feet depending on road grade. A recent draft report by the DNR on road maintenance concluded that the most common drainage problems that caused resource damage to streams were undersized culverts and inadequate cross drain spacing; the most common maintenance related drainage problem was the maintenance of functional inlets (i.e., the drains from roadside ditches that divert water under the road through a culvert).

In addition, the current rules do not address drainage onto unstable slopes. Road drainage onto unstable areas can initiate mass wasting and the drainage onto unstable areas may not be identified when an FPA is reviewed; thus, a road built on stable ground may drain water onto potentially unstable areas. The drainage of water onto steep slopes can increase the risk of slope failure. Where watershed analysis has been conducted, the prescriptions for mass wasting would address and reduce the risk of road-related landslides.

Studies by Toth (1991) and ODF (1999) found that newer roads (younger than 10 years old) experienced a lower rate of mass wasting than older roads. Because there is no requirement under the Alternative 1 rules to upgrade roads to current construction standards unless a public resource has been damaged, the thousands of miles of older roads (both active and inactive) and orphan roads would continue to fail over time and deliver large quantities of sediment to the drainage network. If roads or orphan roads are damaging public resources, the DNR has the authority to require the repair of these roads.

Alternative 2 would result in a low to moderate risk of road-related landslides because:

1) the unstable slope screening process would be refined;

2) the rules and BMPs that address road drainage would be substantially strengthened; and

3) RMAPs would be required.

ALTERNATIVE 2

Under Alternative 2, new roads built on potentially unstable slopes would require greater scrutiny if the forest practices application is processed as a Class IV-Special. Class IV-Special applications would require a specific SEPA review including a site evaluation by a qualified expert and a detailed mitigation plan (see Appendix E for more details). In addition, a more refined screening method would be used to identify potentially unstable slopes that have a potential hazard of delivering sediment to public resources. This more refined screening process would reduce the risk of road construction on high hazard mass wasting areas and reduce the potential of failure on slopes and landforms with a high hazard failure potential.

Road drainage guidelines in rules under Alternative 2 would reduce drainage-related road failures such as plugged culverts. There are more specific BMPs in the rules that address road drainage. Some of these include: outsloping roads so more runoff drains onto slopes, improved cross-drain spacing, and installation of new culverts that can pass a 100-year flow event. Maintenance BMPs include removing debris from culvert outlets and inlets after major storm events and preventative ditch maintenance.

The BMPs under Alternative 2 fail to consider that roads located on stable slopes may drain onto potentially unstable slopes (e.g., a ridge-top road that drains water onto convergent headwalls) without initiating a Class IV-Special application. This omission represents a risk of mass wasting which has been documented in a study by Montgomery (1994).

Under Alternative 2, an existing culvert will be replaced unless it meets the following three requirements: (1) pose "little risk to public resources"; (2) "have been properly maintained"; and (3) be "capable of passing fish" (WAC 222-24-050). The RMAPs to be implemented under Alternative 2 are intended to prevent failure of existing culverts by requiring maintenance and replacement of culverts that pose a significant threat to public resources. There are many existing culverts on type N_p and N_s streams. If damage to public resources is imminent, the existing culvert must be replaced sooner, rather that later. However, if a culvert passes the three requirements mentioned above, the culvert does not need to be replaced to meet upgraded standards until the end of its lifespan.

The required RMAPs would result in landowners with over 500 acres of forested land to upgrade all roads on their ownership by 2015. Landowners with less than 500 acres would submit a RMAP with next forest practices application. This would improve all roads to current construction standards, which has been demonstrated by Toth (1991) and ODF (1999) to have a much lower rate of mass wasting (e.g., failure) than older roads. The use of RMAPs would substantially reduce the risk of road-related landslides compared to

Alternative 1. Orphan roads would be inventoried and assessed. After the inventory and assessment, the maintenance and/or abandonment of orphan roads would be conducted by 2015. Where orphan roads are abandoned, there would be further reduction of potential mass failure of roads, sediment delivery to streams, and potential debris torrent initiation.

> Alternative 3 would result in the lowest risk of road-related landslides because:
>
> 1) there would be no net increases in roads;
>
> 2) the rules and BMPs that address road drainage would be substantially strengthened; and
>
> 3) RMAPs would be required in the shortest timeframe.

ALTERNATIVE 3

The potential risk for road-related mass wasting would be less than under Alternative 2. The no net increase in roads on a per unit basis would reduce the risk of failure because fewer roads would be constructed. In addition, the time frame for RMAPs and the upgrade of older roads to current construction standards would occur over a shorter time frame (10 years) than Alternative 2. The shorter time period for the RMAPs, which include the maintenance of orphan roads, decreases the potential road failures because the potential for failure of older roads would be reduced by 5 years. Roads on stable slopes that drain onto potentially unstable slopes would not be classified as Class IV-Special applications, resulting in the same risk of mass wasting from this impact as under Alternative 2. Alternative 3 would result in an overall reduction of road-related sediment from entering the drainage network.

Landslides Related to Timber Harvest

ALTERNATIVE 1

> Alternative 1 would result in a moderate risk of harvest-related landslides delivering to streams, primarily due to the low frequency of RMZ protection along steep Type 4 and 5 streams.

Under Alternative 1, some landforms with a high potential for mass wasting would most likely be identified during processing of the forest practices application. Due to the rudimentary methods used to screen for unstable areas, there is a greater likelihood that potentially unstable areas may be missed in the application process. In addition, there is little incidental protection of potentially high hazard slopes under Alternative 1 because there are no RMZs for Type 4 and 5 waters, which constitute approximately 80 percent of all streams on the landscape. RMZs of fish-bearing typed waters (Type 1, 2, and 3) provide some incidental protection of areas with a high hazard mass wasting potential; however, the effectiveness of these buffers may be impaired by short-term losses to windthrow.

Under Alternative 1, the only protection provided for small channel junction angles and steep channel gradient slopes would be if they triggered a Class IV-special application based on appearing to be unstable and having a potential to significantly impact a public resource. Because these areas receive no specific protection, there is a moderate risk of debris torrents. The steep small tributary streams tend to be first- and second-order streams that would be Type 4 and 5 waters. These streams have no buffers to protect them from management activities.

Once a debris flow is initiated, the RMZs of higher order streams may act to reduce the channel impacts. The streams most susceptible to riparian damage by channelized debris flows tend to have gradients greater than 20 percent. On the westside, approximately 95 percent of all streams with gradients greater than 20 percent are Type 4 and 5 waters; these streams would receive no buffer protection of riparian damage by channelized debris flows. Lower gradient streams (Types 1-3) would receive some (though probably minimal in some cases) protection against riparian damage by dam-break floods under the existing

RMZ. This alternative would have a moderate risk of harvest-related landslides delivering to streams.

> Alternative 2 would provide greater protection relative to Alternative 1, but would still result in a slight to moderate risk of harvest-related landslides delivering to streams. The risk would result from the lack of RMZs on many steep nonfish-bearing headwater streams.

ALTERNATIVE 2

Under Alternative 2, 5 percent of slopes with a high potential for failure would be incidentally protected by the RMZs based on modeling (see Appendix E). The Class IV-special process (see Section 1.4.1) provides additional environmental review of forest practices on slopes considered to have a high potential to damage public resources or threaten public safety. Currently, there is training of field personnel in the identification of high hazard features as a voluntary commitment of the Forests and Fish Agreement. The greater environmental review should reduce the risk of timber-harvest related mass wasting and potential sediment delivery to streams.

The forested landscape would be subject to more sophisticated screening methods statewide that would account for regional and local variations in soils, geology, and topography. Because the screening tool would be more likely to identify potentially unstable slopes that may affect public resources and/or safety, more applications would be classified as Class IV-special by DNR. In addition, more extensive unstable slope identification training of DNR personnel will also reduce the risk of management activities on potentially unstable slopes. These changes are not rule-based, but rather agency tools used to implement the rules and protect public resources. As a result, the rule-based language of Alternative 2 slightly reduces the risk of management-related mass wasting compared to Alternative 1 because of the greater likelihood of environmental review under SEPA.

Under Alternative 2, areas of high susceptibility to debris torrents (i.e., steep tributary junctions) would receive greater protection than under Alternative 1. If the areas of high susceptibility are on specific geomorphic landforms considered to be highly unstable and have the potential to deliver sediment to a public resource or threaten public safety, a Class IV-Special classification would be required and mitigation might be necessary for the management activity to occur. In addition, perennial nonfish-bearing streams (Type N_p) that intersect would have a 56-foot radius no-harvest buffer. Sensitive areas such as headwall and sideslope seeps, springs, and alluvial fans would also receive a 56-foot radius no-harvest protection. Seasonal nonfish-bearing streams (Type N_s), as well as unbuffered perennial streams (Type N_p) would receive protection from equipment limitation zones (ELZs). Management activities are allowed in ELZs, but with specific mitigation requirements for any soil disturbance greater than 10 percent of the ELZ area. Local buffer effectiveness may be impaired in some cases due to short-term losses to windthrow. There is still a moderate risk of debris torrent initiation because of potential for management activity in areas of susceptibility.

Approximately 25 percent of streams less than 20 percent gradient would have Type S and F buffers and 75 percent would have Type N buffers. These buffers would provide some, but not full fencing effect for debris torrents, and may be subject to short-term losses to windthrow. As a result, Alternative 2 would have a slight to moderate risk of harvest-related landslides delivering to streams.

> Alternative 3 would provide much greater protection relative to Alternatives 1 and 2 and would result in only slight risk of harvest-related landslides delivering to streams because all streams would have RMZs, and small steep streams would have CMZs.

ALTERNATIVE 3

Under Alternative 3, 14 percent of high hazard slopes would be incidentally protected by no-harvest RMZs (based on modeling) (see Appendix E). In addition, potentially high hazard areas identified in advance would automatically trigger a Class IV-special classification and would receive a 50-foot no-harvest buffer. Alternative 3 provides the most protection from mass wasting and delivery of sediment to streams due to timber harvest.

The no-harvest RMZs under Alternative 3 would protect steep stream channel junctions. This would probably reduce the frequency and downstream impacts of debris torrents. Also, there is no timber harvest or road activity permitted on high hazard slopes. Incidental protection of steep tributary junctions would also be provided if the tributary junction areas are considered high hazard mass wasting areas. Streams with channel gradients of 20 to 30 percent would be buffered by 100 feet and streams with gradients greater than 30 percent would receive 70-foot buffers. Further, additional CDZ buffers would be added along steep streams, with expected channelized landslides. These buffers should provide a fencing effect from potential debris torrents. Because buffer widths are wider under Alternative 3, they are more likely to be sufficiently windfirm and thus more likely to function fully and without short-term losses to blowdown.

Hillslope Erosion Related to Timber Harvest

> Alternative 1 would result in nearly full protection of hillslope erosion from directly reaching Type 1, 2, and 3 waters. The lack of RMZs along Type 4 and 5 streams would result in a high risk of hillslope erosion delivering sediment to these waters.

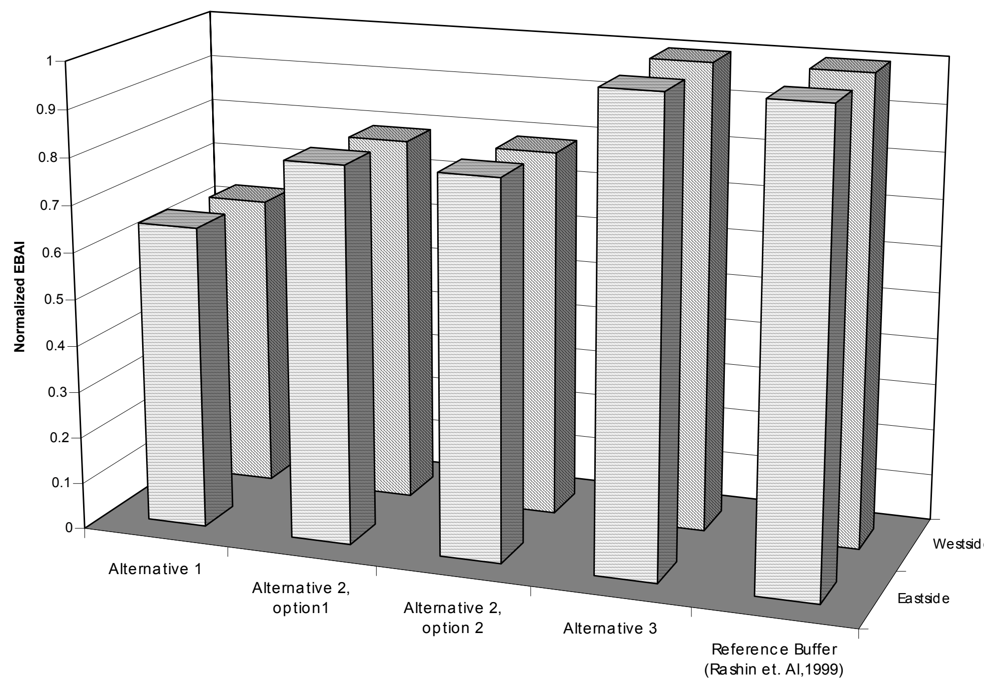
ALTERNATIVE 1

Under Alternative 1, the risk of sediment delivery to streams is greatest along Type 4 and 5 streams, which do not have RMZs. Because Type 4 and 5 streams are the most abundant streams on the landscape, the risk of sediment delivery from harvest-related practices would be high. The sediment EBAI is lowest for Alternative 1 because of the lack of riparian buffers necessary to filter harvest-related surface erosion (Figure 3.2-2). Sedimentation would be short-term until sites become revegetated. Alternative 1 provides an EBAI (see Appendix D) which is 64 percent (weighted by stream type) of the value for maximum protection (Figure 3.2-2). This weighted value is a reflection of high protection along Type 1-3 streams and virtually no protection along Type 4 and 5 streams, which accounts for the majority of stream miles within the affected lands.

In a study on the effectiveness of the existing forest practice rules at preventing sediment delivery, Rashin et al. (1999) concluded that streamside buffers (RMZs and Riparian Leave Tree Areas) were effective at preventing sediment delivery to streams on Type 1-3 streams. Along Type 4 and 5 streams, which are not buffered, physical impacts included extensive fine sediment deposition and other streambed changes such as increased streambed mobility, burial of substrates by logging slash, and loss of pre-existing large woody debris. Rashin et al. (1999) concluded that no-harvest buffers in place at the time, were generally effective in preventing sediment delivery, except where flow was channelized. Most erosion features that were identified as delivering sediment, occurred within 30 feet of a stream. However, they concluded that many of the BMPs and rules were ineffective, particularly where there was no RMZ, as for Type 4 and 5 streams. In another study, Pentec (1991) pointed out that lack of an RMZ and associated BMPs on Type 4 and 5 streams was a fundamental conceptual flaw in the forest practices rules.

In the representative sample area used for the analysis in this EIS, Types 4, 5, and 9 (west side only) streams comprised approximately 80 percent of the total stream length. The risk of sediment delivery to these and other larger streams would be high under this alternative.

Figure 3.2-2. Equivalent Buffer Area Index (EBAI) for Sediment by Alternative



ALTERNATIVE 2

> Alternative 2 would result in full protection of hillslope erosion from reaching Type S and F streams. However, there is a low risk of sediment from hillslope erosion entering Type N_P and N_S streams.

Under Alternative 2, the no-harvest portion of RMZs for Type S and F streams (a minimum of 50 feet on the westside and 30 feet on the eastside) meet or exceed the 30-foot buffer criteria necessary to filter any management-related sediment generated from adjacent harvest units or activities within the RMZs. There is full protection of hillslope erosion along Type F and S streams.

A 30-foot ELZ on each side would be applied to all Type N_s and N_p streams. Landowners must mitigate (e.g., grass seeding, mulching, or installation of water bars) for the disturbance of more than 10 percent of the soil within any ELZ as a result of the use of ground-based equipment, skid-trails, stream-crossings (other than road crossings), or partial suspension of logs during yarding. These ELZs should substantially reduce the amount of timber harvest-generated surface erosion and subsequent delivery to the stream network. Notably, there is no monitoring requirement; monitoring is necessary to determine the effectiveness of erosion control measures.

Approximately 50 percent of the N_P streams on the westside would receive 50-foot no-harvest buffers, which exceeds the 30-foot sediment filtration criterion. In addition, sensitive areas, such as seeps, hyporheic zones, and areas upstream from the confluence with Type S and F waters, would also have 50-foot no-harvest buffers. The no-harvest buffers along many of the N_P streams, and the 30-foot ELZ along the other Type N_p streams and N_S streams should prevent hillslope sediment from entering streams.

Along Type N_P streams on the eastside, if the clearcut option is chosen by a landowner, approximately 70 percent would receive a 50-foot no-harvest buffer. If the partial cut option is chosen, a 50-foot selective harvest buffer would be required. In the cases where activity is allowed, the effectiveness of the RMZ in filtering sediment is compromised, but the mitigation requirements should be effective in reducing any surface erosion from entering streams.

The EBAI for effective function of riparian sediment filtration shows that Alternative 2 would have a greater buffering effect for sediment filtration (80 percent of maximum) compared to Alternative 1 (Figure 3.2-2). However, it does not provide full protection of timber harvest-related surface erosion, specifically along Type N_P and N_S streams that do not have 50-foot no-harvest buffers.

ALTERNATIVE 3

> Alternative 3 would provide full protection of all streams from timber harvest-related hillslope erosion.

The no-harvest buffers on all stream types far exceed the 30-foot buffer criteria. Therefore, all streams should be fully protected from hillslope erosion delivery of sediment. The EBAI for this alternative (100 percent of maximum) is the greatest among the alternatives (Figure 3.2-2).

Effects of Timber Harvest on Bank Stability

ALTERNATIVE 1

> Alternative 1 would generally protect bank stability along Type 1, 2, and 3 streams. However, bank stability would not be protected along Type 4 and 5 streams; therefore, a high risk of bank instability would exist along these small streams.

In western Washington, Alternative 1 (current forest practices rules) would provide full protection for bank stability based on the RMZ buffer widths for Type 1, 2, and 3 streams when maximum RMZ widths are implemented. However, the minimum RMZ width of 25 feet does not meet the one-half crown diameter (0.3 SPTH) required for complete protection of bank stability (Figures 3.4-7 and 3.4-8). For each stream type, RMZ buffer width can vary between the minimum and maximum values, depending on the extent of wetland vegetation and the width needed for shade. Also, selective harvest would likely be implemented adjacent to the stream channel, compromising the combined root strength and increasing the risk of damage to the stream bank directly from timber harvest activities. However, a greater number of leave trees are provided in RMZs along less stable stream channels (i.e., gravel/cobble channels) and this aspect may reduce the risk of bank failure. For streams that do not meet the established criterion of one-half crown diameter (0.3 SPTH), combined with the selective harvest prescriptions, the risk of reducing stream bank stability would increase.

In eastern Washington, full protection would be provided along Type 1, 2 and 3 streams when implementing the maximum and average RMZ widths. One exception is for site class I, which would require a greater RMZ to provide a sufficient width buffer to maintain bank stability. However, minimum RMZ widths of 30 feet provide complete protection of bank stability for all other site classes (Figure 3.2-1).

As for western Washington, the possibility of harvest activity within the RMZ under Alternative 1 leaves the possibility that root strength would be compromised and the stream bank potentially damaged. However, selective harvest does maintain some stream bank integrity through root strength and minimizes stream bank damage relative to clear-cutting.

The greatest risk is for Type 4 and 5 streams that have no leave tree requirement and where timber harvest can occur adjacent to the stream. For Type 4 and 5 waters, RMZs are not required except for site-specific conditions and, in this case, would not exceed 25 feet. Therefore, RMZs for Type 4 and 5 streams do not meet the one-half crown diameter (0.3 SPTH) required for complete protection under the maximum protection provided by the current forest practices rules. Type 4 and 5 streams are smaller, tend to be moderately or highly confined, and have less erosive power; therefore, they do not necessarily require expansive buffers for bank stability protection. However, Type 4 and 5 streams are susceptible to other processes such as mass wasting and peak flows, which could also affect bank stability. The lack of an RMZ along most of these smaller streams means that Type 4 and 5 waters would receive no bank stability protection.

> Alternative 2 would protect bank stability, except along many non-fish streams which lack RMZs. However, some protection would be provided by ELZs.

ALTERNATIVE 2

Under Alternative 2, all Type S and F streams would have RMZ widths that exceed the width recommended in the literature for full protection of bank stability. On the westside, the 50-foot no-harvest zone adjacent to the stream bank (or CMZ) combined with the selective harvest inner zone under Option 1, should provide sufficient bank stability protection. Additional protection due to the no-harvest floor adjacent to the 50-foot no-harvest zone under Option 2 would provide even greater protection of bank stability. On the eastside, the 30-foot no-harvest zone adjacent to the stream bank (or CMZ) combined with the selective harvest inner zone should provide sufficient bank stability protection. Overall, Alternative 2 would provide substantially more bank stability protection than Alternative 1 along Type S and F streams.

For Type N_p streams, at least 50 percent of their lengths would receive a 50-foot RMZ; these segments would have most of the protection required to maintain bank stability. In addition, Type N_p streams are much smaller, tend to be moderately or highly confined, and have less erosive power; therefore, they do not necessarily require buffers as wide for bank stability protection. For other segments of Type N_p streams and for all N_s streams, no RMZ would be provided. However, all Type N streams would receive some protection because of the 30-foot equipment limitation zones that would be implemented. These zones provide more protection than Alternative 1. However, lack of an RMZ restricting tree harvest on these smaller streams would indicate that some Type N_p and all N_s streams are not guaranteed complete bank stability protection.

ALTERNATIVE 3

Alternative 3 would fully protect bank stability along all streams.

Under Alternative 3, the RMZ width and no-harvest prescription would meet or exceed the recommendations in the literature (0.5 SPTH no-harvest buffers) for full protection of stream bank stability on most streams. Overall, for all streams on both the east and westside, bank stability would be completely protected. In addition, where there are small channels that have potential slope stability issues, channel disturbance zone buffers would provide additional protection.

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3.3 HYDROLOGY

3.3.1 Introduction

This section discusses the direct and indirect effects of forest practices on the hydrology of state and private forestlands. The primary emphasis of this section is on peak flows because peak flows can accelerate bank erosion, change channel morphology, degrade water quality, and cause downstream flooding. Peak flows, which can become large floods, can adversely affect aquatic habitat, water quality, public infrastructure, and public safety. Timber harvest activities can affect runoff through two main mechanisms, increased runoff due to timber harvest and increased runoff due to roads.

3.3.2 Affected Environment

Three primary processes affect the hydrologic function of forested watersheds.

1. Precipitation and surface/subsurface water flow regimes determine the rates of delivery of water to forests. These processes are largely controlled by climate.
2. Interception, condensation, evapotranspiration, and canopy snowmelt determine delivery of water to the forest floor. These processes are controlled mainly by vegetation.
3. Surface and sub-surface pathways transport run-off from the forest floor to the streams. These pathways are controlled by the interaction of condensation, precipitation, evapotranspiration, interception, snowmelt, and other physical and biological factors.

The hydrologic functions of a watershed are dependent upon these processes. When these processes are individually or cumulatively altered by road construction, harvesting, or other forest practices, the hydrologic continuity of the watershed is altered. Three major areas of hydrologic concern (annual water yields, low flows, and peak flows) are discussed in this section. Section 3.3.2.4 describes how forest practices have affected hydrology.

3.3.2.1 Water Yield (Annual)

Water yield is the amount of water that enters the stream system in the watershed. Various studies (Helvey, 1980; Bosch and Hewlett, 1982; Harr, 1983; Kattlemann et al., 1983; Troendle, 1983; King and Tennyson, 1984; Trimble and Weirich, 1987; Keppeler and Ziemer, 1990) have shown increases in water yields from timber harvest. However, the increase in water yield is usually beneficial to the aquatic system (unless it results in peak flows - see below) and will not be addressed in this section.

3.3.2.2 Low Flows

Low flows are often referred to as baseflows, dry-weather flows, and groundwater flows depending on the specific need. Low flows are the flows provided by groundwater to the streams during the lowest precipitation months of the year in the summer. In western Oregon, increases in low flow are generally short-term (5 years) following clear-cut timber harvest (Rothacher, 1970; Herr et al., 1982). In a northern California study, summer low flows were increased following selection harvest and then declined irregularly for 5 years until they were indistinguishable from low flows prior to harvest (Koppelar and Ziemer, 1990). Because an increase in low flows (i.e., more water in the stream) for summer months generally does not adversely affect the beneficial uses of the aquatic system, it will not be discussed any further. Small volumetric increases may provide improved habitat conditions (lower stream temperature, increased instream wetted area and volume) and survivability of aquatic species.

3.3.2.3 Peak Flows

Peak flow is the maximum instantaneous discharge measured in stream channels during high flow periods. Management activities can affect peak flows based upon their site specific effect, elevational location within a watershed and proportion of basin forest that has been altered by timber-related activities, such as roads and timber harvest.

<u>Existing Hydrologic Conditions</u>

WESTSIDE PEAK FLOWS

Western Washington (and much of eastern Washington) receives moderate to high precipitation and is influenced by rain-on-snow events. The significance of rain-on-snow events is the increase in water delivered to the stream system during these events compared to rainfall alone. When warm air and rain occur on areas with a snowpack, rapid melting of the snow can occur, resulting in a pulse of water into the drainage network. Rain-on-snow events can occur on mountain slopes in the transient snow zone which extends from altitudes of approximately 1,000 feet to 3,000 feet above sea level (Harr, 1986), but can shift upward or downward during any given storm due to varying meteorological conditions.

Peak flow events associated with rain-on-snow can be of greater magnitude than rain-only events because the rainfall is augmented by snowmelt. The direct effects of peak flows include stream channel alteration, bank erosion, redistribution of sediment and large organic debris, and flooding. In addition to the direct effect of peak flows, rain-on-snow events generate large inputs of water to the soils and can generate unstable conditions on hillslopes by increasing the pore-water pressure, which decreases the strength of the soil (Sidle et al., 1985); a reduction in soil strength increases the potential for slope failure.

EASTSIDE PEAK FLOWS

On the eastside, the buildup of snowpack over winter contributes to large amounts of spring runoff. Rain-on-snow events are less common. In forested areas east of the Cascades, snowmelt is the dominant mechanism for producing peak flows, most commonly in February to July depending upon location and elevation. Greater snowpack in forest openings in the eastside forest can result (Kattelman et al., 1983; Troendle, 1983). Peak flows are predominantly generated by snowmelt and may account for most of the 2- to 10-year flows. The timing of snowmelt runoff is important for many eastern Washington watersheds because this runoff is vital for irrigation supplies and fish habitat.

Management Influences on Peak Flows

ROADS

The design, construction, and maintenance of roads interact with watershed characteristics of soil topography, and geology and natural disturbances (such as large storms) to determine the effects that roads can alter the general hydrology of a particular watershed. The interception or storm routing of surface runoff and interception of subsurface flow by a road prism can affect the hydrology of a watershed. In a general sense, roads can act as extensions of the drainage network if the roads drain to streams. Road-influenced peak flows have been demonstrated in small drainages within watersheds (Ziemer and Lisle, 1977); however, the effects of roads on a river basin scale are more controversial (Jones and Grant, 1996; Beschta et al., 1997)

TIMBER HARVEST

The best understood effect of timber harvest is its influence on streamflow relating to altering snow accumulation and melt rate. Increased peak flows can occur in the winter, when a warm wet storm brings rain after a cold storm deposits significant amounts of snow. The snow melts much faster than from warming of the air temperature alone. Many floods in Washington, mostly on the west side of the Cascades, have occurred as a result of rain-on-snow events. While rain-on-snow events are a natural occurrence, their effects can be exacerbated when a watershed has been logged in a short amount of time (25 to 30 years) (Coffin and Harr, 1992; Troendle and Leaf, 1980). The two most important watershed variables that affect rain-on-snow events are elevation and extent of timber harvest.

Timber harvest has the potential to alter snow accumulation and melt rates in any portion of a watershed, but predominantly in the "rain-on-snow" zone. The rain-on-snow zone in western Washington typically occurs between 1,200 and 4,000 feet in elevation (Washington State Department of Natural Resources, 1997). Forest openings are conducive to increased snow pack accumulations because more snow reaches the ground since less tree canopy intercepts the snow from reaching the ground. Once a rainfall associated with a storm occurs, the forest openings are more conducive to higher rates of convection and condensation to the snow pack than the surrounding forest. The combination of greater snow accumulation and increased melt rates can lead to a greater rate of moisture available at the soil surface in forest openings during a rain-on-snow event than occurs in the adjacent forest (Coffin and Harr, 1992). The net result is that increased in runoff is expected from forest clearcuts in areas where rain-on-snow is prevalent.

Although not as well-understood, timber harvest may increase snowmelt peak flows (Benda et al, 1995). Because timber harvest can cause increased snow accumulation in openings, areas where runoff is dominated by snowmelt can theoretically experience increased peak flows. Existing research in the Pacific Northwest has not consistently demonstrated this effect, however. While Cheng (1989) found as much as a 35 percent increase in peak flows with 30 percent clearcuts in British Columbia, Fowler et al. (1987) found no effect in small watersheds in Oregon. In perhaps the most comprehensive study, Anderson and Hobba (1959) found an 11 percent increase in spring peak flows across 21 watersheds in eastern Oregon. This area is analogous to eastern Washington.

Rain-dominated watersheds, such as along the coast, may also be subject to increased peak flows, but due to different reasons. Studies that have shown peakflow increases in rain-dominated watersheds (Harr et al., 1975; Harr 1986) have correlated the increases with soil compaction, rather than timber harvest itself. Yet other studies indicate no change in peak flow after harvest. (Benda et al., 1995). If they occur, small basins seem to be more likely to experience effects than large basins.

3.3.2.4 History of Forest Practices Affecting Hydrology

The greatest conversion of timberlands to farms and towns occurred between 1850 and 1910. As timber harvest occurred and increased over time, different harvest methods such as splash dams, railroads, and then roads were used to access and transport timber. As a result of the transportation networks in forested environments and the harvest methods, increased erosion and watershed changes occurred. A very brief history of forest practices is described in Section 3.2.2.3.

Research completed within the past 20 years has clearly documented the link between forest practices and impacts on hydrology at the sub-basin scale (Megahan, 1972; Harr et al., 1975; Harr et al., 1979; Lisle, 1981; King and Tennyson, 1984; Hicks et al., 1991). For example, the influence of rain-on-snow events on downstream flooding has been well-documented and forest practices rules have been developed in response to this new understanding (Troendle and Leaf, 1981; Harr, 1986; Coffin and Harr, 1992).

Logging impacts to the hydrologic processes within a watershed include both direct and indirect effects. An example of indirect effects of forest practices on hydrologic processes is related to mass wasting. Timber harvest and road construction has been shown, in some cases, to increase rates of both surface and mass erosion and sediment delivery to streams. Increased sediment delivery can result in increased rates of aggradation throughout the stream network. One outcome of increased aggradation is to lower the flow threshold necessary to cause overbank flooding. Thus the flood frequency may be increased within a sub-basin.

Impacts on hydrology associated with the construction and use of logging roads include:

- increased fine sediment inputs to streams due to road-related surface erosion
- increased coarse sediment inputs to streams due to increased road-related mass wasting events
- increased peak flows at the sub-basin scale due to the creation of an extended drainage network and interception of subsurface flow
- change in timing of peak flows to interruption of natural subsurface flow rates increased flooding due to rain-on-snow events

Some examples of how forest practices rules address these impacts are listed below:

- requiring strict road maintenance and planning that reduces mass failures
- requiring higher standards of road construction which has lowered the number of road-related failures
- minimizing the size of allowable clearcut patch (120-240 acres)
- minimizing the total area within a watershed that can be hydrologically immature and timing of harvest patterns linked to understanding of rain-on-snow zones within watersheds

3.3.3 Environmental Effects

The environmental effects section addresses only peak flows, because the effects of changes in the forest practices rules on low flows and water yield are not considered to cause significant adverse effects on watershed resources and public safety.

3.3.3.1 Evaluation Criteria

Road Influence on Peak Flows

Although the results of studies are varied, there is a potential that road drainage may play some role in peak flow events, which would have greater impacts on first and second order drainages. This potential may be significant in certain basins or weather events, and will be evaluated based upon the road management and drainage criteria and potential for decrease (e.g., abandonment) in roads under each alternative.

Timber Harvest Influence on Peak Flows

Many studies have found a correlation between the hydrologic maturity of a basin, especially in the rain-on-snow elevation zone, and the potential for increased peak flows. The evaluation criteria for timber harvest-related peak flows is how well the forest practices rules under each alternative reduce the potential for large land areas in the rain-on-snow zone of a basin to become hydrologically immature (i.e., early seral stage). It is important to note that although the effect of rain-on-snow events is most pronounced in the rain-on-snow zone, the rain- and snow-dominated zones may also be affected, depending on storm temperature and preceding snow conditions. Therefore, the effects of timber harvest on peak flows in rain-dominated and snowmelt-dominated watersheds was also considered.

3.3.3.2 Alternative Evaluation

Timber Harvest Influence on Peak Flows

Alternative 1 presents a moderate risk of effects on peak flows because they are only addressed through watershed analysis or DNR intervention.

ALTERNATIVE 1

The current forest practices rules address peak flows related to timber harvest by allowing conditioning of the size of clearcuts in the significant rain-on-snow zone of a watershed where peak flows have resulted in material damages to public resources. In addition, watershed analysis addresses peak flow issues, including areas where snowmelt is the dominant contributor to peak flows (e.g., Boise-Cascade, 1996). However, watershed analysis has only been applied to a small percentage of the state (see Appendix H, Watershed Analysis) and is voluntary for private landowners. Under Alternative 1, peak flow issues would be addressed in watersheds where watershed analysis is conducted.

Alternative 2 would result in similar risk of effects on peak flows relative to Alternative 1 because land-owners would have less incentive to conduct watershed analyses, but road drainage would be improved.

ALTERNATIVE 2

Alternative 2 would result in a slight reduction in harvestable timber due to the RMZs, relative to Alternative 1. Also, watershed analysis would be required to the extent funding is available and voluntary for landowners. The rules under Alternative 2 also address peak flows related to timber harvest by allowing conditioning of clearcuts in the significant rain-on-snow zone of a watershed where peak flows have resulted in material damages to public resources. The effects of timber harvest on peak flows occur in watersheds with substantial area in the rain-on-snow elevation zones. The assessment of the watersheds would likely occur with watershed analysis. However, under Alternative 2, there may be less incentive to conduct watershed analysis since many components of watershed analysis have been incorporated into the new rules. If fewer watershed analyses are conducted, the potential impacts of timber harvest and road building on peak flows would receive less consideration. Therefore, the risk of timber-harvest related peak flows could be slightly higher than under Alternative 1.

Alternative 3 would provide the lowest risk of harvest-related peak flow events because the rules would directly address the cumulative hydrologic maturity of the rain-on-snow zone.

ALTERNATIVE 3

Under Alternative 3, a new eastside hydrology module would be developed and applied to eastside watersheds that undergo watershed analysis. Watershed analysis would be required for all state lands and voluntary for private lands. In addition, a landscape rule would be applied to all applications to limit the amount of hydrologically immature (based upon crown closure) land within a watershed in rain-on-snow zones. The rule says that a minimum of two-thirds of lands by ownership, within the rain-on-snow zone of basins 1,000 acres or larger in size, must be maintained in stands that are at least 25 years old. This alternative would provide the greatest protection from potential management-related peak flows from rain-on-snow events.

Road Influence on Peak Flows

Alternative 1 would not encourage reduction of road drainage from streams; therefore, there would be a moderate risk of road-influenced peak flow.

ALTERNATIVE 1

Under Alternative 1, the road drainage BMPs such as rolling grade dips, water bars, and grade dips at stream crossings are encouraged but not required (see Appendix F). Because

Alternative 1 does not require drainage structures that reduce the volume of surface water reaching streams, the implementation of these rules may have a greater effect in extending the drainage network and potentially influencing peak flows.

ALTERNATIVE 2

Alternative 2 would reduce the potential for road-related peak flow because road drainage to streams would be reduced and RMAPs would be implemented.

Under Alternative 2, closer spacing of ditch relief culverts would be required and outlets of ditch relief culverts would have to be located to allow the dispersal of water before reaching any stream. Road maintenance and abandonment plans would have to be implemented by 2015. These include abandonment of roads and the upgrade of all roads (except orphaned roads) to current construction standards, which includes drainage. The reduction in road surface drainage would reduce the potential of road influences on peak flows.

ALTERNATIVE 3

Alternative 3 would have similar or lower effects on road-related peak flows relative to Alternative 2.

Under Alternative 3, the effects of management on peak flows would be similar to Alternative 2. In addition, there would be no net increase in roads allowed for large landowners. However, road maintenance and abandonment plans would be implemented sooner (10 years) than Alternative 2. The reduction in roads and similar drainage guidelines as Alternative 2 would likely reduce the potential influence of roads on peak flows.

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3.4 RIPARIAN HABITATS

3.4.1 Introduction

Riparian habitats include instream habitat and stream channels, adjacent floodplains and wetlands (which often include seeps and springs) (see Section 3.5). A wide variety of hydrologic, geomorphic, and biotic processes determine the character of riparian areas. Raedeke (1988) describes riparian systems as having long, linear shapes with high edge-to-area ratios and microclimates distinct from those of adjacent upland areas. Portions of riparian areas are disturbed from periodic inundation and water is present at or near the soil surface during all or part of the year. These unique characteristics result in variable soil moisture conditions and distinct plant communities that are often more diverse than surrounding upland areas.

Riparian areas have distinctive resource values and characteristics that make them important zones of interaction between terrestrial and aquatic ecosystems. These areas are especially dynamic segments of a watershed. Disturbances in upland areas (e.g., fire and windthrow), as well as disturbance processes unique to stream systems (e.g., channel erosion, peak flows, floods), affect riparian areas. Highly functional riparian areas are generally composed of large conifers or a mixture of large conifers and hardwoods. Riparian vegetation is important for maintaining stream bank and floodplain integrity. The vegetation slows water velocity on the floodplain and plant roots inhibit erosion along stream banks, reducing sediment deposition in streams (Section 3.2). Riparian vegetation also helps to provide shade, leaf, and needle litter important to aquatic food chains, and LWD which is an important component of instream fish habitat (Section 3.7). Riparian ecosystems are also important for a variety of plant and non-aquatic animals. Riparian areas provide important reproductive and foraging areas and/or dispersal/movement corridors for a wide variety of wildlife (Section 3.8).

Clearing or harvesting trees near stream banks and associated road construction can affect riparian ecosystem functions. Figure 3.1-1 displays the relationships among management activities and the environmental components of the aquatic ecosystem. This figure demonstrates the critical central role that riparian functions play in the aquatic ecosystem.

The Affected Environment Section (Section 3.4.2) will summarize the primary functions of the riparian area. In addition, the Affected Environment Section will provide a general understanding of the history of riparian management/riparian protection on private and state lands in Washington and the current riparian conditions in Washington state. In the Environmental Effects section (Section 3.4.3), each alternative will be evaluated focusing primarily on the different riparian management strategies. Section 3.4.3.1 identifies the riparian function criteria used to evaluate the alternatives. Section 3.4.3.2 evaluates how well the different riparian management strategies protect the primary functions of the riparian area using the criteria. This evaluation is also supported by a literature review and summarization of criteria development described in Appendix B and riparian analyses described in Appendix D.

3.4.2 Affected Environment

3.4.2.1 Riparian Functions

To understand the effects of various management actions, it is important to understand the function of riparian areas, which have been reviewed by many authors (e.g., Karr and Schlosser, 1977; Meehan et al., 1977; Raedeke, 1988; Bilby, 1988; Murphy and Meehan, 1991; Beschta, 1991; Castelle et al., 1991a). The most important recognized functions of stream riparian areas include LWD recruitment, leaf and needle litter production, stream shade, microclimate, stream bank stability, and sediment control. Stream bank stability and sediment control are introduced and evaluated in Section 3.2 (sediment). The other riparian functions (LWD recruitment, leaf and needle litter production, stream shade and microclimate) are briefly summarized below.

LWD Recruitment

Riparian areas are an important source of LWD that enters, or is recruited to, the stream channel. LWD includes entire trees, rootwads, and larger branches. Numerous studies have shown that LWD is an important component of fish habitat (Swanson et al., 1976; Bisson et al., 1987; and Naiman et al., 1992). Trees that fall into streams are critical for sediment retention (Keller and Swanson, 1979; Sedell et al., 1988), gradient modification (Bilby, 1979), structural diversity (Ralph et al., 1994), nutrient production (Cummins, 1974), and protective cover from predators. LWD also creates storage sites for sediment in all sizes of streams. In small headwater streams, wood controls sediment movement downstream minimizing the risk of debris flows. In larger streams accumulation of coarse sediment behind LWD often provides spawning gravels. LWD plays an important role in stream nutrient dynamics by retaining leaf litter and needles.

Large wood recruitment originates from a variety of processes including tree mortality (toppling), windthrow, undercutting of stream banks, debris avalanches, deep-seated mass soil movements, and redistribution from upstream (Swanson and Lienkamper, 1978). First and second-order headwater streams can also provide wood to larger higher order channels downstream (Potts and Anderson, 1990; Prichard et al., 1998; Coho and Burges, 1991). Two predominant mechanisms have been observed for the movement of LWD between stream types: transport during high flow events and debris torrents, which includes dam-break floods and debris flows (Swanson and Lienkaemper, 1978). However, the former mechanism is more common in third- to fifth-order streams because much of the wood that falls into streams is too large to float in smaller streams (Swanson and Lienkaemper, 1978). The occurrence of debris torrents, although less frequent than the redistribution of LWD from high flows, can introduce large amounts of LWD (Lamberti et al. 1991). Additionally, debris flows originating in managed forests (albeit, under older less protective rules) occurred at a rate much higher than that of unmanaged forests (Swanson, 1976; Morrison, 1975). The majority of debris flows and dam-break floods are initiated in lower order streams, primarily second-order streams (Coho and Burges 1991). These may travel upwards of 2.5 miles into higher order low gradient valley floors, and cause significant damage to riparian vegetation and aquatic habitat during and after the event (Coho and Burges 1991). “The most obvious schemes for avoiding the destructive forces of organic debris movement are maintaining contiguous riparian zones of mature conifers around low order channel and minimizing deposition of logging slash and debris into those channels” (Coho and Burges 1991).

The potential size distribution of LWD is also an important factor when considering the appropriate activities in buffer strips relative to LWD recruitment. There is a strong relationship between channel width, and the size of LWD that forms a pool (Bilby and Ward, 1989; Bilby and Wasserman, 1989; Beechie and Sibley, 1997; Beechie, 1998), where smaller pieces of LWD function in smaller streams. LWD that is large enough to form a pool is referred to as “functional LWD.” In contrast, “Key piece LWD,” is a subset of “functional LWD,” and considered by some to be a better measure of the important wood recruitment sizes. Key pieces have pool-forming capacity similar to “functional wood size,” but also are effective in trapping other smaller more mobile pieces of LWD (i.e., forming logjams), and are more likely to have long-term stability.

Minimum functional LWD size increases with channel width (Bilby and Ward, 1989; Bilby and Wasserman, 1989; Beechie and Sibley, 1997; Beechie, 1998; Washington Forest Practices Board, 1995). For example, mean functioning LWD diameter increased from 11.7 inches in west side channels 5 feet wide to 21.7 inches in channels 44 feet wide (Bilby and Ward, 1989). Key piece size is also related to stream size and is about 15 percent larger in diameter than functional piece size for a 40 foot wide stream (Washington Forest Practices Board, 1995; Bilby and Ward, 1989). As a result, RMZs need to ensure not only an appropriate amount or volume of wood, but wood of sufficient size to serve as both functional pieces and key pieces (Murphy, 1995). Consequently, the length of time needed for riparian areas to produce LWD after harvest depends upon the size of the stream, tree growing conditions in the riparian area, and the tree type. Measurable contributions of wood from second-growth riparian areas are documented to take anywhere from 60 to 250 or more years depending on region and size of stream (Grette, 1985; Bilby and Wasserman, 1989; Murphy and Koski, 1989). Therefore, larger streams that are deficient in LWD and have early seral stage riparian stands are likely to remain deficient in LWD for a longer period of time than smaller streams (MacDonald et al., 1991).

Leaf and Needle Litter Production

In aquatic systems, vegetative organic materials originate within the stream, such as algae production or from sources outside the stream, such as leaf and needle litter. Stream benthic communities (e.g., aquatic insects) are highly dependent on algal production detrital (i.e., organic debris) inputs. The abundance and diversity of aquatic species can vary significantly depending upon the total and relative amounts of algae and leaf and litter inputs to a stream (IMST, 1999). For example, grazing insects are more commonly found in stream reaches with algae production, while shredding insects are more commonly found in areas rich in leaf and needle input (IMST, 1999). Detrital input from outside of the stream is the primary source of detrital input into small and medium size streams through the annual contribution of large amounts of leaves, cones, wood, and dissolved organic matter (Gregory et al., 1991; Richardson, 1992). In contrast, wide high order streams with higher levels of direct sunlight, or low order streams with an open riparian canopy have more algal production. As a riparian stand ages, the amount of litter-fall increases (IMST, 1999). The importance of this type of detrital input varies among streams, but can provide up to 60 percent of the total energy input into stream communities (Richardson, 1992). Litter deposited into small steep-gradient streams in forested areas high in a watershed is generally transported downstream because higher gradient streams are less likely to retain deposited organic material until it has decomposed. Therefore, small (low-order) streams are important sources of nutrients and contribute substantially to the productivity of larger streams in the lower reaches of a watershed (IMST, 1999).

Stream Shade

There are several factors that make up the heat balance of water (see Section 3.6 and Appendix B) including: air temperature, solar radiation, evaporation, convection, conduction, and advection (Brown, 1983, Adams and Sullivan 1989). Stream temperatures have a natural tendency to warm from a streams headwaters to the ocean (Sullivan et al., 1990; Zwieniecki and Newton, 1999). However, seasonal and daily cycles produce a high degree of variability in stream temperature. For example, water temperatures increase during daytime and decrease at night. Other site-specific factors such as latitude, regional weather (e.g. proximity to the ocean), stream size, groundwater inflow, and distance from watershed divides all can affect stream temperature changes (Beschta et al., 1987; Sullivan et al., 1990). During the summer, when stream temperatures are the highest, the combination of warmer air temperatures, increased direct solar radiation and a decreasedstream flows are the major factors affect stream temperature (Beschta et al., 1987). Of these three factors, forest management can have the greatest effect on direct solar radiation by reducing shade. Shade cannot physically cool the stream down, but it can prevent further heating of the stream and therefore maintain the cool water temperature from groundwater inputs or tributaries (OFPACSW, 2000). Shade provided by riparian vegetation has been shown to be successful in minimizing or eliminating increases in stream temperature associated with timber harvest (Brazier and Brown, 1973; Lynch et al., 1985). Other factors that affect shading include stream size, orientation, local topography, tree species, stand age, and stand density.

Microclimate

Microclimate is a collection of variables that are highly dependent on local conditions; hence, microclimates tend to vary greatly across the landscape. Important components of microclimate include solar radiation, soil temperature, soil moisture, air temperature, wind velocity, and air moisture or humidity (Chen, 1991; Chen et al., 1992; Cadenasso et al., 1997). Changes in microclimatic conditions within the riparian zone resulting from removal of adjacent vegetation can influence a variety of ecological processes that may affect the long-term integrity of riparian ecosystems (Spence et al., 1996). For example, many of the variables considered in microclimate studies (air temperature, humidity, wind velocity) are also variables that affect water temperature (Sullivan et al., 1990); an important component to fish habitat. Additionally, microclimate is known to be important for stream/riparian species other than fish, such as amphibians (see Section 3.8). In general, due to their low-lying position on the landscape, riparian areas tend to be cooler than the surrounding hillslopes, especially during the night. Because riparian areas are adjacent to water bodies, they often have a higher relative humidity under the canopy than similar upslope areas. This increase in humidity combined with shading effects can cause intact forested riparian areas to have a moderating effect on microclimate (Beschta, 1995).

3.4.2.2 Historic Protection of Riparian Areas

The protection of riparian areas is considered critical to the long-term health of aquatic ecosystems (FEMAT, 1993; Cederholm, 1994; Murphy, 1995). The protection of riparian areas is usually implemented by restricting management activities within an area adjacent to water bodies referred to as the riparian management zone (RMZ). Management within RMZs (also known as stream buffers) usually involves two main features: (1) establishment of a protective buffer width, and (2) restrictions on allowable activities (e.g., timber harvest prescriptions) within the buffer. Within the scientific community, protection of riparian areas is considered central to salmonid conservation efforts (FEMAT, 1993; Cederholm, 1994; Murphy, 1995). Protection of water quality and fish habitat is often given the highest management priority, but buffers may also be designed to benefit wildlife and other non-fish aquatic species.

Forest practices are constantly being revised in light of new scientific information, political compromises, and changing public awareness and demands for forest and water resources. The Washington State Forest Practices Act of 1974 created a Forest Practices Board, which promulgates forest practices rules. The first rules only took into consideration changes in stream temperature and bank stability for the aquatic ecosystem. All riparian trees could be cut, sparing only the understory on certain temperature-sensitive streams. In 1987, new forest practices rules that derived from the Timber Fish and Wildlife (TFW) Agreement were implemented. The rules were again revised to further address environmental concerns, including temperature, in 1992.

Under Washington's current forest practices rules, RMZs are required on Type 1, 2, and 3 waters, but not on Type 4 and 5 waters unless warranted by site conditions. In western Washington, the minimum RMZ width is 25 feet. The maximum RMZ width depends on stream type and width, and ranges from 100 feet on Type 1 and 2 streams over 75 feet wide, to 25 feet on Type 3 streams that are less than 5 feet wide. For each stream type, buffer width can vary between the minimum and maximum values depending on the width needed for stream shade. Some timber harvest is allowed in the RMZ depending on stream type. Site-specific information from watershed analysis may result in prescriptions for larger buffers. Rules for eastern Washington are generally similar to those for western Washington. The RMZ width for Type 1, 2, and 3 streams is 30 to 50 feet on each side of the stream for areas of partial harvest, and must average 50 feet for areas to be clearcut.

3.4.2.3 Existing Condition of Riparian Areas

In Washington state, the condition of riparian habitats on private and state forest lands that have been harvested during the past 25 years has largely developed under forest management governed by some form of forest practices rules. The condition of riparian areas in harvest units that are greater than 25 years old, largely reflect a lack of riparian harvest restrictions. This condition is described in the following two subsections according to the riparian vegetation that is currently present and the extent of roads that have developed in these riparian lands.

Riparian Vegetation

The vegetative communities that are commonly associated with riparian areas can be divided into three general areas of Washington: forested areas in western Washington, forested areas in eastern Washington, and the non-forested shrub-steppe region in eastern Washington (Knutson and Naef, 1997). For the purpose of this document only forested riparian areas are generally described. The species, sizes, and density of vegetation occupying a riparian site are dependent upon soil moisture conditions and disturbance history.

Western Washington riparian habitats are associated with wet environmental conditions. Although considerable site-specific variability occurs, general vegetative characteristics include: the presence of a mixture of conifer and hardwood trees (hardwoods are more abundant where natural and human disturbance is frequent); the conifer tree species (e.g., western hemlock, western red-cedar, and sitka spruce) are tolerant of shade and periodically saturated soils; red alder is nearly always found in young and disturbed stands; upland conifers (e.g., Douglas-fir) and hardwoods (e.g., big-leaf maple) are dominant in small streams which have narrow riparian areas; lowland rivers and forested swamps with frequent flooding or gravelly soils often include black cottonwood, willow and red alder; swampy areas may also have vine maple, cascara, willow, western red cedar, Sitka spruce, and western hemlock (Knutson and Naef, 1997).

Eastern Washington riparian habitats can be divided into elevation zones. Forested riparian areas of eastern Washington typically located in deeply-incised ravines in mountainous terrain (Carlson et al., 1990 in Knutson and Naef, 1997). Lower elevations with moist soils and temperate microclimates support cedar, western hemlock, big-leaf maple, quaking aspen and other hardwood trees. Larger trees, snags and downed wood can be abundant in unmanaged areas. These relatively moist riparian areas also include a variety of understory shrubs and herbs including willow, red-osier dogwood, mountain alder, devil's club, and other species. Drier sites are characterized by ponderosa pine in the uplands while trees in riparian areas include Douglas-fir, paper birch, black cottonwood, and quaking aspen. High-elevation riparian sites often have saturated soils that are dominated by understory species rather than by tree species. Where trees exist, they are commonly subalpine fir or Engleman spruce and down wood is abundant because decomposition is slowed by cold temperatures. Shrubs and herbs at high elevation are relatively diverse, but generally stunted due to the more severe environmental conditions (Knutson and Naef, 1997).

Current riparian vegetation condition on private and state lands is mostly a function of past management practices, but natural phenomenon such as wildfire, blowdown, non-management related landslides, and disease have also contributed to conditions in many areas. Because riparian protection rules are a relatively recent phenomenon in Washington State (1982), the majority of riparian forests on state, private, and some federal lands have been logged at least once. Therefore, long-term changes to the riparian habitat character have resulted from multiple forest practices over time. These changes to riparian habitat structure include: simplification of the plant community, both in composition and structure (Knutson and Naef, 1997). Today it is believed that red alder currently dominates more riparian sites on the west side than was "typical" under natural disturbance regimes (McHenry et al., 1998).

Riparian habitat problems somewhat unique to eastern Washington forested areas are related to fire management and other riparian management factors not covered under this EIS, such as grazing, mining, and irrigation. Studies have shown that livestock grazing within riparian areas eliminates or reduces streamside vegetation, destabilizes stream banks, causes channel sedimentation and aggradation, widens channels, increases stream temperature extremes, lowers the water table reduces bank undercut, and reduces pool frequency and depth (Armour et al., 1991; Chaney et al., 1993; Kauffman and Drueger, 1984; Kovalchik and Elmore, 1992; Meehan, 1991; Platts, 1991). Grazing pressure usually is higher in the riparian zone because there typically is more shade, surface water for drinking, and more succulent vegetation (Platts, 1981). As a result, eastern Washington riparian areas include dense understories, dense reproduction and more fire-intolerant species resulting in higher fuel accumulation and more intense and destructive fires as compared to natural conditions (Wissmar et al., 1994) (see Section 3.9). The natural fire return interval for cedar, spruce, and hemlock stands of western Washington is about 937 years and about 217 years for Douglas-fir stands (Agee, 1993). The return interval (cycle or turnover time) is the mean time between disturbances on a given site. For the west side, fires were generally more intense and when they occurred were more often stand-replacement fires. In contrast to the west side, natural fire return intervals for drier east side pine forests (lodgepole pine, ponderosa pine, or mixed conifer) range from 15 to 110 years and were usually not stand-replacement fires (Agee, 1993). Fire management practices in all areas have increased these intervals during the last century (Agee 1993) and more intense stand-replacement fires have resulted with more recent fires. In addition, higher moisture levels can increase fire return intervals in riparian areas (Agee, 1993). Natural disturbance from fire on the east side is an important factor defining stand seral stage characteristics under unmanaged conditions. In contrast, wind storms have a larger effect on west side forests with return intervals of about 119 to 384 years for small-scale to large-scale storms (Harcombe, 1986 as cited in Agee, 1993).

As a basis for discussing current conditions, Table 3.4-1 presents the linear extent of streamside vegetation based on seral types that currently exist on riparian lands subject to Washington forest practices rules (based on a random sample of lands –see Appendix A). Seral stages, which are related to vegetation structure, are described in terms of early seral, mid-seral, or late-seral (see Appendix C for definitions) to reflect the species and/or condition of the vegetation and animal communities that are generally characteristic of different periods of succession. Seral stage provides a general picture of riparian condition and quality.

Unnaturally high levels of early seral stage are primarily a result of timber management activities and, to a lesser extent, fire, blowdown, and other natural processes that occur in riparian areas. This stage generally produces riparian vegetation that cannot provide a property functioning riparian system important to aquatic and terrestrial biota. In contrast, later seral stages can fully provide for riparian functions (e.g., shade and LWD recruitment for aquatic biota [Section 3.7]) and more complex vegetative structure (e.g., downed logs and snags for terrestrial biota associated with riparian habitat [Section 3.8]).

Table 3.4-1. Estimated Percent of Each Seral Stage along Forested Streams on Private Lands [1/]

Water Type	Early	Mid	Late
	Seral Stage - Percent by Water Type (%)		
West Side-Private Lands			
Types 1-3	64%	33%	2%
Types 4-5	81%	18%	1%
All Streams	78%	21%	1%
East Side- Private Lands			
Types 1-3	60%	36%	4%
Types 4-5	61%	33%	6%
All Streams	61%	34%	5%

[1/] Based on a random sample of private and state forest lands (see Appendix A). The sample includes the following stream miles: West side Type 1-3 = 76 miles; West side Type 4-5 = 202 miles; East side Type 1-3 = 21.6 miles; and East side Type 4-5 = 122.8 miles. Seral stage definitions are given in Appendix C.

Within the lands subject to forest practices rules, approximately 78 percent of the west side stream miles and 61 percent of east side stream miles flow through early seral stage riparian areas, while about 1 percent of the west side miles and 5 percent of the east side miles are late seral (see Table 3.4-1). Though natural variability is expected in riparian areas, the level of alteration due to timber harvest and road building is apparent.

Roads in Riparian Lands

People have often taken advantage of flat floodplains along rivers for road building, which have removed riparian vegetation. In narrow canyons with limited floodplains, roads commonly have been located on the sideslope within the riparian zone. Even in the absence of these longitudinal impacts, the continuity of the riparian corridor has been interrupted at each bridge and culvert crossing (Kondolph et al., 1996) (see Section 3.2). Consequently, roads built in riparian lands have changed riparian forest structure and composition and caused permanent land disturbance. It should be recognized that most historic management activities on private and state lands occurred under rules substantially less restrictive than are currently practiced.

The changes due to roads have caused the loss of some or all riparian functions within riparian lands depending on where road construction has occurred. One example is the loss of LWD recruitment potential from trees on the upland side of roads within riparian areas. Most of the trees on the upland side will not be recruited as LWD but are typically removed when the tree falls onto the road. Major changes to the aquatic system have also occurred from riparian land modifications due to road development, including the straightening or simplification of the stream channel system (Knutson and Naef, 1997; Beschta et al., 1995).

Currently, no specific information on statewide road density or distribution of roads in riparian areas is available. However, the National Forests have quantified the number of roads on National Forest System lands in Washington. For a general perspective of the rate of road building that has occurred in Washington, by 1907 only 147 miles of road had been built in all of Washington's National Forest lands. By 1962, the length of roads on National Forest System lands in Oregon and Washington had risen to 22,000-24,000 miles, and to over 90,000 miles in 1990. It was estimated that about 3,000 miles of new roads were being constructed annually in the western forested area of the United States (Knutson and Leaf, 1997). In eastern Washington increased roading has allowed greater access for forest management and some types of recreation, but it has also contributed to the protection of the forest from the spread of fires and catastrophic outbreaks of insects. Railroads were also built into some areas and eventually many railroad grades were converted to roads. The decision of where and when to build roads have always hinged on the logistics of timber harvesting (Oliver et al., 1994). As the density of roads increases, road impacts on riparian areas will inevitably be impacted (Knutson and Leaf, 1997).

3.4.3 Environmental Effects

The establishment of RMZs is generally accepted as the most effective way of protecting aquatic and riparian habitats (Cummins et al., 1994). Evaluation of the anticipated effects of the proposed alternatives on riparian habitats are based primarily on the current or proposed widths and management prescriptions within RMZs and the associated acreages of these habitats as regulated by various state management requirements.

3.4.3.1 Riparian Function Criteria

Criteria used to determine the effectiveness of proposed RMZ management allowed under each alternative, are based on the riparian functions that were summarized in Section 3.4.2 and discussed in detail in Appendix B. The effectiveness of each alternative can best be evaluated within the context of specific protection goals. Most functions are evaluated in terms of protection goals for fish and water quality. However, for microclimate, which is more likely to affect semi-aquatic species such as amphibians adversely, a variety of components was considered, including humidity, soil moisture and temperature, and air temperature. As a result, the riparian functions are evaluated in terms of the level that provides full protection relative to the specific protection goals.

The evaluation criteria are mostly defined in terms of curves, which identify the estimated relationship between the cumulative effectiveness of the riparian function and the distance from the stream bank. Therefore, these curves show the estimated degree of protection of riparian function provided by different RMZ widths. The curves are based on a wide variety of literature. However, they are generally conservative, (i.e., they reflect the widest buffers needed to provide complete protection, as identified in the literature). Note, however, that the discussions also consider lesser widths and other circumstances as appropriate. It should be noted that the relationships between distance from stream and the percent of function maintained are not all linear, and some are more theoretical in nature than based upon empirical data. In many cases, the area closest to the stream is more important for providing function than the areas further away.

Depending on the function, RMZ requirements may be defined as fixed RMZ widths or based on SPTH. A SPTH is sometimes defined as the average maximum height of the tallest dominant trees that can grow on a certain site (FEMA, 1993). However, to maintain consistency with Forest Practice Rules, SPTH in this EIS is defined as the height represented by the approximate midpoint of a stand at a given age and site condition (site class). A SPTH for Washington state varies depending on site-class, species and region (Table 3.4-2). Less productive forest lands (site class IV and V) will have shorter SPTH and more productive forest lands (site class I and II) will have taller trees. Additionally, west side trees tend to grow taller than east side trees for the same site class.

Two stand ages, 100 years and 250 years, were used to evaluate the level of protection to riparian function. A SPTH of 100 years was agreed upon by the parties to the Forests and Fish Report and was used in EIS analyses to represent a mature riparian stand. Numerous comments on the Draft EIS suggested that old-growth stand characteristics were more appropriate for use as a baseline to define adequate riparian effectiveness. Consequently, riparian function effectiveness based upon a 250-year stand was also analyzed. The choice of a 250-year stand was based upon the age at which stands begin to display old-growth characteristics (Franklin and Spies, 1991) and the return intervals for fire and blowdown reported by Agee (1993) for west side forests. SPTH were based upon Site Class II Douglas-fir stands for the west side (McArdle, 1949) and east side (extrapolated from Table I-12 in USDA Forest Service, 1984). Notably, SPTH for ponderosa pine (Meyer, 1961) at 250 years is approximately the same as for Douglas-fir on the east side. Neither of these stand age criteria have been experimentally tested for providing an adequate level of riparian function that is sufficient for maintaining robust populations of salmonids.

It is assumed that RMZ widths based on 100- and 250-year SPTHs represent the range of SPTHs over which most riparian functions are likely to be fully expressed. For example, for an east side site class II riparian area adequate protection would be provided with a buffer somewhere between 110 and 170 feet. This range represents the uncertainty about correctly choosing a particular SPTH hypothesis that provides complete protection. If a 250-year SPTH is chosen as the standard against which to compare RMZ widths, but complete protection is actually provided by a 100-year SPTH, then 60 feet of the 170-foot buffer width would represent over-protection. Conversely, if a 100-year SPTH is chosen for measuring RMZ widths, but a 250-year SPTH is the true SPTH that provides full protection, then the 110-foot RMZ would under-protect by 60 feet. It is possible that an intermediate SPTH is more appropriate or that streams with different morphological and riparian characteristics have different SPTH levels that provide full protection for that stream type.

Table 3.4-2. Site Potential Tree Height (SPTH) for Douglas-fir at 100 years and 250 years for Western and Eastern Washington

	$SPTH_{100}$ (feet)		$SPTH_{250}$ (feet)	
Site Class	**West Side**	**East Side**	**West Side**	**East Side**
I	200	130	247	195
II	170	110	210	170
III	140	90	174	135
IV	110	70	136	105
V	90	60	100	85

LWD Recruitment

This evaluation is based on the level of protection provided for LWD recruitment potential from the riparian area using the RMZ width and silvicultural prescription. Based on the review in Appendix B, it was concluded that a buffer width of approximately one SPTH, is needed to provide full or maximum protection of LWD recruitment by toppling, windthrow, or stream undercutting. An exception to this may occur in second-growth stands where hardwoods have excluded regeneration of conifers or overstocking of stands have lead to the depletion of large size classes of debris (Spence et al., 1997). As a result, consideration was also given to stand manipulation to increase tree size over time. Therefore, growth rate modeling of tree diameter and age to reach functional and key piece recruitment size, based on different silvicultural prescriptions and different stream sizes was also used when evaluating alternatives (see Appendix D). The relationship between the estimated level of LWD recruitment potential and RMZ width used in the alternative evaluation is shown in Figure 3.4-1. It should be noted that most reviews of this issue demonstrate at least 70 percent of LWD is recruited within 100 feet of the stream channel (ISR, 2000; CH2MHILL, 2000); consequently, under most conditions a buffer measuring one-half site-potential tree height would provide substantially more than 50 percent protection of LWD recruitment. In order to quantify this relationship over all streams under different alternatives, an equivalent buffer area index (EBAI) was calculated for each alternative using both a 100-year and 250-year SPTH as baselines for full protection of LWD recruitment potential (see Appendix D for a full description). The EBAI provides a weighted measure of the degree of protection provided by all streams giving consideration to stream size, RMZ widths, RMZ prescriptions, source distance, and the relative length of each stream type over the landscape.

Leaf and Needle Litter Production

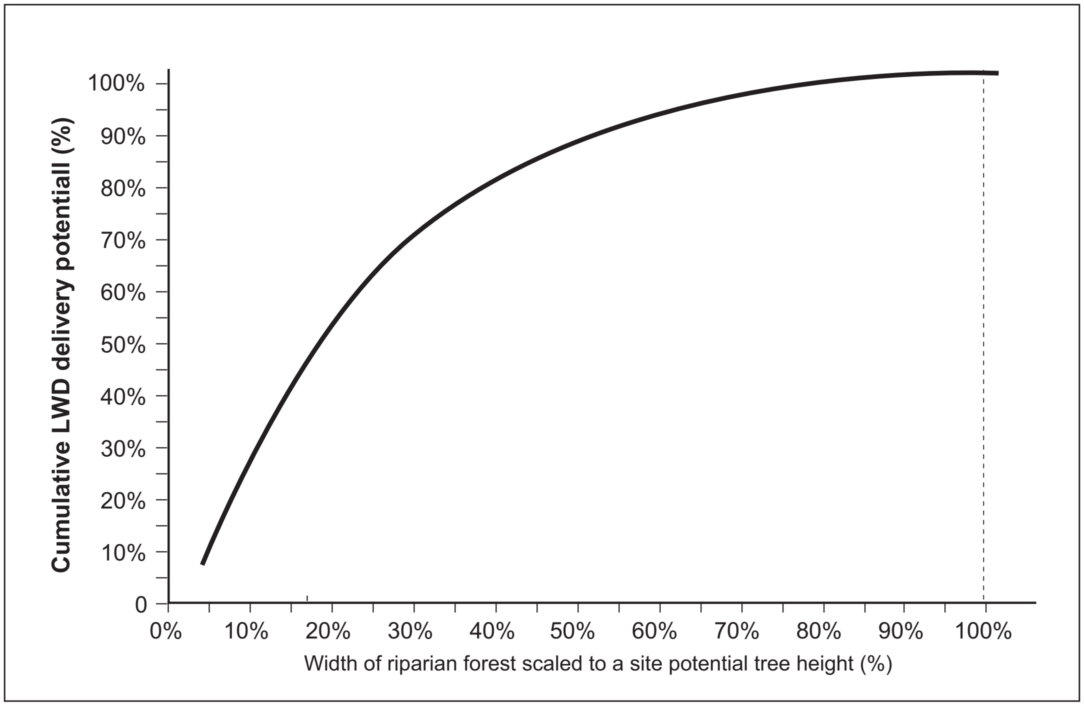
This evaluation is based on width of the respective RMZs and activities allowed within the buffer that may affect leaf and needle litter inputs. Little direct information is available that describes leaf and litter source distances from streams. FEMAT (1993) hypothesized that a distance of approximately 0.5 site-potential tree heights would provide most leaf and litter inputs. The estimated relationship used in this analysis is shown in Figure 3.4-2. FEMAT (1993) based this hypothesis on a study (Erman et al. 1977) of benthic invertebrate diversity in buffered and unbuffered streams in northern California. Erman et al. (1977) suggested that differences in the composition and volume of organic debris from vegetation was one of the most important factors contributing to differences in invertebrate communities observed in these streams. Although there is some uncertainty about the validity of the leaf and litter hypothesis developed by FEMAT (1993) for use in the Pacific Northwest, it was used in this analysis because no other criteria were available.

Stream Shade

Acknowledging that there is site-specific variation that determines shade it was concluded that buffer widths of approximately 0.75 SPTH are needed to provide full protection of stream shading capacity along most perennial streams. This criteria is based upon the shade curve in FEMAT (1993). The estimated relationship used in our analysis for most perennial streams is shown in Figure 3.4-3. However, for small streams (<5 ft wide) that are often completely shaded by woody vegetation and hence have no riparian canopy opening in their undisturbed state, an RMZ width of less than 0.75 SPTH was determined sufficient to provide enough shade to maintain stream temperatures. As a result, a 50-foot buffer was used as the minimum criteria for shade along small perennial streams. For seasonal streams that do not flow during the summer, stream shade should have minimal to no effect on temperature and therefore will not be considered when evaluating shade requirements.

Microclimate

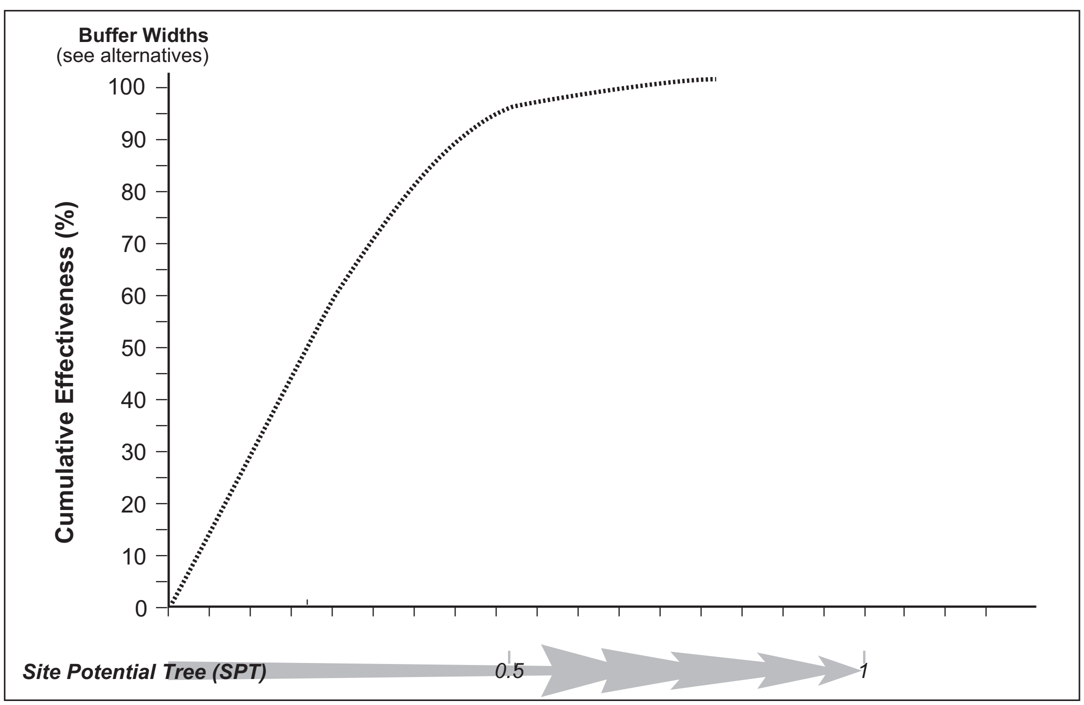
While there are not, as of yet, recommended buffer widths for maintaining microclimate gradients, the results of Brosofske et al. (1997) and Dong et al. (1998) provide crude guidelines to evaluate the alternatives. Based on curves shown in Figure 3.4-4, a minimum of 147 feet is considered necessary to maintain most microclimatic gradients, while for air temperature, buffer widths greater than 230 feet are thought to be required.



Source: McDade et al., 1990

Figure 3.4-1

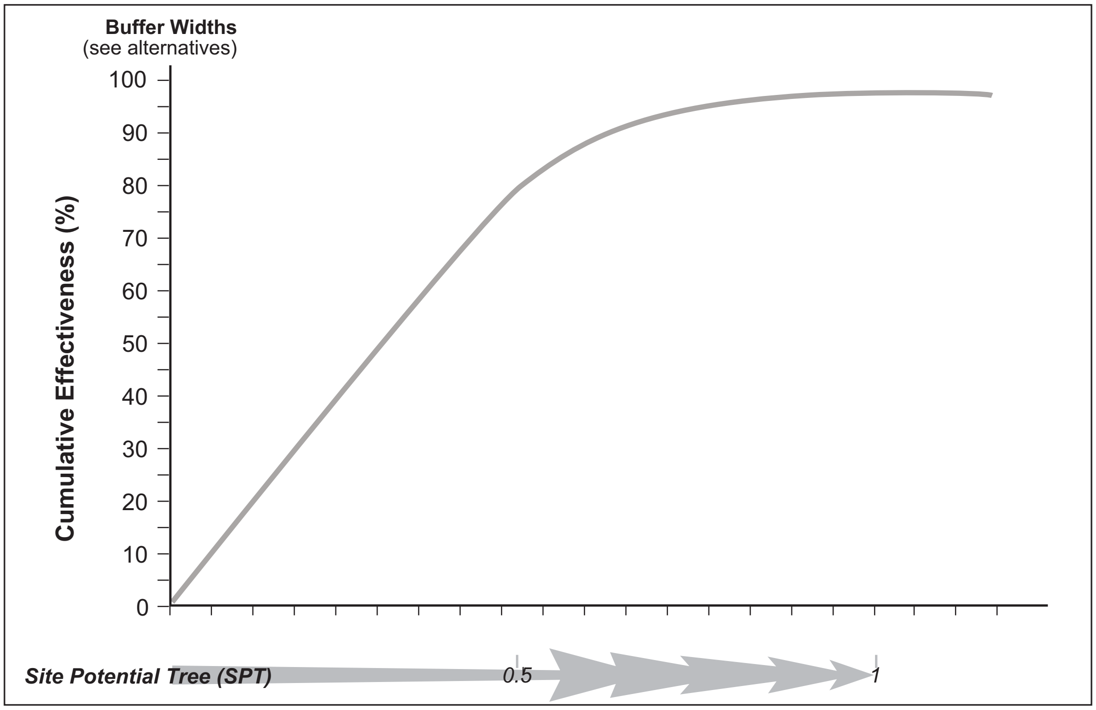
Relationship Between the Estimated Level of LWD Recruitment and RMZ Width Used in the Alternative Evaluation



Source: FEMAT, 1993

Figure 3.4-2

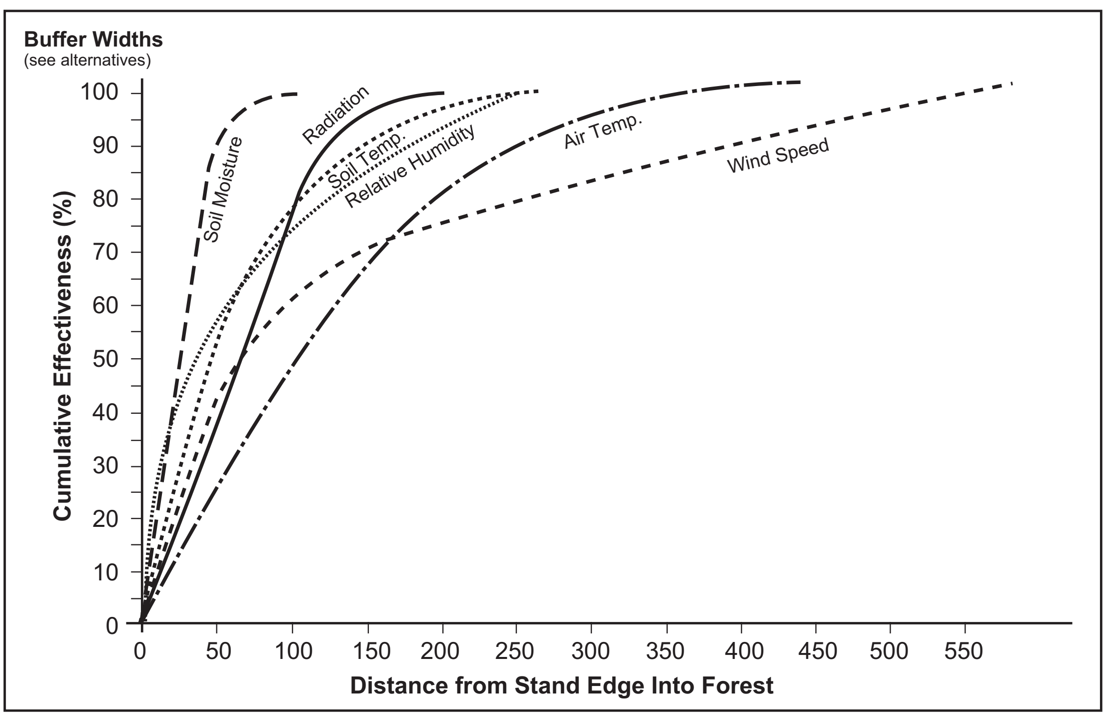
Relationship Between the Estimated Level of Leaf and Needle Litter Recruitment and RMZ Width Used in the Alternative Evaluation



Source: FEMAT, 1993

Relationship Between the Estimated Level of Shade Protection and RMZ Width Used in the Alternative Evaluation

Figure 3.4-3
Relationship between the estimated level of shade protection and RMZ width used in the alternative evaluation.



Source: FEMAT, 1993; Pollock & Kennard, 1999

Relationship Between the Estimated Level of Protection for Micro Climate and RMZ Width Used in the Alternative Evaluation

3.4.3.2 Evaluation of Alternatives

Because each alternative has a different stream classification scheme and different leave-tree requirements, it is difficult to quantitatively compare the effectiveness of the different alternatives in protecting riparian functions. Nevertheless, a quantitative sense of the level of protection afforded to specific processes can be gained by considering riparian buffer width together with allowable level of activity within that buffer. Therefore, for each function analyzed, an evaluation is made of both the RMZ widths and the allowable prescriptions that occur within the RMZ. Figure 3.4-5 compares the RMZ widths and the allowable prescriptions for each stream type under each alternative in western Washington, and Figure 3.4-6 provides the same comparison for the east side.

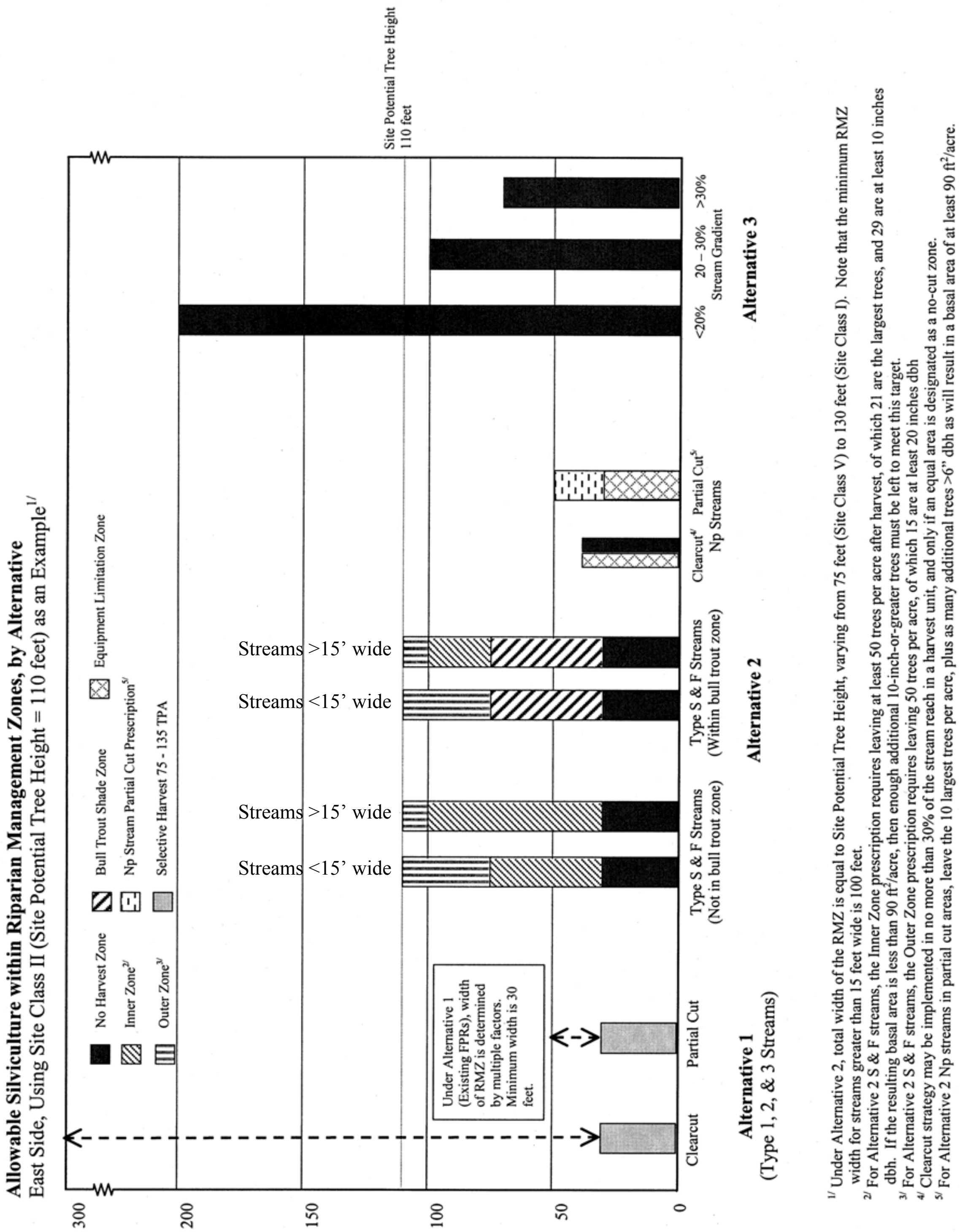
Another important aspect considered when evaluating the alternatives was susceptibility to windthrow or blowdown. If an RMZ blows down, it will not be able to maintain most of the important functions. The RMZs in all alternatives are likely to experience some degree of windthrow in localized areas. Windthrow is a normal occurrence in forests, but is known to increase along harvest unit edges after timber harvest opens formerly interior forest trees to the more direct effects of the wind (Harris, 1989). Buffer strips along streams are subject to similar increases in windthrow. Several studies have attempted to define the relationship between riparian windthrow and various physical and biological features such as topography, valley morphology, aspect, slope, soil wetness and tree type (Steinblums, 1978; Steinblums, 1984; Harris, 1989). Though these site-specific factors may increase the vulnerability of an RMZ to blowdown events, not one factor has been highlighted as of particular importance on a landscape scale. However, since blowdown is generally greater at the windward edge of a buffer, alternatives with wider buffers will provide more protection to aquatic function. Pollock and Kennard (1998) reanalyzed several windthrow data sets looking at the relationship between buffer width and the likelihood of windthrow. They reached the conclusion that buffers of less than 75 feet have a higher probability of suffering appreciable mortality from windthrow than forests with wider buffers. In general, vulnerability to windthrow tends to return to normal a few years after logging (Moore, 1977; Steinblums, 1978; Andrus and Froelich, 1986).

Data for blowdown within buffers from seven studies reported in Grizzel and Wolf (1998) had a mean blowdown rate of about 15 percent for 344 sites in western Washington and Oregon with maximum blowdown rates ranging from 17 to 100 percent in the different studies. Median blowdown rates were usually somewhat lower than the mean because the data are not normally distributed with a relatively few sites having extensive blowdown. For example, the mean blowdown rate for sites reported by Andrus and Froelich (1986) was 21.5 percent while the median value was 15.5 percent (i.e., half of the sites had less than 15.5 percent blowdown). Blowdown rates in Southeast Alaska were found to average about 9 percent in 66-foot no-harvest buffers over a four to six year period following harvest and most windthrow levels were less than 15 percent (Martin et al. 1998). Martin et al. (1998) also suggested that increased windthrow from buffers adjacent to geomorphic stream types with limited natural recruitment (via bank erosion) could be beneficial for

Figure 3.4-5. Western Washington Allowable Silviculture within RMZs by

Alternative for the West Side

Figure 3.4-6. Eastern Washington Allowable Silviculture within RMZs by Alternative for the East Side



fish habitat. Susceptibility to blowdown is addressed as appropriate in the effects analysis using a 75-feet buffer width as a general guideline.

Evaluation of the effects of the proposed alternatives on riparian habitats is also based on a comparison of the estimated changes in total riparian area protected in some way. The estimated amount of area, presented in terms of average RMZ widths, for each protection level provided under each alternative is compared in Figure 3.4-7 for western Washington and in Figure 3.4-8 for eastern Washington (see Appendix D). The histograms presented in these figures have been standardized by estimating the total acreage in each protection category and then converting it back to the average RMZ width required to cover that acreage. Separate comparisons are shown for fish-bearing streams, nonfish-bearing perennial streams, and nonfish-bearing seasonal streams. The histograms show the different management activities allowed within the RMZ (or its zones).

Changes in riparian management and its effects on riparian habitat are addressed for the short term (10 years) and long term (50+ years). For each riparian function, the timeframe to transition from a non-functional riparian system to one that could provide most riparian functions is considered (Table 3.4-3). As discussed in Section 3.4.2 (Affected Environment), most of the riparian landscape appears not to be currently fully functioning.

Table 3.4-3. Percentage of Total Stream Miles Found in the Sample Section by Seral Stage and Estimated Time Scales for Recovery[1/] of Each Riparian Parameter [2/]

			Recovery Periods (in years)			
Seral Stage[3/]	**% Seral Stage on the West Side**	**% Seral Stage on the East Side**	**Shade**	**LWD Recruitment**	**Leaf & Needle Lifter**	**Microclimate**
Early-seral	78	61	5 to 40+ years	100+ years	30 to 80 years	10 to 40 + years
Mid-seral	21	34	20 to functioning[4/]	50 to 100+ years	30 to 60 years	20 to functioning[6/]
Late-seral	1	5	Functioning	Functioning to 100+ years[5/]	30 to functioning	Functioning

1/ Estimated time scales for recovery are based largely on Gregory and Bisson in Stouder et al., 1997.

2/ Hardwoods were excluded because it is unknown if they would convert to coniferous forest in the future. Site-specific investigation would be required to determine whether this is a natural condition.

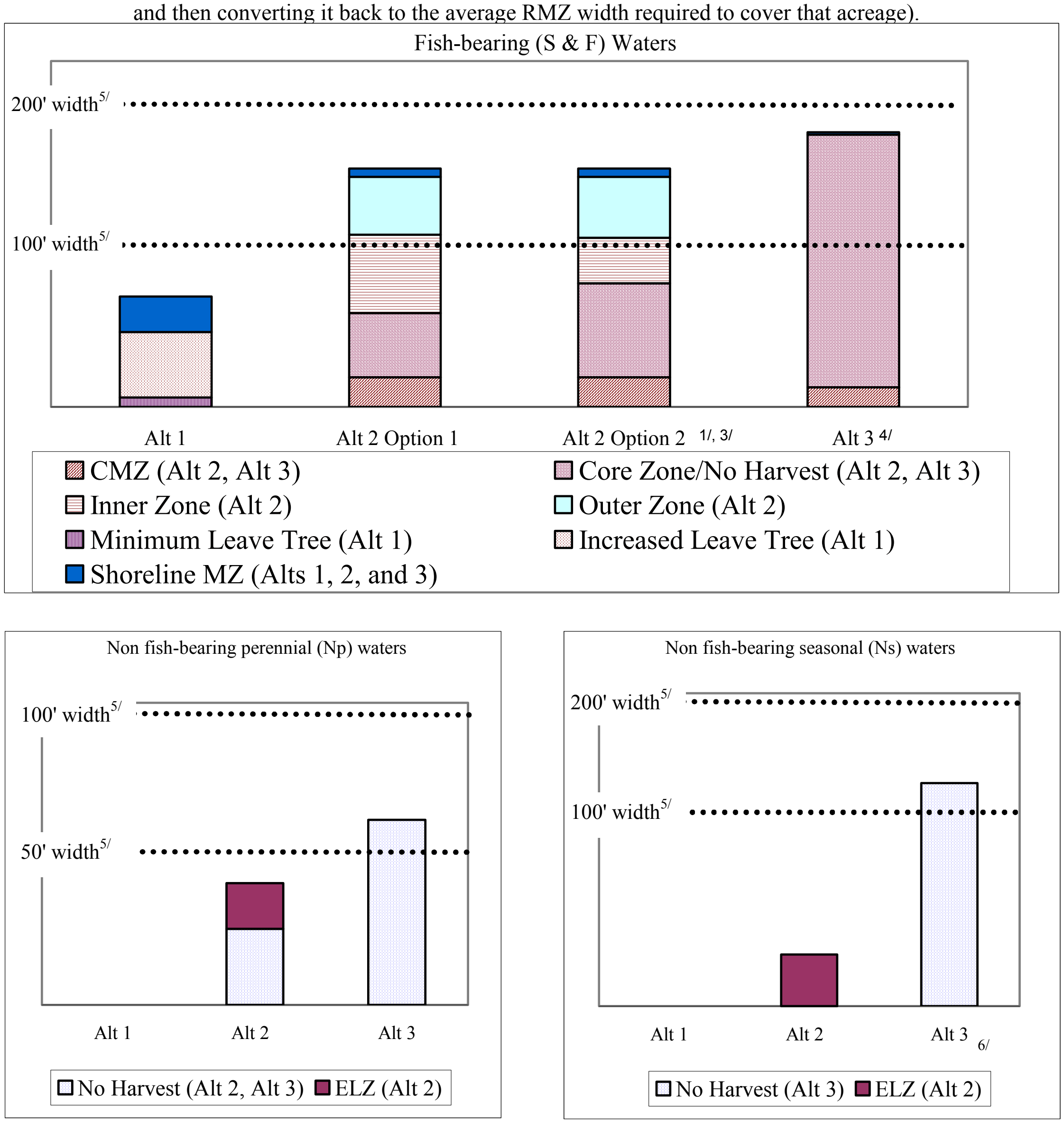
3/ See Appendix A for definitions of seral stage.

4/ The upper end of the seral stage size range is functioning. The lower end of the seral stage size range requires more recovery time prior to meeting function.

5/ Functioning LWD recruitment also depends on stream size for determining recovery. Larger streams require a larger proportion of big trees and, therefore, need a longer period to recover.

6/ Estimated to be the same time frame as shade.

Figure 3.4-7. Total Riparian Area Protection for the West Side by Alternative
(Note: histograms have been standardized by estimating total acreage in each protection category and then converting it back to the average RMZ width required to cover that acreage).



[1] For Alt 2, this does not include implementing the shade rule. Also, all harvest across the landscape will be a mix of Option 1 and Option 2, rather than consisting entirely of either option; each option was modeled separately to capture the differences between the two options.

[2] For Alt 2 Option 1, 17% of the inner zone overlaps with the SMZ and 13% overlaps with the outer zone.

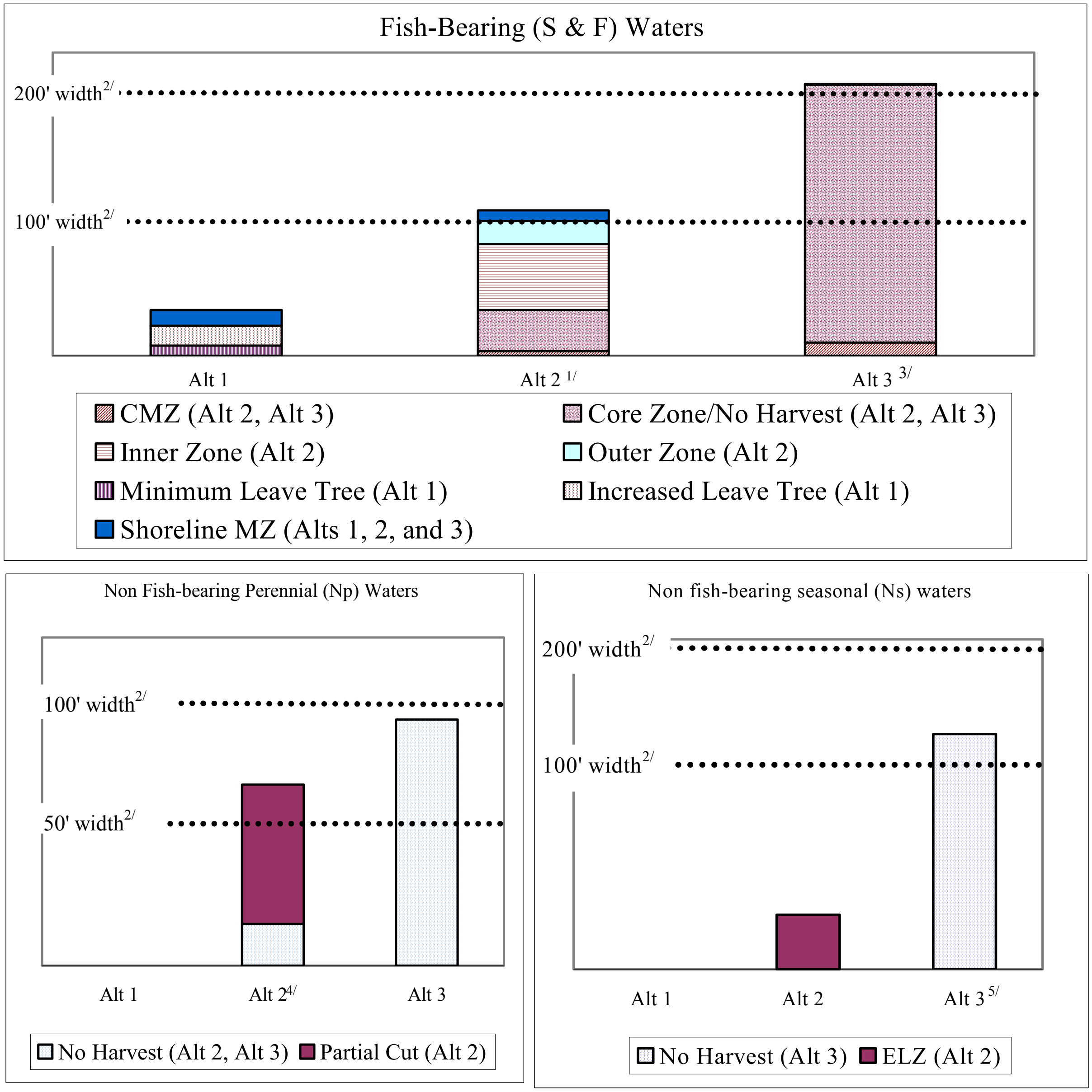
[3] For Alt 2 Option 2, 16% of the inner zone overlaps with the SMZ and 15% overlaps with the outer zone.

[4] Although most fish-bearing streams under Alternative 3 receive a 200-foot RMZ, some stream miles were greater than 20% gradient, and therefore received a RMZ less than 200 feet. This accounts for the failure of the Alt 3 RMZ acreage to meet the 200-foot buffer standard in this figure.

[5] Standardized 50', 100' and 200' buffers were applied to all stream miles, to facilitate comparison among alternatives.

[6] A large proportion of nonfish-bearing seasonal streams were 0-20% gradient under Alternative 3 and therefore receive a 200-foot RMZ. This accounts for Alt 3 RMZ acreage exceeding the 100-foot buffer standard in this figure.

Figure 3.4-8. Total Riparian Area Protection for the East Side by Alternative
(Note: histograms have been standardized by estimating total acreage in each protection category and then converting it back to the average RMZ width required to cover that acreage).



1/ The All Effective Shade requirement for bull trout may provide greater protection to 2% of Alt 2's inner zone RMZ.

2/ Standardized 50', 100' and 200' buffers were applied to all stream miles, to facilitate comparison among alternatives.

3/ Alt 3 exceeds the 200-foot standard in this figure because most fish-bearing streams receive a 200-foot RMZ, plus the CMZ acreages along some fish-bearing streams add additional acreage.

4/ For eastside N_p streams, 70% of the total length of stream was given a 50-foot partial cut RMZ, and 70% of the remaining 30% was given a 50-foot no-harvest RMZ (see Section 2.7.1).

5/ A large proportion of non-fish-bearing seasonal streams were 0-20% gradient under Alt 3 and therefore receive a 200-foot RMZ. This accounts for Alt 3 RMZ acreage exceeding the 100-foot buffer standard in this figure.

Where some level of disturbance has occurred in riparian areas, there would be an extended period to attain desired future conditions that approach fully functioning riparian areas (Table 3.4-3). Although a large proportion of state and private lands subject to forest practices rules is currently in early seral stages (Table 3.4-1), riparian habitat should improve over time (10 to 100+ years) to increase the amount of healthy riparian areas (Table 3.4-3).

LWD Recruitment

To facilitate comparison of the LWD recruitment function among the alternatives, the EBAI for LWD was calculated and is displayed graphically in Figures 3.4-9 to 3.4-12 (see Section 3.4.3.1 and Appendix D). The EBAI analysis for LWD is applied in this section as a relative measure of the protection of streams from loss of LWD recruitment potential. The EBAI is only an approximate measure of full recruitment potential because it does not account for all factors that contribute to recruitment or reductions in recruitment of LWD. For example, the EBAI does not account for redistribution of LWD within streams, reductions that could occur from yarding corridors or roads, or LWD enhancement.

Redistribution of LWD is difficult to quantitatively model because additions in one stream section represents a loss in another. However, headwater streams can be considered net sources of LWD, if it is available for transport. Consequently, reductions in LWD recruitment in low order streams may also indicate some level of reduction of LWD recruitment to higher order streams. In coastal Oregon, preliminary results suggested LWD recruitment from upstream sources ranged between 11 and 59 percent (Gresswell and May 2000). This may be an appropriate range for basins in Washington with a similar geomorphology (i.e., steep to moderate gradient 2^{nd} and 3^{rd} order streams with relatively narrow valleys) and precipitation, but may be an over-estimate for other areas, particularly east side watersheds with substantially lower precipitation and likelihood of debris flows.

All of the alternatives allow yarding corridors across RMZs. Yarding corridors provide landowners flexibility in accessing and harvesting suitable timber when a road and road crossing or helicopter yarding would otherwise be required. Under Alternative 1, there are no requirements for leaving or removing trees cut for yarding corridors (presumably they would generally be removed). Under Alternative 2, trees cut in the core zone must be left, and only a volume of trees in excess of the stand requirement could be removed from the inner or outer zone. Under Alternative 3, all trees cut for the yarding corridor would remain in the RMZ. Under both Alternatives 2 and 3 any cut trees retained in the RMZ could provide potential habitat for wildlife species that utilize down wood. Yarding across fish-bearing streams requires a Hydraulic Project Approval (HPA) from WDFW. HPAs provide a regulatory mechanism for requiring mitigation for the yarding corridor and an opportunity for LWD enhancement.

Existing roads were not considered in the EBAI because they are present under all of the alternatives and their location is very site specific and difficult to incorporate in a representative fashion within the EBAI model. Incorporating existing roads would, therefore, provide additional complexity to the analysis while providing only limited additional clarity about the differences among the alternatives in terms of LWD recruitment potential. However, the presence of roads will reduce the area available for LWD recruitment in an RMZ approximately 5 percent or less depending upon the alternative and region of the state (based on GIS analyses). Alternative 2 includes requirements that will partially mitigate for the presence of roads in the RMZ. This mitigation will be discussed below under the Alternative 2 subsection.

ALTERNATIVE 1

WEST SIDE

Type 1, 2, and 3 Waters

On the west side the current forest practices rules would provide a minimum RMZ width of 25 feet on Type 1-3 waters, with the maximum width depending on stream type and size, extent of wetland vegetation, or the width needed for implementation of the shade rule (WAC-222-30-040), ranging from 25 to 100 feet. Complete LWD recruitment potential to the stream channel for most site classes would not be maintained. The RMZs would all be less than one SPTH (both 100- and 250-year) with the exception of those on site class V lands. As indicated earlier, 100-year and 250-year SPTH assumptions were used to express the range over which full LWD recruitment is likely to be met. The 100-year SPTH assumption is derived from the Forest and Fish Report and is the basis for RMZ widths in Alternative 2 while the 250-year SPTH assumption is the age of stands beginning to display old-growth characteristics (Franklin and Spies, 1991). Based on the more prevalent site classes II and III found on state and private lands, one 100-year SPTH would equal 140 to 170 feet and one 250-year SPTH would equal 174 to 210 feet. In addition, there is an increased risk of blowdown along all streams that have an RMZ, since the average widths implemented are relatively narrow (< 75 ft) and therefore, more susceptible to blowdown. In addition, there would be no protective measures along streams with CMZs if the channel shifted to an area that was previously harvested.

Under Alternative 1, selective harvest would occur throughout the RMZ. Based on modeling (see Appendix D), the post-harvest proportion of trees of recruitable size remaining in the riparian zone would range from 7 to 74 percent (depending on site class and stream size) with a larger proportion remaining along smaller streams. Modeling involved applying prescriptions to a 50-year-old west side riparian stand, which is the stand age generally being harvested on the west side (Bolsinger et al., 1997). This analysis only considered trees left after harvest which were of a “functional” size for LWD. Though only a percentage of functionally sized LWD may actually create pools, the greater the amount recruited, the greater the potential for pool formation. For larger streams, the size of LWD would need to be substantially larger than for small streams. For example, for a stream averaging 45 feet wide, the mean diameter required for LWD has to be 22 inches compared to 8 inches in a 5-foot-wide stream.

Under Alternative 1, there are few restrictions on the harvest of large trees. Therefore, a substantial reduction in trees of functional size would occur in the RMZ. When considering key piece size (which is a subset of functional size) a much smaller proportion of trees would be left in the RMZ that would be considered large enough. The EBAI for LWD, which takes into consideration both RMZ width and the management activities that occur within the RMZ, demonstrates that this alternative would provide the lowest level of protection for future recruitment of LWD (see Figures 3.4-9 and 3.4-11). The 100-year and 250-year SPTH assumptions suggest that Alternative 1 will provide between 38 and 48 percent of the LWD recruitment needed on fish-bearing streams for adequate riparian function. Yarding corridors and roads would decrease these values. Under Alternative 1, no additional measures are provided to address the reduction of LWD recruitment due to these roads or future roads. In addition, there are no incentives for LWD enhancement projects, so these would rarely be implemented.

> The Shoreline Management Act provides additional protection to Type 1 streams within the 200-foot shoreline management zone. However, the level of protection may decline because of the potential to re-enter the riparian area every decade for harvest.

Shorelines of the state (which are Type 1 waters) are managed under the dual jurisdiction of the Forest Practices Act and the Shoreline Management Act (SMA). During implementation of forest practices, the more restrictive of the two acts is applied along Type 1 waters. Restrictions of the Act include a 200-foot shoreline management zone (SMZ) above the ordinary high water mark that is implemented and enforced at the county level. Within the SMZ, a landowner may remove no more than 30 percent of the available merchantable trees using a selective harvest strategy. As a result, a 200-foot SMZ would complement the 25- to 100-foot RMZ applied under this alternative along shorelines of the state. Therefore, the area outside the RMZ, but within the SMZ, would receive the protection required under the SMA (see Figures 3.4-5 and 3.4-7). Under Alternative 1, the SMZ provides for substantially higher protection for Type 1 streams in the short-term than the standard forest practices rules. However, additional entries in SMZs at 10-year intervals are allowed to remove 30 percent of the standing stock of trees. Although this would tend to reduce the level of protection over time, the SMZ would continue to maintain a higher level of protection than the standard rules under Alternative 1.

> On the west side, Alternative 1 would result in high risk of diminished LWD recruitment along Type 1 to 3 streams.

On the west side, most harvests occur on relatively young stands (e.g., 50 years old). Thus, the quality of LWD input would be substantially less than optimum until these areas grow to a point where trees of a sufficient size are prevalent. In addition, the current forest practices rules do not encourage improving riparian stands for long-term gains in LWD recruitment. Under this alternative, young conifer stands and hardwood-dominated stands could require many years to grow to (and may never reach) the size where they can supply functional LWD. Only along smaller Type 1 to 3 streams, would a greater proportion of the available trees function with younger stand age. Key piece size would be even more difficult to attain.

Figure 3.4-9. Equivalent Buffer Area Index (EBAI) for LWD Summed for All, Fish-Bearing, Nonfish-Bearing Perennial, and Seasonal Streams on the West Side, by Alternative Assuming a 100-year SPTH

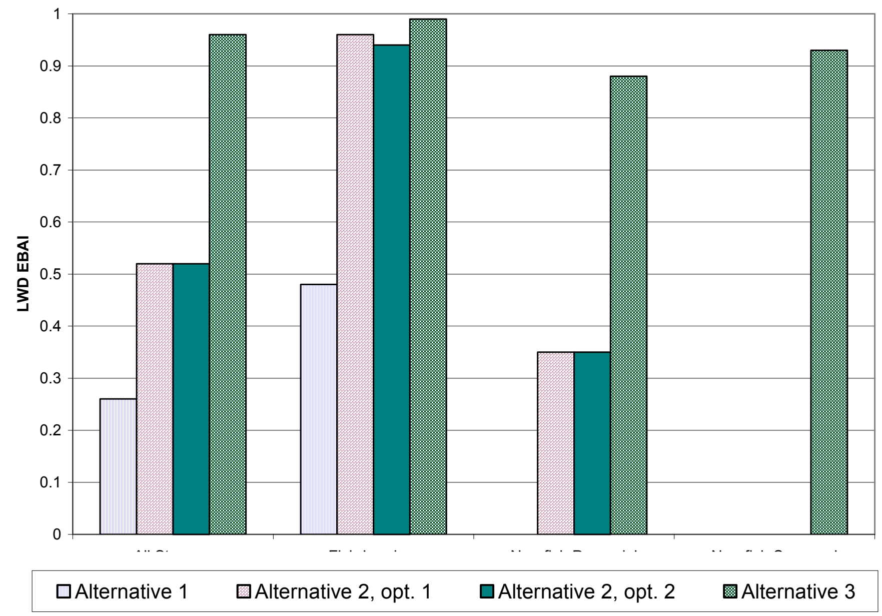


Figure 3.4-10. Equivalent Buffer Area Index (EBAI) for LWD for All, Fish-Bearing, Nonfish-Bearing Perennial, and Nonfish-Bearing Seasonal Streams on the East Side, by Alternative Assuming a 100-year SPTH

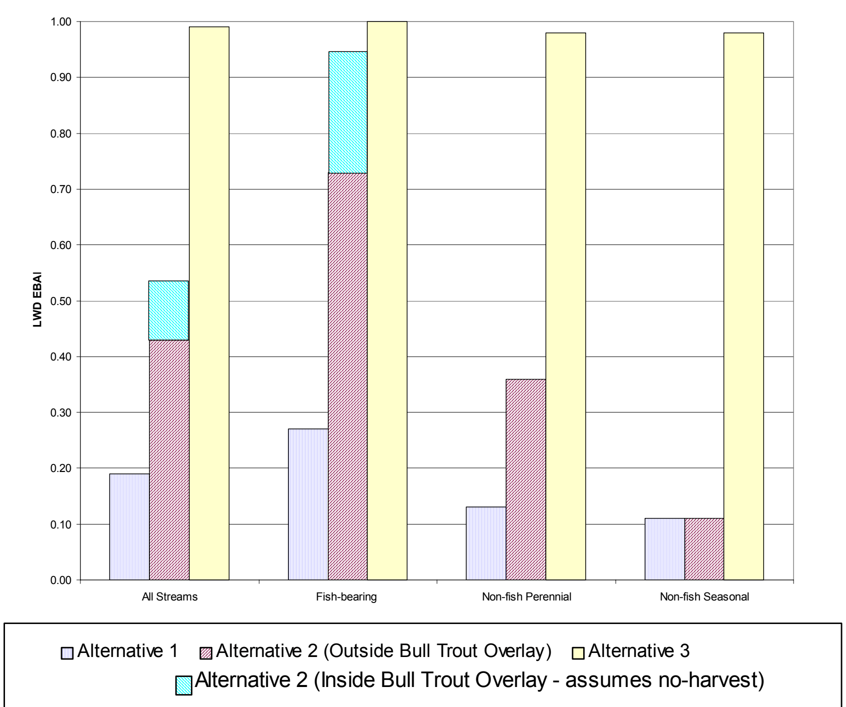


Figure 3.4-11. Equivalent Buffer Area Index (EBAI) for LWD Summed for All, Fish-Bearing, Nonfish-Bearing Perennial, and Seasonal Streams on the West Side, by Alternative Assuming a 250-year SPTH[1]

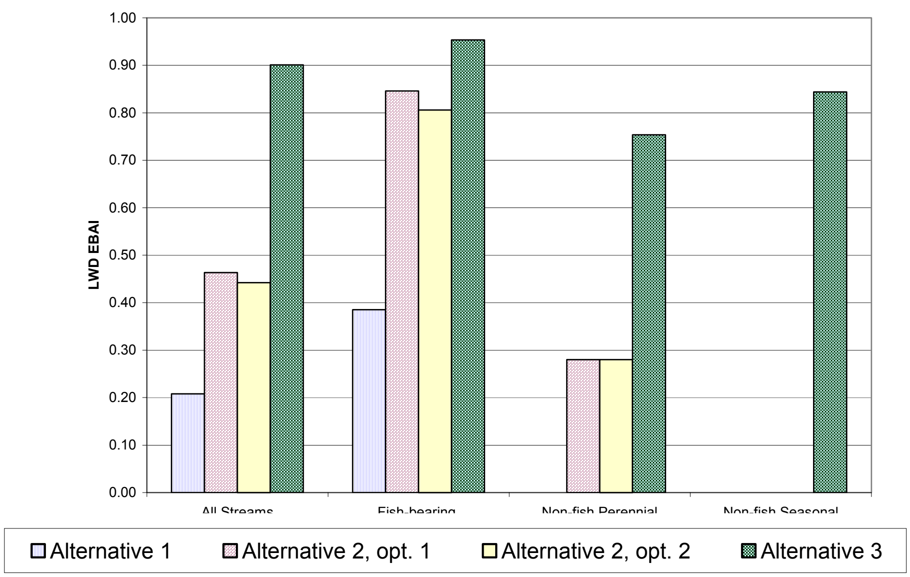
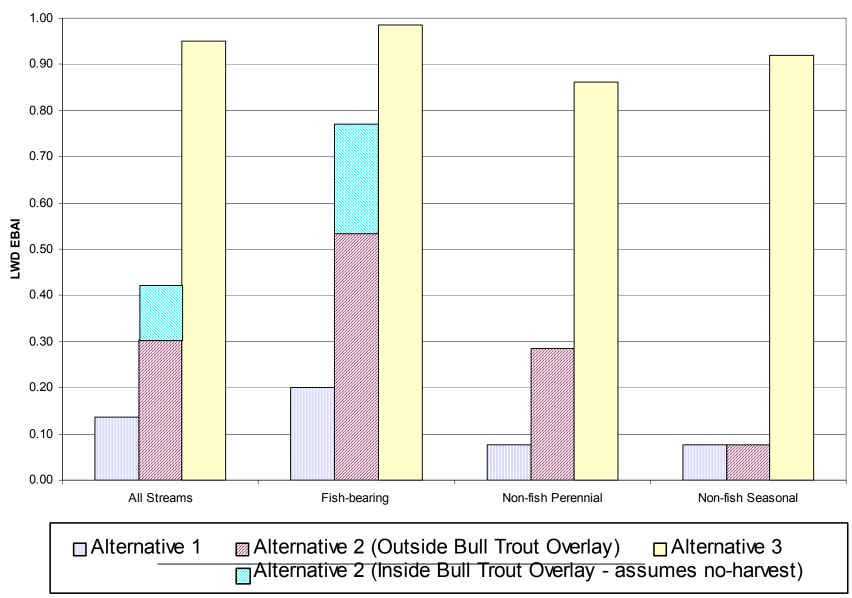


Figure 3.4-12. Equivalent Buffer Area Index (EBAI) for LWD for All, Fish-Bearing, Nonfish-Bearing Perennial, and Nonfish-Bearing Seasonal Streams on the East Side, by Alternative Assuming a 250-year SPTH[2]



[1] The EBAI does not include additional protection provided by the Shoreline Management Act.

[2] The EBAI does not include additional protection provided by the Shoreline Management Act.

RMZs are not static, since trees continue to grow where they are left in an RMZ and regeneration does occur in clear-cuts. Therefore, growth modeling was used to evaluate change over time. Based on the stands that were modeled, it is apparent that there is an increase in tree growth rate, when thinning occurs. Under Alternative 1, thinning increases the size of trees over the mid- and long-term (50-100 years). However, under Alternative 1 there is no limitation on timber harvest re-entry within the RMZ. For the west side, it was assumed that the harvest rotation averages 50 years. Therefore, long-term growth projections are unrealistic and riparian stands would not likely have enough large trees to provide for stable LWD in medium and large streams. In very large streams, (using a 120-foot wide stream as an example), trees as great as 40 inches in diameter (at a minimum) are needed as key pieces for long-term contributions to aquatic habitat. Otherwise the trees run the risk of floating away in large flood events. In addition, Alternative 1 selective harvest does not encourage riparian stand improvements within the RMZ for long-term gains, but encourages the maintenance of the status quo (i.e., maintaining the same ratio of conifers to hardwoods).

Type 4 and 5 Waters

For Type 4 and 5 waters, RMZs are not required except for site-specific conditions, and in this case would not exceed 25 feet. For Type 4 and 5 streams in most scenarios, harvest would be allowed to the stream bank. Consequently, there would be no protection of LWD recruitment potential for these smaller streams. This is shown in the EBAI for nonfish-bearing streams (Figures 3.4-9 and 3.4-11). However, there is some potential for non-merchantable trees to provide some function if left in the short-term, because of the smaller LWD needed in small streams.

On the west side, Alternative 1 would result in very high risk of diminished LWD recruitment along Type 4 and 5 streams.

Along Type 4 and 5 streams that are clear-cut to the bankfull width, long-term modeling indicated that wood of sufficient size begins to be delivered to the channel in approximately 45 to 50 years when considering both functional and key piece sizes. This was assuming an average channel width of 2 to 5 feet. If the harvest rotation rate is 50 years, minimal to no recruitment to the stream would occur over the near and long-term along Type 4 and 5 waters.

EAST SIDE

Type 1, 2, and 3 Waters

Rules for eastern Washington are generally similar to those for the west side. The RMZ width for Type 1, 2, and 3 waters ranges between 30 and 50 feet on each side of the stream for areas under the partial-cut harvest strategy, and averages about 50 feet under the clearcut harvest strategy, but can extend up to 300 feet. As for most scenarios on the west side, the range of east side RMZ widths under current rules do not maintain complete LWD recruitment potential to the stream channel because the buffers are less than one site-potential tree height (which ranges from 60 to 130 feet depending on site class for a 100-year stand and 85 to 195 feet for a 250-year stand). However, an exception occurs when riparian vegetation is extensive. In these cases the RMZ can be expanded far beyond the average 50 feet and could meet or exceed one SPTH. However, most timber harvest on the east side is selective harvest and, therefore, would not require the more expansive RMZ widths (see Appendix D). However, where the shade rule is implemented additional trees may be left in the RMZ. As a result, this would likely increase the proportion of recruitable trees available in the RMZ under some conditions. In addition, under Alternative 1, there is an increased risk of blowdown along all the streams that have an RMZ, since the average widths implemented (30 to 50 ft on the east side) are relatively narrow (< 75 ft) and therefore more susceptible to blowdown. Along streams with a CMZ, no additional protection of potential recruitment is provided if the channel shifts to a previously harvested area.

Similar to the west side, selective harvest can occur throughout the RMZ (Figures 3.4-7 and 3.4-8). In eastern Washington, soils and climate are less favorable for tree growth; this results in an average age of 80 to 100 years for stands at timber harvest (Bolsinger, 1997). Therefore, 80– to 100-year-old stands were used to evaluate post-harvest stand conditions after implementing the RMZ prescriptions.

Based on modeling results (see Appendix D), which implemented the selective harvest prescriptions along Type 1 to 3 streams, the post-harvest proportion of trees of recruitable size remaining in the riparian zone ranged between 12 and 73 percent on the larger streams and 35 and 74 percent on the smaller streams depending on site class and species zone (see Appendix D, Table 12). On the east side, the mean diameter required for LWD to be considered functional for a stream averaging 45 feet in width would be 12 inches, and for a stream averaging 5 feet in width it would be 8 inches (Bilby and Wasserman, 1989). Key piece size has not yet been defined for the east side, though pieces larger than what is considered functional would likely be required to provide the long-term stability that defines key piece size. Similar to functional LWD, key piece size would vary depending on channel size.

On the east side, Alternative 1 would result in high risk of diminished LWD recruitment along Type 1 to 3 streams.

For Type 1 streams, additional leave trees would likely be provided due to the Shoreline Management Act (SMA). The SMA defines a 200-foot shoreline management zone (SMZ) measured from the stream's ordinary high water mark. The SMA requires that no more than one-third of the trees within this zone be removed every 10 years using a selective harvest strategy (Figures 3.4-6 and 3.4-8). However, because the selective harvest strategy occurs more often than the even-aged strategy on the east side, additional trees outside of the RMZ, but inside the one SPTH width, will frequently be available for recruitment.

In addition, roads may be present in the RMZ. Under Alternative 1, no additional measures are provided to address the reduction of LWD recruitment due to these roads or future roads.

The EBAI for LWD under the 100-year SPTH and 250-year SPTH assumptions shows that this alternative provides the lowest level of protection overall for future recruitment of LWD when compared to other alternatives on the east side (see Figures 3.4-10 and 3.4-12 and Appendix D). LWD recruitment potential along fish-bearing streams would range from 20 to 27 percent of the levels needed for adequate protection based upon the two SPTH assumptions (see Appendix D).

On the east side under current conditions, most riparian areas are dominated by younger seral stages. Similar to the west side, the quality of LWD recruitment potential would be less than optimum. Also, similar to the west side, there is no limitation of timber harvest entry within the RMZ. For the east side it was assumed that harvest would occur every 80 years within the RMZ and the largest trees could be removed so long as leave tree requirements were met (see Table 2-2). The selective harvest prescriptions within the RMZ under Alternative 1 does not encourage improvement of the stand for LWD recruitment, but instead requires a minimum number of trees of a specific size and type along all Type 1 to 3 streams, without differentiating between stream size or riparian stand quality. Therefore, a sufficient number of larger trees in riparian stands is not likely to be maintained.

Type 4 and 5 Waters

On the east side, Alternative 1 would result in very high risk of diminished LWD recruitment along Type 4 and 5 streams.

For Type 4 and 5 streams in most scenarios, harvest would be allowed to the stream bank. However, a relatively large proportion of the east side (approximately 70 percent) usually has a selective harvest strategy that leaves some riparian trees. Along streams with a clearcut harvest strategy, there would be no protection of LWD sources and, therefore, no short-term and minimal long-term recruitment potential. Together, the EBAI suggests these harvest strategies would result in recruitment potential along nonfish-bearing streams estimated to be from 8 to 13 percent of adequate protection under the two SPTH assumptions.

ALTERNATIVE 2

GENERAL

The silvicultural prescriptions for riparian management zones (RMZs) under Alternative 2 are implemented within three zones: the core zone is nearest to the water, the inner zone is the middle zone, and the outer zone is furthest from the water. In addition to the RMZ and silvicultural prescription discussions below, it is important to note that additional measures would be implemented to replace lost LWD recruitment due to the presence of roads under Alternative 2. These mitigation measures include one of the following two measures:

- Stand requirements must be met regardless of the presence of stream crossings and stream adjacent roads; basal area shortfalls are made up in the inner and outer zones, if possible, or in nearby RMZs of the same harvest unit.

- An optional LWD placement plan (WDFW approval required) will be implemented.

The additional measures would increase future LWD recruitment potential compared to Alternative 1. The first mitigation measure would mitigate the basal area of trees lost due to the road, but would not mitigate the same level of riparian recruitment potential because the location of mitigation leave trees would be further from the stream and the mitigation leave trees have no size distribution requirements (i.e., the mitigation basal area could be reached entirely with small trees). Alternative 2 is the only alternative that provides incentives for an LWD placement plan by allowing lower leave-tree requirements in the outer zone. An LWD placement plan would increase the presence of in-stream LWD in the short-term in exchange for some trees in the portion of the RMZ that have the lowest probability of becoming in-stream LWD in the distant future. The number of trees that a landowner may remove in the outer zone depends on the plan approved by the WDFW, but leave-tree requirements cannot be reduced below 10 trees per acre.

> Under Alternative 2, RMZs may provide more protection than SMZs depending upon the size of the CMZ, if present. Otherwise, RMZs and SMZs would eventually provide similar levels of protection to riparian trees, depending upon the frequency and level of harvest in the SMZ. However, an SMZ would likely provide more protection to riparian trees in the short term (30 to 40 years).

Similar to Type 1 streams under Alternative 1, Type S streams may be provided additional leave trees under all harvest strategy options because of the Shoreline Management Act (SMA). As indicated earlier, the more restrictive rules would be implemented for any given situation where both the SMA and FPA are applied. In general, a shoreline management zone (SMZ) would likely provide more leave trees in the short-term than an RMZ, particularly for Type S streams that do not have a CMZ. An SMZ is measured from the ordinary high water mark regardless of whether a CMZ is present. Consequently, the added level of protection from an SMZ is reduced depending upon the width of the CMZ. Similar to Alternative 1, the areas outside the RMZ, but inside the SMZ, have a higher level of short-term protection due to the harvest restrictions required by the SMA. However, the level of added protection in the SMZ could decline over time because of additional harvest entries that allow removal of up to 30 percent of the trees during each decade. Nevertheless, the overall level of protection to Type S waters would be equivalent to, or higher than, the standard rules.

Landowners have the option of conducting hardwood conversion in the inner zone of the RMZ on the west side only. The riparian areas must be hardwood-dominated stands with evidence that conifers were dominant in the past. The objective of the hardwood conversion rule is to improve long-term riparian function by allowing landowners to remove hardwoods in the conversion area and restock the area with conifers. There are numerous restrictions to implementing hardwood conversion. Some of these include the following:

- The combined core and inner zone do not meet stand requirements.
- There are fewer than 57 conifer trees per acre 8 inches or larger dbh.
- There are fewer than 100 conifer trees per acre 4 inches or larger dbh.
- Conifer trees greater than 20 inches dbh shall not be harvested in the conversion area.
- No more than 10 percent of the conifer trees greater than 8 inches dbh may be harvested.

- The conversion area must be restocked with conifers and provided with post-harvest treatment.
- Conversion areas are limited to 500 feet in length.
- Landowners must own the land 500 feet above and below the conversion area.
- No stream parallel roads are present in the core or inner zone.
- Several shade restrictions apply (See WAC 222-30-021).

The hardwood conversion rule represents a small risk of reducing short-term LWD recruitment potential from hardwood trees. The loss of LWD recruitment potential from harvested conifers is insignificant because most of the larger trees are protected. The conversion areas provide a small to moderate risk of reduced shade in the immediate area, but the potential adverse effects on a larger scale may be reduced by the additional shade restrictions. Conversely, the potential long-term benefit from restoring the riparian stands to conifer likely outweigh the short-term losses. As indicated earlier, conifers have the potential to provide larger and longer lasting LWD than hardwood trees (Harmon et al. 1986). Nevertheless, the DNR recognizes there is some uncertainty about the adverse effects of the hardwood conversion rule, and includes a component for tracking conversion rates on a watershed basis. The adaptive management program is charged with identifying adverse effect thresholds for conversion levels.

> Because small landowners are permitted to implement less protective RMZs under Alternative 2, the risk that LWD recruitment would not be adequate to maintain a properly functioning system is increased in watersheds with large areas owned by small landowners and with high levels of past harvest.

Under Alternatives 2 and 3, small landowners (owning less than 80 acres of forest land in Washington) would be permitted to implement substantially less protective RMZs on parcels less than 20 acres in size (see Section 2.4.2.2). Although these parcels represent a minority of the lands subject to forest practices rules (about 15 to 20 percent of all private forestlands, less if the total landbase is considered), and the rate of forest practices to be implemented on these lands is unknown, this reduced protection increases the level of concern. In watersheds with a high proportion of small landowners, especially where a high level of past harvest has occurred, this rule would increase the risk that LWD recruitment is not adequate to maintain a properly functioning system.

WEST SIDE

Alternative 2 provides two options for harvesting within the inner zone on the west side, providing that the riparian stand exceeds the requirements for meeting the desired future condition. The Option 1 approach is designed for riparian stands that have a skewed distribution with more numerous, but relatively small trees. In contrast, the Option 2 approach is designed for stands that have a more normal distribution of tree sizes. Option 1 allows harvest by thinning from below. That is, surplus basal area can be harvested, but with priority for removing smaller trees. Option 1 was developed with the objective to shorten the time required to meet large wood fish habitat and water quality needs. Option 2 allows harvest of surplus basal area by prioritizing harvest of trees furthest from the stream and leaving trees closest to the stream. The objective of Option 2 is to retain those trees closest to the stream that provide proportionally more functional benefit than trees farther away from the stream. As described in Chapter 2, both options have specific leave-tree requirements.

Type S and F Waters – Option 1 – Thinning From Below

On the west side, Alternative 2 specifies an overall RMZ width of one SPTH along Type S and F streams based upon a 100-year-old stand. In addition, these buffers are measured from the edge of the CMZ, where present, rather than from the edge of the bankfull channel and, therefore, provide additional protection if a shift in the stream channel occurs. Protection of the CMZ ensures that an established stand of trees would be available for recruitment in the relocated stream channel.

For Type S and F streams under Option 1, no harvest would occur in the core zone, which is 50 feet from the outer edge of either the bankfull width or CMZ (whichever is greater). Approximately 48 to 92 percent of LWD recruitment potential comes from this first zone of the RMZ, based on McDade et al. (1990), site class, and the two SPTH assumptions for stand age. For site class II, this zone accounts for 56 to 70 percent of the recruitment.

On the west side, Alternative 2—Option 1 would result in low risk of diminished LWD recruitment along Type S and F streams.

Selective harvest (thinning from below) would be allowed in the inner zone (the second zone). Specific stand requirements and thinning is based on an assessment of specific site characteristics including site class, species, trees-per-acre, ratio of hardwoods-to conifers, and average stand age, and basal area. The objective of this strategy is to shorten the time required for trees in the inner zone to reach a size adequate to provide functional LWD. This strategy allows for the removal of a portion of the smaller trees present in the inner zone leaving the largest trees which would provide all of the large tree recruitment that is available in the stand. The width of this inner zone varies depending on site class and stream size. Using a site class II modeled stand, approximately 24 to 25 percent of LWD recruitment potential comes from the 50 to 100 foot portion of the RMZ if all trees are left uncut (Appendix D). The inner zone selective harvest prescription would initially reduce the LWD recruitment potential in the RMZ inner zone by approximately 5 percent along small streams ($\leq$ 10 feet wide) with no reduction of recruitable size trees along the larger streams. Stream size affects both LWD recruitment size and the width of the inner zone. In general, along smaller streams a wider range of tree sizes would function if recruited (i.e. smaller LWD would also be functional); therefore, a larger percentage of source trees would be lost if harvested compared to a larger river that requires larger trees to function.

The outer zone under Option 1 would provide for commercial harvest with requirements for a specific number and size of leave trees. Similar to the inner zone, the outer zone width would also vary depending on site class and stream width and would range between 22 and 67 feet. Approximately 6 to 14 percent of the LWD recruitment potential would come from the outer zone under no-harvest conditions depending upon the two site class II SPTH assumptions. Under the 250-year SPTH assumption, about 6 percent of the recruitment potential would derive from outside the outer zone (i.e., 170 to 210 feet) and would receive no RMZ protection. Based on the modeled harvest, the outer zone would contribute approximately 2 to 5 percent of the recruitment potential (see Appendix D).

The total post-harvest proportion of trees of recruitable size remaining in the three zones of the RMZ ranged between 91 percent (for smaller streams less than 10 feet wide) to 96 percent (for larger streams greater than 10 feet wide) under the 100-year SPTH assumption and between 80 to 85 percent under the 250-year SPTH assumption (see Appendix D). A sensitivity analysis was conducted using the 100-year SPTH assumption to see if the recruitment potential would vary substantially between stands on different site classes. The variation of recruitment potential based on the stands modeled (which included a low, medium and high site classes II and III) was relatively narrow, ranging between 87 and 93 percent for smaller streams and between 93 and 96 percent for larger streams (see Appendix D).

Based on the modeled harvest, the same proportion of trees sufficiently large to be considered key pieces would be present in the RMZ both pre- and post-harvest. This result occurs because the inner zone is thinned from below, leaving the largest trees in the inner zone available for potential recruitment. Therefore, depending on stream size, trees of key piece size could be maintained under this option, if they already exist in the stand. However, as stream size increases, the proportion of trees of key piece size decreases because minimum key piece size increases with stream size . This was highlighted in the sensitivity analysis where no trees of functional size (or larger key pieces) were available for recruitment along modeled site class III stands. Growth modeling using the RAIS model suggests that stands will need to be at least 160 years old to obtain key pieces for streams 44 feet wide. Therefore, the concern is over the long-term (and well beyond the expected life span of Alternative 2), since many stands do have sufficient trees of key piece size immediately after harvest.

The EBAI for LWD on the west side, shows that under both the 100-year SPTH and 250-year SPTH assumptions Option 1 would produce a substantially greater recruitment potential along Type S and F streams when compared to Alternative 1, a similar recruitment potential when compared to Option 2, and a lower recruitment potential when compared to Alternative 3 (Figures 3.4-9 and 3.4-11). In addition, it is clear that fish-bearing streams are provided more protection than nonfish-bearing streams under this alternative. However, the EBAI does not take into consideration the long-term benefits associated with thinning to boost the growth rates of source trees remaining in the RMZ. Therefore, long-term modeling was implemented to evaluate the change over time.

The current quality of LWD input potential along most west side streams is well below the optimum, and will remain that way until riparian areas grow to a point when trees are of sufficient size to provide functional LWD recruitment. The 50-year old stand modeled for long-term recruitment using the Riparian Aquatic Interaction Simulator (RAIS) demonstrate there is an increase in tree growth rate under Option 1. However, the modeling suggested that thinning adjacent to small streams (< 10 ft) would not result in a decrease in the time required for trees to reach a functional size (about an 80-year old stand, regardless of thinning). In addition, a wider range of tree sizes along small streams would provide functional LWD if recruited; therefore, a larger percentage of potential source trees would be lost if harvested. However, the benefit of thinning appears to be substantial when considering large streams and key piece size, especially in high

> Based on long-term modeling, Option 1 (thinning from below) would shorten the time required to obtain key piece size LWD, particularly on productive sites along large streams. Along small streams, thinning does not appear to benefit key piece size LWS recruitment and may hinder it.

productivity stands (100-year site index of 128 or greater). For the streams 44 feet wide, the modeling suggested that compared to no harvest, thinning resulted in a shorter time period for the growth of trees large enough to serve as key pieces (160-year stand if thinned and 290-year stand with no harvest). In addition, the modeling suggested there could be an increase in the amount of LWD. The RAIS model indicated that a 300-year old, site class II stand would have about 14 percent (nearly 2 pieces per 1000 feet) more functional LWD following thinning under Option 1 compared to Option 2 or Alternative 3. The modeling suggests that for lower productivity riparian stands or streams less than 30 feet wide, thinning does not provide a substantial benefit for producing functional and key piece LWD at a more rapid rate than no-harvest.

Type S and F Waters – Option 2 – Leaving Trees Closest to the Water

> On the west side, Alternative 2—Option 2 would result in low risk of diminished LWD recruitment along Type S and F streams.

Under Option 2, no-harvest buffers are 80 feet wide on streams less than 10 feet wide and 100 feet wide on streams greater than 10 feet wide. Similar to Option 1, no harvest would occur under Option 2 in the 50-foot-wide core zone measured from the bankfull width or CMZ (if present). Consequently, the core zone would provide the same level of protection under Option 2 as it would under Option 1 (48 to 92 percent under the two SPTH assumptions and five site classes; Figures 3.4-1). In addition, to the core zone, the next 30 feet of the inner zone on streams less than 10 feet wide and 50 feet on streams greater than 10 feet wide, would also have no-harvest. Option 2 can only be applied to Site Class I, II and III areas on streams less than or equal to 10 feet wide and Site Class I and II areas on streams greater than 10 feet wide. Depending upon the SPTH assumption (for site class II), the combined no-harvest buffers from the core zone and inner zone ranged from 73 to 86.5 percent of full LWD riparian function for smaller streams (< 10 feet) and 80 to 95 percent of full function for larger streams.

Selective harvest would be allowed in the remaining portion of the inner zone, which varies in width, depending on site class and stream size. When modeled, the total inner zone recruitment potential for streams greater than 10 feet wide would be maintained. For streams less than or equal to 10 feet a reduction of approximately 3 percent of trees of recruitable size would occur. Under Option 2, if prescriptions in the core and inner zone result in a basal area that exceeds the basal area target, a greater reduction of trees is allowed in the outer zone. In the modeled example, there was no excess (i.e., all 20 trees per acre were retained) resulting in a range of 0 to 2 percent of the recruitable trees remaining, depending on stream size. The leave tree requirement for the outer zone can also be reduced if conifers are retained in the CMZ.

The post-harvest proportion of trees of recruitable size remaining in the combined three zones of the RMZ ranged between 94 and 95 percent of the pre-harvest condition (see Appendix D). The overall recruitment potential of smaller streams (<10 ft) under Option 2 was higher than the recruitment potential under Option 1. In contrast, Option 1 produced greater recruitment potential for larger streams (> 10 ft). However, the differences between the two options were not large, less than 3 percent of the pre-harvest potential. Consequently, the different strategies do not appear to substantially change the amount of recruitable size trees. A sensitivity analysis using the 100-year SPTH assumption and site

> Based on long-term modeling, Option 2 would take longer to produce key piece size LWD

Based on long-term modeling, Option 2 would take longer to produce key piece size LWD than Option 1 along longer streams; however, for smaller streams, Option 2 would produce greater quantities earlier.

class III (low) to site class II (high) showed similar patterns. The differences between options were 5 percent or less and both options left 87 percent or more of the recruitable sized trees.

Under Option 2, the EBAI ranged from 81 to 94 percent for fish-bearing (Type S and F) streams under the 250-year SPTH and 100-year SPTH assumptions, respectively. The EBAI under both SPTH assumptions, suggests that Option 2 of Alternative 2 would produce a substantially greater recruitment potential along Type S and F streams compared to Alternative 1, a similar recruitment potential compared to Option 1, but a lower recruitment potential compared to Alternative 3 (Figure 3.4-9 and 3.4-11).

One limitation of the EBAI is that it fails to take into consideration the growth rate of trees remaining in the RMZ after silvicultural prescriptions are applied. Stand growth modeling suggests the rate of growth is slower with the wider no-harvest area of Option 2 compared to Option 1. Consequently, under this option, wider streams will require a longer period of time to produce the larger trees needed to provide LWD function. However, for smaller streams where smaller size LWD is needed to provide function, this option would ensure a greater number of source trees left in the RMZ for recruitment.

There is high uncertainty regarding the impact of low LWD recruitment along small, nonfish-bearing streams on downstream fish habitat.

Nonfish-bearing Waters

On portions of Type N_p streams, RMZ widths would be 50 feet, which is less than the one site-potential tree height (both 100-year SPTH and 250-year SPTH) recommended in most literature to encompass the source area where an adequate level of LWD recruitment can occur. The 50-foot buffer would provide for approximately 48 to 92 percent of recruitment potential of a mature stand where the buffer is implemented, depending upon site class (McDade et al., 1990). At least 50 percent of the length of N_p streams, which include all sensitive sites within the harvest unit, are required to have the 50-foot no-harvest RMZ. Depending on the number of sensitive sites more than 50 percent of the N_p streams could be given an RMZ. Because of the relatively narrow buffer strip, there is a greater risk of blowdown occurring. As mentioned previously, observed blowdown levels average about 15 percent, but vary widely depending upon site characteristics and could approach 100 percent in rare circumstances. On Type N_s and all other Type N_p streams, harvest would be allowed to the stream bank. Therefore, there would be no protection of LWD recruitment potential.

On the westside, Alternative 2 would result in moderate to high risk of diminished LWD recruitment along perennial nonfish-streams and no protection along seasonal nonfish-streams.

Currently, the contribution of LWD from Type N_p and N_s streams to Type S and F (fish-bearing) streams is not well understood, but Type N_p and N_s streams are known to supply at least some level of LWD to downstream fish-bearing streams (Potts and Anderson, 1990). In narrow coastal streams in coastal Oregon, movement of LWD in second- and third-order streams has been observed to range between 11 and 49 percent (Gresswell and May 2000). In some streams, the level of input can be very high as a result of debris torrents. In addition, trees that fall into streams are important for sediment retention (Keller and Swanson, 1979; Sedell et al., 1988), gradient modification (Bilby, 1979), and nutrient production (Cummins, 1974) in Type N_p and N_s streams.

EAST SIDE

Type S and F Waters

On the east side, Alternative 2 specifies an RMZ width of at least one SPTH along Type S and F streams. There are a few exceptions, which include streams less than 15 feet wide that are on site class V soils and streams greater than 15 feet wide that have a site class of III, IV or V (which all exceed one SPTH). Therefore, Type S and F stream RMZs meet the width recommended in the literature for LWD recruitment. In addition, because these buffers are measured from the CMZ or the bankfull width, there is an additional factor established for the possibility of a shift in the stream channel. This would ensure that an established stand of trees would be available for recruitment in the relocated stream channel.

For Type S and F streams, no harvest would occur in the core zone, which is 30 feet from the CMZ or bankfull width. Approximately 65 percent of LWD recruitment potential comes from the core zone within the RMZ, based on McDade et al. (1990) using a 100-year SPTH of 110 feet and 44 percent of the recruitment potential using a 250-year SPTH of 170 feet.

Selective harvest would be allowed in the inner zone, which varies in width, measured from the outer edge of the core zone, depending on stream width. For streams less than 15 feet wide, the inner zone would be 45 feet wide and for streams greater than 15 feet wide the inner zone would equal 70 feet. Using a site class II modeled stand for comparative purposes, approximately 31 (100-year SPTH) to 33 (250-year SPTH) percent of LWD recruitment potential would come from the 30 to 75-foot zone of the RMZ if all source trees are left uncut along a stream less than 15 feet wide. Streams wider than 15 feet would have approximately 33.5 (100-year SPTH) to 42 (250-year SPTH) percent of recruitment potential from the 30 to 100-foot inner zone of the RMZ. The inner zone selective harvest prescription (using the modeled stand) would maintain 8 (100-year SPTH) to 9 (250-year SPTH) percent of the no-harvest LWD recruitment potential along streams less than 15 feet wide. For streams greater than 15 feet wide, the inner zone selective harvest prescription would maintain between 6 (100-year SPTH) and 14 (250-year SPTH) percent of the LWD recruitment potential.

More restrictive prescriptions will be implemented within the bull trout overlay. The bull trout overlay means those portions of eastern Washington streams containing bull trout habitat as identified on the Department of Fish and Wildlife's bull trout map. The more restrictive prescriptions are designed for a higher level of protection for trees that provide shade, but would also provide increased protection for trees that could become LWD. In areas where the bull trout overlay would be applied, the inner zone was modeled as no-harvest between 30 and 75 feet for all streams to capture the maximum likely shade-retention strategy. For streams greater than 15 feet wide, the area 75 to 100 feet from the stream or CMZ edge was modeled as a partial harvest leaving at least 50 trees per acre including the 21 largest trees, at least 29 trees greater than 10 inches dbh, and basal area of at least 90 ft^2 per acre leave trees. Under this scenario, 31 (100-year SPTH) to 36 (250-

year SPTH) percent of the no-harvest LWD recruitment potential would come from the inner zone (see Appendix D, Table 31a and 31b).

The outer zone has prescriptions that allow for a more intensive selective harvest. Similar to the inner zone, the outer zone width would also vary, depending on site class and stream width, and ranges between 0 and 55 feet. The outer zone provides approximately 1.5 (100-year SPTH) to 2.5 (250-year SPTH) percent of the LWD recruitment potential if all source trees are left uncut. Under the 250-year SPTH assumption for site class II soils, about 11.5 percent of the recruitment potential derive from outside of the outer zone (i.e., 110 to 170 feet) and receive no RMZ protection. The outer zone would maintain less than 1 percent of the recruitment potential under the 100-year SPTH assumption, but would provide about 2 percent of the potential under the 250-year SPTH assumption. This results from the different cumulative recruitment potential curves used under the two assumptions. The 100-year SPTH assumption was based upon the mature stand and the 250-year SPTH assumption was based upon the old-growth curve from McDade et. al (1990). Compared to the mature curve, the old-growth curve has a higher percentage of the total recruitment derived farther from the stream.

On the east side, Alternative 2 would result in moderate risk of diminished LWD recruitment along Type S and F streams.

With all zones combined, in areas outside the bull trout overlay the post-harvest recruitment potential for trees of recruitable size remaining in the three zones of the RMZ would range from 55 (250-year SPTH) to 74 (100-year SPTH) percent of the no-harvest potential for smaller streams less than 15 feet. The range for larger streams greater than 15 feet was 52 (250-year SPTH) to 76 (100-year SPTH) percent (see Appendix D). In areas within the bull trout overlay, the post-harvest recruitment potential of trees of recruitable size ranges from 80 (250-year SPTH) to 96 (100-year SPTH) percent for streams less than 15 feet and 79 (250-year SPTH) to 97 (100-year SPTH) percent for streams greater than 15 feet.

A sensitivity analysis was prepared using the 100-year SPTH assumption to determine the variation among post-harvest recruitment potential between vegetative habitat types (mixed conifer versus ponderosa pine), areas within or outside the bull trout habitat overlay, site classes, and stream size. The results suggested there were moderate differences between vegetative habitat types (8 percent or less), large differences (10 to 28 percent) between areas in or out of the bull trout overlay, large differences (up to 19 percent) between site classes, and small differences (less than 5 percent) between stream sizes (see Appendix D).For both the mixed conifer and ponderosa pine habitat types the post-harvest LWD recruitment potential was consistently higher on sites with lower productivity (see Appendix D). This can be explained by the fact that sites with lower productivity (e.g., site class IV and V) have a lower SPTH than those with higher productivity. Therefore, the 30-foot core zone represents a greater percentage of the total SPTH and recruitment potential.

Also, for most of the stands modeled in the sensitivity analysis, it was apparent that larger streams that require large wood (greater than 10 inch dbh) to function, may not benefit from the 29 smaller trees retained in addition to the 21 largest trees (in order to make up the minimum of 50 trees per acre) retained in the inner zone over the short term. Recruitment potential for these larger streams would likely only come from the 21 largest trees per acre left in the RMZ until the rest of the trees grew to a size that would provide function when recruited. This disparity would likely be even larger for the recruitment of key piece LWD. For these large streams, depending on the size class distribution in the stand, there is a greater risk of recruitable sized trees being harvested that fall in between the gap of the minimum size trees that are retained (10 inch dbh) and the largest trees in the stand that are required to be retained. Mid-size streams, with a wider inner zone compared to streams less than 15 feet wide, would have the lowest risk of LWD recruitment loss over the short-term, though some reduction would occur.

The EBAI for LWD weights the recruitment potential for each stream type and size by the length of the stream in those categories and provides an overall measure of recruitment potential by alternative. The EBAI for LWD on the east side outside of the bull trout overlay ranges from 54 (250-year SPTH) to 73 (100-year SPTH) percent of the no-harvest potential along Type S and F streams. The EBAI suggests that under the protection levels provided outside the bull trout overlay, there is a substantially greater recruitment potential along Type S and F streams under Alternative 2 compared to Alternative 1, but less when compared to Alternative 3 under both SPTH assumptions (Figures 3.5-10 and 3.5-12).

On the east side, thinning in the inner zone would likely shorten the time required to obtain key piece size LWD over the long term, except along small streams that require smaller size LWD.

Within the bull trout overlay, which covers most of the east side forested areas, if a landowner decides not to harvest any trees within 75 feet of the stream to address shade issues (see the stream shade section, below), then the level of protection would increase substantially over the standard rule. Notably, shade producing trees in the inner zone are also those most likely to be the larger trees that would also provide LWD if they fall into the stream. Under this assumption, the EBAI for LWD ranges between 78 (250-year SPTH) and 96 (100-year SPTH) percent of the no-harvest potential. In practice, it is expected that most landowners would harvest some trees between the core zone and 75 feet and the level of protection would thus be intermediate between the standard rule and the potential protection available from the shade rule.

The EBAI under the 250-year SPTH assumption is substantially lower (about 18.5 percent) than the 100-year SPTH assumption. Consequently, there is substantially more risk if a 250-year SPTH is more appropriate for describing the buffer width needed for full protection of LWD recruitment. Overall, there is a moderate (100-year SPTH assumption) to high (250-year SPTH assumption) level of risk that LWD recruitment potential to Type F and S streams may not be at levels adequate to sustain robust salmonid populations, except in situations where implementation of the shade rule results in substantial harvest reductions within the 75-foot bull trout overlay zone.

On the east side under current conditions, most riparian areas are dominated by forests in early seral stages. Thus, the quality of LWD input potential is currently less than optimum to provide LWD recruitment. Using the RAIS growth modeling to predict tree growth rate, it is apparent that thinning results in increasing tree diameter at a faster rate. Under Alternative 2, thinning the inner zone increases the size of trees over the mid- and long-term, producing larger trees sooner (see discussion under west side). However, because the growth rate is slower on much of the east side, the time-frame would likely be extended. Though key piece sizes have not been calculated for the east side specifically, the time that key piece size is achieved would also likely be reduced to some extent, similar to the west side. However, the actual timeframe required to reach key piece size would likely be longer than for the west side. For the larger streams there may be a greater lag time before a larger proportion of trees would be of recruitable size, since the medium/large size trees are at the greatest risk of reduction in the short-term.

Nonfish-bearing Waters

> On the eastside, Alternative 2 would result in moderate risk of diminished LWD recruitment along perennial non-fish streams and high risk along seasonal non-fish streams.

On Type N_p streams, the RMZ width would be 50 feet. The silvicultural prescription for the Type N_p RMZ can be partial cut, clearcut, or no harvest and are designated as part of a timber harvest application. The RMZ is less than the one site-potential tree width recommended in most literature to encompass the entire source area. The 50-foot buffer would provide for approximately 48 to 92 percent recruitment potential, depending upon site class and SPTH assumption (McDade et al., 1990). On some N_p and all N_s stream reaches, harvest would be allowed to the stream bank. Consequently, there would be no protection of LWD recruitment potential along these stream reaches. Trees along Type N_p and N_s streams (like Type S and F streams) that fall in are important for sediment retention (Keller and Swanson, 1979; Sedell et al., 1988), gradient modification (Bilby, 1979), and nutrient production (Cummins, 1974).

> Because small landowners are permitted to implement less protective RMZs under Alternative 2, the risk that LWD recruitment would not be adequate to maintain a properly functioning system is increased in watersheds with large areas owned by small landowners and with high levels of past harvest.

Silvicultural prescriptions within buffers along Type N_p streams include a partial cut and a clearcut option. The partial-cut option has a selective harvest prescription similar to the inner zone along Type S and F streams. The clear-cut option can be implemented along no more than 30 percent of the stream reach within the harvest unit, cannot be more than 300 feet in length, and must be at least 500 feet upstream from the an intersection with a Type S or F stream. A no harvest prescription must be implemented on both sides of the stream over a length similar to that implemented for the clearcut prescription. Under the partial cut option, 24 to 36 percent of the recruitable trees were left in the RMZ depending on site-class and species zone under the 100-year SPTH assumption. Once a partial cut or clearcut strategy is selected, it cannot change during the life of the Alternative 2 plan. Under the clear-cut option 55 to 59 percent of the recruitable trees were left in the RMZ. For all Type N_s streams, no RMZs are maintained, and, therefore, no protection of LWD recruitment potential would occur.

ALTERNATIVE 3

GENERAL

As for Alternative 2, the small landowner exemption would apply to the riparian rules under Alternative 3. Small landowners (owning less than 80 acres of forest land in Washington) would be permitted to implement substantially less protective RMZs on parcels less than 20 acres in size (see Section 2.4.2.2). Although these parcels represent a minority of the lands subject to forest practices rules (about 15 to 20 percent of all private forestlands), this reduced protection increases the level of concern. In watersheds with a high proportion of small landowners, especially where a high level of past harvest has occurred, this rule would increase the risk that LWD recruitment is not adequate to maintain a properly functioning system.

> Alternative 3 provides more protection for riparian trees along shorelines of the state than the SMA.

Under Alternative 3, the Shoreline Management Act (SMA) would not provide any additional protection to riparian trees along shorelines of the state compared to the standard rules. In fact, the standard rules under Alternative 3 would provide a greater level of protection than the SMA because the 200-foot RMZ is a no-harvest buffer and measured from the outer edge of the channel migration zone.

> On the west side, Alternative 3 would result in low risk of diminished LWD recruitment along fish-bearing streams.

> On the west side, Alternative 3 would result in low risk of diminished LWD recruitment along nonfish-bearing streams.

WEST SIDE

On the west side, Alternative 3 would implement 200-foot RMZs along streams less than 20 percent gradient, 100-foot RMZs along streams 20 to 30 percent gradient, and 70-foot RMZs along streams greater than 30 percent gradient. These RMZs would provide 94 to 100 percent, 75 to 100 percent, and 62 to 98 percent of the recruitment potential, respectively, depending upon the SPTH assumption for site class. Similar to Alternative 2, additional protection of LWD recruitment potential is provided by measuring the RMZ from the channel migration zone (CMZ). Other zones that would provide additional protection of recruitment potential include measuring the RMZ from beaver habitat zones (BHZs) and channel disturbance zones (CDZs). These no-harvest zones would provide additional LWD recruitment potential in areas that are not protected under Alternatives 1 and/or Alternative 2. Also, because of the relatively wide RMZs under Alternative 3, the risk of blowdown would be relatively low compared to the other alternatives.

For all three stream types, no harvest is allowed within the RMZ except for specific cases which include 1) converting a hardwood-dominated stand to one that is conifer-dominated, or 2) facilitating the development of 200 year-old stand conditions. As a result, most if not all of the recruitment potential based on RMZ width (described above) would be maintained unless stand manipulation was deemed necessary to facilitate riparian condition.

> Because small landowners are permitted to implement less protective RMZs under Alternative 3, there is some risk of diminished LWD recruitment in watersheds with large areas owned by small landowners and with high levels of past harvest.

> Based on long-term modeling, it is apparent that LWD diameters increase faster when thinning is implemented; generally larger streams would benefit from thinning and smaller streams would benefit from

Under both the 100-year and 250-year SPTH assumptions, the EBAI analysis suggests that Alternative 3 has the greatest recruitment potential along all streams when compared to Alternative 1 and Alternative 2 (Figures 3.4-9 and 3.4-11). In addition, the EBAI suggests that recruitment potential to fish-bearing streams would be about 95 percent or higher. Although the higher gradient streams do not fully meet the one SPTH width to provide complete recruitment potential, virtually all high gradient streams are nonfish-bearing. However, a large proportion (70 percent) of the low gradient streams modeled (see Appendix C) fall in the category of N_s streams under Alternative 2. Therefore, a relatively large proportion of streams that would likely be categorized as seasonal streams (and receive no buffer under Alternative 2), would receive a 200-foot, no-harvest RMZ under Alternative 3. This factor produces a substantial increase in the EBAI value when compared to the more limited protection provided these streams under Alternative 2 and Alternative 1 (see Appendix D and Figures 3.4-9 and 3.4-11).

Using growth modeling, it is apparent that tree diameters increase at a faster rate when thinning is implemented. Therefore, the riparian stands that are along larger streams, thinning as provided by Option 1 of Alternative 2 may be important to increase the growth rate over a shorter period of time depending on the channel condition. However, along the smaller fish-bearing and nonfish-bearing streams that do not necessarily benefit from thinning, this alternative provides the maximum recruitment potential.

EAST SIDE

Silvicultural prescriptions in RMZs are the same on the east side as on the west side. However, SPTH is less than on west side. Therefore, there are some differences in the level of protection for LWD recruitment potential. On the east side, Alternative 3 would provide 100 percent of LWD recruitment potential through the designation of a 200-foot RMZ along streams that are less than 20 percent in gradient under all site classes and both the 100-year and 250-year SPTH assumptions. For the 100-foot RMZ on streams that are between 20 and 30 percent gradient, LWD recrutiment potential would range from 98 – 100 percent for the different site classes under the 100-year SPTH assumption and between 81 and 100 percent for the different site classes under the 250-year SPTH assumption. Under the 250-year SPTH, 100 percent of LWD recruitment potential would occur for site class V soils, but site class III and IV soils would exceed 90 percent of LWD recruitment potential. The RMZs along streams that are greater than 30 percent would would result in 91 to 100 percent of recruitment potential under the 100-year SPTH assumption and 71 to 94 percent of LWD potential under the 250-year SPTH assumption. Similar to Alternative 2, additional protection of LWD recruitment potential is provided by measuring the RMZ from the CMZ and ensuring no-harvest within the CMZ. Other zones that would provide additional protection of recruitment potential include measuring the RMZ from BHZs and CDZs where they apply. Also, because of the relatively wide RMZs under Alternative 3, the risk of blowdown would be relatively low.

On the east side, Alternative 3 would result in low risk of diminished LWD recruitment along fish-bearing streams.

On the east side, Alternative 3 would result in low risk of diminished LWD recruitment along nonfish-bearing streams.

For all three stream types, no harvest can occur within the RMZ except for specific cases which are described above under the west side. As a result, most if not all of the recruitment potential based on RMZ width (described above) would be maintained unless stand manipulation was deemed necessary to facilitate riparian condition.

Because small landowners are permitted to implement less protective RMZs under Alternative 3, there is some risk of diminished LWD recruitment in watersheds with large areas owned by small landowners and with high levels of past harvest.

Similar to the west side, under both the 100-year SPTH and 250-year SPTH assumptions the EBAI suggests Alternative 3 has the greatest recruitment potential along all streams compared to Alternatives 1 and 2 (Figure 3.4-10 and 3.4-12). The major differences in the two SPTH assumptions occur along steeper (greater than 20 percent) slopes that generally (but not always) are nonfish-bearing streams. Of particular note is that the EBAI for all streams is just short of complete protection under the 100-year SPTH assumption, and is just short of complete protection for fish-bearing streams under the 250-year SPTH assumption. These results are primarily due to the fact that, although high gradient stream RMZ width is less than one SPTH, most of the recruitment potential is obtained within 70 feet to the stream. In addition, a large proportion of seasonal streams (defined under Alternative 2), which make up the greatest proportion of stream miles across the landscape fall within the 0 to 20 percent gradient category and therefore, receive a 200-foot, no-harvest RMZ.

Stream Shade

ALTERNATIVE 1

WEST SIDE

Type 1, 2, and 3 Waters

The RMZ width criteria for full stream shade protection is 0.75 SPTH and trees closer to the stream have a greater ability to provide shade (Figure 3.4-3). On the west side a 0.75 SPTH, which ranges from 68 to 150 feet under a 100-year SPTH assumption and 75 to 185 feet under a 250-year SPTH assumption (depending on site class), is considered to provide full protection for stream shade along Type 1-3 streams. Along most Type 1, 2 and 3 streams the RMZ widths do not meet this requirement under Alternative 1. The few exceptions are primarily where maximum RMZs are applied to low site classes. Also, wider buffers and additional riparian leave trees are sometimes required to meet the shade rule, particularly in lower elevation areas.

In addition to RMZ widths that do not meet full protection criteria, shade levels can be further reduced along Type 1 through 3 streams because the FPRs allow substantial canopy removal through selective harvest within the RMZ. In general, the studies reviewed by Belt et al. (1992) indicated that removal of forest canopy within the buffer strip reduces its effectiveness by reducing shade. As a result, the level of protection is too low to maintain adequate stream shade to provide full protection.

On the west side, Alternative 1 would result in moderate to high risk of diminished shade along Type 1 to 3 streams.

However, under Alternatives 1 and 2, the FPRs include the shade rule which is designed to maintain shade so water temperatures will not exceed water quality standards. As guidance for meeting the requirements of the shade rule, the Forest Practices Board Manual includes a shade screening tool and, if necessary, water temperature modeling to determine the likely effects of removing riparian shade trees. The shade rule requires maintenance of specific shade levels depending upon the stream water quality type (A, AA, etc.) and elevation. The screening tool uses overhead canopy closure (measured mid-stream using a spherical densiometer) as an index for actual shade. Depending on elevation (particularly lower elevations) there is increased shade requirements along Type 1-3 streams due to the implementation of the shade rule. As a result, the width of the RMZ and leave tree requirements within the RMZ may increase to the maximum and shade levels are likely to increase. In tests of the shade screening tool, Rashin and Graber (1992) found that the screening tool was effective at 78 percent of the 9 sites examined (excluding those with flow loss within the reach). Consequently, there is some risk that streams could be miscategorized using the screening tool and provided inadequate minimum shade requirements. The results from Rashin and Graber (1992) also suggested that prior to implementation of the water temperature screening tool and model, low elevation streams, under 1,640 feet, were at higher risk of exceeding water quality standards than higher elevation streams. It is not known to what degree the screening tool and model has been more effective at identifying these low elevation, at-risk streams and providing more effective shade retention.

Currently, the majority of trees in the RMZs are in early seral stages (see Table 3.4-3). Therefore, depending on stream size much of the lands may not be effective at providing shade under existing conditions and it may take many years of growth before riparian trees will be able to provide adequate shade. However, because there is no limitation on entry into the RMZs, it is likely that many stands would be harvested again during the next rotation, prior to or near the time that riparian trees are approaching more complete shade function.

> On the west side, Alternative 1 would result in very high risk of diminished shade along Type 4 and 5 streams.

Type 4 and 5 Waters

RMZs are not required for Type 4 waters except under limited site-specific conditions and would not exceed 25 feet in any case. Therefore, RMZs for Type 4 streams do not meet the mimum widths required to maintain adequate shade.

Type 4 streams are most susceptible to alteration in shade since there are no RMZ or leave tree requirements. There is some limited reduction in risk due to the fact that smaller streams can be partially or fully shaded with overhanging shrubs, young trees, and slash (timber harvest debris) which are not large enough to shade larger streams.

EAST SIDE

Type 1, 2, and 3 Waters

A 0.75 SPTH, which ranges from 45 to 98 feet under the 100-year SPTH assumption and 64 to 147 feet under the 250-year SPTH assumption, depending on site class, is assumed to provide full protection for shade on the east side (Spence et al., 1996; FEMAT, 1993). Most RMZ buffer widths along Type 1, 2 and 3 streams do not meet this requirement, since the minimum RMZ width is 30 feet, which is less than 0.75 SPTH for all site classes. The few exceptions where the 0.75 SPTH would be met are primarily where maximum RMZs are applied to low site classes.

> On the east side, Alternative 1 would result in moderate to high risk of diminished shade along Type 1-3 streams.

Similar to the west side, the possibility of harvest activity within the RMZ under Alternative 1 for all stream types leaves the possibility that shade will be further reduced. However, the shade rule would also be implemented on the east side and RMZ width and leave tree requirements could be increased to the maximum for maintenance of shade levels. The magnitude of temperature increases resulting from canopy removal on the east side might be expected to be slightly less than for the west side because the degree of shading provided by more open forest types (e.g., ponderosa pine) is lower than for coastal and western Cascade streams. However, many streams east of the Cascades approach the maximum thermal tolerance level for salmonids during the summer and these smaller increases in temperature might be equally or more detrimental to salmonids.

Similar to the west side, the majority of the riparian vegetation is currently in early seral stage and most of the remainder is in mid-seral stage (see Table 3.4-3). The younger stands are not expected to provide shade that approaches adequate function in the short-term. Similar to the west side, the riparian stands would likely be harvested again prior to approaching adequate shade along all streams. However, because the rotation is longer on the east side a greater proportion of the landscape would likely be functioning prior to the next rotation.

Type 4 and 5 Waters

On the east side, Alternative 1 would result in very high risk of diminished shade along Type 4 and 5 streams.

RMZs are not required for Type 4 streams, except for limited site-specific conditions and, in any case would not exceed 25 feet. Therefore, RMZs for Type 4 streams are less than the minimum buffer width required for adequate protection of shade.

The greatest risk is for Type 4 streams that have no leave tree requirement and consequently no protection for shade. However, for many Type 4 streams, the risk is reduced because they are effectively shaded by overhanging shrubs, young trees, and slash. In addition, selective harvest is the main silvicultural strategy (approximately 70 percent of the landbase) applied to the east side (Pers. Com., Debbie Robinson, DNR, January 5, 2000). Therefore, some protection may be provided even if no RMZ is applied. Overall, however, the lack of RMZ buffers on Type 4 streams would not meet the level recommended for minimum protection, at least in the short- and mid-term.

ALTERNATIVE 2

WEST SIDE

Type S and F Streams

Under Alternative 2, the RMZ widths under the 100-year SPTH and 250-year assumptions nominally exceed the width recommended in the literature to provide complete shade for all Type S and F streams if considering only the width of the RMZ and not the RMZ prescriptions. However, a substantial portion of the available trees can be harvested within the inner and outer zones. Consequently some level of shade reduction can be expected under Alternative 2. Nevertheless, the cumulative percent curve for shade (Figure 3.4-3) shows that the relationship between buffer width and potential shade from the adjacent riparian zone is non-linear with a greater percentage of shade occurring closer to the stream. For example, approximately 75 percent of shade effectiveness is within 0.5 SPTH. In addition, RMZ widths begin at the edge of the CMZ where they are present which provides additional protection to vegetation in close proximity to a stream.

The no-harvest zones adjacent to the stream bankfull width or CMZ range from 50 feet under Option 1 (thinning from below) to 80-100 feet under Option 2 (leave trees closest to the water). A 50-foot no-harvest buffer is expected to provide 53 to 91 percent of full shade protection under the 100-year SPTH assumption and 44 to 86 percent of full shade under the 250-year SPTH assumption, depending upon site class. Under Option 2, an 80-foot no-harvest zone would provide 75 to 100 percent of full shade protection under the 100-year SPTH and 64 to 100 percent under the 250-year SPTH assumption. A 100-foot no harvest zone would provide 86 to 100 percent (100-year SPTH) or 76 to 100 percent (250-year SPTH) of full shade protection. The core zone would maintain the maximum available overstory canopy within the immediate area adjacent to the stream.

Under Option 1, in addition to the core zone adjacent to the stream bankfull width or CMZ, the inner zone extends out to 0.66 of the 100-year SPTH for streams less than or equal to 10 feet wide and to 0.75 of the 100-year SPTH for streams greater than 10 feet wide. These widths equate to 0.54 SPTH or 0.61 of the 250-year SPTH assumption for small and large streams with site classes I - IV, respectively. The core plus inner zone widths exceed 100 feet for site class I and II soils and site class III soils for streams greater than 10 feet

On the west side, Alternative 2 would result in low to moderate risk of diminished shade along Type S and F streams.

wide. However, there are no data in the literature that demonstrates the level of shade protection that is available from the combination of a no-harvest zone and a selective harvest zone. The selective harvest that occurs within the inner zone of Option 1 leaves the largest, and therefore the tallest, trees which have the highest likelihood to provide shade. The taller trees in the inner zone are also those that have the highest likelihood of providing additional shade to the stream. It is possible that under some circumstances leave trees in the outer zone may also provide some shade, but this will likely be minimal or none in most cases.

Similar to Alternative 1, under Alternative 2 the shade rule must also be taken into consideration, which would increase shade in areas where site-specific conditions warrant it. However, the shade rule is slightly different compared to Alternative 1. Under Alternative 1 the shade rule applies to trees up to the maximum RMZ width for that stream type and width. Under Alternative 2, the shade rule applies to all trees within 75 feet of the stream channel or CMZ, if present. In addition, canopy closure measurements are made at the edge of the CMZ when it is present or mid-stream otherwise. Nevertheless, it is unclear to what extent the shade rule would actually contribute additional protection when implemented because most shade producing trees that would be protected by the shade rule would already be protected by the no-harvest core zone, the thin from below requirements under Option 1, and the no-harvest portions of the inner zone under Option 2. Similar to all alternatives reductions in shade would occur from yarding corridors and roads located in the RMZ.

All factors considered, the overall RMZ effectiveness for providing shade protection to Type S and F streams within this alternative is considered moderate to high based upon the FEMAT (1993) shade curve, but high under most situations. Consequently, the level of risk for diminished shade is considered low to moderate. No-harvest buffers 100 feet wide have been suggested to have similar levels of shade protection as old-growth forests in western Oregon and Washington (Murphy, 1995; Johnson and Ryba,1992) and this width would be available under many Option 2 situations. In addition if the channel shifts within the CMZ in the future, the stream would still be provided shade.

The large proportion of RMZs that are in early-seral stages are not expected to be producing complete shade capacity within the short-term (see Table 3.4-2) and some of these stands are under-stocked by conifers and dominated by hardwoods. Mid-seral stands would regrow to the point that canopy closure would be sufficient to produce shade comparable to a later seral stand near the end of a 50-year period (see Table 3.4-3), however core zones that are re-growing as understocked hardwood-dominated stands may not return to their full shading potential (Sullivan, K.; personal communication; February 28, 2001). Consequently, even no-harvest zones have some risk of not supplying long-term shade needs.

On the west side, Alternative 2 would result in moderate risk of diminished shade along perennial nonfish-streams and high risk along seasonal non-fish streams.

Type N Streams

For at least 50 percent of the Type N_p stream length, a 50-foot RMZ will be provided, which meets the small stream width criteria. Sensitive sites (which include seeps, springs, initiation points of perennial flow, and others) would also receive protection from forest practices with 50-foot buffers. In addition, a 50-foot buffer would be required for the first 500 feet upstream of the confluence with the Type F or S stream. These 50-foot buffers would provide 53 to 91 percent of full shade protection under the 100-year SPTH assumption and 44 to 86 percent of full shade under the 250-year SPTH assumption, depending upon site class. For all other Type N streams, no RMZ is provided and therefore no shade protection is guaranteed, though some shade will be maintained from understory vegetation.

> There is moderate to high uncertainty that buffers along Type N_p streams would be effective in maintaining temperature of waters delivered to Type F and S streams.

The greatest risk of shade reduction is along portion N_p streams that have no leave tree requirement, resulting in even-aged timber harvest adjacent to the stream and no shade protection. Similar to the Type 4 waters under Alternative 1, these streams would not receive an adequate shade protection level, at least in the short term which could result in water temperature increases.

However, for Type N_p streams, the risk would be reduced because many N_p streams are effectively shaded by overhanging shrubs and young trees and as discussed above at least 50 percent of these streams are provided a 50 ft no-harvest RMZ. The 50 foot no-harvest buffers along the lower 500 feet of Type N_p streams are intended to allow water temperatures to equilibrate to shaded conditions prior to mixing with, or becoming, a Type F or S stream. There is a moderate to high level of uncertainty that these buffers will be effective. Consequently, this is a priority research topic under the adaptive management program.

In watersheds with high proportions of small landowners, the lack of RMZs on all Type 4 and 5 streams permitted by Alternative 2, would produce increased risk of adverse effects. These effects of Type N streams could also be transferred to downstream fish streams until streams temperatures equilibrated with local environmental conditions.

EAST SIDE

Type S and F Streams

> On the east side, Alternative 2 would result in low to moderate risk of diminished shade along Type S and F streams.

Under Alternative 2, the total RMZ widths nominally exceed the widths recommended in the literature for shade along Type S and F streams, but include both no-harvest and partial-cut silvicultural prescriptions. The 30-foot no-harvest core zone adjacent to the bankfull width (or CMZ) would provide 49 to 86 percent of full shade protection under the 100-year SPTH assumption and 35 to 69 percent of full protection under the 250-year SPTH assumption. Inner zone widths are 45 feet for streams less than or equal to 15 feet wide and 70 feet for streams greater than 15 feet wide. If the inner zones were no-harvest zones, 75 feet would provide 93 to 100 percent of full shade under the 100-year SPTH assumption, and 73 to 100 percent under the 250-year SPTH assumption. A 100-foot buffer would provide 100 percent of full shade under the 100-year SPTH assumption and 87 to 100 percent of full shade under the 250-year assumption. However, some reduction in shade would be present because some level of harvest is allowed within the inner zone. Leave tree requirements for inner zones are dependent upon habitat type (ponderosa pine, mixed conifer, or high elevation) and site class. Leave trees include 21 to 50 of the largest, and consequently tallest, trees per acre in the ponderosa pine and mixed conifer habitat types. The high elevation habitats follow the “thin from below” prescriptions used in western Washington.

There is a moderate level of uncertainty that leave tree requirements in the inner zone will provide adequate shade protection, particularly if the core zone is not fully stocked. In regions with higher ambient air temperature, any potential risk of shade reduction could increase the risk of adverse affects to stream temperature (see Section 3.6.3.2). However, other prescriptions may reduce the risk associated with this uncertainty, including implementation of the bull trout overlay along Type S and F streams, and the shade rule.

Under the shade rule, areas that are part of the bull trout overlay, an additional 45 feet outside of the core zone (75 feet total) is prescribed to maintain all available shade. This does not necessarily imply no-harvest, but the level of additional protection is highly site specific. As discussed previously for the west side, the shade rule is based upon canopy closure and shade protection under the bull trout overlay is implemented similarly. The shade rule protects existing shade rather than potential future shade. Consequently, some trees are potentially at risk of harvest in the inner zone or within 75 feet of the stream within the bull trout overlay because they do not currently provide shade, but could if they were taller. This limitation of the rule is more important on the east side than the west side because stands tend to be more open. In a fully stocked stand, the trees closest to the stream would provide the bulk of the shade protection with trees further out providing a marginal increase in the level of additional shade. In contrast, trees further from the stream have more potential to provide shade in a more open stand. Compared to the west side, there is a greater likelihood that the shade rule will protect additional shade producing trees on the east side, particularly within the bull trout overlay, because the core zone is narrower and the shade rule is consequently applied to a larger area.

Similar to the west side, any yarding corridors and roads located within the RMZ would also reduce the level of shade protection. All factors considered, Alternative 2 is considered to have a low to moderate risk of diminished shade along Type S and F streams.

For a large proportion of the RMZs that are in early seral stage, effective shading from the RMZ is currently compromised. Most of the early seral stages are maturing and, without any new harvest taking place, the reestablishment of suitable canopy cover over the mid term to provide adequate stream shade would occur over most streams. Therefore, as in the case for any alternative, the implementation of wider RMZs retaining more trees for shade protection, would still require many years for sufficient shade to be produced in most cases.

Type N Streams

Type N_p streams with a 50-foot RMZ meet the shade requirement for smaller streams (<5 ft). For some other Type N_p streams, no RMZ is provided and therefore no overstory shade protection is provided.

On the east side, Alternative 2 would result in moderate risk of diminished shade along perennial nonfish-bearing streams and high risk along seasonal nonfish-

The 50-foot no-harvest RMZ along some Type N_p streams would provide complete shade protection. Type N_p streams with 50-foot selective harvest RMZs, have a greater risk of shade reduction. However, for Type N_p streams, the risk is reduced because many Type N_p

streams are effectively shaded by overhanging shrubs and young trees. The greatest risk of reduction of shade is along N_p streams that do not have any RMZs, similar to the west side. Therefore, these streams are at the greatest risk of shade loss over the short- and long term until new trees grow to an adequate size.

As is the case for the west side, under Alternative 2 watersheds on the east side with high proportions of small landowners would have higher risk of temperature effects on Type N streams because no RMZs are required and leave tree requirements are reduced relative to the standard rules. Water temperature increases could be transferred to downstream fish streams until temperature equilibrated with local environmental conditions.

ALTERNATIVE 3

Alternative 3 would result in low risk of diminished shade along fish-bearing streams statewide.

Under Alternative 3 for streams 0 to 20 percent gradient, the 200 feet RMZ width would meet or exceed the width recommended in the literature for maintaining shade under both the 100-year and 250-year SPTH assumptions. Streams with 20 to 30 percent gradient would receive a 100-foot no-harvest buffer that would provide 100 percent of full shade protection under the 100-year SPTH assumption and 87 to 100 percent of full protection under the 250-year SPTH assumption. The only exceptions would be along streams that are greater than 30 percent that have a 70-foot no-harvest RMZ. These high gradient streams meet the 0.75 RMZ for west side site class V and east side site class III, IV and V areas. These high-gradient streams tend to be small and would, likely be provided complete shade protection from the RMZ. Overall, the RMZ width provided should be sufficient to maintain most if not complete protection of shade on these streams. The timing for recovery of shade along early- and mid-seral stage RMZs would be similar to Alternative 2.

Alternative 3 would result in low risk of diminished shade along most nonfish-bearing streams statewide, except for some small streams with very high gradients (which would at least receive a high degree of protection).

Overall, for both the east and west sides and for all streams, most if not all shade is protected. In general, the expansive no-harvest RMZs provide a high level of protection, and have a low risk of shade reduction. Alternative 3 provides the highest level of shade protection, when compared to all other alternatives for all streams. In addition, all the RMZ widths are within the range considered to have less likelihood of being susceptible to appreciable mortality from windthrow.

Leaf and Needle Litter Production

ALTERNATIVE 1

WEST SIDE

On the west side, Alternative 1 would result in moderate risk of diminished leaf and needle litter production along Type 1-3 streams.

A 0.5 SPTH, which ranges from 45 to 100 feet depending on site class under the 100-year SPTH assumption and 50 to 124 feet under the 250-year SPTH assumption, is considered to provide full protection for leaf and needle litter inputs based on FEMAT (1993). For current FPRs, depending on site class, full protection is provided based on RMZ buffer widths to Type 1, 2, and 3 streams when implementing the maximum RMZ widths. However, the minimum RMZ width of 25 feet does not meet the 0.5 SPTH required for complete protection of leaf and needle litter (Figures 3.4-7 and 3.4-8). For each stream type, RMZ buffer width can vary between the minimum and maximum values, depending on the extent of wetland vegetation or the width needed for shade. For Type 4 and 5 waters, RMZs are not required except for site-specific conditions and, in this case, would not exceed 25 feet. Therefore, RMZs for Type 4 and 5 streams do not meet the 0.5 SPTH required for complete protection under the maximum protection provided by the current FPRs.

For Alternative 1, leaf and needle litter recruitment would be compromised along Type 1 through 3 streams because the FPRs allow substantial reduction in overstory conifers and hardwood removal through selective harvest within the RMZ reducing the quantity of biomass that would likely be recruited. For streams that do not meet the established criteria of 0.5 SPTH combined with the selective harvest prescriptions, the risk of reducing leaf and needle litter recruitment would increase. There is a compounding of risk when both the required RMZ width is not met and selective harvest is allowed within the limited size RMZ.

> On the west side, Alternative 1 would result in very high risk of diminished leaf and needle litter production along Type 4 and 5 streams.

Even greater risk is associated with the Type 4 and 5 streams that have no RMZ or leave-tree requirement, however. The size and morphology of a small low-order stream greatly influences the deposition and processing of organic materials. Litter is primarily deposited into small steep-gradient streams in forested areas high in a watershed. Higher order streams are less likely to retain deposited organic material until it has been decomposed. Therefore, these small (low order) streams are important to the productivity of larger (high order) stream in lower reaches of the watershed because they are a major source of organic material (IMST, 1999). The exact proportion of detrital production that comes from Type 4 and 5 streams is not well documented in the literature; however, it may be an important portion of the overall productivity. The lack of RMZ buffers on Type 4 and 5 streams would not meet the protection recommended for detrital input needs, at least in the short term, and probably only in localized areas while vegetation grows back.

There would likely be an interruption of detrital input until the riparian forest has grown for many years after the Type 4 and 5 streams are harvested. The Type 4 and 5 streams would then produce some leaf and needle litter, although production might not reach full production in the short or long term. In addition, the type of the litter may be different than the pre-harvest stands because of shifts in the ratio of coniferous versus deciduous vegetation. The type of detrital input can affect not only its nutritional value, but also the amount of time needed for decomposition (Gregory et al. 1987). To what extent leaf and needle litter composition is altered is difficult to determine because; 1) timber harvest occurs in localized areas at varying times within a watershed; and 2) all forest seral stages provide some level of leaf and needle input, although in varying quantities.

> There is uncertainty as to what order of magnitude leaf and needle litter is altered since timber harvest occurs in localized areas at varying times in a watershed, and all seral stages provide some level of input.

Currently, most riparian vegetation is in an early to mid-seral stage (see Table 3.4-2). Stand age significantly influences detrital input to a stream system. Therefore, these stands will not be producing leaf and needle litter that approach natural background levels in the short term (see Table 3.4-2). Mid-seral stands would re-grow to the point that canopy closure would be sufficient to produce leaf and needle litter comparable to a later seral stand near the end of a 50-year period (see Table3.4-3). As a result, just as the stand is meeting detrital input production levels, the stand would likely be harvested again for the next rotation, never allowing complete return to natural production levels.

EAST SIDE

On the east side, Alternative 1 would result in moderate risk of diminished leaf and needle litter production along Type 1-3 streams

A 0.5 SPTH, which ranges from 30 to 65 feet, depending on site class under the 100-year SPTH assumption and 43 to 98 feet under the 250-year SPTH assumption, is considered to provide full protection of leaf and litter inputs on the east side. Under current FPRs in eastern Washington full protection is provided based on RMZ widths to Type 1, 2 and 3 streams when implementing the maximum and average RMZ widths. Site class I, requires a greater RMZ width to maintain the leaf and needle litter zone which is considered complete protection. The minimum RMZ widths of 30 feet meets the target width of a 0.5 a SPTH for site class V areas only under the 100-year SPTH assumption (Figures 3.4-7 and 3.4-8). For Type 4 and 5 waters, RMZs are not required and, therefore, these do not meet the 0.5 SPTH required for complete protection under all circumstances.

On the east side, Alternative 1 would result in very high risk of diminished leaf and needle litter production along Type 4 and 5 streams.

As for the west side, the possibility of harvest activity within the RMZ under Alternative 1 for all stream types leaves the possibility that leaf and needle litter production would be compromised. The greatest risk is for Type 4 and 5 streams that have no leave tree requirement and timber harvest can occur adjacent to the stream. The lack of an RMZ on these smaller streams would indicate that Type 4 and 5 waters receive no protection of leaf and needle litter recruitment. However, uneven-aged (partial-cut) timber harvest strategies are currently applied to approximately 70 percent of the east side forested landbase (personal communication Debbie Robinson, DNR, January 5, 2000). Therefore, some incidental protection is provided even if no RMZ is applied. Overall, the lack of RMZ buffers on Type 4 and 5 streams would not meet the level required for full protection of leaf and needle litter input, at least in the short term, and probably in most areas for the mid and long term.

Currently, most riparian vegetation is in early-seral and mid-seral stages (see Table 3.4-2). These young stands would not be producing leaf and needle litter that approach natural background levels in the short term (see Table 3.4-2). Similar to the west side, most stands would likely be entered again prior to the complete return of detrital production.

ALTERNATIVE 2

WEST SIDE

On the west side, Alternative 2 would result in low risk of diminished leaf and needle litter production along Type S and F streams.

Under Alternative 2 the overall RMZ widths exceed the width recommended in the literature for leaf and needle litter production for Type S and F streams. Type N_p streams with a 50-foot RMZ receive most of the protection required to maintain leaf and needle litter input, but not at the level recommended by the literature for full protection. For some portions of Type N_p and N_s streams, no RMZ would be provided and, therefore, no protection of leaf and needle litter would be provided.

The no-harvest zone ranges from 50 feet under Option 1 to 80 to 100 feet under Option 2 should maintain most of the RMZs leaf and needle litter input capacity along Type S and F streams. In addition, the inner zone, which is a limited selective harvest prescription on Type S and F streams would not appreciably reduce the ability of the RMZ to contribute leaf and needle litter, especially when combined with the core zone no-harvest area. These RMZs would provide continuous inputs for leaf and needle litter to streams and would

On the west side, Alternative 2 would result in moderate risk of diminished allow the maintenance of stream productivity in the short and long-term depending on the stand age and structure.

The greatest risk of reduction of leaf and needle input is along the Type N_p and N_s streams that have no leave tree requirement resulting in even-aged timber harvest adjacent to the stream. The lack of an RMZ on these smaller streams would indicate that these waters receive no protection of leaf and needle litter recruitment. Similar to the Type 4 and 5 waters under Alternative 1, these streams would not meet the requirements for adequate protection of detrital input, at least in the short term, and probably only in localized areas while vegetation grows back. Similar to Alternative 1, in many areas a shift in the initial type of detrital input can be expected from coniferous needles to deciduous vegetation. However, a large proportion of N_p streams (50 percent or greater depending on the number of sensitive sites) would be provided a 50-foot, no-harvest RMZ, substantially reducing this risk.

Recruitment of leaf and needle litter from nonfish-bearing streams to downstream fish-bearing streams is of concern, especially in watersheds with a high level of past harvest and/or high proportion of ownership by small landowners.

Because of the large proportion of RMZs that are in early- and mid-seral stages, they would not be expected to produce leaf and needle litter that approaches natural background levels in the short term (see Table 3.4-2). Mid-seral stands would grow to the point that canopy closure would be sufficient to produce leaf and needle litter comparable to a later seral stand near the end of a 50-year period (see Table 3.4-3). Because the RMZs would not be re-entered until the desired future condition was met, most stands would have the opportunity to return to natural production levels over the long-term.

EAST SIDE

Under Alternative 2, for all Type S and F streams total RMZ widths exceed the 0.5 SPTH recommended in the literature for leaf and needle litter production. For Type N_p streams that receive a 50-foot RMZ, the 0.5 SPTH is met for site class II through V and protects most of the area for site-class I. Under the partial-cut strategy, all N_p streams are provided with an RMZ, and under the clear-cut strategy, at least 70 percent of the N_p streams are provided with an RMZ. For all other Type N_p and N_s streams, no RMZ would be provided, and, therefore, no protection of leaf and needle litter would be provided.

On the east side, Alternative 2 would result in low risk of diminished leaf and needle litter production along Type S and F streams.

Along Type S and F streams, the 30-foot core zone, which is no-harvest, combined with the selective harvest inner zone, should maintain most of the RMZs leaf and needle litter input capacity. These RMZs would provide continuous inputs of leaf and needle litter to streams and would allow the maintenance of stream productivity in the short- and long-term depending on the stand age and structure.

On the east side, Alternative 2 would result in moderate risk of diminished leaf and needle litter production along perennial non-fish streams and high risk along seasonal nonfish-bearing streams.

As described earlier, landowners must identify either a partial cut and/or clearcut strategy within the 50-foot RMZ along Type N_p waters. When the clearcut strategy is identified along no more than 30 percent of the stream in the harvest unit, no harvest RMZs of equal length on both sides of the stream must also be identified. The 50-foot no-harvest RMZ along some Type N_p streams and the 50-foot selective harvest RMZ along others would provide some if not all of the leaf and needle recruitment capacity. However, the some risk would be present from Type N_p designated for the clearcut strategy and N_s stream reaches that do not have any leave tree requirements. Therefore, these streams are at the greatest risk of having detrital inputs interrupted over the short- and long-term until new trees grow back in localized areas. For a large proportion of the RMZs that are in early seral stage, production of leaf and needle litter is currently compromised. As a result, only over time will the increased tree biomass occur to allow for increased litter recruitment to streams.

ALTERNATIVE 3

STATEWIDE

Alternative 3 would result in very low risk of diminished leaf and needle litter production along all streams statewide.

Under Alternative 3, the RMZ width for most streams (0 to 30 percent gradient) would meet or exceed the width recommended in the literature for full leaf and needle litter recruitment potential. In addition, the RMZs are no-harvest, providing complete protection of leaf and needle litter production along these streams. The only exceptions are along streams that are greater than 30 percent. These high gradient streams meet the 0.5 RMZ for the west side of site classes III through V and the east side of all site classes. These streams are provided with a no-harvest RMZ of 70 feet. Though the exact proportion of detrital production that comes from these streams is not well documented in the literature, it may be an important portion of the overall productivity. However, in general the RMZ buffer provided should be sufficient to maintain most the detrital inputs on these streams at or near natural conditions. The timing for recovery of leaf and needle input along early and mid seral stage RMZs would be similar to Alternative 2.

Overall, most if not all leaf and needle litter input would be protected for all streams statewide. Alternative 3 would provide the most protection of leaf and needle input when compared to all other alternatives for all streams.

Microclimate

ALTERNATIVE 1

Alternative 1 would result in moderate risk for some, but high risk for most microclimatic variables, statewide.

Under this alternative, microclimatic gradients, and particularly relative humidity and air temperature, would be negatively affected. Sullivan et al. (1990) studied the effects of current forest practices rules on water and air temperature in riparian areas and found significant increases in air temperature. A nearly one-to-one correlation was found between air temperature and percent shade.

Because the RMZ widths would, at most (maximum of 100 feet on Type 1 and 2 streams on the west side and generally 50 on the east side), be only about two-thirds or less of the 147 feet minimum, and because there would be harvest within the buffer, microclimatic conditions would be negatively affected, relative to natural conditions, on all stream types. Air temperature and humidity would be greatly affected. In addition, on the east side, which naturally has higher ambient air temperatures, the change in microclimate could further increase air temperature. On the west side, where the dominant early seral riparian area is predominantly made up of coniferous forest, there is no long-term goal for returning the condition of the riparian area to a conifer-dominated stand which would maintain a seasonally altered riparian zone.

ALTERNATIVE 2

Alternative 2 would result in a moderate risk for mostmicroclimatic variables along Type S and F

Although there are some differences between the two options under this alternative that might affect air temperature and overall microclimatic gradients, there is not enough resolution in the existing understanding of microclimatic gradients to distinguish the effects of Options 1 and 2. Therefore, they are treated the same.

In contrast to Alternative 1, total buffer widths for site classes I and II approach or exceed the minimum buffer widths for overall microclimate gradient maintenance, at least on fish-bearing streams. However, because some level of harvest is allow within the RMZs, the natural gradients would not likely be maintained. Within the no-harvest zone of buffers on fish-bearing streams, relative humidity and other parameters would probably be somewhat lower than under natural conditions, since decreased humidity in the adjacent selectively harvested inner and outer zones would affect the core zone to some extent.

The adverse effects to microclimate along nonfish-bearing streams would be greater. For the Type N_p and N_s stream segments that do no receive an RMZ, no protection would be provided. On Type N_p stream segments that receive some protection from no-harvest RMZs, the 50-foot width is at most one-third of the minimum recommended buffer for the various microclimate variables.

Air temperature and humidity would be affected under this alternative, because the buffer width for maintaining these gradients is even greater than for other microclimatic gradients. The eastside air temperature in the RMZ is likely to have a greater change since ambient air temperatures tend to be higher then the west side.

ALTERNATIVE 3

Among the alternatives considered in detail, Alternative 3 provides the highest degree of protection of microclimatic gradients. Streams with instream gradients of less than 20 percent would receive 200-foot, no-cut buffers. This would be sufficient to maintain microclimatic gradients for most variables. Air temperature, humidity, and windspeed would nonetheless be affected to some extent, since they require wider buffers (240 to 787 feet) to maintain natural gradients.

> Alternative 3 would result in low risk for modifying most microclimate variables along streams less than 20 percent gradient and moderate to high risk elsewhere.

Streams with higher instream gradients would receive somewhat less protection. A stream with an instream gradient between 20 and 30 would receive a 100-foot, no-cut buffer, while streams with higher instream gradients would receive a 70-foot, no-cut buffer, which is high risk for most microclimate variables. Under both situations, natural microclimate gradients, would be modified, but the extent of modification would be lower than Alternatives 1 and 2. However, as with lower gradient streams, air temperature, humidity, and wind speed would be significantly affected across riparian areas.

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3.5 WETLANDS

3.5.1 Introduction

Wetlands are defined in terms of their physical, chemical, and biological characteristics, such as hydrologic regime, soil type, and plant species. Wetlands are formally defined as those areas that are inundated or saturated with surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions (40 CFR 230.41 (a) (1)) and WAC 222-16-11. This definition includes forested swamps, marshes, bogs, and other similar areas. Wetlands are subject to regulation through the Clean Water Act by the Corps of Engineers and the Environmental Protection Agency. Sections 404 and 401 of the Clean Water Act were created specifically with the intent "to restore and maintain the chemical, physical and biological integrity of our nation's waters" (see Section 1.4.3.4).

Wetland ecosystems provide a variety of physical and biological functions. Additionally, they provide many values to society including recreation, water quality enhancement, and flood attenuation. The National Wetland Policy Forum (Conservation Foundation, 1988) identified eight natural functions that wetlands may perform at a landscape level. These functions are: (1) nutrient removal and transformation; (2) sediment and toxicant retention; (3) shoreline and bank stabilization; (4) flood flow alteration; (5) groundwater recharge; (6) production export; (7) aquatic diversity and abundance; and (8) wildlife diversity and abundance. Values to society of these wetland functions include recreation, water quality enhancement, and flood control.

3.5.2 Affected Environment

3.5.2.1 Wetland Functions

As noted above, wetlands provide a variety of functions and values. The key wetland functions that are the focus of this EIS include fish and wildlife habitat, water quality, and hydrology. These functions were chosen because they are the ones that may be most directly impacted by timber harvest related activities. The functions are briefly discussed below.

Fish and Wildlife Habitat

Wetland and riparian habitats are considered to be among the richest zones for aquatic and terrestrial organisms (Clark, 1977; Dodd, 1978; Brinson et al., 1981; Kauffman and Krueger, 1984). Because wetland and riparian habitats exhibit an "edge effect" due to overlapping types of habitats, more niches are provided by these areas than are provided by any other habitat types. Eighty-six percent (359 out of 414) of the terrestrial vertebrate species in western Washington and 85 percent (320 out of 378) of terrestrial vertebrate species in eastern Washington utilize wetland and associated riparian habitats for portions of their life needs (Brown, 1985; Thomas, 1979).

Wetlands provide habitat or perform functions that contribute to the health of ecosystems of many anadromous and resident fish species within Washington. Wetlands are known to help maintain cool water temperatures, retain sediments, store and desynchronize flood flows, maintain stream base flows, and provide food and cover for fish (Cederholm and Scarlett, 1981; Beechie et al., 1994; Mitsch and Gosselink, 1993; DOE, 1993).

Water Quality

Wetlands can improve water quality through nutrient removal and transformation (Hammer, 1989). For example, wetlands can remove nitrate and phosphorus from agricultural runoff. Nutrient-rich sediments may also become trapped and removed from the water. Wetlands can also remove toxic chemicals, such as pesticides, heavy metals, or excess nutrients from water (Mitsch and Gosselink, 1993). Wetlands can reduce shoreline and bank erosion by binding soil substrates in wetland plant roots. Thus, wetlands protect upland habitats along streams and rivers from erosion, and protect downstream habitats from sedimentation and pollution. Wetlands can help maintain desirable stream temperatures in the summer as they discharge cool groundwater. Additionally, forested riparian and wetland areas serve an important role in shading streams from direct solar heating.

Hydrology

Headwater riverine and depressional wetlands can delay discharge of peak run-off into streams and impede passage of overbank flow downstream during storm events, thus reducing the potential for downstream flooding (Winter, 1988; Roth et al., 1993). Depressional wetlands can help maintain existing quantities of groundwater by delivering water to underlying aquifers (Dinicola, 1990; Economic and Engineering Services Inc., 1991). Additionally, wetlands can help maintain minimum stream base flow by naturally regulating the release of groundwater discharge into streams and by recharging aquifers that discharge groundwater to streams (Dinicola, 1990; Hidaka, 1973; O'Brien, 1988; Mitsch and Gossselink, 1993).

3.5.2.2 Historic/Current Wetland Protection

Wetlands are subject to regulation under Sections 401 and 404 of the Clean Water Act. Discharge into wetlands may also be regulated under section 402 of the Clean Water Act. Exemptions granted under Section 404(f)(1) allow for normal agricultural, ranching, and silvicultural activities, as well as maintenance of existing drains, farm ponds, and roads. The construction or maintenance of forest roads for silvicultural purposes is exempt from regulation when such roads are constructed and maintained in accordance with best management practices (BMPs). The BMPs "assure that flow and circulation patterns and chemical and biological characteristics of water of the United States are not impaired, that the reach of the waters of the United States is not reduced, and that any adverse effect on the aquatic environment will be otherwise minimized."

On private and state lands in Washington, the FPRs provide protection for wetland resources from timber harvest-related activities. For management purposes, the FPRs recognize two major categories of wetlands: forested and nonforested. Nonforested wetlands are divided further into two classes: Type A (greater than 0.5 acre, with open water) and Type B (other nonforested wetlands). FPRs require buffers, termed WMZs, on all Type A wetlands and most Type B wetlands. Harvest may occur in forested wetlands; however, harvest methods are to be limited to low impact harvest or cable systems.

For Type A wetlands greater than 5 acres in size and containing open water, an average WMZ of 100 feet is required. For Type A wetlands between 0.5 and 5 acres, a 50-foot average WMZ is required. For Type B wetlands greater than 5 acres, a 50-foot average WMZ is required. For other wetlands between 0.5 and 5 acres, a 25-foot WMZ is retained. Wetlands less than 0.5 acre have no buffer.

In addition to leaving WMZs, there are several other harvest restrictions around nonforested wetlands. For example, individual trees and small patches of forested wetlands (0.5 acre) cannot be harvested if surrounded by a Type A or Type B wetland. Harvest of upland areas or larger forested wetlands require a plan approved by the DNR if they are surrounded by Type A or Type B wetlands. Additionally, Timber cannot be felled into or cable-yarded across a Type A or Type B wetland without prior approval by DNR.

3.5.2.3 Existing Condition of Wetlands

Since the time of colonization, Washington state has lost between thirty to fifty percent of its wetlands (National Wetlands Inventory; USFWS, 1999). Additionally, the functions of existing wetlands have been reduced. Various factors have contributed to wetland loss and wetland function reduction including agriculture development, urbanization, timber harvest, road construction, and other land management activities. It is difficult to assess the current conditions of wetlands in forested lands across the entire state of Washington. However, some wetlands on lands subject to FPRs have been altered in the past due to actions associated with timber harvest activities, such as harvest and road building. These actions can impact wetland sites directly through vegetation alteration, soil compaction, and changes in hydrologic regime and water quality or indirectly through sedimentation from adjacent land management practices. Additionally, harvest of trees in or adjacent to wetland sites can impact microclimates of wetland sites. Other impacts to wetlands have likely occurred from fires and other natural disturbances.

Wetlands are described in this document using the DNR wetland GIS coverage, which separates wetland habitats into two major categories: forested and nonforested. The nonforested wetland are further divided into Type A wetlands (greater than 0.5 acre, including any acreage of open water) and Type B (other non-forested wetlands), and other (forested wetlands and open water habitats).

Overall, approximately 4.4 percent of the land base evaluated for this section is comprised of wetland habitats (Table 3.5-1). Wetland areas comprise approximately 2 percent of the land base on the east side and approximately 6 percent on the west side. The percent of wetlands by type in the sample sections subject to FPRs can be found in Table 3.5-1.

Table 3.5-1. Approximate Wetland Area as a Percentage of Forested Ownership, by Region and Wetland Type[1/]

Region	Ownership	Type A Wetland	Type B Wetland	Other Open Water	Forested Wetland
Westside	Private Lands	0.7 percent	<0.1 percent	<0.1 percent	5.7 percent
Eastside	Private & State Lands	0.4 percent	<0.1 percent	<0.1 percent	1.2 percent
Statewide	**Private and State on Sampled lands**	**0.6 percent**	**<0.1 percent**	**<0.1 percent**	**3.8 percent**

[1/]Based on random sample of lands subject to FPRs in each region/ownership category (see Appendix G).

3.5.3 Environmental Effects

3.5.3.1 Evaluation Criteria

The evaluation criteria for this EIS for wetland resources includes an analysis of the degree of protection provided by the Forest Practices Rules for wetlands and their associated functions (i.e., water quality, hydrology, and fish and wildlife habitat). Provisions under the alternatives that are evaluated against the evaluation criteria include timber harvest (application of protective buffers (WMZs and RMZs) and the degree of harvest or disturbance allowed in forested wetlands), road management practices, and application of new wetland mapping and classification systems.

<u>Timber Harvest</u>

FORESTED WETLANDS

Timber harvest and associated activities can affect wetland sites by changing species composition, reducing stand density and shading, changing fuel profiles, and altering disturbance regimes (Castelle et al., 1992; Harris and Marshall, 1963; Darrnell, 1976). Timber harvest may alter wetland hydrology and cause a rise in the water table elevation (Veery, 1997). Changes in hydrologic patterns of wetland sites can directly influence plant species and growth within the wetland site resulting in an increase in undesirable plant species. Additionally, the altered water table and associated streamflow relationship could increase localized runoff and flooding (Grigal and Brooks, 1997). Soil rutting and compaction from timber harvest activities can reduce infiltration, redirect flow, and alter pathways by which water moves through and from wetlands.

Water quality of wetland sites can be affected by harvest activities (Shepard, 1994). Harvest and associated activities can deliver sediment to wetlands, diminish water quality and lead to the filling of wetland sites. Nutrient pathways within wetlands can also be affected.

Alterations of forested wetland sites discussed above can impact microclimates within wetland sites and can effect habitats of associated fish and wildlife species. Changes to wetland hydrology may diminish suitable amphibian breeding, feeding, and rearing habitat (Hruby et al., 1998). Reduced cover and changes in plant species composition can influence invertebrate populations (Cyr and Downing, 1988) and impact food sources, den/nest sites for aquatic mammals, birds, and amphibians (Hruby et al., 1998). Additionally, fish populations in waterways associated with harvested forested wetlands may be effected by increased sedimentation and hydrologic and temperature alterations.

A method of reducing impacts to forested wetland sites is to implement reduced harvest scenarios and restrict equipment operation and yarding practices in these areas. Residual vegetation left behind after reduced harvest and associated activities would provide shading for wetland sites and act as a buffer to filter out sediments and pollutants (Broderson, 1973; Corbett and Lynch, 1985). Effects on wetland hydrology would be reduced in light harvest areas. As a result, impacts to fish and wildlife would be reduced.

NON-FORESTED WETLANDS

Due to the lack of commercial timber within nonforested wetland habitats, these areas would not be harvested. However, adjacent timber harvest may indirectly impact these sites through increased sedimentation from upslope timber harvest activities and potential reduction of shading from removal of adjacent trees. These disturbances could disrupt nutrient pathways, affect water temperatures, and affect hydrology within these nonforested wetlands, causing short-term indirect effects on water quality, vegetation composition, and microclimates.

A method of reducing impacts on wetlands from land management activities is to apply a protective buffer around wetland sites. Characteristics of buffer zones, particularly slope and vegetative cover, directly influence buffer zone effectiveness. The effectiveness of removing sediments, nutrients, bacteria, and other pollutants from surface water runoff increases with buffer width. Although buffer protection distances for wetlands can vary markedly, depending upon site conditions, buffers of 100 feet or greater have been found to control course and fine sediments if channelization in the buffer zone does not occur (Broderson, 1973; Corbett and Lynch, 1985; Lynch et al., 1985). Additionally, buffers of at least 100 feet have been found to minimize water temperature fluctuations (Lynch et al., 1985). To protect wetland values for wetland-associated wildlife species, slightly larger buffers, ranging from 200-300 feet, are generally needed (WDW, 1992).

Wetland buffers or WMZs that are required under the alternatives are described in Table 3.5-2.

Table 3.5-2. WMZs under Alternatives 1, 2, and 3

Wetland Type	Size of Nonforested Wetland (in acres)	Alternatives 1 and 2 Average WMZ width	Alternative 3 Average WMZ width
A (including bogs)	> 5	100	200
A (including bogs)	0.5 to 5	50	200
A (bogs Only)	0.25 to 0.5	50	200
A (including bogs)	< 0.25	No WMZ required	No WMZ required
B	> 5	50	100
B	.5 to 5	25	100
B	0.25 to 0.5	No WMZ required	100
B	< 0.25	No WMZ required	No WMZ required
Forested		No WMZ required, some restrictions may apply	Leave 70 percent canopy closure, understory vegetation, snags, and non-merchantable trees.

Road and Landing Management

Road construction in wetland areas can directly impact wetland sites by permanently removing or eliminating the biological functions (i.e., water quality, hydrology, and fish and wildlife habitat) from the affected portion of the wetland. Additionally, crossing wetlands with roads, without adequate provision for cross-drainage, can lead to flooding on the upslope side and drainage changes on the downslope side of crossings (Stoeckeler, 1967; Boelter and Close, 1974). Road and landing construction and use can deliver sediment to wetlands, diminish water quality and lead to the filling of wetland sites. Nutrient pathways within wetlands can also be affected.

Avoidance of wetlands during road and landing layout is a primary method for eliminating direct impacts to wetlands associated with road and landing establishment. Where wetlands can not be avoided, a method of offsetting impacts from road construction includes the implementation of wetland replacement mitigation measures. Mitigation ratios may vary depending upon the type, size, and health of an effected wetland site. Additionally, best management practices implemented during road and landing construction and use can minimize associated impacts to wetland sites. Road management options under the alternatives are outlined in Chapter 2 and Appendix F.

Wetland Classification System

Wetland ecosystems in the United States occur under a wide range of climatic, geologic, geomorphic, and hydrologic conditions. This diversity of conditions makes the task of assessing wetland functions difficult, because not all wetlands perform functions in the same manner, or to the same degree. Therefore, to simplify the assessment process, it is useful to classify wetlands into groups that function similarly. Classification narrows the focus of attention to: (1) the functions a particular type of wetland is most likely to perform, and (2) the characteristics of the ecosystem and landscape that control these functions. Classification provides a faster and more accurate assessment procedure, thereby providing land managers a better tool for identifying and protecting wetlands, or mitigating for lost wetlands or wetland functions (water quality, hydrology, and fish and wildlife habitat).

Current DNR wetland classification and mapping is based on the National Wetland Inventory (NWI) maps, which uses the Cowardin classification system (Cowardin et al., 1979). Wetlands are mapped and classified based on size, vegetative structure, and hydrology. A shortcoming of this classification system is that it does not identify functional values of wetland sites. In contrast, hydrogeomorphic classifications group wetlands on the basis of three fundamental characteristics: geomorphic setting, water source, and hydrodynamics. At the highest level of the classification, wetlands fall into one of five basic hydrogeomorphic classes including; depressional, slope-flat, riverine, fringe, and extensive peatland.

A hydrogeomorphic classification can be applied at a regional level to narrow the focus even further. The regions identified by Omernik (1987), Bailey (1994), or Bailey et al. (1994) are based on climatic, geologic, physiographic, and other criteria and provide a convenient starting point for applying the classification within a region. Any number of regional hydrogeomorphic wetland subclasses can be identified based on landscape scale factors such as geomorphic setting, water source, soil type, and vegetation. The number of regional subclasses identified depends on the diversity of conditions in a region and assessment objectives.

A description of wetland mapping and classification provisions under the alternatives can be found in Chapter 2 and Appendix G.

3.5.3.2 Evaluation of Alternatives

Timber Harvest

FORESTED WETLANDS

Under all the alternatives, forested wetlands may be harvested with some restrictions (Table 3.5-2). Harvest of forested areas on or adjacent to wetland sites would have the greatest short-term impacts on these resources by changing species composition, reducing stand density and shading, altering disturbance regimes, altering successional rates and pathways, altering hydrologic regimes, increasing undesirable vegetation, and altering nutrient/chemical cycles (Castelle et al., 1992; Harris and Marshall, 1963; Darrnell, 1976). The greatest restrictions (protection) for forested wetlands occur under Alternative 3 since a minimum of 70 percent canopy closure along with understory vegetation, snags, and non-merchantable timber must be retained. This harvest restriction associated with Alternative 3 would lessen impacts to wetlands, particularly hydrologic alterations and impacts on fish and wildlife habitat. Under Alternative 1 and 2 a level of protection is afforded to forested wetlands associated with nonforested wetlands sites. Harvest of forested wetlands which are surrounded by open water and emergent wetlands must be conducted in accordance with a plan, approved in writing by the department. Additionally, under Alternative 2, Alternative 3 provides the greatest protection to forested wetlands, when compared to Alternatives 1 and 2, since a minimum of 70% canopy closure must be retained after harvest.

forested seeps and springs with an obvious connection to Type N perennial streams are protected. Also under Alternative 2, a wetlands working group would be established to conduct research and, through the adaptive management process, provide recommendations directed at improving protection of forested wetlands. The adaptive management process in Alternative 2 and the functional classification method in Alternative 3 would decrease the likelihood of an adverse effect on stream flows because these methods can be used to understand the hydroperiod of different wetland types or complexes prior to developing harvest plans.

Forested wetlands receive incidental protections under the alternatives through the establishment of WMZs and RMZs, in proportion to the widths of these zones under the alternatives.

WMZs and RMZs established under the alternatives provide varying levels of incidental protection to forested wetlands sites. Reduced management may occur in these buffers to varying degrees (see Table 3.4-2 and Section 3.4 *Riparian Section*), however, impacts to hydrologic, water quality, and fish and wildlife functions of incidentally protected wetlands would likely be reduced. The greatest degree of incidental protection would occur under Alternative 3 where 52 percent of forested wetlands would be protected under established WMZs and RMZs followed by Alternative 2 (27 percent) and Alternative 1 (20 percent) (Table 3.5-3). The high degree of incidental wetland protection provided under the alternatives is mainly due to protection provided to riparian associated wetlands through the establishment or RMZs. Incidental protection would also occur to non-forested wetland sites; however, because these sites are non-forested, no management activity in these areas is anticipated.

NON-FORESTED WETLANDS

The greatest level of protection to non-forested wetlands occurs under Alternative 3, when compared to Alternatives 1 and 2, due to greater widths of established WMZs.

Under all alternatives, non-forested wetlands are provided varying levels of protection through the application of WMZs. Wetland type and size determine the widths of WMZs and their application (Table 3.5-2). The greatest level of protection to wetland sites occurs under Alternative 3 due to greater widths of established WMZs, and application of a WMZ for Type B wetlands between 0.25 and 0.5 acre (Table 3.5-2). Under this alternative, all Type A nonforested wetlands greater than 0.25 acre would receive a minimum average WMZ of 200 feet, and all Type B wetlands greater than 0.25 acre would receive a minimum average buffer of 100 feet.

Alternatives 1 and 2 provide similar levels of protection to non-forested wetland sites (Table 3.5-2 and Section 3.5.2.2).

Table 3.5-3. Percent of Forested Wetlands in Sample Sections Incidentally Protected through the Establishment of WMZs and RMZs

Alternative and Wetland Type	Percent of Wetlands Protected by WMZs Only			Percent of Wetlands Protected by RMZs Only			Percent of Wetlands Protected by Both WMZs and RMZs			Total Incidental Protection
	East Side	West Side	State Wide	East Side	West Side	State Wide	East Side	West Side	State Wide	State Wide
Alternative 1	15%	5%	6%	6%	14%	13%	1%	1%	1%	20%
Alternative 2	12%	4%	6%	12%	21%	20%	4%	1%	2%	27%
Alternative 3	13%	9%	10%	27%	35%	34%	20%	7%	8%	52%

As stated earlier, although site-specific characteristics of wetland sites dictate buffer need requirements, in general, a protective buffer width of 100 feet or greater has been found to provide protection to wetland sites from hydrologic and water quality impacts including sedimentation and temperature alteration, and water table fluctuations. Larger buffers may be required to provide protection to habitat for fish and wildlife species associated with wetland sites. Therefore, using this rational, Alternative 3 would provide the greatest level of protection by providing buffers of 100 feet or greater to areas of Type A and B wetlands. Additionally, unlike Alternative 1 and 2, Alternative 3 provides a WMZ for Type B wetlands between 0.25 and 0.5 acre (Tables 3.5-2). Alternative 1 and 2 would provide less protection to the non-forested wetland sites due to reduced buffer widths and WMZ applications.

WMZs are provided incidental protection under all alternatives through the establishment of RMZs.

It must also be noted that management may occur within established WMZs under all the alternatives. Management activities within these buffers can reduce the functional value of the WMZs. Additionally, timber harvest may indirectly impact wetlands through increased sedimentation from upslope timber harvest activities and potential reduction of shading from removal of adjacent trees. These disturbances can disrupt nutrient pathways within these wetland sites causing short-term indirect effects on water quality, vegetation composition, and fish and wildlife. Additionally, harvest of adjacent areas could initially increase water tables in harvested areas due to reduced transpiration from tree removal. However, if the WMZ is revegetated quickly, impacts may be reduced. Consequently, long-term effects are expected to be minor. Additionally, some areas of the WMZs are provided incidental protection by the establishment of RMZs. Prescriptions within RMZs are dependent upon water types and other site conditions. For this section, the area (acres) of RMZs that overlap onto WMZ under the alternatives were evaluated, however, the individual prescriptions within the RMZs were not identified. Under Alternative 3 approximately 43 percent of wetland buffers occur with established RMZs and, therefore, would be provided incidental protection (Table 3.5-4). Under Alternative 2, approximately 27 percent and under Alternative 1 approximately 15 percent would occur within RMZs. These WMZs are expected to receive fewer disturbances due to their inclusion in RMZs although the level of incidental protection in these areas will be dependent upon the specific prescriptions of the RMZs and location of the WMZs in relation to the RMZs (core zone, inner zone, or outer zone of the RMZ).

Table 3.5-4. Percent of WMZs in Sample Sections on Forested Lands Incidentally Protected through the Establishment of RMZs Under the Alternatives

Alternative	Percent of WMZ within RMZ
Alternative 1	15%
Alternative 2	27%
Alternative 3	43%

Road Management

As stated earlier, road construction and use may have the greatest direct impact on wetland sites by permanently removing portions of the affected wetland from the landscape.

Further, roads that cross wetlands without adequate provision for cross-drainage can lead to hydrologic changes (Stoeckeler, 1967; Boelter and Close, 1974). Additionally, sedimentation from road construction and use has been found to indirectly impact wetland ecosystems (Stoeckeler, 1967; Boelter and Close, 1974). To offset impacts to wetland sites from these actions, BMPs and wetland replacement mitigation is proposed under the alternatives.

When compared to Alternative 1, Alternatives 2 and 3 provide the most stringent protection/ mitigation measures by implementing a policy of no net loss in wetland functions following road and landing construction.

Under Alternative 1 wetlands would be avoided during road and landing planning and construction. If wetlands could not be avoided, impacts would be reduced by minimizing subgrade width and spoil areas. Applications which propose to fill or drain more than 0.5 acre of an individual wetland (Class IV-special) would require an accurate wetland delineation and replacement of the lost wetland functions. This would be accomplished by replacing the lost wetland functions by enhancement of existing wetlands or creation of new wetlands, generally with an acre for acre basis and of the same type and in the same general location.

Alternative 2 and 3 contain the most stringent protection/mitigation measures by implementing a policy of no net loss in wetland functions following road and landing construction. Under these alternatives, roads cannot be constructed in bogs or fens or in wetlands if there would be a substantial loss or damage to wetland functions or acreage. Additionally, accurate wetland delineation must be performed if a road or landing construction fills or drains more than one-tenth of an acre of a wetland, which would better quantify wetland impacts than Alternative 1. Filling or draining more than 0.5 acre of a wetland is classified as a Class IV-special action and requires a replacement by substitution or enhancement of the lost wetland functions, generally with a two-for-one basis of the same type and in the same general location. Additionally, sediment deposition to wetland sites would likely be reduced (compared to Alternative 1) during road and landing construction and use due to the implication of new BMPs (see Appendix F, Forest Roads).

Classification System and Wetland Mapping

As described earlier, the current wetland classification and mapping system (Alternative 1) used by the DNR for application with the FPRs is based on the NWI system. This wetland classification system does not identify functions of wetland types within the affected landscape, and therefore, is a less effective tool for evaluating wetland impacts or developing protection or mitigation measures.

Under Alternative 3, a new wetland classification system, likely hydrogeomorphic, is to be adopted. A hydrogeomorphic system could provide additional protection to wetland areas by identifying functions of wetland types within the landscape, thereby providing a mechanism for implementing applicable protection measures. This system could provide a tool for comparing project alternatives and pre- and post- project conditions for determining impacts. Additionally, it could compare mitigation success to provide guidance for avoiding and minimizing project impacts, and to determine mitigation requirements.

Under Alternatives 2 and 3, new wetland classification systems incorporating wetland functions would be developed.

Under Alternative 2, a similar wetland mapping and classification system is proposed in accordance with procedures and other provisions of the Adaptive Management program (see Appendix I). Applications of the procedures and provisions of the Adaptive Management program are subject to funding and priorities. Under Adaptive Management, a wetlands working group would be convened to further define functions of forested wetlands, revise the current wetland classification system based on wetland functions, evaluate the regeneration and recovery capacity of forested wetlands, evaluate current WMZs, perform research on wetland functions, recommend what functions of forested wetlands need to be provided, and determine wetland size and functions that trigger any needed mitigation sequence. Under Alternative 2, landowners would be required to perform additional wetland mapping procedures (Chapter 2 and Appendix G: Wetlands). The DNR would incorporate the mapped wetlands into a GIS layer. This increased mapping effort would enhance the ability to apply wetland protection measures outlined in the FPRs.

Summary of Alternatives

Overall, Alternative 3 was found to have the greatest level of protection for wetland resources, due to WMZ and RMZ widths and the level of forested wetland protection. For road and landing construction, Alternatives 2 and 3 provide greater protection to wetlands than Alternative 1 by implementing a policy of no net loss of wetland functions, outlining higher replacement mitigation ratios for wetlands (of 0.5 acre in size) that are filled or drained, and avoiding roads and landings in bogs and fens. Additionally, Alternatives 2 and 3 require accurate delineation of wetlands where impacts to wetlands would be 0.1 acre or more. These alternatives would also reduce potential sedimentation of wetland sites through the application of new BMPs. Alternative 3 mandates the adoption of a new classification system that would incorporate the evaluation of wetland functions, thus providing a better tool for evaluating wetland impacts and designing wetland protection and mitigation measures. Alternative 2 also incorporates this measure under Adaptive Management; however, development of this classification system and other research proposed under this alternative is continent upon funding and priority evaluation. Alternative 2 was found to provide greater protection than Alternative 1 because it mandates the mapping of select wetland types and incorporates these into a DNR GIS database that would provide data for wetland evaluation and protection measure development.

To some extent, wetland functions (i.e., hydrology, water quality, and fish and wildlife habitat) are likely to be reduced under all the alternatives since forested wetlands may be harvested; however, wetland impacts under Alternative 3 are expected to be less due to the 70 percent canopy retention in forested wetlands. Non-forested wetlands receiving a buffer of less than 100 feet may be impacted by adjacent timber harvest. However, these functions would likely be reduced for the short-term if the wetland sites or buffers become revegetated. All of the alternatives contain provisions for mitigation for wetland loss due to road and landing construction. However, “no net loss” of wetlands or wetland functions due to road or landing construction is anticipated to occur only under Alternatives 2 and 3.

3.6 WATER QUALITY

3.6.1 Introduction

Water quality is measured by many parameters. The physical properties and chemical constituents of water serve as the primary means for monitoring and evaluating water quality. Forest practices have the greatest potential effect on the following water parameters: 1) stream water temperature; 2) sediment-related water quality parameters such as turbidity; and 3) pesticides/herbicides. The Forest Practices Rules must comply with the Clean Water Act to meet state water quality standards for surface waters and groundwater. Moreover, they must provide for adequate water quality protection for fish and wildlife habitat. The impacts of forest practices to water are also described in Section 3.2 (Sediment) and Section 3.3 (Hydrology). This section briefly describes the issue of water quality, and the current water quality status of lands subject to FPRs. It closes with cross-references to other sections that evaluate the potential water-related environmental consequences of the alternatives.

3.6.2 Affected Environment

3.6.2.1 Surface Water

Wet Pacific weather systems combined with the rain shadow effect produced by the Cascade Mountains, produce heavy rains on the western slopes of the Cascades and drier conditions east of the Cascades. As a result, a myriad of surface water conditions occur in Washington state. Literally all forested lands in Washington have distinct surface water features, ranging from small, intermittent streams to the very large Columbia and Snake rivers. Most of these rivers and streams support complex aquatic ecosystems, including stocks of endangered Pacific salmon and numerous other aquatic communities. Many of the major rivers and streams on the west side of the Cascades and the east side of the Olympics drain into Puget Sound, a complex and valuable marine resource to Washington state.

3.6.2.2 Groundwater

Groundwater depths, volumes, uses, and vulnerability to contamination vary considerably across Washington state. Groundwater provides drinking water for 60 to 70 percent of the population throughout the state. In large areas east of the Cascade mountain range, 80 to 100 percent of available drinking water is obtained from groundwater resources. In addition, some areas of the state, including most of Island and San Juan counties, rely solely on groundwater sources for potable water. As a whole, over 95 percent of Washington's public water supply systems use groundwater as their primary water source (U.S. EPA, 1999).

As noted above, certain areas of Washington state acquire 100 percent of their potable water from groundwater sources (sole-source aquifers). Arid areas east of the Cascades as well as islands in the Puget Sound region are particularly dependent on sole-source aquifers. State and federal programs and regulations that address groundwater quality and nitrate contamination (e.g., the Safe Drinking Water Act) mandate the routine monitoring of public supply wells to protect groundwater quality. The FPRs do not directly address protection of sole-source aquifers, however, the widespread use of forest chemicals in Washington state is a concern to sole-source aquifer users.

Groundwater is also often connected directly or indirectly to rivers, streams, lakes, and other surface water bodies, with the exchange of water occurring between these resources. In some areas of the state, groundwater contributes significantly to the base-flow of streams and summer-flow to lakes. Depending on the geologic and hydrologic conditions of the aquifer, contaminated groundwater may discharge to surface areas within one day, or may take as long as a thousand years or more (U.S. EPA, 1986). In addition, surface waters can contribute to groundwater recharge. Impacts on groundwater, therefore, also can lead to impacts on surface waters (and vice versa) as well as to aquatic organisms.

3.6.2.3 Water Quality Parameters for Surface Waters

Temperature

Stream temperature is influenced by many factors including latitude, altitude, season, time of day, flow, channel width and depth, groundwater flow, stream shading from topography or vegetation, and coastal fog (MacDonald et al., 1991). Temperature plays an integral role in the biological productivity of streams. Aquatic life is the beneficial use of the water that is most sensitive to water temperatures. Salmonids and some amphibians appear to be the most sensitive to water temperatures. Thus, they are used as indicator species regarding water temperature and water quality. Salmonid temperature requirements can vary by species and lifestage (Bjornn and Reiser, 1991; Hicks, 2000). However, in general, juvenile salmon and trout are susceptible to sublethal adverse effects when the average stream temperature is above about 59°F (Hicks, 2000). Bull trout may be susceptible when average temperatures are greater than about 50°F. The upper lethal temperature for salmonids common in the Pacific Northwest ranges from 73 to 79°F (Bjornn and Reiser, 1991). The preferred range for most salmon and trout is 54 to 57°F (Bjornn and Reiser, 1991).

Stream water temperature is regulated by heat exchange between the stream water and the aerial and subsurface conditions. Heat energy is transferred to and from streams by direct solar radiation (short wave), long-wave radiation, convective mixing with air, evaporation, conduction with the stream bed, and advective mixing with inflow from groundwater or tributary streams (Beschta et al., 1987; Sullivan et al., 1990). Streams exhibit a natural warming trend as water flows from headwaters to the sea (Sullivan et al., 1990). However, changes in environmental conditions along a reach can modify temperatures beyond the normal trend. In small- to intermediate-size streams of forested regions, incoming solar radiation represents the dominant form of energy input to streams during the summer, with convection, conduction, evaporation, and advection playing relatively minor roles (Brown, 1980; Beschta et al., 1987; Sullivan et al., 1990). In larger streams, the effects of riparian shading and advective mixing diminish and evaporative heat-loss processes increase. In small streams, groundwater discharge may also be important where it provides a large percentage of the overall discharge, particularly in the summer months during low flows.

Brosofske et al. (1997) suggested that groundwater and stream temperatures could increase due to heating of upslope soils in clearcuts. In their study, stream temperatures were correlated with shallow (4 inches) upslope soil temperatures. However, the Brosofske et al. (1997) study was focused on microclimate gradients in riparian zones rather than water heating and watershed hydrology; no measurements of interflow (horizontal movements of water above the water table) and groundwater temperatures were taken. St. Hilaire et al. (2000) incorporated interflow in their mechanistic stream-heating model. Their unverified modeling predictions suggested that less than a 0.4°C increase would occur during a tropical storm if 50 percent of the watershed were harvested. Overall, the magnitude of effects of upslope clearcuts on stream temperatures, if any, is uncertain.

Sediment

Two of the most common water quality parameters measured and monitored for sediment are suspended sediment and turbidity. Both are related to sediment delivery and transport in hydrologic systems. Streams that exceed water quality objectives for sediment would have high suspended-sediment delivery rates and/or turbidity. Suspended sediment is the portion of the sediment load suspended in the water column. The grain size of suspended sediment is usually less than one mm in diameter (clays and silts) (Sullivan et al., 1987). Turbidity refers to the amount of light scattered or absorbed by a fluid and is measured in nephelometric turbidity units (NTU). In streams, turbidity is usually a result of suspended particles of silts and clay, but also organic matter, colored organic compounds, plankton, and microorganisms.

Biological effects of increased turbidity may include a decrease in primary productivity of algae and periphyton due to the decrease in light penetration (see Section 3.8). Declines in primary productivity can adversely affect the productivity of higher trophic levels such as macroinvertebrates and fish (Gregory et al., 1987). Siltation and turbidity have also been shown to affect fish adversely at every stage in their life cycle (Iwamoto et al., 1978); spawning and incubation habitats are most directly affected (Spence et al., 1996). Deposited sediments tend to have a greater impact on fish than suspended sediment.

Pesticides

Pesticides used in forest management include a wide variety of chemicals introduced to the forest environment with the intent of controlling or halting the proliferation of nuisance organisms. Pesticides are commonly grouped according to one of three target organisms: plants (herbicides), insects (insecticides), and fungi (fungicides). In general, pesticide application rates on forested lands are fairly infrequent, with roughly one to two applications every 40 to 60 years (Ecology 1993). The effects of individual pesticides usually are determined by the active ingredients. In addition, prior to application, most pesticides are combined with a surfactant (i.e., a surface-active agent) or other adjuvant (i.e., a pharmacological agent added to increase or aid the pesticide's effect) to control and improve the desired effect. Although these additives typically present lesser threats to the environment than the active ingredients in the pesticides, their impacts can be significant, and in some cases the impacts are greater than those associated with the active ingredients.

Pesticides used in the forest environment can become water contaminants if they are transported to surface waters or groundwater. Transportation to surface waters would most likely occur through wind drift; however, heavy rains can result in pesticide transport in stormwater runoff or through contaminated soil erosion. Pesticides can also be directly applied to surface waters by overspray and spills. Groundwater contamination can occur through contaminated surface water recharge and through the direct transport of pesticides from the soil surface by rainwater. Most pesticides that have been detected in streams and groundwater are present at very low concentrations, usually well below regulatory drinking water criteria (USGS, 1996a,b,c, 1997b). However, some pesticides have been detected at concentrations that exceed the more restrictive guidelines for the protection of aquatic life (freshwater chronic criteria) or health advisories for drinking water (USGS, 1996c; Ecology, 1993). Although studies focused specifically on forestry applications have found violations of applicable water quality standards resulting from chemical applications, these violations usually resulted from the lack of spray buffers or from applications over dry or ephemeral streams (Neary and Michael, 1996; Ecology, 1993). Finally, although low levels of pesticide contamination in surface water and groundwater have been found throughout Washington state, the source of the contamination (e.g., forest applications, agriculture, urban activity) is difficult to identify and cannot be linked directly to forest applications, unless no other possible sources exist.

3.6.2.4 Regulatory Background

The Forest Practices Rules must comply with the Clean Water Act to meet state water quality standards for surface waters and groundwater (Table 3.6-1). Water quality standards are set to provide for the protection of beneficial uses such as public water

Table 3.6-1. Washington State Water Quality Standards for the Major Non-Chemical Parameters of Concern[1/]

Water Quality Parameter	Washington State Standard (Class AA, Excellent)	Washington State Standard (Class A, Good)
Temperature	Shall not exceed 16.0°C due to human activities. When natural conditions exceed 16°C, no temperature increase greater than 0.3°C is allowed. Incremental temperature changes from nonpoint source activities shall not exceed 2.8°C.	Shall not exceed 18.0°C due to human activities. When natural conditions exceed 18°C, no temperature increase greater than 0.3°C is allowed. Incremental temperature changes from nonpoint source activities shall not exceed 2.8°C.
Sediment	In regard to forest practices, implementation of approved BMPs will meet narrative water quality criteria such as support characteristic water uses, aesthetic values, etc.	Same as AA.
Turbidity[2/]	Shall not exceed 5 NTU (nephelometric turbidity units) over background when the background level is 50 NTU or less, nor increase more than 10% of background when the background level is 50 NTU or more.	Shall not exceed 5 NTU over background when the background level is 50 NTU or less, nor increase more than 10% of background when the background level is 50 NTU or more.

[1/] New water quality standards have been proposed and are currently in a draft status. The new standards for temperature would be lower and more specific to fish populations (DOE, 2001).

[2/] Nephelometric turbidity units are the measurement units of turbidity using a nephelometer (light reflected by particles in suspension at a right angle to the original source).

supplies, aquatic habitat, and recreation. The Forest Practices Act of 1974 authorizes the adoption of regulations establishing water quality standards for forest practices. Forest practices rules pertaining to water quality protection were co-adopted by the Forest Practices Board and the Department of Ecology. All other forest practices regulations are adopted by the Forest Practices Board.

ESHB 2091 changes Ecology's role in order to decrease duplication in state government. Ecology no longer has to go through the process of co-adopting water quality related Forest Practices Board rules. The Ecology representative on the Forest Practices Board now simply has to concur with the rules prior to adoption by the Forest Practices Board.

3.6.2.5 Existing Water Quality

Currently, Washington has 643 water bodies—lakes, streams and estuaries—that have been identified as impaired, of the 1,099 for which data have been collected. The 643 water bodies represent only about two percent of all the waters in Washington (Washington Department of Ecology, 1998). The water bodies measured were generally those that have a history of pollution. It is possible that other unmeasured water bodies also exceed water quality standards at some time. In 1996, the Department of Ecology listed 611 water bodies. The number of water bodies on the 1998 list increased by 32 over the 611 on the 1996 list.

The primary water quality problem on forest lands throughout the state is temperature which also happens to be the most prominent water quality problem for the state's water bodies. There is no readily available information on the number of impaired water bodies on forest lands throughout the state. Elevated water temperature generally occurs in areas where timber harvest or development has removed trees, taking away shade, which is necessary to keep the water temperature low and healthy for fish. Other problems include erosion from road building, construction, and agriculture, which increases sediment in streams.

3.6.3 Environmental Effects

3.6.3.1 Evaluation Criteria

<u>Water Temperature</u>

Many factors can influence stream temperature such as shade, air temperature, and groundwater inflow. Forest practices can reduce canopy cover near streams. The evaluation criteria for stream water temperature is the protection of stream-side shade to maintain ambient stream temperature. As discussed in Section 3.4.3.1., a no-harvest buffer width of 0.75 of a site-potential tree will be used as the criterion to evaluate the effectiveness of riparian management zones to maintain shade, and thus stream water temperature for streams greater than 5 feet in width (Spence et al., 1996). For streams less than 5 feet in width, the evaluation criterion will include the protection of hyporheic zones (i.e., areas where groundwater enters a stream), seeps, and sensitive sites in combination with maintenance of a 50-foot no-harvest RMZ that provides full shade protection of small streams (Broderson, 1973).

<u>Sediment</u>

Timber harvest activities such as road building and timber yarding may increase sediment input into streams (see Section 3.2, Sediment, for detailed discussion). Fine sediment can impair municipal and agricultural use of water, affect bed material size, and alter the quantity and quality of habitat for fish and benthic invertebrates. The evaluation criterion for sediment-related water quality parameters is the overall reduction in sediment delivery to streams from management activities. These include reduction in chronic erosion sources such as surface erosion and episodic sediment such as landslides from BMPs for timber harvest, road construction, road use, road maintenance, and road abandonment.

Pesticides

Pesticides have the potential to contaminate surface waters and groundwater depending on the amount of pesticides applied, the application technique, and the environmental conditions under which they are applied (e.g., ambient wind speed, soil runoff potential, storm frequency; Ecology 1993; Neary and Michael 1996). The evaluation criteria for pesticide applications focus on how well the Forest Practices Rules protect water resources from contamination resulting from pesticide applications (e.g., spray drift, runoff, erosion, seepage to groundwater). In addition, the evaluation criteria take into account how well the alternatives protect riparian plants from damage caused by pesticide applications. Finally, the criteria also consider the potential impacts on fish and aquatic wildlife resulting from contamination of water resources.

3.6.3.2 Effects on Water Temperature

Alternative 1

> Alternative 1 would result in a low to moderate risk of stream temperature increases along Type 1, 2, and 3 waters and a high risk along Type 4 and 5 waters.

Under the current rules, Type 1, 2, and 3 waters would receive some type of shade protection regardless of RMZ width. As part of the RMZ, a shade requirement in the forest practices rules must be maintained before any harvest activity can occur within the RMZ. The shade rule is based upon elevation of the stream and the water quality classification of the stream (A or AA; see discussion above). The shade rule reflects the fact that lower-elevation streams require more shade and higher elevations require less shade. The shade rules are meant to achieve state water quality standards, which include a small temperature increase. The shade rules decrease the allowable amount of trees that can be removed from RMZs by requiring specified levels of canopy closure over streams at different elevations. RMZ widths at lower elevations tend to be larger to meet the requirements of the shade rule.

On the westside, the minimum RMZ width of 25 feet on Type 2 and 3 waters (Type 1 waters have much wider buffers due to SMZs) does not meet the 0.75 SPTH required for complete protection for any site class (Figure 3.4-3). For each stream type, RMZ buffer widths can vary between the minimum and maximum values, depending on the extent of wetland vegetation or the width needed for shade (based on elevation in regard to meeting water quality standards). For Type 4 and 5 waters, RMZs are not required under certain conditions and, in this case, would not exceed 25 feet. Therefore, RMZs for Type 4 and 5 streams do not meet the 0.75 SPTH required for complete protection. This is important because Type 4 and Type 5 waters comprise approximately 80 percent of the drainage network (see Appendix C).

On the eastside, most RMZ widths along Type 1, 2, and 3 streams do not meet the 0.75 SPTH requirement. The few exceptions are primarily where maximum RMZs are applied to low site classes. However, minimum RMZ widths of 30 feet do not meet the 0.75 SPTH required for complete protection for any site class (Figure 3.4-3). Similar to the westside, the RMZ buffer width can vary between the minimum and maximum values, depending on the extent of wetland vegetation or the width needed for shade.

For Types 4 and 5 waters, RMZs are not required except for site-specific conditions and in this case would not exceed 25 feet. The lack of RMZs on Type 4 streams does not meet the 50-foot RMZ criterion for full shade protection. However, shade is provided to these streams from understory and slash. Caldwell et al. (1991) documented temperature increases in harvested Type 4 waters of 2°C to 8°C on several westside streams. Although in many cases the water quality temperature criteria were met, the increases observed were still violations of the 2.8°C increase allowed for nonpoint source activities. However, where a harvested Type 4 stream flows into a Type 3 stream, the temperature increases in the Type 4 stream were negligible approximately 150 meters downstream of the confluence (Caldwell et al., 1991). In addition, Zwienecki and Newton (1999) found that streams returned to normal temperatures within 500 feet after accounting for a stream's natural downstream warming trend. Furthermore, there is no protection of seeps and hyporheic zones for Type 4 waters. In conclusion, there is a high risk of temperature increases along harvested Type 4 waters, particularly in lower elevation watersheds less than 1,640 feet in elevation.

Alternative 2 would result in low risk of reduced stream shade along Type S and F streams. There would be moderate to high risk of reduced stream shade along Type N streams, which would likely affect temperature in these streams. The effect of temperature increases in nonfish-bearing streams on downstream fish streams is uncertain and could be important in watersheds with a high degree of past harvest or already elevated stream temperature.

The shade provided by RMZs under Alternative 1 is further compromised by the reduction in canopy from allowable harvest within the RMZ, because the shade rule only protects a portion of the trees that provide overhead canopy directly above the stream. Alternative 1 does not meet the protection requirements for maintaining stream temperature along Type 1, 2, and 3 waters, resulting in a low to moderate risk of stream temperature increases. Type 4 and 5 waters are at high risk of stream temperature increase, because there are no buffers along Type 4 and 5 streams.

Alternative 2

WESTSIDE

Under Alternative 2, the stream typing would increase the protection of shading provided to the entire drainage network, because more streams would receive some type of buffer; approximately 66 percent of the Type 4 streams that become Type F streams would receive some buffer to provide shade compared to Alternative 1. Under Alternative 2, the nominal RMZ widths for Type S and F streams exceed the criteria to provide complete shade, using both 100-year and 250-year SPTHs (Table 3.4-1), but some level of harvest would be allowed within the inner and outer zones.

At least 50 percent of the distance along Type N_p streams would receive a 50-foot no-harvest buffer. Seeps and sensitive areas, such as hyporheic zones, would also receive protection from forest practices with 50-foot no-harvest buffers. In the areas where two Type N_p streams meet (at initiation points), a 56-foot radius no-harvest buffers would also be established. In addition, where an N_p stream meets a Type F or Type S stream, a 50-foot no-harvest buffer would be required for the first 500 feet upstream of the confluence with the Type F or S stream. These buffers should maintain stream water temperatures in N_p streams. However, there may be a low to moderate risk of temperature increases at the mouth of N_p streams containing reaches with no buffers. However, any potential increases in stream temperatures is expected to be attenuated downstream within 500 feet, when the water flows through shaded no-harvest RMZs.

Type N_S streams would not likely be adversely affected because these streams tend to be dry during the warmest summer months when the beneficial uses of the waters are most vulnerable to warming. However, Type N_s streams that may have water present during this time may not have adequate shade from overstory trees to maintain stream temperature because there would be no buffers required along these streams. Shrubs and debris in the streams may provide adequate shade; but, because of this uncertainty, there is a high risk of water temperature increases in Type N_S streams with flowing water during the summer months.

There are no data from the scientific literature that conclusively demonstrates that the combination of a no-harvest zone with a selective harvest zone out to 0.75 SPTH will provide complete shade protection. In general, the no-harvest portions of RMZs and the implementation of the shade rule would provide a higher level of protection and increase shade in areas where applied. Overall, the RMZ effectiveness to provide shade to Type S and F streams within this alternative is high (see Section 3.4, Riparian Habitats, for a more detailed discussion). RMZs along Type S and F waters are adequate to maintain shade; however, potential increases in water temperature may occur along Type N_s and N_p streams. The potential cumulative effects of temperature increases in Type N_p streams delivering to Type S and F streams is uncertain, but could be important in watersheds with a high degree of past harvest or a history of elevated temperatures. This is a priority research topic under Alternative 2's adaptive management program.

EASTSIDE

Under Alternative 2, RMZ buffer widths exceed the width recommended in the literature for shade for Type S and F streams (Figure 3.4-3). Along Type S and F streams the 30-foot no-harvest zone adjacent to the stream bank (or CMZ) combined with the inner zone's selective harvest prescription (out to 0.75 SPTH) should protect most if not all of the RMZs capacity to shade the stream (see Section 3.4, Riparian Habitats, for a more detailed discussion). In addition, the shade rule and bull trout overlay would require more trees to remain in the inner zone, primarily at lower elevation sites. The protection of shade would maintain stream water temperatures.

For Type N_P streams, sensitive sites would be buffered with either a partial cut buffer for the partial cut strategy or 50 no-harvest buffer for the clearcut strategy. The 50-foot partial cut strategy RMZ does not provide complete protection of shade. However, these buffers should protect hyporheic zones and seeps and provide sufficient shade with understory vegetation to protect stream water temperatures. For the clearcut strategy, the 50 feet of no-harvest protection would only be provided on one-third of the N_p stream. There is a low to moderate risk of temperature increases for segments of unbuffered N_p streams. However, stream temperatures that may increase would be reduced downstream when the water flows through an RMZ. In addition, sensitive sites are also protected from harvest which protect groundwater seeps and hyporheic zones. N_s streams would not likely be adversely affected, because these streams tend to be dry during the warmest summer months when the beneficial uses of the waters are most vulnerable to warming. However, Type N_s streams that may have water present during this time may not have adequate shade from overstory trees to maintain stream temperature because there are no buffers required along these streams. Shrubs and debris in the streams may provide adequate shade; but, because of uncertainty, there is a moderate to high risk of water temperature increases in N_s streams with flowing water during the summer months.

Alternative 3

Overall, for all streams on both the eastside and westside, most if not all shade is protected (Figures 3.4-7 and 3.4-8). In general, the expansive no-harvest RMZs provide a higher level of protection eliminating risk of shade reduction. Alternative 3 provides the most protection of shade when compared to all other alternatives for all streams. Stream water temperatures would be maintained.

3.6.3.3 Effects on Sediment

Alternative 1

Alternative 1 would result in a high risk of sediment-related impacts to streams.

Under Alternative 1, the current FPRs provide prescriptive based BMPs that have been approved by Department of Ecology. However, as many studies (see Section 3.2, Sediment) have shown, the implementation of BMPs does not always reduce water quality-related impact from sediments (see Rashin et al., 1999). As discussed in Section 3.2 and Appendix E (Forest Roads), the rules under Alternative 1 may decrease sediment as BMPs are implemented, but the cumulative effects of the BMPs and the paucity of road maintenance plans present a high risk of sediment delivery to streams.

Alternative 2

Alternative 2 would result in a moderate risk of sediment delivery in the short term (next 15 years) and a low to moderate risk of sediment delivery to streams in the long term; this conclusion has a moderate degree of uncertainty.

Under Alternative 2, the cumulative effect of the implementation of RMAPs, BMPs, and specific road management, use, maintenance, and construction guidelines in the Board Road Manual, RMZs and ELZs on all perennial and intermittent streams, and greater environmental review of practices on potentially unstable slopes, should substantially reduce sediment delivery to streams compared to Alternative 1. The effect in sediment reduction will occur over time as the RMAPs are implemented and completed by 2015. In addition, a greater percentage of the landscape will not experience future ground disturbance because of no-harvest or ELZ protections.

Until the completion of the RMAPs, road related generated sediment from surface erosion and mass wasting will continue at lower rates than Alternative 1. In conclusion, sediment reduction will occur over time, with the greatest reduction occurring by 2015 or later.

Alternative 3

Alternative 3 would result in a moderate risk of sediment delivery in the short term (next 10 years) and a low risk of sediment delivery to streams in the long term; this conclusion has a moderate degree of uncertainty.

Under Alternative 3, the reduction in sediment will be greater overall and occur in a shorter timeframe. The shorter timeframe for implementation of RMAPs by 2010, the no-net-increase in roads, and the more rapid maintenance and abandonment of orphan roads will reduce sediment delivery to streams to a greater degree than Alternative 2.

3.6.3.4 Effects of Pesticides

The effects of forest chemicals are discussed from a water source perspective: surface waters, groundwater, and sole-source aquifer. The following paragraphs focus on the differences among the three alternatives pertinent to the issues of forest pesticide use and application, with particular emphasis on forest pesticide impacts on water resources (surface waters, groundwater, and sole-source aquifers).

In addition, it is important to note that several other laws and regulations, aside from the forest practices rules, apply to the conduct of forest practices (WAC 222-50). In particular, all alternatives are subject to WAC 222-16-070 (pesticide uses with the potential for a substantial impact on the environment), which requires all aerial applications to first go through a site-specific evaluation to obtain approval for all aerial applications. This preliminary process addresses the available information on the toxicity of the specific pesticide and the potential impacts of the proposed applications. The regulations imposed by this preliminary analysis are highly situation specific. In the most extreme circumstances, the required "key for the evaluation of site-specific use of aerially applied chemicals" (WAC 222-16-070) may identify the application as "Class IV-special" which in turn, would trigger additional environmental precautions and documentation (WAC 22-16-50). The important consideration is that the forest practices rules are not the single means of environmental protection for pesticide applications. Thus, the analysis presented in this EIS focuses on an evaluation of each alternative with the purpose of making comparisons among the three alternatives and is not intended to include a discussion of all applicable forest chemical regulations.

Alternative 1 would result in a risk of surface water contamination resulting from adverse weather conditions, runoff or erosion of highly mobile or persistent pesticides applied near surface waters, and/or inappropriate equipment use and selection.

Alternative 1

SURFACE WATER IMPACTS

The allowance of hand application of pesticides within the RMZ should not result in overspray of pesticides to the degree that the pesticides would directly enter surface waters. However, application of highly persistent pesticides, or pesticides with high mobility, could result in measurable surface water contamination through localized erosion or storm runoff. The overall impact would be situation- and chemical-specific, depending on the specific chemical properties as well as the timing, duration, and extent of contamination. In general, because of the slow surface and subsurface runoff from forested lands and the relatively infrequent pesticide applications, most pesticide applications in the RMZ are not expected to result in significant impacts on water quality.

The 50-foot buffer required for aerial applications on all Type 1, 2, and 3 waters and flowing portions of Type 4 and 5 waters does not provide sufficient protection against the risk of pesticides entering surface waters. Wind conditions favoring atmospheric drift toward a given surface water could result in a direct application of pesticides to the surface water. Alternative 1 does not include any special provisions or modifications for pesticide application based on weather conditions or equipment (e.g., wind speed, application height, nozzle type, or droplet size). Variations in wind conditions, droplet size, air shear (a function of nozzle angle and air speed), nozzle height, and boom length all have a significant influence on pesticide spray drift (SDTF 1997a; Ecology 1993). By not accounting for these variations, Alternative 1 presents a risk of surface water contamination caused by spray drift, adverse weather, or inappropriate equipment selection and use. Although the entry of pesticides into surface waters does not necessarily result in significant impacts (e.g., very low levels of pesticide contamination may not even be measurable), Ecology (1993) found a 50-foot buffer to be partially effective to ineffective at meeting applicable water quality standards, Forest Practices Rule requirements, and certain product label restrictions.

In addition, the application of pesticides to dry portions of Type 4 and 5 waters and other ponds and sloughs could result in high in-stream concentrations if future runoff returns flow to the dry streams (Ecology 1993). Research has shown instances where applications over dry channels resulted in very high in-stream concentrations of chemicals. The results were generally temporary but significant enough to cause adverse impacts on water quality and aquatic organisms (Neary and Michael 1996; Ecology 1993). Because none of the alternatives provide any greater protection of dry streambeds, the impacts would be the same under all alternatives.

When applying pesticides using power equipment from the ground, the 25-foot buffer required for all typed waters (excluding dry Type 4 and 5 waters) and all Type A and B wetlands should adequately protect surface waters from receiving significant pesticide overspray. However, as with the hand and aerial applications, the 25-foot buffer does not provide a high level of protection from highly mobile or highly persistent pesticides that may be transported to the surface waters through erosion or storm runoff. On the other hand, the slow runoff from forested lands, relatively infrequent application of pesticides, and generally low toxicity of most pesticides are likely to limit surface water contamination. Hand application of pesticides within the wetland management zone should not result in significant impacts to surface waters, provided that those pesticides are only applied to specific targets and the required application rates are not exceeded. The 200-foot buffer required for applications around residences (unless the application is acceptable to the resident or land owner) designed to limit contamination of residential land in general, should also provide incidental protection of any surface waters near residences. This assumes that applications that are allowed by the land owners would still be subject to the applicable buffers for any surface waters on the property. On the other hand, the smaller 100-foot buffer incorporated to protect agricultural land from contamination could result in spray drift of pesticides to the agricultural land that in turn could allow the transport of forest pesticides to surface waters. Given the considerable level of pesticide applications on agricultural land in general (e.g., by the land owners for agricultural uses), the potential contribution from spray drift of forest applications is expected to be small and is not considered a significant threat to surface water contamination.

Any leaks, drips, and spills of pesticides could contaminate forest soils. The potential impacts of an accidental spill are highly dependent on the effectiveness of the required containment and cleanup procedures. If effective safety and cleanup measures are not implemented and contaminated soils erode, the contaminants could be passed to downstream waters.

Finally, possible impacts on surface waters could occur through contaminated groundwater flow to surface waters. The extent of these impacts is difficult to predict but depends on the degree of contamination of the groundwater, the volume of water exchanged, the length of time between contamination of groundwater and contact with surface water, and the persistence and mobility of the pesticide in question.

Overall, pesticide applications under Alternative 1 present a risk of surface water contamination and may result in impacts on surface waters. For further details on the water quality impacts associated with forest pesticide applications, see Appendix J, Forest Chemicals.

GROUNDWATER IMPACTS

> Because all alternatives are subject to specific provisions for the protection of groundwater having a high susceptibility for contamination (WAC 222-16-070), statewide application of forest pesticides should not result in significant impacts on groundwater quality.

Alternative 1 includes provisions to limit groundwater contamination resulting from forest pesticide applications. Groundwater protection is provided under WAC 222-16-070 (pesticide uses with the potential for a substantial impact on the environment), where the Forest Practice Rules require an evaluation of site-specific use of aerially applied pesticides. However, localized groundwater impacts could also occur through contaminated surface water recharge to groundwater. The extent of these impacts is difficult to predict but depends on the degree of contamination of the surface water, the volume of water exchanged, and the mobility and persistence of the chemical contaminant.

The likelihood that a given pesticide would impact a groundwater aquifer depends in part on geologic and hydrologic conditions that vary considerably across the state. Local conditions determine how rapidly groundwater moves, whether it is connected directly or indirectly to surface waters and how groundwater withdrawals affect surface waters, the depth of the water below the soil surface, and how effectively soils attenuate or filter out chemical contaminants (U.S. EPA, 1986). This complex interaction between soil and water makes it difficult to predict the likelihood and extent of groundwater contamination.

Because Alternative 1 provides provisions for groundwater protection, statewide application of forest pesticides should not result in significant impacts on groundwater quality. However, groundwater impacts could occur in localized areas with particularly vulnerable aquifers and in areas where highly persistent and mobile pesticides are applied. Likewise, the continual application of forest pesticides to forested lands may contribute to cumulative effects on groundwater quality, the net effects of which are area- or site-specific and somewhat unpredictable. Additional details on the potential impacts to groundwater quality are discussed in Appendix J.

The widespread use of pesticides could lead to groundwater contamination in sole-source aquifers unless adequate protective measures are taken. Alternative 1 does not include any specific provisions for the protection of sole-source aquifers, but does provide for the protection of groundwater having a high susceptibility for contamination. In general, Alternative 1 is not expected to result in significant impacts on sole-source aquifers. To date, there are no data that indicate that the existing forest pesticide applications (Alternative 1) have resulted in significant impacts to sole-source aquifers, therefore, no significant impacts are expected to occur if the same rules continue to apply. Continuing application of forest pesticides, however, could contribute to cumulative impacts associated with contamination of sole-source aquifers. Appendix J contains additional details on the potential for sole-source aquifer contamination.

Alternative 2

SURFACE WATER IMPACTS

> Additional requirements targeting the protection of surface water resources under Alternative 2, would result in a reduced risk of impacts on surface water and groundwater (through a reduction in exchange with contaminated surface water).

Alternative 2 is similar to Alternative 1 but contains additional requirements targeting the protection of water resources. Alternative 2 includes the implementation of BMPs designed to "eliminate the direct entry of pesticides to water (defined as the entry of medium to large droplets), while minimizing off-target drift" (WDNR, 1999). By recommending variable buffer widths for aerial applications depending on water type, environmental conditions, and the method of application, Alternative 2 would result in a lower risk of water quality impacts compared to Alternative 1. Specifically, by adjusting the buffer widths to suit wind conditions, nozzle types, and application heights, Alternative 2 would reduce the pesticide drift into surface waters compared to Alternative 1 (Washington Department of Ecology, 1993). Buffer widths specified for Alternative 2 also are correlated with the critical management or habitat zones identified for each water type. Therefore, Alternative 2 also would minimize impacts within the RMZs identified for each water type. Moreover, Alternative 2 recommends using the maximum applicable buffer width in situations where the recommended buffer width and recommended offset from the critical surface water zones are different.

Alternative 2 restrictions on ground applications of pesticides with power or hand equipment provide for greater protection of Type S or F waters compared to Alternative 1. Specifically, ground application with power equipment is not permitted within the core and inner zones of Type S and F waters, and hand applications are not allowed within the core zones of Type S or F waters (unless prescribed to meet specific localized requirements). In addition, operators must maintain a 25-foot "no application" buffer strip around Type A or B wetlands and on all sides of all other surface waters, resulting in a greater reduction in the potential for surface water contamination. These increased buffer widths afforded by Alternative 2 would result in less drift and erosive transport of pesticides than under Alternative 1.

Overall, the increased attention given to the required buffer widths under Alternative 2 would reduce the risk of surface water impacts compared to Alternative 1. However, because Alternative 2 still allows for pesticide application over dry segments of some watercourses, some contamination of surface waters is possible if flow returns to the creek soon after the application. Likewise, even with the increased buffer width for most surface waters, Alternative 2 could allow low levels of pesticides to reach surface waters, either directly or through stormwater runoff, soil erosion, and sediment transport. Nevertheless, the net impacts would be less than those expected under Alternative 1.

GROUNDWATER IMPACTS

Groundwater impacts associated with Alternative 2 are expected to be similar but slightly less than under Alternative 1. Direct impacts on groundwater from pesticide leaching to groundwater aquifers would occur at the same rate under Alternative 2 as with Alternative 1. However, because the increased buffer widths required under Alternative 2 would result in fewer surface water impacts, the likelihood that contaminated surface water would reach and contaminate groundwater (via water exchange with a susceptible aquifer) is also reduced.

Alternative 2 is expected to result in similar but slightly lower impacts on sole-source aquifers compared to Alternative 1. The increased buffer widths required for pesticide applications under Alternative 2 would result in slightly less impact on surface waters resulting in a reduction in the potential for the interaction of contaminated surface water with sole-source aquifers. Overall, however, the impacts are expected to be nearly identical to those described for Alternative 1 (i.e., no significant impacts).

Alternative 3

SURFACE WATER IMPACTS

Increased buffer widths required for hand applications near surface waters under Alternative 3 would result in a reduced risk of contamination of surface waters compared with Alternative 1, and a slightly reduced risk of contamination compared with Alternative 2.

Alternative 3 is nearly identical to Alternative 2, with the exception of three main additions. Under Alternative 3, plants with cultural value would be protected from forest pesticides, hand application of forest pesticides would be prohibited within 50 feet of all typed waters, and forest pesticide applications needed to restore RMZ functions would require an alternative plan. Therefore, surface water impacts from pesticide applications under Alternative 3 are expected to be slightly less than under Alternative 2 and considerably less than under Alternative 1.

The increased buffer required for hand applications near surface waters under Alternative 3 would greatly reduce the amount of pesticides that reach surface waters directly via spray drift compared to Alternative 1, and only slightly reduce the potential for contamination compared to Alternative 2. The recommended 50-foot buffer for hand applications is greater than that required under both Alternatives 1 and 2, with the exception of the core zone buffer on westside Type S and F streams required under Alternative 2 (westside core zone is 50 feet). However, as with Alternatives 1 and 2, low levels of pesticides may reach surface waters through storm runoff, soil erosion, and sediment transport. In addition, alternative plans required for forest pesticide applications when restoring RMZs under Alternative 3 are expected to reduce the amount of pesticides that enter surface waters.

GROUNDWATER IMPACTS

The potential groundwater impacts resulting from pesticide application under Alternative 3 are expected to be nearly identical to the impacts associated with Alternatives 1 and 2. The only difference is that the minor reduction in the potential for pesticide drift to surface waters under Alternative 3 could result in a slight decrease in the level of pesticides reaching groundwater compared to Alternatives 1 and 2 (through a reduction in the exchange with potentially contaminated surface waters, as discussed above).

Alternative 3 is expected to result in similar but slightly lower impacts on sole-source aquifers compared to Alternatives 1 and 2. The increased buffer widths required for pesticide applications under Alternative 3 may result in slightly less sole-source aquifer contamination, through a reduction in the potential for contaminated surface water to interact with and adversely impact groundwater. Overall, the potential impacts to sole-source aquifers are expected to be nearly identical under all alternatives.

Chapter 3

3.7 FISH

Continued

3.7.1 Introduction

Fish are an important natural resource that has both biological and economic significance in the State of Washington. In particular, Pacific salmon and trout are indicators of a properly functioning aquatic ecosystem because they require cool, clean water, complex channel structures and substrates, and low levels of silt (Bjornn and Reiser, 1991). In addition, Pacific salmon and trout have fostered economically important commercial and sport fishing industries. Many residents of the state consider the presence and ability to harvest salmon and trout an important component to a "northwest lifestyle" that makes Washington state a desirable place to live.

This section discusses the affected environment for selected species of salmon and trout in Washington and the expected environmental effects from implementing the Alternatives described in Chapter 2. The fish species selected as the focus of the discussion include chinook salmon (*Oncorhynchus tshawytscha*), sockeye salmon (*O. nerka*), coho salmon (*O. kisutch*), chum salmon (*O. keta*), steelhead (*O. mykiss*), coastal cutthroat trout (*O. clarki clarki*), and bull trout (*Salvelinus confluentus*). The rationale for selecting these species will be more fully explained in Chapter 3.7.2 (Affected Environment).

The Affected Environment section will also describe important components of the aquatic environment that Pacific salmon and trout require and that forest practices may have a significant effect. These components include water quality, water quantity, channel conditions, LWD, channel morphology, and fish passage. Many important factors that effect the sustainability of Pacific salmon and trout populations will not be discussed in detail or may not be mentioned because they are not influenced by forest practices.

The Effects Analysis (Chapter 3.7.3) relies heavily on discussions presented earlier in this document and within a number of appendices. These discussions and appendices are:

- Sediment (Section 3.2)
- Hydrology (Section 3.3)
- Water Quality (Section 3.6)
- Riparian Habitats (Section 3.4)
- Water Type Modeling (Appendix C)
- Riparian Analyses (Appendix D)
- Slope Stability Analysis (Appendix E)
- Forest Roads Evaluation (Appendix F)
- Watershed Analysis (Appendix H)
- Adaptive Management (Appendix I)
- Forest Chemicals (Appendix J).

In essence, the fish effects analysis in Section 3.7.3 synthesizes the appropriate components of the above analyses as they reflect upon the components of the aquatic environment described in the Affected Environment (Section 3.7.2) and the major issues developed during the scoping process. These issues are:

- Water quality
- Fish passage
- Fish habitat elements
- Channel conditions and dynamics
- Hydrology
- Watershed condition relative to roads.

A more complete discussion of the issues and the criteria used to evaluate the alternatives is provided in Section 3.0 (Environmental Effects).

3.7.2 Affected Environment

Below is a discussion of the affected environment for selected salmon and trout species on state and private lands within the state of Washington regulated by Forest Practices Rules. This discussion includes a short description of the species selected as indicators for the effects analysis and the rationale for their selection from all the fish species present in the state. The discussion also contains a review of their distribution and status within the 10 regions described in Chapter 2. Finally, this section contains a review of important components of the aquatic ecosystem upon which salmon and trout rely for sustaining healthy, well-dispersed populations.

More than 70 species of freshwater fish are present in the more than 30,000 miles of fish-bearing streams within Washington (Wydoski and Whitney, 1979). One or more fish species are often found in perennial streams with gradients less than 20 percent (Fransen et al., 1997). Occasionally, fish are found in streams with steeper gradients, but these circumstances are rare. Although fish may not be found in extremely steep streams, land-use practices can affect fish-bearing waters by transportation through the stream network. Consequently, the affected environment for fish includes both fish-bearing and nonfish-bearing streams.

SEPA requires that all significant effects must be addressed in an EIS. Two of the four goals of the Forest Practices Board for the Washington Statewide Salmon Recovery Strategy (FPB, 1999) have special reference to fish. One of the goals is to provide compliance with the ESA for aquatic and riparian-dependant species on all lands subject to the Forest Practices Act. A second goal is to restore and maintain riparian habitat on these forestlands to support a harvestable supply of fish. The analysis for fish will target fish species ("priority species") that have commercial and/or sport harvest value, are candidate or listed species under ESA, and are known to be sensitive to forest practices.

Notably, NMFS has not listed any Pacific salmon or trout species as threatened or endangered throughout their entire range and many populations are considered healthy or at least stable. Rather, NMFS has listed salmon and trout based upon distinct populations that are "substantially reproductively isolated" and "represent an important component in the evolutionary legacy of the species" (Waples, 1991). NMFS has termed these populations "Evolutionarily Significant Units" or ESUs. In an analogous fashion, the USFWS has chosen to use the term "Distinct Population Segments" or DPSs for freshwater fish species under their regulatory authority.

Beginning in 1991 with the listing of Snake River sockeye salmon by NMFS, the ESA has increasingly affected the way government agencies and public and private landowners conduct business in or near the streams and rivers found in the state. The rate of new listings has escalated in recent years such that all of the Pacific salmon species, with the exception of pink salmon, have been listed as threatened or endangered within one or more areas of Washington (Table 3.7-1). In addition to the Pacific salmon and trout listed by NMFS, the FWS has listed bull trout throughout its range in the contiguous United States. Consequently, there are few areas within Washington State that do not have at least one listed fish species (Figures 3.7-1 through 3.7-3).

3.7.2.1 Life History of Priority Species

A basic understanding of the life history and habitat requirements of Pacific salmon and trout is important for recognizing the type and level of effects that may result from a land use activity such as timber harvest. The life history characteristics can vary significantly in different locations depending on climate, food supply, stream flow, and other factors (Flosi and Reynolds, 1994).

Table 3.7-1. ESA-listed Anadromous and Candidate Freshwater Fish Species Found in Washington State

Species	Scientific Name	Population1/	ESA Status	Publication Date	Federal Register Citation
Chum Salmon	Oncorhynchus keta	Hood Canal Summer–run	Threatened	March 1999	64 FR 14508
		Columbia R.	Threatened	March 1999	
Coho Salmon	O. kisutch	Puget Sound—Straight of Georgia	Candidate	July 1995	60 FR 38011
		Lower Columbia River/SW Washington	Candidate	July 1995	
Sockeye Salmon	O. nerka	Snake R.	Endangered	November 1991	56 FR 58619
		Ozette Lake	Threatened	March 1999	64 FR 14528
Chinook Salmon	O. tshawytscha	Snake R.—Fall-run	Threatened	April 1992	57 FR 14653
		Snake R. Spring/Summer-run	Threatened	April 1992	
		Puget Sound	Threatened	March 1999	64 FR 14308
		Lower Columbia R.	Threatened	March 1999	
		Upper Willamette R.	Threatened	March 1999	
		Upper Columbia R. Spring-run	Endangered	March 1999	
Steelhead	O. mykiss	Upper Columbia R.	Endangered	August 1997	62 FR 43937
		Snake R.	Threatened	August 1997	
		Lower Columbia R.	Threatened	March 1998	63 FR 13347
		Upper Willamette	Threatened	March 1999	64 FR 14517
		Middle Columbia R.	Threatened	March 1999	
Sea-run Cutthroat Trout	O. clarki clarki	SW Washington/Columbia R.	Threatened	April 1999	64 FR 16397
		Puget Sound	Not Warranted	April 1999	64 FR 16397
		Olympic Peninsula	Not Warranted	April 1999	64 FR 16397
Bull Trout	Salvelinus confluentus	Columbia River	Threatened	June 1998	63 FR 31647
		Coastal - Puget Sound	Threatened	November 1999	64 FR 58909

[1/] Populations of Pacific salmon are designated as Evolutionarily Significant Units by NMFS. The USFWS designates population segments as Distinct Population Segments.

Figure 3.7-1. Distribution and ESA Status of Chinook and Chum Salmon within Washington State.
(Source: Streamnet Version 99.1; NMFS 1999. Evolutionarily Significant Units GIS Data Layer. http://www.nwr.noaa.gov/1salmon/Salmesa/mapsuits.htm)

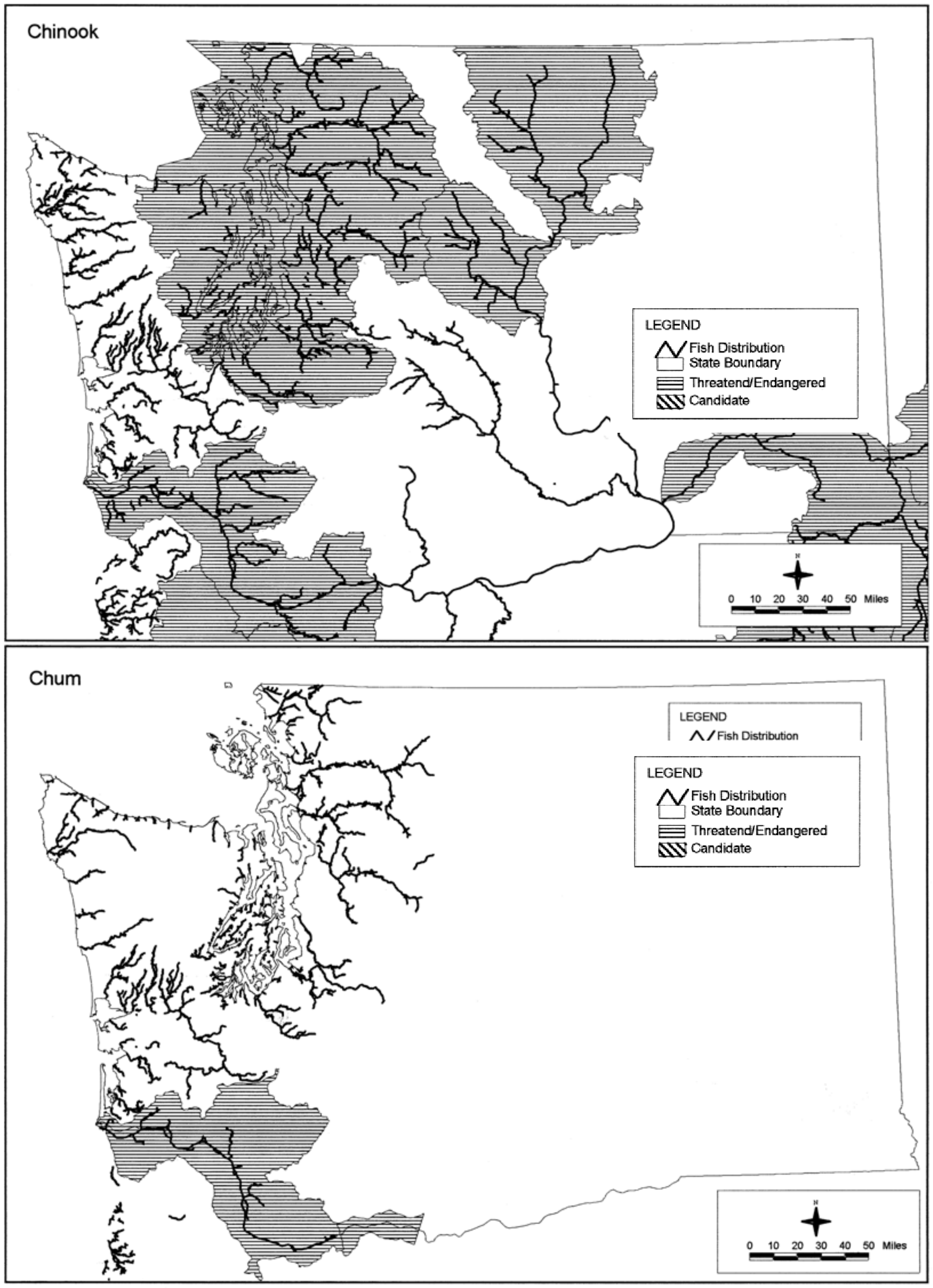


Figure 3.7-2. Distribution and ESA Status of Coho and Sockeye Salmon within Washington State.
(Source: Streamnet Version 99.1; NMFS 1999. Evolutionarily Significant Units GIS Data Layer. http://www.nwr.noaa.gov/1salmon/Salmesa/mapsuits.htm)

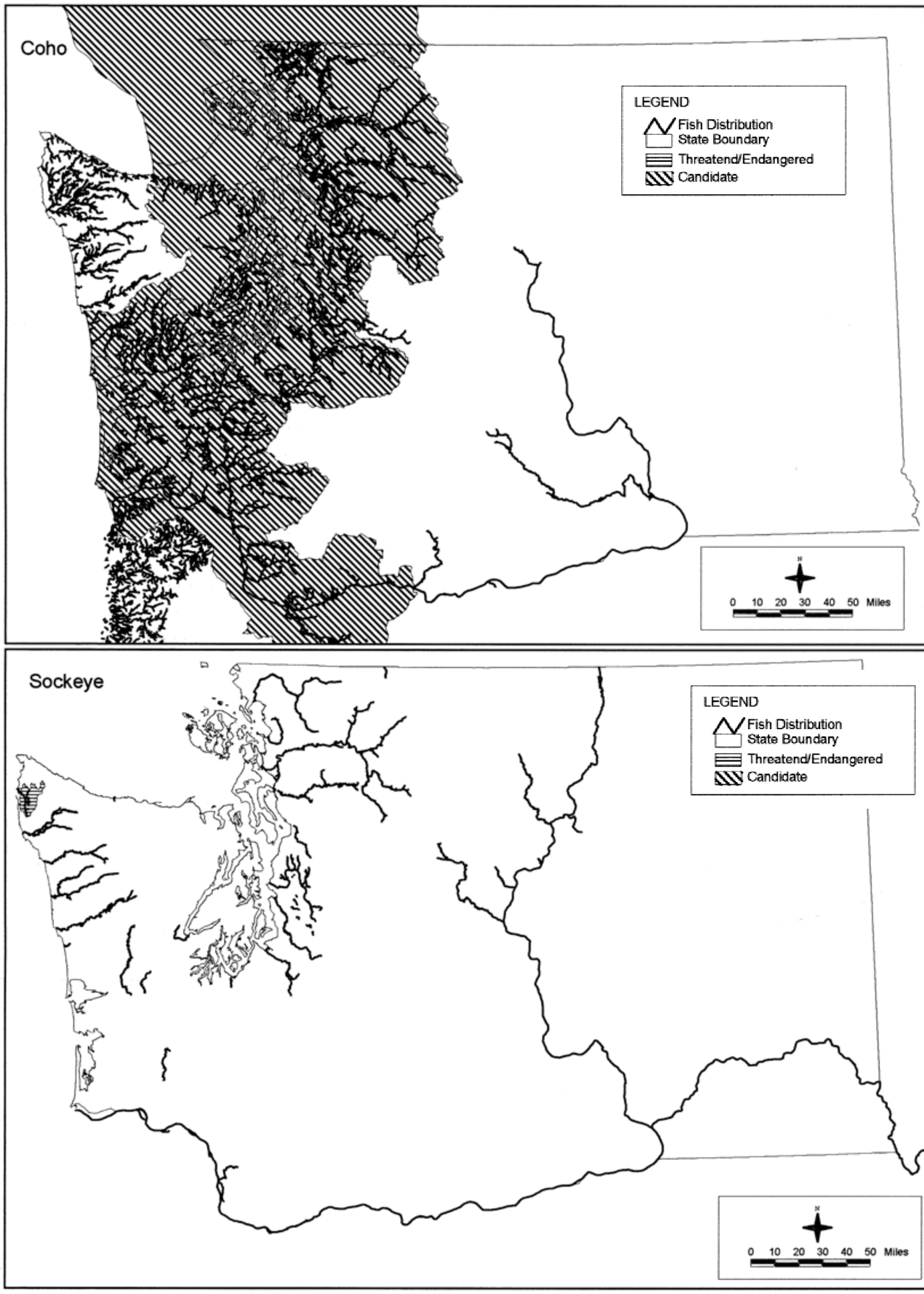
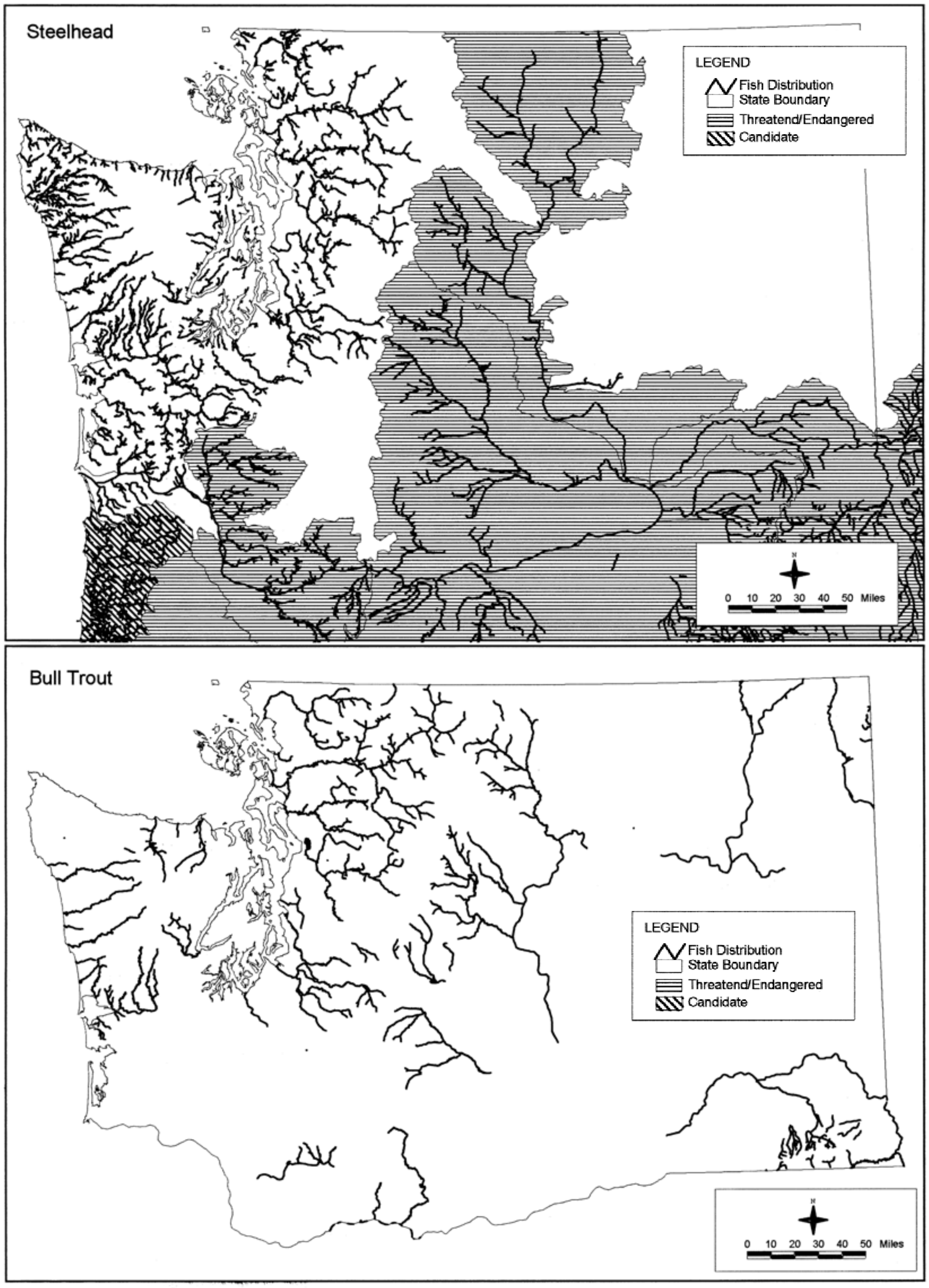


Figure 3.7-3. Distribution and ESA Status of Steelhead and Bull Trout (listed as Threatened throughout their Range) within Washington State.
(Source: Streamnet Version 99.1; NMFS 1999. Evolutionarily Significant Units GIS Data Layer. http://www.nwr.noaa.gov/1salmon/Salmesa/mapsuits.htm for Bull Trout-Washington DNR)



The life cycle of Pacific salmon and trout can be divided into seven distinct phases or lifestages: upstream migration, spawning, egg incubation, fry emergence, juvenile rearing, smolt outmigration, and marine rearing. Two important common denominators in the life history of Pacific salmon and trout is they all construct redds (nests) in gravel beds for spawning and they all include life history forms that exhibit anadromy. In other words, spawning occurs in freshwater, followed by migration to the ocean for feeding and maturation, and finally fish return to their natal sites for completion of the life cycle. Five of the species (*O. nerka, O. mykiss, O. clarki*, and *S. confluentus*) have life history forms that do not express the marine phase and live their entire lives in freshwater. The life cycle of Pacific salmon and trout can be considered a series of migrations operating at different spatial and temporal scales. The first migration occurs over a few centimeters of gravel that must be crossed by fry within a few hours while the final homing migration may span several thousands of kilometers and many weeks of travel. Within this relatively simple strategy of anadromy, several species demonstrate extremely complex variations in length of freshwater rearing, use of lake systems, run timing, degree of anadromy, and age structure. These variations, in conjunction with geographically separate spawning populations, have led to the stock concept of salmon management (Larkin, 1972). Indeed, it is the demonstration of unique behavioral patterns, physical characteristics, and ultimately genetic makeup that has made it possible to list any salmon stocks within the framework of the Endangered Species Act (Nehlsen et al., 1991; Waples, 1991).

One commonly recognized variation in life history traits for Pacific salmon and steelhead is run timing. The seasonal stock distinctions are based upon the date individual stocks of maturing adults enter freshwater. For example, chinook salmon are often divided into “spring,” “summer,” and “fall” runs while steelhead stocks are divided into “winter” and “summer” runs. Sockeye and chum salmon usually do not have multiple distinct runs and the seasonal descriptor is often omitted (but not always). Most pink and chum salmon in the Puget Sound Region enter freshwater during the fall while sockeye salmon runs peak in early July.

Additional stock and species-specific variability is demonstrated in the duration of freshwater rearing and the type of habitat that is utilized. Spring chinook salmon, coho salmon, and steelhead juveniles typically spend one or two years rearing in streams prior to outmigration. Similarly, sockeye salmon usually spend a year rearing in a lake prior to outmigration. In contrast, fall chinook and chum salmon outmigrate to the ocean as fry. Chum salmon usually complete their outmigration shortly after emergence (Wydoski and Whitney, 1979), while fall chinook may have a protracted outmigration period that occurs throughout the summer (Dawley et al., 1986). While most summer/fall chinook outmigrate during their first year, a small proportion overwinter in freshwater and then migrate as yearlings the following spring.

Bull trout and coastal cutthroat trout also express high variability in migratory behavior and habitat use. They have four different migratory forms: anadromous, adfluvial, fluvial, and resident. Adfluvial stocks rear in lake systems, but migrate to tributary streams for spawning. Fluvial stocks rear entirely in larger streams or rivers, but have significant migrations between headwater spawning and rearing areas. In contrast, resident stocks demonstrate little migratory behavior.

During the period of freshwater rearing, Pacific salmon and trout have life-stage and species-specific habitat requirements for spawning and rearing. Important components to spawning habitat include substrate size, water depth, and water velocity (Bjornn and Reiser, 1991). In general, the larger species utilize larger substrates and deeper and faster water (1.3-10.2 cm, >24 cm depth, 32-109 cm/s velocity; Bjornn and Reiser, 1991). Tail-outs to pools (the downstream end where the pool changes to a riffle) that meet criteria for these features are generally considered optimal spawning areas because stream morphology maximizes the passage of oxygenated water through redds. However, runs and riffles are also utilized during spawning. During spawning, females guard spawning territories and fight with other females for the best locations. In contrast, male salmon and trout fight with other males to earn the right to spawn with a female. Females dig redds by turning sideways to the stream bottom then rapidly flexing their tails. The digging results in a pit into which the eggs and milt are laid. The females dig a series of egg pits moving from downstream to upstream, consequently gravels removed during digging cover the eggs and pit downstream. Redd building is important for three principle reasons (Chapman, 1988): 1) redds provide physical protection to eggs during periods when they are extremely fragile; 2) redd digging removes a portion of the fines and sands deleterious to egg survival; and 3) redd construction and morphology enhances the passage of water through the egg pits.

Following emergence from the redd, salmon and trout fry typically utilize shallow and slow moving areas of a stream. Optimal depths and velocities increase as the fish grow, but preferred areas are usually associated with some form of cover, usually pools with LWD or boulders. Differences among the species are apparent in the degree of flexibility for utilizing riffles, runs, and other habitat features. Stream dwelling juvenile salmonids are typically territorial and exhibit a dominance hierarchy among individuals and species. Drifting insect larvae and benthic macroinvertebrates account for the majority of food items eaten by juvenile salmon and trout within streams. In contrast to the typical stream dweller, sockeye fry migrate to a lake shortly after emergence where shallow nearshore (or littoral) areas are preferred habitat. As sockeye fry grow, they begin to move offshore and have a characteristic diurnal vertical migration timed for utilization of zooplankton food sources.

Riparian areas have distinctive resource values and characteristics that are critical to salmonid production. Riparian vegetation is important for maintaining streambank and floodplain integrity. The vegetation slows water velocity on the floodplain and roots inhibit erosion along stream and riverbanks, which reduces sediment deposition in streams. Riparian vegetation also helps to provide shade, leaf and needle litter important to aquatic food chains, and LWD. Clearing or harvesting trees near streambanks removes riparian vegetation and can affect sediment delivery, fish habitat and reproduction, and stream productivity.

In general, the marine phase of salmonid life history is not understood as well as the freshwater phase. Only recently have ocean environmental conditions been considered an important factor in the management of salmon resources (Bisbal and McConnaha, 1999). Historically, the ocean was assumed an unlimited resource for salmon production, but this assumption is now being widely questioned. Forest practices have little to no direct effect on this important lifestage of anadromous salmonids.

The following sections provide a life history for each of the priority species considered in this EIS.

Chinook Salmon

Chinook salmon are the largest of the salmon with weights sometimes exceeding 88 pounds. Their size makes them one of the most valuable of the salmon, giving them the moniker “King” salmon. They also have one of the most complicated life history patterns. Their large size results in part from their relatively long lives. Chinook salmon may live up to 8 years, although most stocks return predominately as 3, 4, or 5-year olds to spawn in larger streams and rivers. A small, but significant portion of most chinook stocks returns precociously after spending 1 year in the ocean. These individuals are usually males and commonly called “jacks.” Some immature chinook salmon (sometimes referred to as “blackmouth”) from the Puget Sound region remain within the sound throughout their marine rearing phase. Most chinook from Washington State rear along the continental shelves bordering Washington, British Columbia and Southeastern Alaska.

As discussed earlier, chinook salmon are referred to as spring, summer, or fall stocks depending upon the time of return to freshwater. However, all chinook salmon spawn in the late summer or early fall. Freshwater rearing strategies are often different among the three stock types. Spring chinook salmon are often called “river-type” while summer and fall stocks may be called “ocean-type.” River-type stocks usually spend an entire year in freshwater prior to smoltification and out-migration. In contrast, ocean-type stocks begin to migrate to the ocean during their first year of life.

Coho Salmon

Coho salmon are medium-sized, reaching weights up to 10 pounds or more, but more commonly weighing 4 to 7 pounds. Coho salmon are also commonly known as silver salmon. Coho salmon primarily spawn at age 3 (never 4), but also have a small proportion that return precociously as 2-year-old jacks. Coho salmon usually spend their first year rearing in rivers and streams prior to smoltification and outmigration. During their marine phase, coho salmon from the Pacific Northwest rear primarily on the continental shelf off Washington and British Columbia.

Sockeye Salmon

Sockeye salmon are a medium-sized fish averaging about 5 to 6 pounds. They are also known as red salmon because of their firm red flesh, and the red spawning colors that become apparent after maturing adults enter fresh water. Sockeye salmon are unique among the Pacific salmon for requiring lakes during their freshwater rearing phase. Most sockeye salmon undergo smoltification during their second year and migrate to the ocean.

Most sockeye salmon return to spawn after 2 or 3 years of rearing in the ocean, but a small proportion return as jacks. Two sockeye salmon populations have been listed by NMFS under the Endangered Species Act. Snake River sockeye have been listed as endangered, and the Ozette Lake population on the Olympic Peninsula have been listed as threatened. The Snake River population spawn in Idaho. Consequently, Washington State is primarily concerned with maintaining properly functioning migratory habitat for this population.

Chum Salmon

Chum salmon are relatively large, reaching an average size of nine pounds after spending 4 or more years rearing during their marine phase (Wydoski and Whitney, 1979). Chum salmon are commonly called dog salmon because Native Americans often utilized this species to feed sled dogs in Alaska and Canada. Chum salmon fry migrate to estuarine and marine waters shortly after emergence and migrate long distances. One tagged individual was known to migrate over 3,000 miles within 6 months (Scott and Crossman, 1973). Spawning areas utilized by chum salmon are usually in the lower reaches of larger river and streams.

Steelhead

Steelhead trout have a freshwater rearing period of 1 to 3 years before smoltification and outmigration while the alternative form, rainbow trout, spend their entire lives in freshwater. The marine phase for steelhead lasts an additional 2 to 4 years. Most steelhead are 4 years old when they return to their natal stream for spawning and weigh between 5 and 10 pounds (Wydoski and Whitney, 1979). Steelhead may spawn more than once. However, fewer than 15 percent of a spawning population are usually repeat spawners. Rainbow trout are usually much smaller than their anadromous counterpart, but under some conditions can reach lengths of 20 inches or more. In general, rainbow trout do not appear to be at the same level of risk as steelhead and other species in the family. However, some subspecies, such as redband trout (*O. mykiss gairdneri*) which are found in some areas east of the Cascade Crest are a species of concern on lands managed by the Forest Service.

Coastal Cutthroat Trout

The West Coast sea-run cutthroat trout is currently listed as threatened in the southwest Washington and Columbia River DPSs. The coastal sea-run cutthroat trout is 1 of 13 subspecies of cutthroat trout indigenous to North America. Of the 13 subspecies, only the coastal sea-run cutthroat trout is anadromous. Throughout its range, the coastal cutthroat trout also exhibits a stream resident form and adfluvial form.

The life history of the coastal cutthroat is one of the most complex and flexible of any Pacific salmonid (Wydoski and Whitney, 1979; Johnson et al., 1994). Cutthroat trout in the region exhibit resident, fluvial, adfluvial, and anadromous life histories. Little is known about the life histories and the relative proportion of each life history in this population. Coastal cutthroat trout spawn in the smallest headwater streams and tributaries used by any salmonid species, and the young usually remain in these streams about a year before moving down into larger streams (Palmisano et al., 1993). They live in these larger streams for another 2 to 5 years (usually 3) before migrating to the Pacific Ocean (Wydoski and Whitney, 1979; Johnson et al., 1994). Some stocks, primarily those with limited or no possibility of return migration from the ocean, remain as residents of small headwater tributaries, or migrate only into rivers or lakes (Scott and Crossman, 1973; Johnson et al., 1994). Sea-run cutthroats do not migrate to the open ocean; rather, they stay in estuarine habitats near the mouths of their natal streams for 5 to 8 months of the year (Palmisano et al., 1993; Johnson et al., 1994). Upstream migration to freshwater feeding/spawning areas occurs from late June through March; re-entry timing is consistent from year to year within streams, but varies widely between streams (Johnson et al., 1994). Spawning generally occurs between December and May in the tails of pools located in streams with low gradient and low flows or in shallow riffles (Wydoski and Whitney, 1979; Johnson et al., 1994).

Bull Trout

Bull trout in the Puget Sound Region and Columbia River are currently listed as a threatened species by USFWS under ESA. Historically, bull trout and its conspecific, Dolly Varden trout, were considered the same species. The names were commonly used to distinguish anadromous coastal stocks from resident stocks. During the early 1990s, genetic and meristic (counts of physical characters) analyses demonstrated that the species were distinct from each other. From a practical aspect, however, the two species are indistinguishable in the field, even for experienced professional fisheries biologists. Furthermore, life history traits and habitat requirements appear to overlap considerably between the two species.

Similar to cutthroat trout, bull trout have a flexible life history that includes resident, fluvial, adfluvial, and anadromous forms. Bull trout populations in the Columbia River system generally do not exhibit anadromy. Anadromous bull trout, which are found in the Puget Sound Region and coastal regions, initially rear in freshwater for 2 to 3 years. Large oceanic migrations do not occur. Instead, anadromous bull trout migrate to estuarine and nearshore areas in the spring then migrate up-river during the fall to over-winter in freshwater.

Bull trout appear to be one of the more sensitive salmonids to degraded habitat conditions, primarily due to having fairly restrictive requirements. In freshwater, adult bull trout prefer very cool water temperatures for rearing (less than 55°F) and spawning (less than 50°F; Oregon DEQ, 1995). In addition, this species prefers a stream morphology that is complex, including large amounts of LWD and boulders, which contribute to large, deep pools with complicated water velocity patterns and cover. Bull trout and Dolly Varden trout also appear to be more sensitive to the effects of fines on the survival of incubating eggs than other salmonids.

3.7.2.2 The Aquatic Ecosystem

Key physical components of the aquatic ecosystem include channel morphology (floodplains, streambanks, channel structure), water quality, and water quantity. Habitat complexity is created and maintained by rocks, sediment, large wood, and favorable water quantity and quality. Upland and riparian areas influence aquatic ecosystems by supplying sediment, woody debris, and water. Disturbance processes such as landslides and floods are important mechanisms for delivery of wood and bedload to streams.

Natural channels are complex and contain a mixture of habitats differing in depth, velocity, and cover (Bisson et al., 1987). They are formed during storm events that have associated flows which mobilize sediment in the channel bed (Murphy, 1995). The hydrologic regime of a watershed, combined with its geology, hillslope characteristics, and riparian vegetation determines the nature of stream channel morphology (e.g., number and spacing of pools and width-to-depth ratio) (Beschta et al., 1995; Sullivan et al., 1987). Therefore, activities in these areas would be expected to affect the shape and form of the stream channel. For example, substantial increases in volume and frequency of peak flows can cause streambed scour and bank erosion. A large sediment supply may cause aggradation (i.e., filling and raising the streambed level by sediment deposition) and widening of the stream channel, pool filling, and a reduction in gravel quality (Madej, 1982). Upslope activities (e.g., timber harvest, land clearing, and road development) can change channel morphology by altering the amount of sediment or water contributed to the streams. This, in turn, can disrupt the balance of sediment input and removal in a stream (Sullivan et al., 1987).

Stream habitat conditions in Washington are affected by a wide range of factors including geophysical changes (e.g., volcanic eruptions, earthquakes and associated uplifting), extremes of flow (e.g., flooding and low flow), existing geological conditions (e.g., erodible soils), and land-use practices (e.g., timber harvest, grazing, urban development, road construction and operation, and gravel mining). The effects of these combined factors result in the existing stream habitat conditions.

Streams that lack a balance between pools and riffles are often less productive than streams that have more complex structure. Pools are used as holding and resting areas for adult fish prior to spawning, deep water cover for protection, and cool water refugia during low flow summer months. Riffles are important for reoxygenation of water, habitat for food organisms such as aquatic macroinvertebrates, and as rearing areas for fish (Gregory and Bisson, 1997). Intensive timber harvest has been reported to decrease pool depth, surface area, and the general diversity of pool character (Ralph et al., 1994). Possible mechanisms include decreased occurrence of LWD (which can help form and stabilize pools) and filling of remaining pools with bed material.

A range of optimum pool-to-riffle ratios for a properly functioning system has been described in the literature (NMFS, 1996; FWS, 1998). Applying any values within this range to field conditions would require considering site-specific characteristics such as existing LWD, stream gradient, bank characteristics, sediment load, bed material (e.g., bedrock and boulders), and other watershed factors such as hydrologic conditions (Murphy, 1995).

The following describes components to the aquatic ecosystem that are influenced by forest practices. These include coarse sediment, fine sediment, hydrology, LWD, leaf/needle litter recruitment, floodplains and off-channel features, water temperature, forest chemicals (contaminants), and fish passage.

Coarse Sediment

A certain amount of bedload material is necessary to provide substrate for cover and spawning habitat for fish. For example, anadromous salmon typically use gravels ranging from 0.5 to 4 inches (12.7 to 101.6 mm), whereas steelhead and resident trout may use smaller substrates ranging from 0.25 to 4 inches (6.4 to 101.6 mm; Bjornn and Reiser, 1991). Increased levels of coarse sediment bedload above background levels can, however, lead to stream bank instability, pool filling, and changes in the water transport capacity of the channel (Spence et al., 1996). The larger the sediment size, the higher the flow that is required to mobilize the sediment. Consequently, the recovery periods for streams with severe coarse sediment aggradation could range from decades to 100 years or more. The major factors influencing the excessive delivery of sediment to a stream include the intensity and location of stream bank erosion, mass-wasting events, and road and culvert failures.

Fine Sediment

Adequate dissolved oxygen (DO) levels are important for supporting fish, invertebrates, and other aquatic life. Salmonids are particularly sensitive to reduced DO (DEQ, 1995). Intergravel DO has been recognized as crucial to the survival of salmonid embryos. Intergravel DO depends on several interrelated factors such as water temperature, surface-water concentrations, percentage of fine sediment and gravel in pores, and the oxygen demand of the eggs. Management-induced depletion of DO in stream water can occur from harvest activities, such as excessive amounts of logging debris left in a stream that can result in decreased DO (MacDonald et al., 1991). Critical levels of DO also depend on the velocity of the water passing the eggs, as less oxygen is needed at higher velocities (DEQ, 1995). Forest management activities can exacerbate any intergravel DO problems through increases in fine sediment which reduce intergravel water velocity (Bjornn and Reiser, 1991; Ringler and Hall, 1975; Moring, 1975).

Fine sediment (0.004 to 0.033 inch or 0.1 to 0.84 mm in diameter) can reduce stream habitat quality, restrict sunlight penetration, and fill pores between the gravel, thus preventing the flow of oxygen-rich water to fish eggs that may be deposited in the gravel. In laboratory studies, a substrate containing 20 percent fines was found to reduce emergence success of young salmon and trout by 30 to 40 percent (Phillips et al., 1975; MacDonald et al., 1991). According to study results and summaries from Peterson et al. (1992) and Chapman (1988), a properly functioning aquatic habitat would have substrates that contain less than 11 to 16 percent particles within the fine sediment category.

Fine sediments and larger particles (up to about 0.27 inch [6.84 mm] or sand-sized fractions) can also smother fish eggs and developing young in the gravel. In addition, they may also clog pores or breathing surfaces of aquatic insects, physically smother them, or decrease available habitat (Spence et al., 1996; Nuttall and Bielby, 1973; Bjornn et al., 1974; Cederholm et al., 1978; Rand and Petrocelli, 1985). Important factors influencing the excessive delivery of fine sediment to a stream include the presence of adequate streamside vegetation to filter fine sediment derived from hillslopes and road surface erosion (see Sections 3.2 and 3.5). Also, fine sediment is usually present with coarse sediment delivery processes described above.

Biological effects of increased turbidity may include a decrease in primary productivity of algae and periphyton due to the decrease in light penetration. Declines in primary productivity can adversely affect the productivity of higher trophic levels such as macroinvertebrates and fish (Gregory et al., 1987). Turbidity can also interfere with feeding behavior or cause gill damage in fish (Hicks et al., 1991), but may provide some positive benefits. For example, it can provide cover from predators (Gregory and Levings, 1998).

Hydrology

The amount of water provided to aquatic ecosystems at critical times is important for sustaining fish and other aquatic species. Many fish have become adapted to natural flow cycles for feeding, spawning, migration, and survival needs. The timing, magnitude, and duration of peak and low flows must be sufficient to create and maintain riparian and aquatic habitat. Flows can be influenced by management activities such as timber harvest and roads (see Section 3.3). In general, low- or base-level stream flows that occur during the late summer often limit habitat for rearing juvenile salmon and trout. They can also negatively affect migration and access to habitat and food resources, as well as disrupting spawning behavior. Such conditions can occur naturally during this period due to lack of precipitation. However, low flows can be exacerbated by water withdrawals, silting (which can decrease pool depth), and stream widening resulting from unstable banks.

High winter flows and floods that scour the streambed can be detrimental to eggs or young fish that may be incubating in the stream gravels. Both extreme high and low flow conditions may occur in different regions of the state. Rain-on-snow events are a common reason for flooding and streambed scour on the west of the Cascade Mountains. In contrast, the eastern side of the state lies in the rainshadow of the Cascade Mountains. Consequently, extreme low flows and high water temperatures can be detrimental during the summertime.

Large Woody Debris

LWD includes trees and tree pieces greater than 4 inches in diameter and 6 feet long (Keller and Swanson, 1979; Bilby and Ward, 1989). LWD is one of the most important components of high quality fish habitat (Marcus et al., 1990). LWD provides food and building materials for many aquatic life forms and is important for stream nutrient cycling, macroinvertebrate productivity, and cover for juvenile and adult fish (Marcus et al., 1990). LWD is the primary channel-forming element in some channel types and affects many aspects of channel morphology including stream roughness, sediment storage, water retention, energy dissipation, and fish habitat (Marcus et al., 1990; Lisle, 1986; Swanson et al., 1987; Martin, et al., 1998). Pools formed by stable accumulations of LWD provide important habitat for rearing salmonids, particularly in winter (Heifetz et al., 1986; Murphy et al., 1986). The value of LWD in providing aquatic habitat depends on stream size, tree species, and numerous other factors (see Section 3.5).

Field studies in old-growth, Douglas-fir forest streams in coastal Oregon and Washington have shown that the number of woody debris pieces varies by channel width and size of debris under undisturbed conditions. For example, studies by Bilby and Ward (1989) and Forest Practices Board (1995) show that the number of LWD pieces decreased with increasing width of a stream; however, the average diameter, length, and volume of LWD increased. The type of wood is an important factor (see the Riparian Function Section). For example, coniferous wood (e.g., Douglas-fir or cedar) is more resistant to decay than deciduous wood (e.g., alder). Therefore, coniferous wood has a greater longevity in a stream (Cummins et al., 1994, as quoted in Spence et al., 1996).

Historical forest management practices often included splash dams and stream cleaning efforts (Maser and Sedell, 1994). During the last century, splash dams were built to aid in floating and transporting harvested trees to the mill. From the 1950s through the 1970s, removal of LWD from streams was based on the belief that it was detrimental to salmon migration. Both of these practices contributed to major changes in the amount of cover habitat available and often changed stream habitats to a single, cobble-bed channel lacking pools and LWD or to bedrock channels lacking gravel, woody debris, and other channel features (Murphy, 1995; Maser and Sedell, 1994). This decrease in LWD corresponds to a reduction in salmonid use (House and Boehne, 1987). Due to the time required for streamside trees to grow and mature to potential LWD, there may be a considerable lag period (e.g., greater than about 50 years and up to 300 years) before additional LWD is contributed to a cleared stream (Gregory and Bisson, 1997).

In general, information on LWD must be viewed from the perspective of the timber harvest activity in the area, historic floods that have removed or redistributed LWD, and the activities that were performed to actively remove LWD (see the Riparian Function Section). Potential LWD recruitment from existing mature or old-growth riparian zones would be anticipated to be higher than younger or recently clearcut areas (see the Riparian Function Section). There may be no potential for LWD recruitment in currently open areas such as prairies and grasslands, which may not develop into forested areas in the foreseeable future.

LWD enhancement has become a more common method for improving stream reaches lacking wood. The methods for placing LWD are fairly advanced (ODF and ODFW 1995). LWD placement would provide short-term benefits to stream systems providing a more complex habitat structure, nutrient input, and substrate for invertebrate colonization, all of which would benefit fish habitat. These benefits may improve current conditions in many areas until the natural riparian corridor can regenerate and provide consistent inputs of LWD.

The Aquatic Food Chain

The base of the aquatic food chain is derived from the combination of dissolved chemical nutrients and detrital materials. The chemical constituents such as nitrogen (usually in the form of nitrates and nitrites), phosphorus, and carbon can be derived from the breakdown of detritus and through leaching and runoff from surrounding soils (Gregory et al., 1987). Many bacterial and macroinvertebrate species rely directly on detrital material from leaf and needle litter, branches, and stems from the surrounding riparian zone vegetation. Some estimates indicate that leaf and needle recruitment may provide up to 60 percent of the total energy input to stream communities (Richardson, 1992). Other macroinvertebrate species rely on aquatic algae that primarily use dissolved chemical nutrients and require solar radiation. In streams containing spawning habitat for Pacific salmon, significant influxes of nutrients from the marine environment occur during the decomposition of carcasses (Bilby et al., 1996).

The abundance and diversity of macroinvertebrate food sources to salmonids is dependent upon the primary algae and detrital food sources. Forest harvest activities affect the food chain by changing the relative macroinvertebrate production between herbivores and detritivores (Gregory et al., 1987). The magnitude and duration of the change is dependent upon a variety of factors including stream size, gradient, location (headwater versus mainstem) and the type of riparian vegetation and management prescriptions. Gregory et al. (1987) suggest that tree harvest in riparian areas initially lead to higher production of fewer invertebrate species and that recovery of the macroinvertebrate community occurs over periods similar to recovery of riparian zones. Bilby and Bisson (1992) observed higher summer production of coho fry in streams in a watershed with extensive clearcuts relative to a nearby, undisturbed watershed with an old-growth riparian stand. However, no differences in coho production were present during fall censuses and the higher summer fish production was attributed to higher algae production (Bilby and Bisson (1992). Bilby and Bisson (1992) and Spence et al. (1996) have noted that other changes in habitat features (e.g., numbers of pools) required by yearling and adult fish could likely offset any increases in sub-yearling production. Gregory et al. (1987) argued that short-term higher fish productivity might occur downstream of timber harvest units in some areas, but at the expense of long-term stability in the overall abundance and diversity of the aquatic community.

Floodplains and Off-channel Habitat

Floodplains and off-channel areas are an important component of aquatic habitat that include side channels, backwater alcoves, ponds, and wetlands. They provide important habitat seasonally to particular life stages as well as input of organic matter and LWD. Seasonally flooded channels and ponds are particularly important for rearing coho salmon and other fish species during winter months. Large floodplains can also function as filters for subsurface flows and maintenance of water quality (Gregory and Bisson, 1997). Some backwater alcoves and ponds result from groundwater seeps and may have shade levels higher than the main channel. These areas provide cool water refugia during high summertime temperatures. Major floodplains in the planning area generally are located in the lowest reaches of major rivers. Beavers can play a significant role in the development of ponds and wetlands important as habitat for salmon and trout, particularly for juvenile coho salmon (Cederholm et al., 2001).

Water Temperature

Water temperature plays an integral role in the biological productivity of streams. Water temperature fluctuations and their relationship to DO can affect all aspects of salmon and trout life histories in fresh water including

- incubation and egg survival in stream gravel;
- emergence, feeding, and growth of fry and juvenile fish;
- outmigration of young fish;
- adult migration, holding and resting; and
- prespawning and spawning activities.

A rise in temperature increases the metabolic rate of aquatic species. Consequently, more energy is required, even during periods of low activity. In addition, DO decreases as water temperature increases, potentially increasing stress on fish. Water temperatures in the range of 70°F (about 21°C) or greater can cause death in cold-water species such as salmon and trout within hours or days (Oregon DEQ, 1995). In general, water temperatures of 53.2 to 58.2°F (11.8 to 14.6°C) have been found to provide a properly functioning condition for juvenile salmon and trout. However, bull trout require much lower temperatures during spawning (4-10°C) and egg incubation (1-6°C) (Oregon DEQ 1995).

Increases in water temperature in forest streams can often be traced to reduction of shade-producing riparian vegetation along fish-bearing and tributary streams that supply water to other fish-bearing streams. However, streams also naturally tend to become warmer as water flows from headwaters to the sea (Sullivan et al. 1990, Zwieniecki and Newton 1999). This warming occurs as water equilibrates to local environmental conditions including air temperature, which in turn is highly correlated with elevation. In addition, water temperatures can be affected by stream widening, sedimentation/stream depth, microclimate, groundwater, and other upstream inputs (see Section 3.6). Long-term sublethal temperature effects can be detrimental to the overall health of a population as well as short-term acute effects of warmwater temperatures on cold-water aquatic species. Heat stress may accumulate such that increased exposure for juvenile fish in an environment in which growth is reduced or the inability to meet increased metabolic (energy) demands increases their susceptibility to disease (Oregon DEQ, 1995).

More shade or complete shading does not always maximize aquatic productivity. The availability of instream algae can be a limiting factor in some streams. Algae and other sources of vegetable matter are at the lowest level of the food chain and important to higher trophic level production such as fish. Nutrients (e.g., nitrogen and phosphorus) are key factors along with light that result in algae production. High levels of shade can result in low levels of algae production even if adequate nutrient sources are present (Gregory et al., 1984). Under unmanaged conditions, forested lands generally have low light and low primary productivity in low order streams with high canopy cover. In contrast, primary productivity in wide high order streams is generally unaffected by riparian management because adequate light penetration occurs even under mature riparian conditions (Gregory et al., 1984).

Forest Chemicals

Water quality contaminants (e.g., petroleum products, chemicals, sewage, and heavy metals) can severely impair aquatic ecosystems either by sublethal (e.g., reduced growth) or lethal effects (e.g., fish kills). The water quality contaminants considered here are pesticides used to prevent tree diseases and deter pest plant species that compete with trees for nutrients, space, and light.

Fish Passage

Upstream migration of adult salmon, steelhead, and trout to spawning areas or redistribution of rearing fish to potential habitat in upstream areas can be impeded or blocked by a number of different mechanisms. These mechanisms can include the following:

- Water Temperature—Elevated water temperatures (e.g., greater than 68°F [20°C] or 60°F [15.6°C] for fall chinook salmon and coho salmon, respectively) are known to stop the migration of fish (Bjornn and Reiser, 1979).
- DO—At least 5 mg/l of DO is recommended to provide oxygen needs for migrating fish (Bjornn and Reiser, 1979). Decreased oxygen can occur as a result of high water temperatures and oxygen consumption created by decay of organic debris, chemicals, and respiration.
- Turbidity—High levels of sediment (e.g., 4,000 mg/l) have been reported (Bjornn and Reiser, 1979) as ceasing upstream migration.
- Physical Barriers—High waterfalls or cascades that are beyond the jumping or physical capabilities of fish, can prevent upstream migration. Similarly, excessive water velocities that result in conditions that are beyond the physical capabilities of a given fish species can also restrict or prevent upstream migration. The maximum velocity beyond which coho and chinook salmon cannot successfully move upstream is about 8 feet per second (2.44 meters per second) (Bjornn and Reiser, 1979).
- Man-made Barriers—Man-made barriers include features such as dams and stream crossings (usually culverts, but sometimes bridges as well).

Stream crossings by forest roads are the most common passage barrier influenced by Forest Practices Rules. A hydraulic project approval (HPA) is needed for the construction of stream crossings which are regulated by WDFW under the Hydraulic Code (WAC 220-110-070). Shallow water depths from conditions such as low flow can impede or prevent passage (e.g., upstream migration of chinook or coho salmon is not generally successful at depths less than about 0.8 foot (0.24 meter) or 0.6 foot (0.18 meter), respectively (Bjornn and Reiser, 1979). Such conditions can occur during low flow periods where riffles between pools can become completely dry or lack sufficient depth for passage. Barriers such as culverts used at stream crossings can prevent passage due to high water velocities, restricted depths, excessive elevation for successful entry, size and length, and other factors. Similarly, debris jams can prevent or delay upstream passage (Bjornn and Reiser, 1979).

3.7.2.3 Regions of the State

For the purposes of this analysis, the state has been divided into the following ten regions. These regions are mapped in Figure 3.7-4.

- Puget Sound;
- Islands;
- Olympic Coast;
- Southwest;
- Lower Columbia;
- Mid-Columbia;
- Columbia Basin;
- Upper Columbia below Grand Coulee Dam;
- Upper Columbia above Grand Coulee Dam; and
- Snake River.

The distribution of the priority species and state or commercial forestlands is very different within each of the regions. In addition, the number and type of factors that influence the current conditions of the aquatic system and status of the priority species in each of the regions are very different. NMFS sometimes refers to general factors affecting listed salmonid species as "the 4-Hs." These are habitat, hatcheries, hydropower, and harvest. Forest Practices Rules are generally considered to affect only the habitat part of the complex issues. In addition, other land-use practices such as agriculture and urbanization can also have a significant effect on habitat.

Two of the regions, Islands and the Columbia Basin, will not weigh heavily in the analysis for fisheries because only a relatively small number of streams exist in forested portions of these regions or they contain low numbers of priority species. The following is a short synopsis of the remaining eight regions in regards to the priority species present and the components of the 4-Hs affecting their ESA status. Tables 3.7-2 and 3.7-3 show the distribution of fish-bearing and nonfish-bearing streams among different forest ownership and non-forested categories. The relative distribution of fish and nonfish-bearing streams can be important from the perspective of sediment production and delivery. High gradient, nonfish-bearing streams are generally source and transport reaches for sediment and low

Figure 3.7-4. Ten Regions of Washington Used for Analysis in this EIS

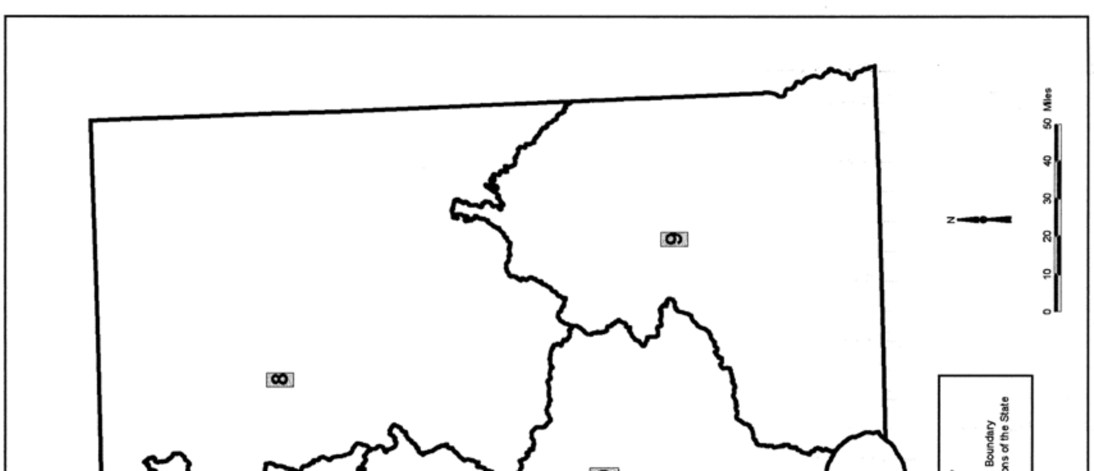


Table 3.7-2. Estimated Distribution of Fish-bearing[1/] Stream Miles among Forested Ownership and Nonforested Categories in Washington State

Region	Percent of Fish-bearing Stream miles within Region					Total Fish-bearing Stream Miles
	Private Forested	State Forested	Federal Forested	Other[2/] Forested	Non-Forested	
Puget Sound	43.0	8.7	8.7	4.3	34.7	9,843
Islands	29.9	2.6	1.3	0.0	66.2	444
Olympic Coast	40.9	22.7	9.1	9.1	18.2	2,831
Southwest	71.4	9.5	0.0	0.0	19.0	5,420
Lower Columbia	61.5	7.6	7.6	0.0	23.0	3,524
Middle Columbia	36.4	9.1	18.2	9.1	27.3	1,874
Snake	33.0	0.0	16.7	0.0	50.0	342
Columbia Basin	0.0	0.0	0.0	0.0	100.0	10
Upper Columbia Downstream of Grand Coulee	20.0	0.0	20	0.0	60.0	1,316
Upper Columbia Upstream of Grand Coulee	30.8	0.0	15.4	15.4	38.5	3,694

[1/] Stream Types 1 to 3.
[2/] Other includes city, county, tribal, and unknown ownership.

Table 3.7-3. Estimated Distribution of Nonfish-bearing[1/] Stream Miles among Forested Ownership and Nonforested Categories in Washington State

Region	Percent of Nonfish-bearing Stream miles within Region					Total Nonfish-bearing Stream Miles
	Private Forested	State Forested	Federal Forested	Other[2/] Forested	Non-Forested	
Puget Sound	36.4	11.7	40.3	2.6	10.3	32,953
Islands	73.9	4.3	0.0	0.0	17.4	133
Olympic Coast	25.6	23.0	38.5	10.2	2.6	10,038
Southwest	79.7	11.4	3.8	0.0	3.8	20,390
Lower Columbia	56.3	11.4	27.6	0.0	3.4	23,584
Middle Columbia	30.3	11.2	36.0	13.5	10.1	15,162
Snake	20.2	2.1	42.6	0.0	33.0	5,355
Columbia Basin	0.0	0.0	0.0	0.0	0.0	0
Upper Columbia Downstream of Grand Coulee	16.8	7.4	64.2	4.2	6.3	25,008
Upper Columbia Upstream of Grand Coulee	32.1	5.7	28.7	25.3	8.0	24,718

[1/] Stream Types 4, 5, and 9 (westside only).
[2/] Other includes city, county, tribal, and unknown ownership.

gradient, fish-bearing streams are areas of sediment accumulation. The information provides some insights on which regions might be most affected by changes in FPRs. It also provides an indication of the type of management approach might be prevalent on fish versus nonfish-bearing waters of the state. For example, in regions on the west side (Puget Sound, Olympic Coast, Southwest, and Lower Columbia) streams within federal Ownership are managed based upon the Aquatic Conservation Strategy outlined in the Northwest Forest Plan. The tables (3.7-2 and 3.7-3) suggest that federal management on the west side has a larger influence on nonfish-bearing streams than fish-bearing streams. They also suggest that forest practices rules on private forested lands have a relatively large influence on management strategies along fish-bearing streams.

Puget Sound

This region includes all of Puget Sound south of the Canadian border, exclusive of the San Juan Islands (the Islands Region). This region also includes rivers and streams along the Straights of Juan de Fuca from Puget Sound to the Elwha River (inclusive). Puget Sound has the lowest overall stream density of the westside regions with a density of 3.2 mi/mi^2. All of the priority species are present in the Puget Sound Region (Figures 1 to 3). Chinook, and bull trout are listed as threatened in the region plus a summer run of chum salmon that are found in the Hood Canal portion of the region. Coho salmon is a candidate species. Each of the 4-Hs has been cited as contributing to the listing of one or more of the species (see Table 3.7-1 for Federal Register citations). Notably, the two major hydroelectric dams on the Elwha River have blocked large portions of spawning habitat from access and are under consideration for breaching. Many of the lowland areas of the region are highly urbanized. This region is the most heavily populated region of the state. About 52 percent of the fish-bearing and 48 percent of the nonfish-bearing streams occur on private and state forestlands (Tables 3.7-2 and 3.7-3). In contrast, Federal management strategies occur on about 9 percent of the fish-bearing and 40 percent of the nonfish-bearing streams. A substantial portion of this region with state and private forestlands is currently managed under HCPs. All state lands within the range of the northern spotted owl have been operating under a DNR HCP since 1997. This includes all of the Puget Sound region.

Olympic Coast

The Olympic Coast region includes coastal rivers and streams from the north of and including the Copalis River to the west of, but not including, the Elwha River. Overall stream density is relatively high in the region with 4.7 mi/mi^2. All of the priority species are present in the Olympic Coast Region. Bull trout are listed as threatened throughout the region and the Ozette Lake population of sockeye salmon is listed as threatened. Coho salmon is a candidate species. Of the 4-Hs, habitat appears to be the highest priority factor for bull trout. State and private forestlands include 63 percent of the fish-bearing streams and 57 percent of the nonfish-bearing streams. Federal management is also significant with 9 percent of the fish-bearing and 39 percent of nonfish-bearing streams. No significant hydroelectric facilities are present in the region and no hatcheries are stocking bull or sockeye salmon. However, small diversion dams for agricultural purposes are present in some watersheds. For the purposes of this EIS, only private commercial forestlands are considered because state lands are currently managed under an HCP.

Southwest

The Southwest Region includes coastal rivers and streams north of the Columbia River to the Grays Harbor drainage. This region has the highest overall stream density in the state (7.2 mi/mi^2). All of the priority species are present in this region except sockeye salmon. Bull trout and cutthroat trout are listed in the region, but coho salmon is a candidate species. Streams in the region are substantially influenced by FPRs because 81 percent of fish-bearing and 91 percent of nonfish-bearing streams are on state or private forestlands. Federal management strategies have only a minor influence on streams in the region with no fish-bearing and 3.8 percent of nonfish-bearing streams on federal ownership. Similar to the Olympic Coast Region, habitat degradation appears to be the leading factor influencing listing of species in the region. State lands in the region are covered by an HCP.

Lower Columbia River

The Lower Columbia Region includes the Columbia River and rivers and streams that drain from Washington into the Columbia River from its mouth to streams west of (but exclusive of) Rock Creek. This region also has a very high stream density (5.6 mi/mi^2). All of the priority species are present in this region. Sockeye do not spawn or rear in the region, but use the mainstem Columbia River as a migration corridor. Chinook salmon, chum salmon, steelhead, and sea-run cutthroat trout are listed as threatened in the region and found downstream of Mossyrock Dam and Merwin Dam on the Cowlitz River and Lewis River, respectively. Bull trout are listed as threatened throughout the region where they are present. Coho salmon is a candidate species. State and private forestlands include 68 percent of the region's fish-bearing streams and 67 percent of the nonfish-bearing streams. Federal ownership includes about 8 percent of the fish-bearing and 28 percent of the nonfish-bearing streams. Each of the 4-Hs has been cited as contributing to the listing of one or more of the species (Table 3.7-1). State lands in the region are covered by an HCP.

Middle Columbia River

This region includes rivers and streams that drain from Washington State to the Columbia River from Rock Creek through the Yakima River, not including the Snake and Walla Walla Rivers which is considered separately in their own region. Overall, stream density (1.7 mi/mi^2) is relatively low in the region, reflecting the relatively arid conditions in the eastern and southern parts of the region. All of the priority species are present in this region, except chum and sea-run cutthroat trout. Sockeye do not spawn or rear in the region, but use the mainstem Columbia River as a migration corridor. Chinook and chum salmon are listed in the westernmost portions of this region as part of the lower Columbia River ESU, and steelhead are listed as threatened throughout the region except for the White Salmon River. Bull trout are present in many parts of the region, but their distribution has been fragmented by dams, degraded water quality and other factors. State and private forestlands include about 46 percent of the region's fish-bearing streams and 44 percent of the nonfish-bearing streams. Federal management strategies also have a significant influence on forested lands with about 18 percent of the fish-bearing and 36 percent of nonfish-bearing streams on federal ownership. Each of the 4-Hs has been cited as contributing to the listing of one or more of the species (see Table 3.7-1 for Federal Register citations).

Snake River

This region includes all portions of the Snake River and its tributaries that lie within Washington State. The region also includes the Walla Walla River drainage. The Snake River region is relatively arid and has a low stream density of 1.2 mi/mi^2. In addition, the region has a relatively low proportion of fish-bearing streams (about 6 percent, 342 miles). Chinook salmon, sockeye salmon, steelhead and bull trout are present in the region. However, sockeye salmon do not spawn or rear in the region but use the mainstem Snake River as a migration corridor. Sockeye spawning and rearing occur within Idaho. Chinook, steelhead, and bull trout are listed as threatened within the region. Chinook salmon and steelhead are not found upstream of a natural barrier on the Palouse River. In addition, chinook salmon are not listed within the Walla Walla drainage. About 33 percent of the fish-bearing streams and 20 percent of the nonfish-bearing streams are located on private forested lands. Few state lands are in the region. Federal management includes about 17 percent of fish-bearing streams and 43 percent of nonfish-bearing streams. Each of the 4-Hs has been cited as contributing to the listing of one or more of the species (see Table 3.7-1 for Federal Register citations). Relative to other regions, the Snake River region is relatively arid and does not include large amounts of commercial forestlands. Consequently, this region accounted for only 4 of the 188 sample sections used in the analysis.

Upper Columbia River downstream of Grand Coulee Dam

This region includes the mainstem of the Columbia River and its tributaries to Grand Coulee Dam. The region has a moderate stream density of 3.2 mi/mi^2. The major tributaries include the Wenatchee River, Methow River, Okanogan River, and Lake Chelan and its tributaries. The priority species found in the region include chinook salmon, sockeye salmon, steelhead, and bull trout. Chinook (endangered), steelhead (threatened), and bull trout (threatened) are listed within the region. Private forestlands include about 20 percent of the fish-bearing streams in the region and about 17 percent of the nonfish-bearing. Federal management is also very important in the region with 20 percent of the fish-bearing and 64 percent of the nonfish-bearing streams located on federal ownership. Each of the 4-Hs has been cited as contributing to the listing of one or more of the species (see Table 3.7-1 for Federal Register citations).

Upper Columbia River upstream of Grand Coulee Dam

This region includes all of the Columbia River mainstem and its tributaries upstream of Grand Coulee Dam within Washington. Major tributaries include the Sanpoil River, Spokane River, Kettle River, and Colville River. Stream density in region is relatively low with 2.8 mi/mi^2. Grand Coulee Dam is a complete barrier to anadromous fish. Consequently, the only priority species present in this region is bull trout which are listed as threatened. Hydroelectric and irrigation dams which have fragmented bull trout distribution plus habitat degradation have been cited as major factors leading to the listing in this region (Federal Register 63 No. 111). Private forestlands include about 31 percent of the fish-bearing streams and 32 percent of the nonfish-bearing streams. Relatively few state lands are present in the region which include about 6 percent of the nonfish-bearing and no fish-bearing streams. Federal management has a an important influence in the region with 15 percent of the fish-bearing and 29 percent of nonfish-bearing streams within federal ownership.

3.7.3 Environmental Effects

The forest practices rules are designed to protect public resources to an acceptable level while maintaining an economically viable commercial forest industry. Defining what constitutes "an acceptable level" is public policy that results from both scientific inquiry and public discourse. However, the Forest Practices Board goals related to fish suggest that acceptability is the level that results in compliance to the ESA, and in the restoration and maintenance of riparian habitat needed to support a harvestable supply of fish.

Criteria for determining potential effects of the alternatives on priority fish species and aquatic habitat were based on two broad-scale perspectives:

- Management approaches under each alternative in riparian and upslope areas
- Habitat needs and biological requirements of priority fish species

The aquatic habitat in the planning area is extensive and complex. Current freshwater habitat conditions in many areas do not fully meet requirements for priority fish species. For example, at certain times of the year (e.g., during late summer), water temperatures in some streams exceed favorable levels for priority species. This is often associated with lack of streamside vegetation to provide shading. Such shading can reduce the water temperature, but can also be influenced by other factors such as weather conditions, air temperatures, elevations, and groundwater inflow.

In a broad sense, management approaches under each alternative are expected to affect aquatic habitat conditions in a similar manner. However, the magnitude of the effects may be different depending upon site-specific conditions. For example, conditions in some areas may be at or near levels that would support healthy populations of priority fish species and a change in management approach might not change that condition. This is particularly true for regions of the state that do not have significant state or commercial forestlands or lack the priority species for reasons unrelated to forest practices. In contrast, conditions in water quality limited streams may be less able to fully support populations of any priority fish species, and management changes could have a significant effect.

It is difficult to predict aquatic habitat conditions under a specific alternative, particularly if those predictions are for an extended period that could include significant changes in FPRs resulting from adaptive management (Appendix I). The reason for this difficulty is the complex and dynamic nature of the aquatic system and the surrounding terrestrial environment (flooding, earthquakes, fire, and other major events that affect aquatic and streamside habitat).

Trends in aquatic habitat changes also involve a time consideration. For example, priority fish species have a relatively short life cycle (up to six years). In areas where habitat is degraded, habitat restoration would only begin to become effective after a longer period (greater than 10 years). Therefore, several life cycles of priority fish species may encounter less than desirable habitat conditions before any management measures become effective. However, a reduction in any factor that limits aquatic habitat in the planning area during the short term should establish a trend toward more favorable conditions for maintaining or recovering priority fish species.

When predictions cannot be precisely made, as is the situation when applying any of the alternatives to the planning area, monitoring is often required to determine if a trend toward favorable or target conditions is occurring and the strength of that trend. For example, monitoring of water temperature at various locations over a number of years would provide the information needed to determine if a trend toward lower temperatures (e.g., in late summer) could be correlated with increasing re-growth of streamside vegetation.

Evaluation of the environmental consequences on aquatic resources focused on the strength of the trends that the management conditions would have in achieving target conditions under each alternative. A strong trend in changes leading to attainment of target conditions would indicate that maintaining or restoring priority fish populations is more probable than under weaker trends. Even with conditions meeting requirements for a properly functioning aquatic system, however, there is no certainty that current populations will be maintained or recover.

It is impossible to precisely predict specific salmon population numbers for any particular alternative. It is also impossible to precisely predict other factors (e.g., ocean conditions, predation, disease, harvest, or competition) that may affect these populations. Therefore, the environmental assessment of potential effects has been focused on habitat requirements. If habitat is properly functioning, then other factors need to be assessed to determine why chinook salmon and other salmonid species are either depressed or at risk of extinction.

To achieve a properly functioning aquatic system and to safeguard priority fish species or populations, unlimited or complete protection across a landscape is not needed to maintain habitat conditions at an acceptable level. There is a point beyond which, for example, the width of an RMZ would not provide any significant additional levels of protection. For instance, stream buffers greater than about 100 feet with 80 percent canopy closure would not provide additional shade to reduce stream temperature (see Section 3.5). Less than full protection can achieve target conditions because it is the full range of management prescriptions (including for slopes and roads) and the totality of riparian function that must be considered in aggregate. In addition, forest practices often occur within a mosaic of other land use practices with different levels of protection. For example, private or state timber lands can be adjacent to National Forest lands that are managed to meet different goals. Timber harvest activities on National Forest lands on the west side of the state follow guidelines in the President's Forest Plan. Prescriptions that provide substantial LWD and detritus input, shading, coarse and fine sediment control, and streambank stability, for example, can set a trend toward achieving target conditions and a properly functioning aquatic system.

Because the threshold of significance for fish and aquatic habitat considers the effects of an aggregate of management prescriptions in each alternative, this section relies on the conclusions of several other sections. For example, the amount of LWD that is recruited to a stream is determined by RMZ width and the number of trees prescribed to remain in it (see Section 3.5). Similarly, potential changes in erosion and sediment from upslope areas or from roads also directly affect aquatic habitat conditions (see Sections 3.2 and 3.5). Evaluation criteria for measuring effects from riparian and upslope management are identified below in Section 3.7.3.1.

The following section (Section 3.7.3.2) evaluates these individual criteria and aggregates their overall effects on the aquatic system to determine if an individual alternative provides the likelihood of achieving target conditions (i.e., properly functioning aquatic system) and does not threaten individual priority fish species or fish populations. The concluding section (Section 3.7.3.7 Synthesis) attempts to place lands regulated under FPRs in perspective with other practices that affect Pacific salmon and trout viability.

3.7.3.1 Issues and Evaluation Criteria

Issues relevant to fish resources were identified during the scoping process described in Chapter 1. The issues were categorized according to NMFS matrix of pathways and indicators of a properly functioning aquatic ecosystem (NMFS, 1996). The issue categories evaluated here include the following:

- Coarse sediment
- Fine sediment
- Hydrology
- Large woody debris
- Leaf and needle litter
- Floodplains and off-channel features
- Water temperature
- Forest chemicals
- Fish passage

One or more measures and evaluation criteria were identified for each of the issues and is used to compare and contrast the likely effects of implementing each of the alternatives. As described earlier, the measures used in this section are drawn primarily from other sections of this document. The goal of this chapter is to synthesize and examine these measures and others as they relate to the priority fish species and a properly functioning aquatic ecosystem. The following is a brief description of the issues and their measures and criteria. Most of the descriptions will refer the reader to previous sections where more complete descriptions have been provided.

Coarse Sediment

Coarse sediment affects the amount of spawning habitat, pool filling, bank stability, and stream hydrology. The three alternatives address coarse sediment delivery to streams from forest practices by protecting streams from accelerated coarse sediment production from mass wasting and reducing coarse sediment production from road and culvert failures.

The effects of the alternatives on coarse sediment production from mass wasting and roads were evaluated in the Sediment and Channel Conditions Section (Section 3.2.3). Mass wasting was evaluated by comparing the proportion of area within the RMZs and upslope areas that contain moderate to high hazard areas. Coarse sediment production from roads was analyzed by qualitative evaluation of road management practices under the three alternatives.

Fine Sediment

High levels of fine sediment in streams can be detrimental to the survival of eggs and fry incubating in redds. Sources of fine sediment can include hillslope erosion, surface erosion from roads, unstable stream banks, mass wasting, and culvert failure. Vegetation in RMZs provide filtering of fine sediments from upslope areas and stability to stream banks. The effect of the alternatives on hillslope erosion and bank stability was evaluated in the Sediment and Channel Dynamics Section (Section 3.2.3). Hillslope erosion was evaluated by comparing the percent of riparian vegetation that is protected under the different management prescriptions for the different stream types and regions using the EBAI. The bank stability evaluation was based upon the percentage of the riparian area important for stream bank stability that is protected by different management prescriptions.

Improperly constructed and maintained forest roads can also be an important source of fine sediments. Furthermore, stream crossings can be the location of direct delivery of fine sediments into streams. Numerous factors can affect the production and delivery of fine sediment from roads including the number of road miles, the construction materials, road drainage structures, the level of use and maintenance, and the number of stream crossings. The Road Analysis Appendix provides a more complete description of these and other factors and assesses the risk of sediment delivery from roads among the three alternatives.

Hydrology

The amount of timber harvest in a watershed and the forest road density can affect the hydrologic regime of a stream. Particularly in rain-on-snow regions, immature forest stands and high levels of road density can result in higher frequency and higher magnitude of peak flow events. This issue was evaluated for the alternatives in Section 3.3 (Hydrology) by considering the effect of the alternatives on the percentage of a watershed to be harvested and on limiting road densities.

Large Woody Debris

LWD is one of the most important components of high quality Pacific salmon and trout habitat affecting nutrients, food, cover, and channel morphology. The effects of the alternatives on LWD recruitment have been evaluated previously in the Riparian Habitat Section (Section 3.4) using the EBAI as comparative tool for alternative RMZ management prescriptions.

Leaf/Needle Litter Recruitment

Leaf and needle litter is an important nutrient source for forested streams and can be affected by harvest within or near riparian zones (Bilby and Bisson, 1992). The effects of the alternatives on leaf and needle litter recruitment have been evaluated previously in the Riparian Habitat Section (Section 3.5) using 0.5 SPTH as a criteria for protecting most leaf and needle litter inputs to streams.

Floodplains and Off-channel Areas

Floodplains and off-channel areas are an important component of aquatic habitat that include side channels, backwater alcoves, ponds, and wetlands. The effects of the alternatives on floodplain and off-channel areas were evaluated in the Sediment Section based upon a qualitative analysis of the different prescriptive features of the alternatives (Section 3.2.3).

Water Temperature

As described in Section 3.7.2.2, Pacific salmon and trout require cool, clean water to thrive. Stream shading is an important component to regulating stream temperatures. The effect of the alternatives on shade levels has been evaluated in the Riparian Habitat Section (Section 3.4.3.2) by comparing the percent of riparian vegetation that is protected under the different management prescriptions for the different stream types and regions.

Forest Chemicals

Fish production and water quality can also be affected by the presence of pesticides used to control undesirable plants, insects, and fungi. Pesticide use is an important management tool for speeding reforestation by reducing competition and disease. Pesticide use under the three alternatives is described and evaluated in Appendix J (Forest Chemicals). For evaluation of this component to water quality, minimum buffer widths along surface water bodies were used as the comparative measure among the alternatives.

Fish Passage

One of the important ways that forest practices affect the ability of fish utilize all of the available habitat is through barriers at stream crossings by roads. Historical road building under much less conservative rules than currently practiced has sometimes led to habitat loss without documenting historical fish utilization. Consequently, the current known distribution of fish is generally recognized to be much smaller than historically existed. Criteria for the construction of stream crossing structures are currently based, in part, on whether a stream is fish-bearing (WAC 222-24-040). For example, culverts must be a minimum diameter of 24 inches for streams with anadromous fish and a minimum diameter of 18 inches for streams with resident game fish. Therefore, the assumptions made in determining a fish-bearing stream are critical for the construction of new stream crossings and for evaluating whether existing stream crossings meet FPRs.

The evaluation of the potential effects of the alternatives on fish passage will be based primarily upon how the rules will change stream typing assumptions and the effect this will have on new stream crossing construction and compliance of existing structures. The measure to be utilized will be proportion of stream miles that are considered to fish-bearing versus nonfish-bearing. In addition, a qualitative comparison will be made on the alternative programs for decommissioning roads, road maintenance, and replacement of problem culverts.

3.7.3.2 Alternatives Analysis

This section presents a synthesis of the results of the alternative evaluations for each issue as they relate to the fish resource. Tables 3.7-4 and 3.7-5 summarizes the outcome of the evaluations determined within this and other sections of this EIS.

Coarse Sediment

Coarse sediment loading levels to streams results primarily from three sources: mass wasting events, road failures, and stream bank instability. Mass wasting and road failures can deliver large, but infrequent inputs of coarse and fine sediment to streams. In contrast, stream bank instability can be a chronic problem resulting from changes in riparian root-strength and/or hydrology. In one sense, stream bank instability does not provide any new sediment to the stream. However, it does change the amount of sediment that is mobile and its distribution along the channel. Mass wasting is a natural phenomenon that occurs in watersheds without any major land-use activities. Both mass wasting (including debris flows) and stream bank stability are natural channel processes and can be an important source of coarse sediment and LWD to streams. However, forest practices have been implicated in increasing the natural frequency of mass wasting events and the amount of stream bank instability. The two major factors that contribute to increased mass wasting and decreased bank stability are timber harvest and roads. Timber harvest on high hazard slopes can increase the risk of mass wasting events by removal of tree root strength that helps maintain soil cohesion. Forest roads can increase mass wasting risk by placing roads on high hazard landforms, concentrating water drainage in high hazard areas, and

Table 3.7-4. Estimated Level of Risk Associated with Issues Related to the Fish Resource in Westside Streams

Issue	Alternative 1	Alternative 2		Alternative 3	EIS Section
		Option 1	Option 2		
Coarse Sediment	Moderate	Low to Moderate	Low to Moderate	Low to Moderate	3.2
Fine Sediment	High	Moderate	Moderate	Low to Moderate	3.2
Hydrology	Moderate	Moderate	Moderate	Low	3.3

Large Woody Debris	High	Low to Moderate	Low to Moderate	Low to Very Low	3.4
Leaf/Needle Recruitment	High	Moderate	Moderate	Very Low	3.4
Floodplains and Off-Channel Areas	High	Low	Low	Low	3.7
Water Temperature	Moderate	Low to Moderate	Low	Very Low	3.5
Forest Chemicals	Moderate	Low	Low	Low	3.6
Fish Passage	High	Low	Low	Low	3.6

Table 3.7-5. Estimated Level of Risk Associated with Issues Related to the Fish Resource in Eastside Streams

Issue	Alternative 1	Alternative 2	Alternative 3	EIS Section
Coarse Sediment	Moderate	Low to Moderate	Low to Moderate	3.2
Fine Sediment	High	Moderate	Low to Moderate	3.2
Hydrology	Moderate	Moderate	Low	3.3
Large Woody Debris	High	Moderate to High	Low to Very Low	3.4
Leaf/Needle Recruitment	High	Moderate	Very Low	3.4
Floodplains and Off-Channel Areas	High	Low	Low	3.7
Water Temperature	Moderate	Low to Moderate	Very Low	3.6
Forest Chemicals	Moderate	Low	Low	3.6
Fish Passage	High	Low	Low	3.7

culvert failures. Road-related mass wasting often has higher negative effects to streams because initiation points can occur at stream crossings.

Alternative 1

Under Alternative 1, harvest and road-related mass wasting events would continue to adversely affect fish habitat in local areas.

Under Alternative 1, the current rate of harvest-related and road-related mass wasting events are expected to continue and risk from mass wasting is considered to be moderate (Section 3.2 Sediment). New roads crossing unstable slopes require Class IV special permits, but no standardized method is currently in use for identifying unstable slopes. Currently, to the extent possible, unstable slopes are identified in watershed analysis and forest practices applications. Existing roads would only be upgraded following watershed analysis or forest practices applications. Rarely used roads greater than 10 years old and orphaned roads would continue to be at high risk of failure in some areas. Streambank stability is also likely to be periodically reduced along all westside and eastside streams subject to adjacent harvest. Fish-bearing streams (Types 1 to 3) will have some protection provided by RMZs, but selective harvest within the RMZs would result in less than full protection. In addition, Type 4 and 5 waters would have no protection resulting from RMZs. Depending on tree species, loss of root strength by root die-back and decline of streambank stability after timber harvest can take as long as 5 years while restoration of stability from new tree and vegetation growth may take more than 12 years. Overall, the risk to streams from excessive coarse sediment delivery is considered moderate.

Alternatives 2 and 3

Coarse sediment, resulting from new forest practices would result in a low to moderate risk of effects on fish habitat under Alternative 2. However, existing roads would continue to produce moderate effects in the short term, with a reduction in the effect over time and a low risk under Alternative 3.

Relative to Alternative 1, Alternatives 2 and 3 would receive greater protection from harvest-related mass wasting because a more-refined and uniform high hazard screening method would be implemented. Greater success in identifying high hazard slopes should result in more Class IV-special applications, greater scrutiny, and implementation of more restrictive harvest prescriptions for these areas. Alternative 3 has higher protection to streams from harvest-related mass wasting events compared to Alternative 2 because it includes wider no-harvest buffers on all streams. Overall, Alternatives 2 and 3 are rated as having moderate and low levels of risk for harvest-related mass wasting, respectively.

Under Alternatives 2 and 3, significant improvements would occur in the planning and implementation of new roads (see Appendix F). Relative to Alternative 1, more new roads planned for potentially unstable slopes (based upon new DNR hazard maps) would require a Class IV- special application that would result in greater scrutiny. Alternatives 2 and 3 also require the preparation of RMAPs. The RMAPs would require inventories of roads and work plans for improvements of identified problems. Alternatives 2 and 3 also require road upgrades to new standards within 10 to 15 years (Alternative 3 and 2, respectively). Alternative 3 also requires a cap at current road densities. Relative to roads, Alternatives 2 and 3 are considered to have low to moderate risk of adverse effects. It is probable that some coarse sediment delivery to streams from forest roads would occur regardless of management activities (exclusive of decommissioning all moderate to high risk roads); however, the frequency and magnitude of events should be substantially reduced.

Under both harvest prescription options, Alternative 2 provides substantial streambank protection compared to Alternative 1, but does not provide full protection. Changes in the stream typing system (see Fish Passage below) and the presence of no-harvest core zones substantially increases the number of Type F and S stream miles that receive a relatively high level of protection. However, up to 50 percent of Type N_P stream reaches and all Type N_S reaches would receive no protection from harvest, but would have equipment limitation zones. Consequently, there would be a moderate risk that coarse sediment would be delivered from Type N to Type F and S streams.

Alternative 3 provides complete bank stability protection for nearly all streams. The RMZ widths proposed under this alternative are at least 70 percent of the one-half site-potential tree height and exceed this criterion under most situations. In addition, the RMZs include a no-harvest prescription. Consequently, Alternative 3 is rated as having a low risk of bank instability while Alternative 2 is rated as low to moderate risk and Alternative 1 is rated as high risk.

COARSE SEDIMENT: CONCLUSION

Alternative 1 has a high risk of coarse sediment delivery. Alternatives 2 and 3 would both have low to moderate levels of risk. Alternative 3 is considered to provide slightly lower risk than Alternative 2 because it includes wider no-harvest buffers, an accelerated schedule for implementing RMAPs, and no net increase in road densities. Both Alternatives 2 and 3 would potentially have lower risk in the long-term through the implementation of the monitoring and adaptive management plan. Higher levels of protection would result in less stream bed aggradation resulting from forest practices and a reduction in the risk of habitat degradation from pool filling and modified channel capacity.

Fine Sediment

Fine sediment loading to streams effects the quality and quantity of spawning and rearing habitat by filling in the spaces between gravels and cobbles and by filling pools. Similar to coarse sediment loading, fine sediment production is related to both timber harvest and road management practices. Vegetation in riparian zones is important for filtering and retaining fine sediment eroding from hillslope areas. Similar to coarse sediment, some fine sediment is delivered to streams during infrequent mass wasting events and road failures. In addition, roads can be a chronic source of fines from surface erosion, and harvest activities can contribute to increases in hillslope erosion. The EBAI for sediment was calculated for the proposed management prescriptions under the three alternatives (see Appendix C, Riparian Habitat Appendix). In addition, the maximum EBAI for a no harvest condition was also calculated for comparison.

ALTERNATIVE 1

> Alternative 1 would result in high risk of adverse effects on fish habitat in many areas from fine sediment delivery to streams.

Under Alternative 1, the EBAI for sediment was calculated as about 64 percent of the maximum EBAI (full protection). The difference between the level of protection for eastside and westside stands was less than 1 percent. Consequently, Alternative 1 is considered to provide high risk of hillslope erosion.

Under Alternative 1, the current approach to road management is based primarily upon the implementation of best management practices (BMPs) that have been approved by the Department of Ecology and described under the Forest Practices Rules and the Forest Practices Board Manual. In addition, many of the rules include discretionary language by encouraging, but not requiring, certain activities. Unfortunately, a recent study on the effectiveness of BMPs for new road construction found that many practices were ineffective even when implemented according to standards and guidelines (Rashin et al., 1999, see Appendix F). Other activities such as preparation of a road maintenance and abandonment plan or additional maintenance or culverts only occur when asked for by the DNR. However, there are no descriptions of specific triggers that would prompt the DNR to require these activities. Under current FPRs there appears to be little incentive for landowners to abandon (i.e., close and remediate) roads. Consequently, many roads remain in an inactive status with minimal maintenance requirements because abandonment requires activities such as stream crossing removal. Roads built before 1974 and unused since 1974 have been termed "orphan" roads. The current FPRs have no policies directed towards management of orphan roads. Alternative 1 is considered to have high risk for the delivery of fine sediment from roads to streams.

ALTERNATIVES 2 AND 3

> Alternative 2 would result in low to moderate risk and Alternative 3 would result in low risk of adverse effects on fish habitat from fine sediment delivery to streams. There is a high degree of uncertainty regarding the effectiveness of protections along Type N streams with Alternative 2.

The EBAI suggests that Alternative 2 would provide about 80 percent protection relative to no harvest in the RMZ. The EBAI suggests that Alternative 3 would provide a level of protection that is 100 percent of the maximum EBAI. The EBAI for sedimentation suggests that Alternative 3 would provide the maximum level of sediment filtering while Alternative 2 would provide a relatively high level of protection. Both Alternatives 2 and 3 would provide substantially more sediment filtering protection than Alternative 1.

Road maintenance and abandonment plans are not required under current regulations unless requested by DNR and their contents are not specified. Furthermore, there are no specific requirements for road maintenance or provisions for orphaned roads (not used since 1974). Alternatives 2 and 3 significantly improve the current regulations by requiring landowners with greater than 500 acres of forestland to prepare road maintenance and abandonment plans within five years if watershed analysis has not been completed. Alternatives 2 and 3 differ in that upgrades identified in the plans must be completed within 15 years for Alternative 2 and within 10 years for Alternative 3. The schedule for correcting problem orphan roads is also different among Alternatives 2 and 3. Under Alternative 2, activities on problem orphan roads will not begin for 5 years after all large landowner RMAPs have been submitted. In contrast, Alternative 3 requires that activities to fix problem orphan roads occur on the same schedule as other roads. In addition to scheduling differences, Alternative 3 requires a no net increase in road density within an ownership or watershed and occurs concurrently with implementation of RMAPs. Small landowners (less than 500 acres) are also required to prepare RMAPs, but are not required to submit them until their first Forest Practice Application.

An important component to RMAP preparation is review. Under Alternatives 2 and 3, RMAPs will be open to review by WDFW, Tribal entities, and the Washington State Department of Ecology. However, the authority to require changes to an RMAP will be held solely by DNR. Similar to other components to the Forest and Fish Plan, adaptive management is key to ensuring that positive results occur. Monitoring will be important to ensure that revised road BMPs in the Board Manual are implemented and effective. Ineffective BMPs will require strengthening. Alternative 3 provides a small, but significant, added level of protection over Alternative 2 by capping road densities at current levels.

Many watersheds are currently at road densities considered too high for a properly functioning aquatic ecosystem (less than 2 mi/mi^2, NMFS, 1996; less than 1 mi/mi^2, USFWS, 1998). However, road density criteria should be viewed with caution because the functional relationship between road density and effects to the aquatic ecosystem can vary among different watersheds depending upon watershed characteristics (soil, climate, and topography) and characteristics of the road system (age, usage, and level of maintenance). Nevertheless, road density can be a useful descriptor to enhance understanding the overall level of disturbance to a watershed. Notably, road density is only one of nineteen physical indicators recommended by NMFS and USFWS to assess a properly functioning aquatic ecosystem, including several that evaluate road effects more directly (e.g., sediment and channel condition).

Of the three alternatives, Alternative 3 provides the lowest risk to streams from the delivery of fine sediment from roads due to the “no net increase” clause and accelerated improvement schedule. However, it is followed closely by Alternative 2. It is unlikely that road surface erosion and delivery to streams can be eliminated under any of the alternatives. In part, this results from the highly developed forest road network that currently exists and the lack of requirements to reduce the network. Alternatives 2 and 3 can provide significant improvements, primarily through the requirement that roads meet upgraded road standards within 10 (Alternative 3) or 15 (Alternative 2) years. Furthermore, the requirement for road maintenance and abandonment plans would improve ongoing road conditions.

FINE SEDIMENT: CONCLUSION

Considering both harvest-related and road-related management prescriptions including mass wasting and road failure from above, Alternative 1 is considered to be at high risk for the delivery of fine sediment to streams. Alternative 2 is considered to be at a moderate level of risk to streams, primarily because of the requirements for RMAPs and road upgrades. Alternative 3 is considered to be low risk because no-harvest buffers are more extensive, RMAP implementation is accelerated, and because it includes a “no net increase” clause for road density. Similar to the coarse sediment discussion, implementation of the monitoring and adaptive management plan would potentially provide higher levels of protection for Alternatives 2 and 3. Although Alternatives 2 and 3 would provide substantial improvements over Alternative 1, none of the alternatives would be expected to eliminate all risk of fine sediment deposition from forest practices.

Hydrology

Forest roads and timber harvest can affect the hydrologic regime of a stream. High levels of road density and immature forest stands, particularly in rain-on-snow regions, can result in a higher frequency and higher magnitude of peak flow events. Roads influence stream hydrology by routing water collected on the road surface. The primary negative effect of peak flows to salmonids occurs while eggs incubate in redds, but other effects include accelerated bank erosion and changes in channel morphology. Peak flows can result in scour that disturbs the highly sensitive eggs and causes increased mortality.

Alternatives 1 and 2 would result in moderate risk of effects on peak flows. Alternative 2 would have slightly less protection because fewer watershed analyses would be performed, but would have more protection because it addresses road drainage more effectively.

Under Alternative 1, the risk of effects on peak flow events is reduced in areas that have watershed analysis. The DNR is required by state law to conduct watershed analysis within all non-agricultural watersheds of the state with more than 1,000 acres of forested land and less than 80 percent federal ownership. A watershed analysis can be prepared voluntarily by a private landowner. Under Alternative 1, watershed analysis provides landowners with increased certainty about the prescriptions that would be required on their lands and aided in the planning of their management. Alternative 1 is considered to have a moderate level of risk because watershed analysis would provide more restrictive prescriptions in westside watersheds where risk of peak-flow events is high. However, many watershed analyses have remained incomplete because negotiations during the prescriptive phase have stalled (M. Hunter, WDFW, personal communication, February 2001). Consequently, the effectiveness of watershed analysis in providing added protections has declined in recent years.

Alternative 2 would have a slightly higher risk of effects on peak flows in the near-term, relative to Alternative 1, because fewer watershed analyses are likely to be performed by private landowners. Under Alternative 2, the prescriptive phase of watershed analysis for riparian zones would be deleted and the certainty of prescriptive measures would be contained within the new riparian strategies implemented by changes in the Forest Practices Rules. In addition, watershed analysis under Alternatives 2 and 3 would have more modules that would make them more costly to conduct. Consequently, many of the benefits of watershed analysis would likely be delayed until the DNR conducted the analyses and incorporated the results during their review of FPAs. The level of risk from peak flows provided under Alternative 2 is considered slightly higher than Alternative 1, but still moderate.

Alternative 3 would result in low risk of effects on peak flows because it addresses cumulative watershed harvest in the ROS zone.

In the long-term, Alternative 3 would provide the lowest risk from peak flows relative to Alternatives 1 and 2 because it includes rules restricting the amount of hydrologically immature stands that could be present within the rain-on-snow zone and watershed analysis would incorporate a new eastside hydrology module. The differences in the alternatives relative to potential effects on peak flows are more apparent in westside watersheds than eastside watersheds because rain-on-snow zones are more prevalent on the west side.

Road-related effects on peak flow in forested watersheds are relatively minor compared to harvest-related effects. Consequently, Alternatives 2 and 3 are considered to have similar road prescriptions that would provide only slight improvements relative to Alternative 1 for addressing peak flow issues. Improvements to the road system resulting from RMAPs should provide some added protection; however, neither Alternative 2 nor Alternative 3 requires reductions in road density over current levels. Alternative 3 does provide a cap on road density.

HYDROLOGY: CONCLUSION

Overall, Alternatives 1 and 2 are considered to have moderate risk to streams from peak flow events on the west side and moderate protection on the east side, but Alternative 1 provides slightly less risk as a result of regulatory incentives for the implementation of watershed analysis by private landowners. Alternative 3 is considered to be low risk because it would limit the size of clearcuts in the rain-on-snow zone.

Large Woody Debris

Instream LWD is considered by many to be the highest priority habitat component lacking in most streams categorized as “not properly functioning.” Large woody debris levels have declined for a number of reasons including splash dams, logjam removal programs, removal at dam trashracks, removal for firewood, and low recruitment from forest practices. This portion of the assessment evaluates the level of protection and enhancement the alternatives provide for instream LWD using the EBAI described in the Riparian Habitat Section and Appendix D. As a reference point the analysis assumed that a no-harvest buffer width that was one site potential tree height would provide full protection. Consequently, all EBAI values for the alternatives were relative to the full protection EBAI value (i.e., 0.0 is no protection, 1.0 is full protection). EBAI analyses were conducted based upon both a 100-year SPTH and 250-year SPTH assumption (see Section 3.4).

ALTERNATIVE 1

> Alternative 1 would likely contribute to continued degradation of fish habitat due to inadequate recruitment of LWD on both eastside and westside forests.

Under Alternative 1, current FPRs would continue to regulate RMZ widths. Westside RMZ widths range from 25 feet to 100 feet for fish-bearing streams (Types 1 to 3) depending upon the stream type and width. Similarly, in eastside forests, RMZ widths range from 30 feet to 300 feet for fish-bearing waters depending upon the harvest prescription (partial versus even-aged) in the adjacent harvest unit. RMZs are not required along nonfish-bearing streams (Types 4 and 5), except occasionally along the lower 1,000 feet of Type 4 waters to protect public water resources. In addition to the RMZ widths, the FPRs provide guidance on the number of leave trees required within the RMZs.

The EBAI suggests that Type 1 to 3 streams in eastern Washington would receive about 27 percent of full protection that would be available from a no-harvest buffer under the 100-year SPTH assumption and about 20 percent of full protection under the 250-year SPTH assumption. All streams combined would receive about 14 to 19 percent of full protection (Tables 3.7-6 and 3.7-7). Consequently, Alternative 1 is considered to be at high risk of having inadequate LWD recruitment potential. In western Washington, protection levels would be higher. Type 1 to 3 streams would have about 48 percent of full protection while all streams combined would have about 26 percent of full protection under a 100-year SPTH assumption. Type 1 to 3 streams would have about 38 percent of full protection while all streams would have about 21 percent of full protection under a 250-year SPTH (Tables 3.7-6 and 3.7-7). Relative to the other alternatives, Alternative 1 has the highest level of risk of reduced LWD recruitment potential to streams.

ALTERNATIVE 2

Alternative 2 would likely provide adequate direct LWD inputs to fish-bearing streams on the west side under both Option 1 and Option 2.

Under Alternative 2, the stream typing system would change and new rules for RMZ widths and harvest prescriptions would be implemented. Total RMZ widths for fish-bearing streams would range from 90 feet to 200 feet on the west side and 75 feet to 130 feet on east side depending upon the site class (see Chapter 2). Unlike Alternative 1, nonfish-bearing streams (Type N) would have RMZs over at least 50 percent of their length and would provide protection for sensitive areas. As described earlier, RMZs along fish-bearing streams would incorporate three smaller zones, a no harvest core zone, an inner zone, and an outer zone. On the west side, landowners have two harvest prescription options for inner zones which exceed basal area stand requirements, Option 1 which allows thinning in the inner zone to accelerate riparian tree growth, or Option 2 which requires any tree harvest in the inner zone to occur at its outer edge. On the east side, harvest prescriptions are dependent upon the habitat type and the basal area of the stand in the inner zone. On both sides of the Cascades, outer zones have leave tree requirements that may be dispersed or clumped.

Table 3.7-6. Percentage of Full Protection for LWD Recruitment to Streams under a 100-year SPTH Assumption Based upon the EBAI Analysis

		Alternative 2		
Region/Stream Type	**Alternative 1**	**Option 1**	**Option 2**	**Alternative 3**
West side—Fish-bearing	48	96	94	99
West side—All streams	26	52	52	96
East side—Fish-bearing	27	73[1]	---	100
East side—All streams	19	43[1]	---	99

[1.] Does not include additional potential protection within the bull trout overlay

Table 3.7-7. Percentage of Full Protection for LWD Recruitment to Streams under a 250-year SPTH Assumption Based upon the EBAI Analysis

Region/Stream Type	Alternative 1	Alternative 2 Option 1	Alternative 2 Option 2	Alternative 3
West side—Fish-bearing	38	85	81	95
West side—All streams	21	46	44	90
East side—Fish-bearing	20	54[1]	---	95
East side—All streams	14	30[1]	---	90

1. Does not include additional potential protection within the bull trout overlay

It is uncertain whether Alternative 2 provides adequate protection for LWD recruitment from non fish-bearing streams to fish-bearing streams.

The EBAI indicates that Alternative 2 would provide considerably more protection than Alternative 1 under both the 100-year and 250-year SPTH assumptions. On the west side, Option 2 provides a high level of protection to Type S and F streams (81 to 94 percent of full protection (Tables 3.7-6 and 3.7-7) but for all streams, the level of protection would be much lower (about 44 to 52 percent of full protection). The lower level of protection indicated for all streams results from prescriptions on Type N streams which produce LWD that have a lower value for fish habitat creation. This is because trees from the smaller nonfish-bearing streams must be transported downstream during flood or debris flow events to become functional for the creation of fish habitat. In some areas, this can be a significant influx of wood. In coastal Oregon, 11 to 49 percent of the LWD in 2nd and 3rd order streams was derived from debris flows (Gresswell and May, 2000). However, the scientific literature does not provide clear guidance that buffers on Type N streams under Alternative 2 are sufficient for providing LWD to fish-bearing streams. See Section 3.4 (Riparian Habitat) for additional discussion of these prescriptions.

Alternative 2 would produce a moderate risk of diminished LWD recruitment to fish-bearing streams on the eastside; it is uncertain how strongly diminished LWD recruitment in non-fish-bearing streams affects downstream fish habitats.

Landowners on the west side that implemented Option 1 would provide about 85 percent (250-year SPTH) to 96 percent (100-year SPTH) of the assumed full protection level for Type S and F streams and about 46 to 52 percent protection for all streams. On the east side, the EBAI of Type S and F streams would be about 54 percent (250-year SPTH) to 73 percent (100-year SPTH) of the assumed full protection level. Overall, this suggests that under Alternative 2, most streams on the west side currently deprived of wood should eventually return to at least a moderate level of function. Depending upon site specific conditions and the Option chosen by the landowner, LWD function could be even higher.

On the east side, Alternative 2 provides substantial improvements over Alternative 1, but it provides a lower proportion of full LWD recruitment relative to the west side, and the range between the 100-year and 250-year SPTH assumptions is wider. The precise level of LWD required is unknown and different for different species (Bisson et al., 1987). Consequently, the level of uncertainty that eastside streams may be under-protected is higher and the risk level is estimated to range from moderate (100-year SPTH) to high (250-year SPTH).

One aspect of LWD recruitment that the EBAI does not reflect is the growth rate and future size of trees in the RMZ following implementation of a harvest prescription (see the

Riparian Habitat Section). The tree growth model in the Riparian Aquatic Integration Simulator (RAIS; see Appendix D) indicated that thinning increases the rate of growth for remaining trees. Larger streams require larger pieces of LWD to function adequately. Consequently, for larger streams and rivers, the EBAI would underestimate the protection available under Option 1. In situations where the RMZ stand is characterized by numerous, but smaller trees, Option 1 would more rapidly result in a future condition of fewer larger trees that have a higher potential to be functional once recruited to the stream. However, the RAIS model suggests stand ages that include trees of functional wood size range from 80 to 150 years depending upon stream size and site class. Consequently, the benefits from thinning become available in the long-term.

In addition to future stand conditions, the EBAI does not reflect instream wood placement strategies that can be implemented when existing stream adjacent roads result in the inability to meet basal stand requirements. Under these situations, a landowner may design a LWD placement plan in cooperation with the WDFW. Optionally, the LWD placement plan can include removing up to 10 trees per acre in the outer zone as incentives for landowners to implement the plan. Specifications of the required information in a LWD plan are currently under development.

Alternative 2 includes an option for hardwood conversion to conifers within inner zones that meet specific requirements (see Section 3.4.3.2). The hardwood conversion rule is intended to improve inner zone riparian areas over the long-term in areas that cannot meet basal stand requirements because of over-stocking by hardwood trees. These areas must also have evidence that conifers historically dominated the site. The rule provides for harvest of no more than 10 percent of the conifers 8 to 20 inches dbh and none larger. In terms of LWD, the hardwood conversion rule is considered a long-term benefit to these riparian areas. Alternative 3 also includes a hardwood conversion option.

Similar to Alternative 1, downstream movement of LWD can be restricted at culverts. However, Alternatives 2 and 3 include the preparation of Road Maintenance and Abandonment Plans (RMAPs). These plans include a change in culvert size requirement from the ability to pass water from a 50-year flood to a 100-year flood. All new culverts, and culverts that currently degrade resources will be required to meet the new rule. Larger culverts will have the ability to pass larger pieces of wood as well as floodwaters. However, culverts will not be able to pass all wood and some may build-up on the upstream side of a culvert. To the extent practicable without significant soil disturbance, RMAPs are required to include measures for moving built-up LWD from above to below culverts during standard road maintenance. Consequently, both Alternatives 2 and 3 have less risk than Alternative 1 for limiting LWD redistribution.

ALTERNATIVE 3

Alternative 3 is considered to have a low to very low level of risk of reduced LWD recruitment. Under Alternative 3, all streams would receive 95 to 96 percent of full protection under the 250-year and 100-year SPTH assumptions, respectively, from the 70 to 200-foot no-harvest RMZs proposed. Notably, heavily stocked stands with small trees near large streams will have less opportunity for thinning to accelerate stand growth and

Alternative 3 would provide low risk of diminished LWD recruitment along eastside and westside fish-bearing and non-fish-bearing streams.

average tree size. Under Alternative 3, thinning can only be done to convert hardwood-dominated stands to conifers and to accelerate development of 200-yr stand characteristics. However, these prescriptions would require SEPA review and cut trees could not be removed and sold unless monitoring determined that the prescriptions were effective. These requirements would provide little incentive for landowners to pursue these options.

Significantly, Alternative 3 provides no incentives or mechanisms for implementing instream wood placement strategies. Consequently, streams that have the potential for instream LWD placement under Alternative 2 will require more time for recovery. For LWD-poor streams surrounded by early- to mid-seral stage riparian stands, recovery could require 40 or more years on the west side and 60 or more years on the east side.

LARGE WOODY DEBRIS: CONCLUSION

Overall, LWD levels would be expected to gradually increase under Alternatives 2 and 3. Without any RMZ management, Alternative 3 is likely to provide the highest level of long-term protection and is considered to have the lowest level of risk of the alternatives. On the west side, Alternative 2 is considered to have a low to moderate level of risk for inadequate recruitment potential for functional LWD that can contribute to fish habitat in the long-term and provides incentives for landowners to commit to instream LWD enhancement plans and accelerate recovery of over-stocked riparian zones through thinning. The moderate level of risk is particularly relevant for streams with high levels of LWD recruitment from Type N streams. On the east side, Alternative 2 is considered to have a moderate to high level of risk for inadequate LWD recruitment potential. The call for the east side is based primarily upon the EBAI results which suggest that east side has between 54 and 73 percent of full protection along Type S and F streams, depending upon the SPTH assumption, but also considers that some additional reduction is likely from stream parallel roads. Alternative 1 would provide the lowest level of protection for LWD recruitment to streams and would likely contribute to continued degradation of fish habitat and is considered high risk.

All alternatives would have some level of risk related to blockage of LWD at culverts. However, Alternatives 2 and 3 include RMAPs and culvert upgrade requirements that reduce this risk. Blockages at culverts can potentially result in fish passage problems and culvert failure.

The RMZ prescriptions for all of the alternatives have a greater effect on instream conditions in the mid- to long-term (west side: 20 to 60 years; east side: 50 to 100 years) relative to the short-term (west side: less than 20 years; east side: less than 50 years). Currently, most stands (65 percent on west side; 54 percent on east side; Riparian Habitat Section) along fish-bearing streams are in early seral stage. Assuming that these conditions are representative of nearby upslope stands, new rules many not be applied for many years along most streams because timber stands will be too young to harvest economically. In addition, the rate of natural recruitment of functional LWD will initially be low and then increase as riparian stands mature. The recovery of natural LWD recruitment process from the current condition will take from decades to centuries (Bilby and Ward 1989).

> Active wood-placement strategies are important for meeting near-term LWD needs in many fishbearing streams. In fact, streams with low existing levels of LWD and early- to mid-seral riparian stands, may require active placement in order to meet adequate LWD levels over the near term (the next 30 or more years).

Only Alternative 2 provides incentives for instream LWD placement. LWD placement would provide short term benefits to stream systems by providing a more complex habitat structure, nutrient input, and substrate for invertebrate colonization, all of which would benefit fish habitat. These benefits may improve current conditions until the natural riparian corridor can regenerate and provide consistent inputs of LWD. Many Washington streams currently have low levels of instream LWD and adjacent riparian stands are early- to mid-seral. Thus, LWD placement may be the only way to achieve adequate instream LWD levels over the next 30 or more years.

The development of methods for placing large woody debris is fairly advanced (ODF and ODFW 1995), and there would be no significant negative effects to fish from the placement strategies outlined in the Forest Practices Board Manual. The incentive program exists in Alternative 2 for landowners to place wood in stream channels in exchange for removal of additional trees from the outer zone, which have a relatively low probability of naturally recruiting to streams. The relative improvement of current conditions in fish habitat would outweigh the potential risk of loss of LWD from the outer zone over time. The relative addition of wood from the outer zone to the stream channel is a very small percentage and would not provide the same benefits of direct placement of wood within the channel. The major risk of LWD placement is to the transportation infrastructure, including bridges and dams, in the event that structures move from their planned locations.

All of the alternatives allow yarding corridors across RMZs. Yarding corridors provide landowners flexibility in accessing and harvesting suitable timber when a road, stream-crossing, or helicopter yarding would otherwise be required. Requirements for leaving or removing trees cut for yarding corridors would be different under the three alternatives, but these differences in down wood left in the RMZs would be more important for wildlife habitat than aquatic species. Yarding across fish-bearing streams requires a Hydraulic Project Approval (HPA) from WDFW. HPAs provide a regulatory mechanism for requiring mitigation for the yarding corridor and an opportunity for LWD enhancement.

All of the alternatives have a small reduction in LWD potential relative to natural conditions that results from existing stream crossings and stream parallel roads. Alternatives 2 and 3 also include the small landowner exemption that increases the level of risk related to LWD potential in areas with high numbers of small landowners that implement forest practices. Small landowners qualified for the exemption are estimated to own 15 to 20 percent of the private lands in the state and an even small percentage of the total land base (including state and federal lands). See Section 3.4.3.2 for a more detailed discussion of these effects. Existing roads in RMZs and rule exemptions provide a small increase in overall risk of reduced LWD potential relative to natural conditions, but does not substantially change the relative risk among the three alternatives.

All of the alternatives are expected to have increased levels of blowdown along the edges of clearcut units (See Section 3.4.3.2). Blowdown levels should decrease after about five years following harvest unless windstorms are exceptionally mild during that period. Streams with low levels of LWD may benefit in the short-term from increased blowdown rates, but this would also reduce the standing stock of trees available for future recruitment.

Streams with narrower buffers would likely have a higher proportion of fallen trees that also become instream LWD because the unit edge is closer to the stream.

Leaf and Needle Recruitment

Alternative 1 would provide high risk, Alternative 2 would provide moderate risk, and Alternative 3 would provide very low risk of diminished leaf and needle litter recruitment potential.

The level of risk for reduced leaf and needle recruitment to streams is somewhat analogous to the protection of LWD recruitment, including additional risk related to blowdown, yarding corridors, stream crossings and stream parallel roads, and the small landowner exemption. However, small headwater streams, including seasonal streams that usually flow when leaf litter is at its highest level, have a greater influence on leaf and needle litter recruitment to fish-bearing streams than to LWD recruitment because leaf and needle litter is more easily transported in smaller streams. Furthermore, between 25 and 77 percent of stream miles on forested land are smaller nonfish-bearing streams (Type N or Type 4 and 5). Consequently, the level of protection provided by the alternatives for leaf and needle recruitment would be lower than for LWD. Alternative 1 is expected to provide low protection to streams for leaf and needle recruitment and is considered high risk, Alternative 2 is expected to have a moderate level of risk, and Alternative 3 is considered to be very low risk. Leaf and needle recruitment potential are at slightly higher risk under Alternatives 1 and 2 in the Lower Columbia and southwest regions because 63 and 77 percent of forested streams are smaller nonfish-bearing streams located on state or private ownership affected by Forest Practices Rules.

Floodplains and Off-channel Areas

Alternative 1 would provide high risk to floodplains and off-channel habitats. Alternatives 2 and 3 would protect CMZs in addition to riparian buffers. Alternative 3 would also protect beaver habitat zones (BHZs).

As described earlier, off-channel areas include side channels, backwater alcoves, ponds, and wetlands attached at least seasonally to flowing waters. Off-channel areas can be important habitat seasonally or to particular life stages. Off-channel areas may have shallow, low velocity water that is important during fry rearing periods. These areas can also provide protection from high water velocities during flood flows. Some backwater alcoves and ponds result from groundwater seeps and may have shade levels higher than the main channel. These areas provide cool-water refugia during high summertime temperatures.

Off channel habitat occurs most often in low gradient (less than 4 percent) reaches, but occasionally occur in streams with gradients up to 8 percent. These areas are also in the most active parts of the channel. New off-channel habitats are naturally created within the CMZ which is the area that the stream and any side channels could potentially occupy under existing climatic conditions (Pollock and Kennard, 1998). This section assesses the level of protection the alternatives afford off-channel habitat through protection of the CMZ.

Alternative 1 provides very little protection to the CMZ. Widths of riparian buffers are based entirely on the current location of the active channel. Consequently, any new off-channel habitat that develops after RMZ harvest prescriptions were implemented would potentially have reduced riparian protections. For example, if a new side channel were to develop 25 feet from a Type 2 stream with an average buffer width of 50 feet. The RMZ width to that side channel would effectively be reduced to 25 feet.

Under Alternatives 2 and 3, RMZs are measured from the edge of the CMZ (if present) or the bankfull water's edge. In addition, Alternative 3 RMZs also provide protection for existing beaver ponds or potential beaver habitat. The presence of beaver ponds can be particularly important to coho salmon production (Cederholm et al. 2001). Consequently, existing and potential off-channel habitat has high levels of protection under both Alternatives 2 and 3, but is slightly higher for Alternative 3 because of the added protection for beaver habitat.

Water Temperature

Maintenance of natural water temperature regimes is important for all of the listed salmonid species. As described earlier, changes in water temperatures can have both lethal and sub-lethal effects that can affect the species long-term fitness. Of the seven species considered in this document, bull trout tend to be the most sensitive to water temperature increases and have the lowest temperature requirements.

All of the alternatives have some risk of reduced shade and increased water temperatures related to blowdown, yarding corridors, existing stream crossings, and existing stream parallel roads. Alternatives 2 and 3 also include some added risk related to the small landowner rule exemption described in Chapter 2. These effects are described in more detail in Section 3.4.3.2. This added risk from roads and yarding corridors is expected to be relatively small, but difficult to quantify. The added risk from the small landowner rule exemption is dependent the density of small landowners in a watershed and the rate at which they implement forest practices. Overall, these added risks do not substantially change the relative risk among the three alternatives.

ALTERNATIVE 1

Alternative 1 would provide moderate to high risk of effects on fish bearing stream temperatures.

Under Alternative 1, RMZ widths for the east side and west side do not generally meet the 0.75 SPTH shade criterion for Type 1, 2, or 3 streams under either the 100-year or 250-year SPTH assumptions. Alternative 1 includes a shade rule that describes minimum shade requirements by elevation and water quality class (see Section 3.6), but implementation of the rule under Alternative 1 is restricted to the maximum RMZ width. Type 4 and 5 streams do not receive any protection except under limited circumstances and RMZs are much smaller than needed for full shade protection. Adverse water temperature effects are generally more common in eastside watersheds because the climate is warmer and forest types are generally more open compared to the west side. Overall, Alternative 1 is considered to be at high risk of not meeting salmonid temperature requirements on the east side and at moderate risk on the west side (Tables 3.7-3 and 3.7-4).

ALTERNATIVE 2

For Alternative 2, RMZs for Type S and F streams are wider relative to Alternative 1 and include both no-harvest and selective harvest zones. Under some site class situations (e.g., Option 2 with site class III, IV, or V), the no-harvest portions of the RMZs would provide complete shade, and consequently water temperature protection under the 100-year SPTH assumption. Under some situations, Option 1 could provide slightly less protection than Option 2 because thinning in the inner zone could remove some shade-producing trees closer to the stream. However, under Alternative 2, RMZs must maintain minimum canopy closure under the shade rules included in Alternative 1, regardless of the riparian management option chosen by the landowner. Relative to Alternative 1, Alternative 2 improves the shade rule by removing the restriction for the maximum width under which the rule would be implemented. Alternative 2 also provides additional protection for eastside streams within the bull trout distribution by protecting all trees that provide shade to the stream within 75 feet of the channel. Both the shade rule and the bull trout overlay determine shade based upon canopy closure measured with a spherical densiometer which effectively measures most, but not all of the tree shading of direct beam sunlight. In addition, the shade rule protects trees that currently provide shade, but does not take into account the future growth of trees that might eventually provide shade. Consequently, there is some uncertainty about the extent to which these rules would result in higher levels of protection, given the silvicultural prescriptions to be implemented in the core and inner zones. Overall, the risk levels under Alternative 2 for water temperature are considered low for Type S and F westside streams, low to moderate for eastside streams within the bull trout distribution, and moderate elsewhere.

The bull trout overlay is not available on the west side, even though bull trout are present in many westside watersheds. Under Option 1, the largest trees, which likely have the greatest potential to provide shade, would be left in the inner zone. Under Option 2, the lack of the bull trout overlay has no effect because no-harvest buffers would be 80 to 100 feet wide depending upon stream width which are wider than the 75 feet width considered by the bull trout overlay. Overall, the effect of not implementing the bull trout overlay on the west side is expected to be small.

On both the east and the west sides, protection of seeps and springs that provide very cold water is important for bull trout, which have lower temperature requirements compared to other salmonids. Sensitive sites (headwall seeps, side-slope seeps, and alluvial fans) are provided 50-foot no-harvest buffers under Alternative 2 that will provide some thermal protection. In addition, the DOE is considering revisions to Washington State temperature standards (see Section 3.11). These revisions are likely to include species- and lifestage-specific standards to be applied to stream reaches where they are present or expected to be present. Specific standards are likely to be implemented for bull trout. The adaptive management program of Alternative 2 is expected to adjust prescriptions, if necessary, to meet new temperature standards when they are implemented.

Alternative 2 would provide low to moderate risk of effects on fish bearing stream temperatures; however, there is a high degree of uncertainty regarding the effect of no RMZs on many Type N streams on downstream fish streams.

Alternative 2 provides RMZs for at least 50 percent of the length of Type N_p stream reaches, including groundwater seeps and hyporheic zones that would provide cool water. However, no RMZs are required on Type N_p streams for small landowners. Partial protection to narrow Type N_P streams unprotected by buffers can be provided within about 10 years of harvest from the growth of overhanging shrubs and young trees. Some increases in water temperature within Type N_p streams are expected following adjacent timber harvests. Nevertheless, there is still high uncertainty regarding the influence Type N streams on downstream temperatures in Type S and F streams. Type N_s streams do not receive any protection, but this should generally not effect fish because these streams usually do not contain water during hot summer weather.

Overall, Alternative 2 is ranked as having low to moderate risk of not providing adequate water temperature protection on the east side and on the west side. Moderate risk is more likely on the west side in areas where Option 1 is implemented and in lower elevation basins (<1,640 feet) where the possibility of adverse water temperatures is more likely. Moderate risk is more likely on the east side in areas outside of the bull trout overlay.

One area of moderate uncertainty is the effect of nearby clearcuts on air temperatures surrounding streams, even in the presence of shady buffers. Significant increases in air temperatures could lead to negative effects to water temperatures. Another area of uncertainty is the affects of nearby clearcuts on groundwater temperature. Evidence for this effect is not available, but an effect has been hypothesized by Brosofske et al. (1997). Under Alternative 2, research conducted as part of adaptive management could reduce the level of uncertainty for these two issues.

ALTERNATIVE 3

Alternative 3 would provide low risk of effects on fish bearing stream temperatures.

Alternative 3 includes no-harvest RMZs for all streams. With the exception of streams greater than 30 percent gradient, the widths of the RMZs are expected to provide full shade protection relative to the 0.75 SPTH criterion. Consequently, Alternative 3 is ranked as having very high protection to provide shade for both eastside and westside watersheds. Alternative 3 also has some uncertainty concerning the effects of upslope clearcuts on stream temperature under shady conditions. However, since RMZs are wider under Alternative 3, the level of risk is low.

Forest Chemicals

The application of pesticides commonly occurs on commercial forestlands to decrease disease from fungal and insect pests and to decrease competition by undesirable vegetation (see Appendix H, Forest Chemicals). Of these three forest chemicals, herbicides are the most commonly used. Application techniques include hand, machine, and aerial spraying. Improper application of pesticides that results in delivery to fish-bearing streams can result in direct acute losses of fish and chronic reductions in fitness through disease, stress, or reduced feeding (Appendix H).

Alternative 1 would provide moderate risk, Alternative 2 would provide low to moderate risk, and Alternative 3 would provide low risk to fish from forest pesticide applications.

Under Alternative 1, flowing streams and other areas with surface water have a 25-foot or 50-foot buffer that excludes machine or aerial spraying, respectively. However, no buffers are required for hand spraying. Under Alternatives 2 and 3, buffers for aerial application will include the inner zones for fish-bearing waters plus an additional buffer (up to 325 feet) and offset (up to 50 feet) dictated by wind conditions and application height. Type N streams with flowing water will have buffers ranging from 50 to 100 feet depending upon wind conditions and application height. However, Alternative 2 would allow spraying directly on seasonal streams without surface water. Consequently, persistent chemicals could be delivered to fish-bearing stream when flowing waters return. In addition to buffers, Alternative 3 requires that all plants with cultural value be protected from pesticides and that no pesticides be used within 50 feet of all typed streams, including hand spraying.

In comparing the alternatives, it should be recognized that evidence of acute or chronic negative effects of forest pesticide use to fish under current FPRs (Alternative 1) is generally lacking. However, it is also clear that many of the commonly used pesticides have severe effects under laboratory conditions and if improperly used, applied during adverse conditions, or otherwise are allowed to enter fish-bearing waters at toxic concentrations, these effects could be realized in the environment. Consequently, the use of many pesticides in some areas requires a Class IV-special permit (WAC 222-16-070) under all alternatives.

Based primarily upon required buffer widths, Alternative 1 is considered to have low to moderate risk from negative effects to fish while Alternatives 2 and 3 are expected to have low risk. Some uncertainty is present under Alternative 2 because implementation of buffer widths relies entirely on the skill and professional judgment of the pilot applying the pesticide. Implementation of the buffers requires that pilots accurately judge wind speed, wind direction relative to the stream, and distance from the stream. In addition, direct spraying is allowed on Type N_s streams and persistent pesticides could eventually be transported to fish-bearing waters. Alternative 3 would have very high protection because all spraying is eliminated within 50 feet of all streams. The requirement under Alternative 3 that plants with cultural value be protected is problematic for implementation of the prescription. It is unclear which plants are considered to have cultural value and how they will be identified and protected in the field. Consequently, it is possible that for areas where extensive field surveys would be required to protect plants of cultural value, aerial pesticide spraying could be eliminated as a practical application technique.

Fish Passage

Concerns for fish passage on commercial forestlands usually refer to passage through culverts at stream crossings. Historically, concerns were also raised about large log jams which led to stream cleaning programs in some western states (Maser and Sedell, 1994). However, the concerns over passage at log jams were later found to be unrealistic and stream cleaning programs were actually detrimental in many areas. Reduced fish passage or complete blockages at culverts are usually the result of undersized culverts or culverts with water velocities too high for their length, sub-optimal placement relative to stream grade and aspect, and lack of downstream holding pools (Hicks et al., 1991).

Little difference in fish passage protection is present among the three alternatives for new roads because all crossings require HPAs from the Washington Department of Fish and Wildlife.

Salmon and trout have a powerful instinctual desire to move upstream during spawning migrations which leads them to pass seemingly insurmountable obstacles such as waterfalls. However, biological and physical limitations can restrict their movements. These limitations include burst swimming speed and duration, leaping ability, and water velocities and depth. Factors that effect burst swimming speeds and duration include fish size and condition. Larger fish can swim faster and fish approaching senescence have reduced capacity or require longer rest periods between bursts. Leaping ability is a combination of swimming speed and the availability of suitably sized pools from which to leap. Optimally sized pools allow the fish to reach maximum speed at the proper angle to make the leap. Swimming speeds and water velocities determine the length of pipe through which a fish can successfully maneuver.

Culverts become barriers when their physical characteristics exceed the capacity of fish biology. Barriers can occur to both juveniles moving upstream and downstream and adults primarily moving upstream. Common problems include perched outlets with unsuitable leaping pools, culverts that become dry during summer months, culverts that are too long, culverts with high gradients resulting in high water velocities, and culverts with inadequate resting places. In addition, undersized or poorly constructed culverts that blowout during peak flows can become obstacles until fixed.

Little difference in the protection of fish passage is apparent among the three alternatives for the construction of new roads. Under Alternative 2 and 3, changes in stream crossing standards specific to anadromous fish passage (WAC 222-24-040 Paragraph 3) are deleted from the rules and standards are deferred to WDFW as part of a HPA as defined in the Hydraulics Code (WAC 220-110). HPAs are also required under Alternative 1. Consequently, the alternatives are essentially equivalent.

Substantial differences are present among the alternatives for identifying and modifying or replacing existing culverts that are passage barriers. As mentioned earlier, criteria for the construction of stream crossing structures under current regulations are currently based, in part, on whether a stream is fish-bearing (WAC 222-24-040). For example, culverts must be a minimum diameter of 24 inches for streams with anadromous fish and a minimum diameter of 18 inches for streams with resident game fish. Therefore, the assumptions made in determining a fish-bearing stream are critical for evaluating whether existing stream crossings meet FPRs.

The current DNR classification system has five categories:

- Type 1—All waters inventoried as "shorelines of the State"; highly productive fish-bearing waters
- Type 2—Highly productive fish-bearing waters not designated as Type 1 streams
- Type 3—Fish-bearing waters with substantial populations
- Type 4—Perennial streams without substantial fish populations

- Type 5—Nonfish-bearing intermittent streams

Numerous additional criteria based upon channel width, gradient, flow, size of impoundment (if present), and level of domestic use are utilized to categorize a stream (WAC 222-16-030). Recent checking of this classification system has shown that many fish-bearing waters were mistyped as nonfish-bearing waters. Therefore, under Alternative 1, some passage problems could occur as a result of stream typing errors.

Under Alternative 1, the current stream typing criteria would continue because there would be no systematic upgrade of culverts with fish passage problems. Some culverts would be identified and fixed as part of watershed analysis, but watershed analysis is voluntary for private landowners. Consequently, problem culverts could remain as passage barriers until a forest practices application was received for a nearby harvest or the state identified the problem through a state-sponsored watershed analysis. Based upon the forest practices application or watershed analysis, the DNR could then require improvements to or replacement of problem culverts. Alternatives 2 and 3 both would require new stream typing systems that would increase the number of streams typed as fish-bearing and would expedite correction of fish passage problems.

Changes in stream typing systems under Alternatives 2 and 3 would increase the stream miles classified as fishbearing.

Under Alternative 2 a new stream typing system would be implemented for state and commercial forestlands (see Appendix C). The new system will include:

- Type S: All waters inventoried as "shorelines of the State";
- Type F: Waters not classified as Type S, which contain fish habitat; and
- Type N: Waters not classified as Type S or F, which do not contain fish habitat and are either perennial streams (Type N_p) or intermittent (Type N_s)

Determination of default Type F waters lacking ground-truthing will occur using a model, currently under development, that is likely to include stream gradient, drainage size, and other factors. Type F waters are likely to include all streams currently categorized as Type 2 and Type 3, plus a portion of Type 4 streams. Consequently, the number of stream miles assumed to be fish-bearing will expand considerably under Alternative 2 compared to Alternative 1. Notably, Type F waters do not require fish presence, but do require fish habitat that could be used if fish were present. Errors in stream types from the model can be corrected based upon field observations.

Alternative 3 would also implement a new stream typing system based upon geomorphic characteristics:

- Type 1: <20 percent gradient; all fish-bearing streams and other channels are considered important for fish.
- Type 2: 20 to 30 percent gradient; channels are considered important for coarse sediment storage and as sources of LWD.
- Type 3: >30 percent gradient; channels are considered prone to channelized landslides and as sources of LWD.

Under Alternatives 2 and 3, flow condition criteria at culverts appear adequate for most species, but may be too high for trout under some circumstances.

Under Alternative 2, landowners would be required to upgrade road networks to current standards within 15 years and a road maintenance and abandonment plan must be prepared within 5 years. Alternative 3 also includes road plans, but upgrades would be required within 10 years. Included in the revised Forest and Fish Emergency Rules Board Manual (FPB, 2000) are flow condition criteria for a given culvert length and fish species, and specific requirements for prioritizing roadwork based upon fish passage. Passage criteria in the Emergency Rules for fish through culverts appear adequate for most species and life stages when compared to criteria reported by Powers and Orsborn (1984). However, water velocity criteria for trout are 50 to 100 percent higher than criteria reported in Powers and Orsborn (1984). Consequently, passage protection may not be adequate under all circumstances for trout.

Based upon the sample sections, the eastside state and commercial forestlands include 9.7 percent of culverts on fish-bearing streams (Types 1 to 3) under Alternative 1 while the west side has 12.5 percent fish-bearing streams (Table 3.7-8). Based upon proposed changes in stream typing systems, Alternative 2 (Types F and S) would have 27.6 percent and 17.9 percent of culverts identified as being on fish-bearing streams for the east side and west side, respectively. The proportions for Alternative 2 and 3 are similar because not all streams less than 20 percent gradient were assumed to be fish-bearing, only Type F and S. Under Alternatives 2 and 3, higher scrutiny and potential upgrades for fish passage would occur on 5.4 percent more streams on the west side and 17.9 percent on the east side. In combination, the new plans, passage criteria, and stream-typing systems should result in substantial improvements in fish passage within the next 10 to 15 years for Alternatives 3 and 2, respectively, with the largest amount of restoration occurring in east side forests.

Table 3.7-8. Percentage of Stream Crossings on Fish-bearing and Nonfish-bearing Streams by Alternative

Alternative	Westside		Eastside	
	Fish-bearing	Nonfish-bearing	Fish-bearing	Nonfish-bearing
1	12.5	90.3	9.7	87.4
2	17.9	82.1	27.6	72.4
3	17.9	82.1	27.6	72.4

Fish-bearing includes Stream Types 1, 2, and 3 for Alternative 1 and Types F and S for Alternatives 2 and 3.

Neither Alternative 2 or 3 require upgrades to all culverts. Upgrades will be required based upon the effect of a culvert on public resources. If no negative effects are present from a culvert, then the culvert will not require replacement until the end of its life.

FISH PASSAGE: CONCLUSION

Based upon the discussion above, Alternative 1 is considered to have a high level of risk for fish passage. Under Alternative 1 substantial amounts of spawning and rearing habitat will continue to be underutilized by listed salmonids. Both Alternatives 2 and 3 provide substantially more protection than Alternative 1 and are considered to have low risk, with the possible exception of trout under some high-flow circumstances. Notably, changes in the stream typing system under both Alternatives 2 and 3 would result in more streams being typed as fish-bearing. Alternative 3 provides slightly more protection than Alternative 2 because it accelerates the schedule for implementing RMAPs and requires a cap on road densities. Flow condition criteria, in culverts, for trout are higher than reported in some of the scientific literature. Additional research is recommended to determine if criteria used in the Emergency Rules are adequate for the protection of trout passage.

3.7.3.3 Synthesis

This section is designed to provide a regional perspective of the alternatives, and a discussion on how they might affect the status of priority fish species found in the regions. Numerous factors, including forest practices, affect the abundance and distribution of Pacific salmon and trout. Other factors such as urbanization, agriculture, fish harvest, hatchery management practices, ocean conditions, and dams for hydroelectricity, flood abatement, irrigation, and drinking water all contribute in varying strengths to the current status of listed fish species. NMFS suggest in their listing documents (see Table 3.7-1) that human-influenced changes in all of these factors (except perhaps ocean conditions) will be required to progress towards a regional recovery of these species. Depending upon the watershed, each of the factors will have more or less influence on the recovery of any listed species in that watershed. Consequently, in any individual watershed, Forest Practices Rules may be either major or minor influences on the salmonids in that watershed. Relative to other factors influencing their status, Forest Practices Rules have a large effect on bull trout because populations are found predominantly in forested areas upstream of major hydroelectric dams and in agricultural and urbanized areas. Most bull trout populations are not anadromous. Marine conditions, therefore, have little to no influence on populations (other than potentially affecting regional climate).

> Forest practices are among many factors affecting the status of listed fish species. Improvements in FPRs alone are unlikely to lead to recovery of listed fish species in most areas.

The analysis in this section is based upon the assumption that factors unrelated to forest practices may prevent attainment of robust, harvestable populations of salmonids even if the prescriptions in the EIS alternatives were 100 percent effective, and the first two goals under the purpose and need were met. Under the first goal, private timber companies can comply with ESA by avoiding take, or obtaining protection under Section 10 or Section 4(d) of ESA. ESA does not require private parties to recover listed species. Goal 2 is to restore and maintain riparian habitat on nonfederal forest lands to support a harvestable supply of fish. It is possible to meet this goal even if other factors prevent salmonids from utilizing this habitat. Some salmonid populations could be extirpated in the future because of non-forest practice-related factors. This assumption is necessary because integration of all the various factors and their range of possible future outcomes is highly speculative and would require a level of detail and site specificity far beyond the scope of this analysis.

The analysis area covers about 39 percent (9,483 square miles) of lands on the west side and about 15 percent (6,287 square miles) of lands on the east side of Washington state. This is a significant amount of land for both regions of the state. Areas with larger amounts of forestland and timber harvest activities should roughly have proportionally larger potential effects on listed salmon and trout because of FPRs. However, this simple relationship is complicated by mixed ownership and mixed management objectives in most parts of the state. As indicated earlier, few lands or priority fish are affected by FPRs in the Islands and Columbia Basin regions because these regions have few fish-bearing streams or are mostly non-forested. Consequently, it is unlikely that FPRs will have any effect on the recovery of any listed species in these two regions.

Within all regions, implementation of Alternative 1 would likely continue habitat degradation in some forested regions and contribute to any further declines in listed species living in these areas. In contrast, Alternative 2 is considered to have moderate to high protection, and Alternative 3 is considered to have high to very high protection. One major improvement under Alternatives 2 and 3 is that CMZs are provided more protection because RMZs begin at the edge of CMZs rather than from the ordinary high water mark boundary as practiced under Alternative 1. Alternatives 2 and 3 both include monitoring and adaptive management, albeit in slightly different forms (see Appendix I). Consequently, both of these alternatives could be equitable and include high levels of protection in the long-term, based upon future changes in prescriptions.

Monitoring and adaptive management are important tools needed to ensure Alternatives 2 and 3 would achieve desired future conditions over the long-term.

Alternative 3 would implement the widest no-harvest buffers, includes an accelerated schedule for RMAPs, and provides a cap on road densities. Consequently, it has the highest level of long-term protection of the three Alternatives. However, in contrast to Alternative 2, Alternative 3 does not provide incentives to landowners to accelerate the recovery of some streams through active LWD placement strategies or thinning of over-stocked riparian stands. These strategies are allowable under Alternative 3 provided the landowner obtains a Class IV–special permit or hydraulic project approval, but there is little to no economic incentive to implement these strategies.

All of the alternatives will include watershed analysis. Alternatives 2 and 3 improves upon current watershed analysis methods by adding modules for cultural resources and stream restoration activities, and makes improvements in the hydrology and water quality modules. Alternative 3 would also include a module for monitoring watershed conditions and prescription effectiveness. A major difference is that Alternative 2 would delete the prescriptive phase of the riparian analysis while the phase would continue under Alternative 3. Under Alternative 2, the prescriptive phase would not be needed, based upon the assumption that standard rules would be effective for preventing cumulative effects. This is a moderate to high-risk assumption because prescriptions under Alternative 2 do not include a watershed-level perspective. Under Alternative 2, effectiveness monitoring under adaptive management program and focused in representative watersheds is assumed to result in a better understanding of the effects of forest practices on salmonids and their habitat. The adaptive management program is also assumed to implement any needed changes in prescriptions to maintain adequate levels of protection. Failure of these assumptions would be detrimental to the recovery of listed species even if individual forest prescriptions appear adequate. If standard rules provide all the necessary certainty to landowners concerning activities on their lands, the benefits of voluntary watershed analysis may not outweigh the costs to private landowners. Because prescriptions are generally equivalent or more conservative under Alternative 3, the likelihood of voluntary completion of watershed analysis by landowners is probably about the same under

Instream and riparian enhancement can be an important

Alternative 3 as Alternative 2. Nevertheless, watershed analysis will eventually be completed for all watersheds, but will likely require a longer period for completion. Watershed analysis, when implemented, will continue to be important for obtaining and organizing baseline information needed for monitoring.

Changes in FPRs under Alternatives 2 and 3 will have the greatest influence on the long-term recovery of the species rather than the short-term. Improvements in road management practices and road upgrades should be apparent first, particularly related to fine sediment which influences the survival of incubating salmon and trout eggs, and fish passage through culverts. A reduction in the frequency and magnitude of mass wasting events that deliver coarse sediment to streams should become apparent. However, some streams may require many years (20 to 100 years or more) to adjust to historical deposits of coarse sediment. Similarly, LWD recruitment is a long-term process. Moderate levels of recovery may require 80 years or more in areas with early-seral stage riparian stands. Some stands will require longer periods to obtain key pieces without some form of management such as thinning or removal of hardwoods. Consequently, in severely degraded forested areas, it is unlikely that fish habitat conditions will improve substantially in the near term (less than 20 to 40 years) without enhancement.

Puget Sound

The Puget Sound region is the most urbanized region in the state.

Chinook salmon and bull trout are listed as threatened in the region plus a summer run of chum salmon that is found in Hood Canal. Coho salmon is a candidate species. Each of the 4-Hs has been cited as contributing to the listing of one or more of the species. Many of the lowland areas of the region are highly urbanized. This region is the most heavily populated region of the state with 386 square miles (about 3 percent) of the land categorized as urban growth areas. FPRs regulate commercial timber activities on about 34 percent (4,464 square miles) of the lands in the region while the federal government manages about 34 percent (4,418 square miles) and the DNR manages about 8 percent (997 square miles) under their HCP. All of the major river systems in the region have hydroelectric and/or drinking water dams and reservoirs. Overall, the improvements to FPRs under Alternatives 2 and 3 could have a significant effect on the recovery of the listed species. However, because non-forest related activities also have a large effect on these species, it is unlikely that changes in FPRs, by themselves, would lead to the recovery of these species. Changes in FPRs would likely have the largest effect on bull trout because they are predominantly found in forested areas and are influenced less by marine factors, harvest, hatcheries and urbanization.

Olympic Coast

DNR lands in the Olympic Coast region are managed under the state's HCP.

All of the priority species are present in the Olympic Coast Region (Figures 1 to 3). Bull trout are listed as threatened throughout the region and the Ozette Lake population of sockeye salmon is listed as threatened. Coho salmon is a candidate species. Of the 4-Hs, habitat appears to be the highest priority factor for bull trout. The hydroelectric facilities present in the region are not considered a major issue in general, although one or more dams may be important in specific basins. No hatcheries are stocking bull or sockeye salmon in the region. FPRs regulate commercial timber activities on about 26 percent (705 square miles) of the lands in the region. An additional 38 percent (1,032 square miles) of the land is managed by the Federal Government (mostly National Forest and National Park in higher elevations) and 17 percent (464 square miles) are managed under the DNR's Habitat Conservation Plan. Consequently, the improvements to FPRs under Alternatives 2 and 3 could have a significant effect on the recovery of the listed or potentially listed species, particularly bull trout, but other protection and recovery programs in the region would also have a large influence. The distribution of listed sockeye salmon is restricted and NMFS status review cited several major non-forestry related factors including non-native introductions, ocean conditions, and harvest affecting their status. Nevertheless, Nehlsen et al. (1991) also indicated forest practices in the 1940s and 50s may have contributed to their decline. Consequently, improvements in FPRs could have a positive effect on their recovery.

Southwest

> Improvements in FPRs under Alternatives 2 and 3 would likely have a significant effect in the Southwest Region because a large proportion of lands are in private commercial forest management.

All of the priority species are present in this region except sockeye salmon. Only bull trout and sea-run cutthroat trout are listed in the region, but coho salmon is a candidate species. Similar to the Olympic Coast Region, habitat degradation appears to be the leading factor influencing listing of species in the region. A few hydroelectric projects are present in the region, but they are not considered a major issue and no hatcheries are stocking bull trout. FPRs regulate commercial timber activities on about 70 percent (2,493 square miles) of the lands in the region. The state manages an additional 11 percent (374 square miles) of the land under their HCP. Federal forestlands include about 203 square miles or 6 percent of the land. Consequently, the improvements to FPRs under Alternatives 2 and 3 are likely to have a significant effect on the recovery of the listed or potentially listed species with only a moderate level of influence from other land-use practices.

Lower Columbia River

> FPRs regulate forest activities on nearly half of the lands in the Lower Columbia region.

All of the priority species are present in this region. Sockeye do not spawn or rear in the region, but use the mainstem Columbia River as a migration corridor. Chinook salmon, chum salmon, and steelhead are listed, and present downstream of Mossyrock Dam and Merwin Dam on the Cowlitz River and Lewis River, respectively plus other tributaries and the mainstem Columbia River. Bull trout are listed as threatened throughout the region where they are present and sea-run cutthroat trout are also listed as threatened. Coho salmon is a candidate species. Each of the 4-Hs has been cited as contributing to the listing of one or more of the species. FPRs regulate commercial timber activities on about 45 percent (2,179 square miles) of the land in the region. The DNR manages an additional 9 percent (433 square miles) of land under their HCP. About 32 percent (1,562 square miles are under Federal management. Consequently, the improvements to FPRs under Alternatives 2 and 3 could have a significant effect on the recovery of the listed or potentially listed species, but improvements in other factors are probably needed as well.

Middle Columbia River

> Improvements in FPRs would be important for fragmented bull trout populations in the Middle Columbia River Region

All of the priority species are present in this region, except chum and sea-run cutthroat trout. Sockeye do not spawn or rear in the region, but use the mainstem Columbia River as a migration corridor. Chinook and chum salmon are listed in the westernmost potions of this region as part of the lower Columbia River ESU, and steelhead are listed as threatened throughout the region except for the White Salmon River. Bull trout are listed as threatened throughout the region. Each of the 4-Hs has been cited as contributing to the listing of one or more of the species. FPRs regulate state and private commercial timber activities on about 13 percent (1,360 square miles) of the lands in the region. The Federal government manages slightly more land (18 percent, 1,810 square miles). Agriculture is an important land-use within the region, particularly within the Yakima Valley and irrigation diversions have been cited as a major concern in the region. Several major dams are also present in the region for hydroelectricity (Bonneville, The Dalles, John Day) and irrigation (Cle Elum, Kachees, Keechelus, Rosa) Consequently, the improvements to FPRs under Alternatives 2 and 3 could have a moderate overall effect on the recovery of the listed or potentially listed species. Changes in FPRs would likely be a major factor in the recovery of bull trout in the region because they are predominately found in forested areas and are influenced less by marine factors, dams, commercial harvest, hatcheries and urbanization. Improvements in FPRs would also be significant for the recovery of chinook salmon and steelhead, however improvements in other land-use practices will also likely be required for successful recovery.

Snake River

FPRs regulate only a small proportion of lands in the arid Snake River Region.

Chinook salmon, sockeye salmon, steelhead and bull trout are present in the region. However, sockeye salmon do not spawn or rear in the region but use the mainstem Snake River as a migration corridor. Chinook, steelhead, and bull trout are listed as threatened within the region. Each of the 4-Hs has been cited as contributing to the listing of one or more of the species. However, the region is relatively arid and only about 5 percent (346 square miles) of the lands are regulated by FPRs. Federal management occurs on about 7 percent of the land (491 square miles). The state manages a very small amount of forestland (about 32 square miles) in the region. Nearly 88 percent (5,941 square miles) of the land in this region is unforested. A significant portion of the fish habitat upstream of this region in Idaho is unavailable to listed anadromous species because of impassable dams (Dworshak, Hells Canyon Complex). Four other major hydroelectric dams (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite) are present along the lower Snake River and are considered by many to be a major influence on the status of chinook salmon, sockeye, and steelhead in the region. Consequently, any improvements in FPRs under Alternatives 2 and 3 would only be a very minor contribution towards the overall recovery of listed species in the region. However, within those areas that do have forest practices, improvements to FPRs should provide benefits to species that live in those areas.

Upper Columbia River downstream of Grand Coulee Dam

FPRs affect forest activities on about 11 percent of the land in the Upper Columbia River Region downstream of Grand Coulee Dam.

The priority species found in the region include chinook salmon, sockeye salmon, steelhead, and bull trout. Chinook (endangered), steelhead (threatened), and bull trout (threatened) are listed within the region. Each of the 4-Hs has been cited as contributing to the listing of one or more of the species. FPRs regulate commercial timber activities on about 6 percent (655 square miles) of the lands in the region while Federal management occurs over about 39 percent of the lands (4,073 square miles). State forestlands occur over about 5 percent of the lands (469 square miles). About 47 percent (4,865 square miles) of the lands are unforested in the region. The region also includes a number of dams for hydroelectricity (Rocky Reach, Wanapum, Priest Rapids, Rock Island, Wells, Chief Joseph, and Lake Chelan). Consequently, the improvements to FPRs under Alternatives 2 and 3 could have a low to moderate overall effect on the recovery of the listed species, and other factors will be important for their recovery. However, the effect of improved FPRs could be significant within the watersheds with commercial and state forestlands. Changes in FPRs would likely have the largest effect on bull trout because they are predominately found in forested areas and are influenced less by marine factors, harvest, hatcheries and urbanization.

Upper Columbia River upstream of Grand Coulee Dam

FPRs only affect bull trout and other resident species in the Upper Columbia River Region upstream of Grand Coulee Dam.

The only priority species present in this region is bull trout, which are listed as threatened. Hydroelectric and irrigation dams that have fragmented bull trout distribution plus habitat degradation has been cited as major factors leading to the listing in this region. FPRs regulate commercial timber activities on about 25 percent (2,685 square miles) of the lands in the region. State forests are present on about 4 percent (440 square miles) of land and Federal management occurs on about 21 percent (2,241 square miles). Consequently, the improvements to FPRs under Alternatives 2 and 3 could have a significant effect on the recovery of bull trout in the region.

Chapter 3

3.8 WILDLIFE

3.8.1 Introduction

The goal of the wildlife section is to describe the biology of and analyze the impacts of the three proposed alternatives on six selected amphibian species that are considered sensitive to forest practices, as well as other riparian-dependent species that may be significantly affected by the proposed changes to the Washington FPR. The six amphibian species are the Van Dyke's salamander (*Plethodon vandykei*), the Dunn's salamander (*Plethodon dunni*), the Columbia torrent salamander *(Rhyacotriton kezeri*), the Cascade torrent salamander (*Rhyacotriton cascadae*), the Olympic torrent salamander (*Rhyacotriton olympicus*), and the tailed frog (*Ascaphus truei*). They were selected because: 1) they are closely associated with aquatic and riparian habitats; 2) they have been shown to be sensitive to timber harvest; and 3) they lack significant federal protection in some portion of their range (either through status or occurrence on federal lands). Some other aquatic or riparian-associated species with special status are generally addressed. These species include the red-legged frog, Oregon spotted frog, western pond turtle, harlequin duck, great blue heron, beaver, muskrat, mink, and otter. Although most of Washington's terrestrial vertebrate species use riparian habitats for essential life activities (Knutson and Naef, 1997), analysis of the alternatives emphasizes those species with special status most likely to be affected.

Quantitative analyses presented in the environmental effects section based primarily on analyses presented in Sections 3.5 (Riparian Habitat) and 3.6 (Wetlands), as well as on Appendices C (Riparian Habitat) and F (Wetlands). These analyses will be used to compare the two proposed alternatives with the current FPRs using three different evaluation criteria: (1) how well the alternatives would protect the quality and quantity of riparian habitat as measured by a variety of forest microhabitat variables important to the target species (e.g., microclimate, downed wood, and sedimentation); (2) how well the alternatives would protect unique habitats known to be priority habitat for amphibians (e.g., stream junctions); and (3) how well the alternatives would protect habitat of other riparian-dependent species (i.e., beaver).

3.8.2 Affected Environment

3.8.2.1 Importance of Riparian Habitats to Wildlife

Riparian areas are among the most important wildlife habitats in Washington. Approximately 85 percent of Washington's terrestrial vertebrate species use riparian habitat for essential life activities (Knutson and Naef, 1997; Thomas et al., 1979; Brown et al., 1985). O'Connell et al. (1993) and Oakley et al. (1985) provide extensive reviews of the literature on wildlife use of riparian areas. This section highlights some significant contributions of several attributes of riparian habitat that are of particular importance to amphibians and other riparian-dependent species. These include complex vegetation structure, snags and downed woody debris, edge effect, and connectivity.

Complex Vegetation Structure

Riparian zones are noted for their structural complexity. They often are characterized by a variety of vegetation layers, including herbaceous, shrub, sapling, tree, and overstory layers (Oakley et al., 1985). This floristic diversity is encouraged by the frequent disturbance in most riparian areas, particularly along larger streams, due to flood events, mass wasting events, fire, windthrow, etc (Wissmar et al., 1994; Agee, 1994). A high degree of vegetative structures in a riparian zone provides abundant sites for breeding, roosting, foraging, and hiding for numerous species. In particular, riparian vegetation structure has been shown to be very important to breeding songbirds (Sanders and Edge, 1998; Knopf, 1985; Martin, 1988; Hagar, 1999). Doyle (1990) and McComb et al. (1993) reported that structural diversity of riparian vegetation was important to small mammals. However, narrow riparian zones along small streams often do not provide structural diversity enhancement beyond that provided by adjacent upland areas.

Snags and Downed Woody Debris

Snags and downed woody debris serve very important biological functions for a wide variety of species. Many birds and small mammals use cavities in snags for nesting and resting. Brown (1985) estimates that over 100 species of wildlife use snags, with approximately 53 of them being cavity-dependent. These species include woodpeckers, cavity-nesting ducks, owls, bats, and most mustelids. Marten and fisher use cavities in live and dead trees as nest sites (Ruggiero et al., 1994). Snags and downed woody debris provide other important habitat functions, including foraging, roosting, and perching. Wildlife will use a wide variety of trees in different stages of decay, including trees with heart rot, hollow trees, broomed trees, completely dead snags, and downed logs of all decay classes (Bull et al., 1997). For instance, Bull et al. (1992) found that pileated woodpeckers in the Blue Mountains of Oregon selectively roosted in live and dead grand firs that were extensively decayed by Indian paint fungus. In the same region, downed logs provide important habitat for forest-dwelling ants, which are a primary prey of pileated woodpeckers (Torgersen and Bull, 1995). Similarly, density of cavity-nesting birds in other regions has been positively correlated with the density of large snags (Raphael, 1980; Madsen, 1985). Marten use large downed logs for predator avoidance, thermal protection, and natal dens (Buskirk and Ruggiero, 1994).

Timber harvesting has been shown to reduce the density of snags in the landscape and this has been correlated with reduced abundance of cavity-nesting species (Dickson et al., 1983; Brown et al., 1985; O'Connell et al., 1993). Retention of riparian buffer strips has the potential to maintain greater densities of snags and downed logs in the landscape. Environmental conditions in riparian and wetland areas can contribute to the production of snags and downed logs. Undercut slopes, soil saturation, ponding, high water, and other types of soil disturbance that are common in riparian areas can all contribute to the weakening of trees and subsequent production of snags or deformities. Furthermore, riparian buffer strips that border clearcuts are very vulnerable to windthrow. One study of 40 buffers on small streams in northwest Washington found that an average of 33 percent of all trees in the buffers were affected by windthrow (Grizzel and Wolff, 1998). This windthrow increased the large in-stream woody debris counts in this study by 52 percent compared to counts at the time of harvest (1 to 3 years earlier). This study concluded that windthrow may be the most important mechanism for LWD recruitment to stream channels. However, these authors caution that much of this LWD is suspended over narrow, confined channels and does not contribute to sediment retention (Grizzel and Wolff, 1998). Partially submerged snags in wetlands, particularly beaver ponds, are important habitat for species such as cavity-nesting ducks, tree swallows, woodpeckers, and osprey (Knutson and Naef, 1997).

Windthrow is not the only mechanism that can reduce the amount of snags in a riparian zone. Some snags in a given riparian zone will have to be removed prior to and during adjacent timber harvest activities to meet state safety regulations. According to chapter 296-54 of the WAC, any tree that presents a hazard to workers because of some observable natural or manmade defect is labeled a "danger tree" and must be removed. Although no data is available to quantify the effect of this regulation on the amount of snags in riparian areas, Alternative 2 does include several restrictions and requirements that would protect snags and other wildlife trees. These include: (1) any trees in the core or inner zone in Western Washington damaged by yarding must be left; (2) at least 5 wildlife trees per acre must left in RMZs on westside 20-acre exempt parcels; (3) all wildlife trees must remain in RMZs on eastside 20-acre exempt parcels; and (4) the minimum trees per acre requirements for westside RMZs would be expected to be high enough that a component of dead snags is insured.

Edge Effect

The edge effect is a term used to describe the potentially positive and negative effects associated with the ecotone between two different habitat types. These effects can include increased exposure to predation, increased prey availability, increased vegetative structural complexity, and increased exposure to light and heat. It is generally used in reference to the ecotone between recently harvested areas and older forests, but it can also be applied to the ecotone between riparian areas and upland habitats. Riparian areas, due to their usually long and sinuous shape, are dominated by edge habitat. Edge habitat is characterized by the presence of species representative of both the riparian zone and the adjacent habitat. The diverse vegetation and complex structure that characterizes the edge of riparian zones makes this area attractive and beneficial to many species, particularly generalist species (Knutson and Naef, 1997; Wilcove et al., 1986). These species benefit from the myriad of different nesting and perching substrates as well as multiple vegetation layers (e.g., grass, herb, shrub, tree) and usually more abundant food sources such as berries or insects (Knutson and Naef, 1997). Species richness is thus often greater in edge habitat (Fraver, 1994). On the other hand, some studies have demonstrated the negative effects of edge habitat on species that are adapted to the conditions of forest away from the edge (i.e., interior habitat). Increased edge habitat can increase exposure to predators such as crows and ravens, brown-headed cowbirds, and raccoons. A literature review by Paton (1994) suggested that predation and parasitism rates are often significantly greater within 164 feet of an edge. Nelson and Hamer (1995) found that successful marbled murrelet nests were located significantly farther from edges (> 180 feet) than unsuccessful nests. The effects of predation have been shown to extend up to 2,000 feet into a stand (Wilcove et al., 1986).

Numerous studies have demonstrated or suggested widths for riparian buffers to maintain the diversity of interior forest species. Several studies have shown that riparian buffer strips up to 230 feet wide maintain some, but not all, of the species diversity of the interior forest bird guild (Hagar, 1999; Kinley and Newhouse, 1997). Even wider zones (>1,500 feet) were suggested by Kilgo et al. (1997) to maintain all the species associated with undisturbed bottomland hardwood forests in South Carolina. Most riparian buffers would be too narrow to support populations of many species, particularly larger mammals such as marten or fisher (Ruggiero et al., 1994). However, for some species that are more dependent on the aquatic and riparian habitats, such as beaver, mink, and river otter, riparian buffer strips may be able to maintain enough habitat to support all their habitat requirements. Beavers do most of their foraging and dam construction within 700 feet of the water's edge (Allen, 1983). Similarly, river otter and mink spend most of their time in close proximity to moving water (O'Connell et al., 1993). Other species, such as black bear, often occur in riparian areas due to abundance of food and prey items, but are not limited to those areas for reproduction (O'Connell et al., 1993).

Connectivity

Riparian areas can provide important habitat linkages in the landscape. Many different species have been documented using riparian areas for travel and dispersal (Lovejoy et al., 1986; Brown et al., 1985; Gibbs, 1998; Harris, 1984). Although very few species are limited to riparian corridors for movement, many mobile species such as marten, fisher, cougar, deer, and birds will utilize riparian corridors. Beier (1993) documented cougars in the Santa Ana Mountains of southern California using relatively narrow riparian corridors for movement. Machtans et al. (1996) found that forest birds would utilize habitat corridors more often than clearcuts. The potential value of riparian corridors increases in a fragmented landscape as they become the only safe way for some species to cross unsuitable habitat, which is the case for the cougars in the Beier (1993) study.

3.8.2.2 Target Amphibian Species

In this section the six target amphibian species are discussed. The discussions include a general description of each species and its status in Washington, the distribution of the species by region, a description of the habitat preferences and relationships with forest management.

Van Dyke's Salamander

The Van Dyke's salamander is a plethodontid salamander endemic to Washington. Van Dyke's salamanders are known from three areas of Washington: the Olympic Mountains, the southern Cascades (including populations in southeastern Thurston County), and the Willapa Hills (Leonard et al., 1993). Populations of this species are generally small and fragmented compared to other Pacific Northwest woodland salamanders (Nordstrom and Milner, 1997; Wilson et al., 1995; Brodie, 1970). Most of the recorded locations for this species come from the wetter, western slopes of these areas (Dvornich et al., 1997). The Van Dyke's salamander is a Washington State Candidate species for listing, is considered an "at-risk" species by the Washington State GAP Analysis Project (Cassidy et al., 1997), and is a Survey and Manage species under the Northwest Forest Plan (USDA and USDI, 1994). Two out of three regions where this species occurs are dominated by federal ownership (Olympic National Park and Wilderness Area, Mount Saint Helens National Monument, Gifford Pinchot National Forest), and the third is dominated by private commercial forest lands (southwest Washington).

This species has been said to be more strongly associated with aquatic and riparian environments than most other plethodontids, with the possible exception of the Dunn's salamander (Leonard et al., 1993). However, relatively few studies have been done to characterize the habitat limitations of the Van Dyke's salamander (Jones, 1989; Wilson et al., 1995). Van Dyke's salamanders have been found inhabiting seeps, streams, and north-facing slopes with rocky substrates in forested areas from sea level to 3,600 feet (Leonard et al., 1993; Nordstrom and Milner, 1997). They have also been found associated with large downed woody debris in riparian and upland areas removed from any rocky substrates (Wilson et al., 1995). These sites were usually in areas of high precipitation along the Washington Coast (Wilson et al., 1995). Wilson et al. (1995) found that the distribution of this species in Washington was limited by precipitation, unconsolidated geologic deposits, and temperature. Areas where Van Dyke's salamander populations have been found, in almost every case, have precipitation greater than 59 inches annually, do not have unconsolidated sediments, and have a soil temperature above 43 degrees F (Wilson et al., 1995).

Some studies have suggested that the distribution of Van Dyke's salamander has been limited by clearcutting (Wilson et al., 1995; Corn and Bury, 1989). Wilson et al. (1995) suggests that rapid logging of the lowland forest separating the three concentrations of the Van Dyke's salamander may have contributed to their isolation. It is logical that where this species is more dependent on downed woody debris it would be more susceptible to negative impacts from logging. Furthermore, logging can compact rocky substrates where this species may be seeking shelter. Another reason this species is particularly sensitive to timber management is because it is often found associated with headwaters and nonfish-bearing streams, which currently receive relatively little protection (i.e., riparian buffers) from harvest. At least one study has shown that riparian buffers can encourage persistence of amphibians following timber harvest (West and O'Connell, 1998). However, exactly how disturbance types, timber harvest prescriptions, or potential RMZ prescriptions may affect persistence of Van Dyke's salamanders in the landscape is unknown.

Dunn's Salamander

The Dunn's salamander is one of our largest plethodontid salamanders. It can reach 6 inches in total length (Leonard et al., 1993; Nussbaum et al., 1983). Dunn's salamanders are known to occur from northwestern California to extreme southwestern Washington (Nussbaum et al., 1983; Leonard et al., 1993). In Washington, they only occur in the Willapa Hills, which is the northernmost limit of their range (Leonard et al., 1993). Most of the record locations for this species come from Pacific, Lewis, Wahkiakum, and Cowlitz counties (Dvornich et al., 1997). The Dunn's salamander is a Washington State Candidate species, is considered an "at-risk" species by the Washington State GAP Analysis Project (Cassidy et al., 1997). Most of the range of this species in southwest Washington is dominated by private commercial timberlands.

Dunn's salamanders have been found inhabiting wet, rocky substrates that are heavily shaded, including seeps, streams, wet talus slopes, and stream edges in forested areas from sea level to 3,300 feet (Leonard et al., 1993; Nordstrom and Milner, 1997). Corn and Bury (1991) found a significant association between the abundance of Dunn's salamanders in the Oregon Coast Range and the percent cover of rock. They also found that Dunn's salamanders occurred more often on steep slopes, where exposed talus was present, and in stands at higher latitudes (Corn and Bury, 1991). Dunn's salamanders are not considered aquatic, but rather riparian associates (Corkran and Thoms, 1996; Gomez and Anthony, 1996). Results of Bury et al. (1991) support this conclusion. Approximately 90 percent of Dunn's salamanders observed in their study were found in stream bank habitat as opposed to riffle or pool habitat.

Timber management has been identified as a human activity that can disturb habitat for Dunn's salamanders (Nordstrom and Milner, 1997). Timber harvest can remove canopy cover that maintains microclimatic conditions favored by this species, including cool substrate temperatures and high relative humidity (Nordstrom and Milner, 1997; Ledwith, 1996; Chen et al., 1993, 1995). Timber harvest can also disturb the rocky substrate that is preferred habitat of Dunn's salamanders. Another reason this species is particularly sensitive to timber management is because it is often found associated with headwaters and nonfish-bearing streams, which currently receive relatively little protection (i.e., riparian buffers) from harvest. At least one study has shown that riparian buffers can encourage persistence of amphibians following timber harvest (West and O'Connell, 1998). Furthermore, several studies have demonstrated a direct relationship between buffer width and the maintenance of cool microclimate and high humidity (Ledwith, 1996; Brown and Krygier, 1970).

Olympic Torrent Salamander

The Olympic torrent salamander is the original species from which four species of torrent salamander were split by Good and Wake (1992). Three of these four torrent salamanders occur in Washington; the Olympic, Cascade, and Columbia torrent salamanders. All torrent salamanders are stream-adapted larval salamanders (larvae have gills and four legs) characterized by very short gills, depressed body, and a low short caudal fin (Nussbaum et al., 1983). Olympic torrent salamanders are known to occur only on the Olympic Peninsula of Washington (Nussbaum et al., 1983; Leonard et al., 1993). Most recorded locations for this species come from Clallam, Jefferson, and Mason counties (Dvornich et al., 1997). The Olympic torrent salamander is considered an "at-risk" species by the Washington State GAP Analysis Project (Cassidy et al., 1997). Most of the range of this species is dominated by federal land ownership (mainly Olympic National Park and Wilderness Area).

Habitat requirements for torrent salamanders are thought to be similar to the other three species. Therefore, this discussion makes reference to studies on all four species across their range. Generally, torrent salamanders are very closely associated with cold, clear streams, seeps, or waterfalls (Leonard et al., 1993). They are often found in the splash zone of rapidly flowing, steep gradient streams or in saturated moss or talus nearby (< 1m), hiding under cover objects (Blaustein et al., 1995; Bury et al., 1991). Several studies have observed a strong association between the abundance of torrent salamanders and the presence of old-growth forests (Corn and Bury, 1991; Corn and Bury, 1989; Welsh and Lind, 1991). These studies suggest that the cause of this association is that old-growth forest help maintain suitable cool water temperatures that torrent salamanders require for survival. Welsh and Lind (1996) reported that suitable water temperatures for torrent salamanders are usually between 6.0 and 15.0 degrees Celsius. This association with old-growth forests may be secondary to other factors such as slope, aspect, and geologic formation in some areas, particularly moist coastal environments such as northwestern California (Diller and Wallace, 1996; Welsh and Lind, 1996).

Timber harvest can remove canopy cover that maintains microhabitat conditions favored by this species, including cool substrate temperatures and high relative humidity (Nordstrom, 1997; Ledwith, 1996; Chen et al., 1993, 1995). Timber harvest and associated road construction activities have also been documented to increase the risk of debris torrents, causing scouring and increasing the presence of fine sediments in headwaters and high-gradient streams (Morrison, 1975; Swanston and Swanson, 1976). The presence of fine sediments has been shown to severely reduce instream habitat quality by filling interstitial spaces critical to salamanders for movement and larval development (Corn and Bury, 1989; Diller and Wallace, 1996). However, another study has suggested that deposition of the finest sediments, which are mainly composed of organic matter, are important to these salamanders for food (Welsh and Lind, 1996). Notably, most of the studies that demonstrate negative effects of sedimentation are from the ranges of the southern species, not the Olympic torrent salamander. Streams in the range of the southern torrent salamander (northwestern California and southwestern Oregon) are prone to carry heavier sediment loads than streams in the Olympics and Washington Cascades due to the presence of unconsolidated marine sediments, heavier rainfall, and warmer climate. Thus, the northern torrent salamanders may experience fewer sedimentation problems than the southern species.

Even more so than Van Dyke's or Dunn's salamander, the torrent salamander is associated with headwater streams, seeps, and springs (Nordstrom, 1997; Welsh and Lind, 1996; Diller and Wallace, 1996). This means that they receive even less benefit or protection from the current FPRs. However, most of the range of this species in Washington is in federal ownership.

Cascade Torrent Salamander

The Cascade torrent salamander is the most variable species of torrent salamander. Cascade torrent salamanders are distributed in the Cascade Mountains of Washington and Oregon from just north of Mount Saint Helens, Washington to northeastern Lane County, Oregon (Leonard et al., 1993). The valley of the Cowlitz River separates its range from that of the Olympic torrent salamander. Most recorded locations for this species in Washington come from Skamania, Cowlitz, and Clark counties (Dvornich et al., 1997). The Cascade torrent salamander is a state Candidate species in Washington and is considered an "at-risk" species by the Washington State GAP Analysis Project (Cassidy et al., 1997). Federal land ownership (Gifford Pinchot National Forest and Mount Saint Helens National Monument) dominates much of the range of this species.

Habitat requirements and effects of timber management on the Cascade torrent salamander are similar to those of the Olympic torrent salamander (see above).

Columbia Torrent Salamander

The Columbia torrent salamander is distributed in the Coast Ranges of Washington and Oregon from the Willapa Hills/Long Island area of Washington to the Grand Ronde River Valley in Oregon (Leonard et al., 1993). The valley of the Chehalis River separates its range from that of the Olympic torrent salamander. Most recorded locations for this species in Washington come from Pacific, Lewis and Wahkiakum counties (Dvornich et al., 1997). The Columbia torrent salamander is a state Candidate species in Washington and is considered an "at-risk" species by the Washington State GAP Analysis Project (Cassidy et al., 1997). Most of the range of this species in Washington is dominated by private commercial timberlands.

Habitat requirements and effects of timber management on the Columbia torrent salamander are similar to those of the Olympic torrent salamander (see above). In particular, a recent study by Grialou and others (2000) found that Columbia torrent salamanders were absent from clearcuts in southwestern Washington within several years after harvest.

Tailed Frog

The tailed frog is a widely distributed frog endemic to the Pacific Northwest. It is the only member of the genus *Ascaphus*, one of the two extant genera in the world's most primitive frog family (Welsh et al., 1993). Tailed frogs are found in the Olympic, Cascade, Blue, Wallowa, and Siskiyou mountains of Washington and Oregon, as well as the Oregon Coast Range and northwestern California (Leonard et al., 1993; Blaustein et al., 1995). They have been found from sea level to approximately 7,000 feet in elevation (Leonard et al., 1993). In Washington, tailed frogs have also been reported from the Willapa Hills and Capitol State Forest (Dvornich et al., 1997). The tailed frog is considered an "at-risk" species by the Washington State GAP Analysis Project (Cassidy et al., 1997) due to its strong association with cold, clear mountain streams. Due to its wide distribution, the range of the tailed frog includes a wide variety of land ownerships throughout the mountainous regions of the state.

The tailed frog is considered more strongly associated with cold, permanent, fast-flowing streams than any other anuran (Nussbaum et al., 1983; Welsh et al., 1993). Tailed frogs are highly adapted for life in fast-flowing headwater streams. These adaptations include internal fertilization of females, reduced lungs, hardened fingertips, and lack of vocalizations (Leonard et al., 1993; Welsh et al., 1993). Larvae are entirely aquatic, requiring between one year (in lowland areas) and four years (in high elevation areas) to reach metamorphosis (Leonard et al., 1993; Welsh et al., 1993). Tailed frogs have also been shown to be strongly associated with old-growth forests (Blaustein et al., 1995; Welsh et al., 1993; Corn and Bury, 1991; Aubry and Hall, 1991; Corn and Bury, 1989; Welsh and Lind, 1988). These older forests are usually more structurally complex, containing a multi-layered canopy and an abundance of downed woody debris. This structural complexity may contribute a stable streamside environment with the microhabitat characteristics that are required by tailed frogs. Tailed frogs have the narrowest range of temperature requirements of any frog native to Washington. Their eggs require water temperatures between 5 degrees and 18.5 degrees Celsius (Brown, 1975). Tailed frogs have also been shown to be sensitive to sedimentation, which may negatively impact important food sources such as nonfilamentous algae (Welsh and Ollivier, 1998). The tailed frogs narrow habitat requirements suggest that they are more vulnerable than other frogs to population declines following habitat disturbance. This conclusion is supported by studies in northwestern California (Welsh et al., 1993) and Washington (Aubry and Hall, 1991) and Oregon (Bull and Carter, 1996).

Timber harvest has the potential to diminish the quality of tailed frog habitat by increasing sedimentation in streams, removing canopy cover important for maintaining stream temperatures, removing downed woody debris, and compacting riparian substrates

(Leonard et al., 1993; Blaustein et al., 1995). Corn and Bury (1989) and Dupuis and Steventon (1999) found that logging had significant negative effects on densities of tailed frogs. The latter study also found that buffered creeks in their study area (in British Columbia), on average, had higher densities of tailed frogs than logged creeks. This study also suspected that increased sediment input from logging played a larger part in their results than did increased stream temperature. Several studies have also suggested that riparian buffer strips may be able to protect the streamside microhabitat variables required by tailed frogs even if the surrounding habitat is not maintained as old-growth (Bull and Carter, 1996; Corn and Bury, 1989).

3.8.2.3 Other Riparian-Dependent Species

This section presents a general description of the other wildlife species in Washington, including rare, threatened, and endangered species, that would be most affected by the alternatives. Table 3.8-1 lists all of these riparian-associated species that have some special status within the state. This list is not intended to be a complete list of all species native to Washington that use riparian areas; instead, it is a list of sensitive species or species with some sort of state or federal status that would potentially be significantly impacted by the proposed alternatives.

Seventy-nine percent of Washington amphibian species use streams, ponds, and temporary waters for mating, egg deposition, and larval development (Nussbaum et al., 1983). Because of their limited range, limited mobility, and sensitivity to water temperature and quality, amphibians are particularly sensitive to alterations of riparian and aquatic habitat (Nussbaum et al., 1983). Several of the amphibian species with special status in Washington, such as the Oregon spotted frog, have limited distributions and thus may be more at risk from disturbance than other species (Knutson and Naef, 1997).

One reptile species with special status, the western pond turtle, uses aquatic and riparian habitats for most of its life requisites (Hays et al., 1999). Large woody debris is particularly important for cover and basking sites for this species (Knutson and Naef, 1997).

Table 3.8-1. Washington Special Status and High Profile Species with Strong Riparian Associations

Common Name	Scientific Name	Status[1/]	Distribution[2/]	Use of Riparian Areas[3/]
Amphibians				
Columbia torrent salamander	Rhyacotriton kezeri	SC, FSC	5 6	Stream/Creek - b, f
Cascade torrent salamander	*Rhyacotriton cascadae*	SC	5 6	Stream/Creek - b, f
Dunn's salamander	*Plethodon dunni*	SC	5 6	Stream/Creek - b, f
Van Dyke's salamander	*Plethodon vandykei*	SC, FSC	5 6	Stream/Creek - b, f
Red-legged frog	*Rana aurora*	FSC	4 5 6	Lake/Pond/Slough - b, f
Cascades frog	*Rana cascadae*	FSC	2 3 4 5 6	Lake/Pond/Stream - b, f
Northern leopard frog	*Rana pipiens*	SC	1 2 3 5	Lake/Pond - b, f
Oregon spotted frog	*Rana pretiosa*	SE, FC	5 6	Lake/Pond - b, f
Columbia spotted frog	*Rana luteiventris*	SC, FSC	1 2 3 4	Lake/Pond - b, f
Western toad	*Bufo boreas*	SC	1 2 3 4 5 6	Lake/Pond - b, f
Olympic torrent salamander	Rhyacotriton olympicus		6	Stream/Creek – b, f
Tailed frog	Ascaphus truei		1 2 3 4 5 6	Stream/Creek – b, f
Reptiles				
Western pond turtle	*Clemmys marmorata*	SE, FSC	4 5 6	Lake/Slough/Stream - f
Sharptail snake	*Contia tenuis*	SC	2 3 5 6	Wetlands - b, f
Birds				
Common loon	Gavia immer	SC	1 2 3 4 5 6	Lake - b, f
Aleutian Canada goose	*Branta canadensis leucopareia*	ST, FT	5 6	Lake - b, f
Harlequin duck	*Histrionicus histrionicus*	FSC	1 2 3 4 5 6	River/Stream - b, f
Bald eagle	*Haliaeetus leucocephalus*	ST, FT	1 2 3 4 5 6	River/Lake - f
Sandhill crane	*Grus canadensis*	SE	1 2 3 4 5 6	Wetlands - b, f
Yellow-billed cuckoo	*Coccyzus americanus*	SC	1 2 4	Stream/Slough - b, f
Willow flycatcher	*Empidonax traillii*	FSC	1 2 3 4 5 6	Stream/Pond - b, f
Pileated woodpecker	*Dryocopus pileatus*	SC	1 2 3 4 5 6	River/Stream – b, f
Great blue heron	*Ardea herodias*	P	1 2 3 4 5 6	Stream/Wetlands – b, f
Wood duck	*Aix sponsa*	P	1 2 3 4 5 6	River/Stream – b, f
Mammals				
Shaw Island Townsend's vole	*Microtus townsendii pugeti*	FC	4	Stream/Lake/Pond - b, f
Columbian white-tailed deer	*Odocoileus virginianus leucurus*	SE, FE	5	Stream/Slough – b, f
Mink	*Mustela vison*	P	1 2 3 4 5 6	River/Stream – b, f
Beaver	*Castor canadensis*	HP	1 2 3 4 5 6	Stream/Creek – b, f
Muskrat	*Ondatra zibethicus*	HP	1 2 3 4 5 6	Stream/Wetlands – b, f
River Otter	*Lutra canadensis*	HP	1 2 3 4 5 6	River/Stream – b, f

[1/] SE = State Endangered; ST = State Threatened; SC = State Candidate; FE = Federal Endangered; FT = Federal Threatened; FC = Federal Candidate; FSC = Federal Species of Concern; P = Priority species with WDFW, but not listed; HP = high profile/high public interest.

[2/] Numbers indicate WDFW Regions: 1 = Eastern; 2 = North Central; 3 = South Central; 4 = North Puget Sound; 5 = Southwest; 6 = South Puget Sound and Coastal.

[3/] Indicates type of riparian area used, and type of use (b = breeding; f = foraging), based on Brown, 1985.

Several groups of birds are closely associated with riparian areas. These include many neotropical migrants, cavity-nesting birds (i.e., woodpeckers and waterfowl), waterfowl, and raptors (mainly the bald eagle and osprey). The complexity of riparian vegetation, as described earlier (see Section 2.1.1), provide breeding, foraging, and cover habitat for many of these species (Knutson and Naef, 1997).

A wide variety of mammals are closely associated with riparian areas. At least five endemic small mammals are considered obligate inhabitants of streamside areas: water shrew, marsh shrew, muskrat, beaver, and water vole (O'Connell et al., 1993). The habitat characteristics of riparian areas, including presence of water, abundance of food, moist microclimate, and edge habitat support the life requisites of these species and a wide variety of other mammal species, including river otter, mink, raccoon, black bear, fisher marten, mule deer, and elk (Knutson and Naef, 1997). Timber harvest has the potential to reduce (and in some cases increase) the populations of these species by affecting cover, decreasing or increasing the prey base or food sources, and affecting breeding areas.

3.8.3 Environmental Effects

3.8.3.1 Evaluation Criteria

This section describes the three evaluation criteria that were chosen to evaluate how the proposed alternatives would impact wildlife resource. They are: (1) the degree of protection afforded to various microhabitat variables, such as humidity and air temperature, sedimentation, and downed wood, that are important to the six target species by each alternative, (2) the degree of protection afforded to various unique habitat types that are important to the target amphibian species, and (3) the degree of protection afforded to various habitat types important to the other riparian-associated wildlife species identified in Table 3.8-1. These evaluation criteria are described in more detail below.

Microhabitat Variables Important to the Target Amphibian Species

There are several components of the microenvironment of riparian areas that influence the suitability of that habitat for amphibians. They include microclimate, downed wood, and sedimentation.

Some of the important microclimatic parameters of riparian areas include solar radiation, soil temperature, soil moisture, air temperature, wind velocity, and air moisture or humidity. These microclimatic parameters are generally different in riparian than upland areas. Riparian areas are usually lower in the landscape, are closer to water, and tend to have more complex vegetation structure. These characteristics contribute to a cooler, moister microenvironment for amphibians. Timber harvest activities can disrupt this microclimatic gradient between upland and riparian areas (see Section 3.5 - Riparian Functions, Microclimate for more information). For instance, timber harvest can expose a riparian area to increased solar radiation, thus potentially increasing the ambient air and water temperatures in that area and reducing the relative humidity and soil moisture. Brosofske et al. (1997) found that no-harvest riparian buffers between 148 feet and 984 feet in width were needed to maintain unaltered microclimatic gradients near streams.

Based on this study, many standard buffer widths currently in use may not fully protect riparian microclimate.

Timber management activities can change the quantity and size of sediment that is delivered to a stream. This can lead to stream channel instability, pool filling by coarse sediment, or introduction of fine sediment to spawning gravels. Increased sedimentation in headwater streams has been shown to negatively impact some amphibian species by filling interstitial spaces in the stream substrate that are important for movement and larval development (Corn and Bury, 1989; Diller and Wallace, 1996). Riparian buffer strips in Washington have been shown to be effective in filtering overland sediment, with strips of no-harvest buffers of at least 30 feet identified as effective in some cases (Rashin et al., 1999).

Downed wood is an important microhabitat feature for amphibians. Bury et al. (1991a) found that terrestrial salamander abundance was associated with the presence of coarse woody debris. Ensatina and western redback salamander abundance was positively correlated with amounts of coarse woody debris in western Washington forest (Aubry et al., 1988; Aubry and Hall, 1991). Coarse woody debris provides moist sites where amphibians can seek shelter from predators, forage on the soil surface while still maintaining body moisture, and breed. Nordstrom and Milner (1997) recommend that a minimum of 5 uncharred hard logs at least 12 inches in diameter and 23 feet long per acre, as well as all soft logs the same size, should be retained to provide suitable coarse woody debris for Dunn's and Van Dyke's salamanders. Large woody debris in streams also provides cover for amphibians, as well as erosion control and substrate for egg deposition (see Section 3.5 - Riparian Functions, LWD Recruitment, for more discussion of LWD).

All of these components are evaluated according to how adequately the proposed alternatives provide riparian buffers and other suitable regulations to maintain them. For management of amphibians, WDFW recommends buffer widths between 35 and 100 feet to retain appropriate shade on streams, widths between 100 and 180 feet to maintain woody debris recruitment, and widths up to 300 feet to control sedimentation (Larsen, 1997). As described in Section 3.5.3.1 (Riparian Function Criteria), the results of Brosofske et al. (1997), Dong et al. (1998), and Chen (1991) indicate that a minimum of 147 feet is considered necessary to maintain most microclimatic gradients, buffer widths greater than 230 feet for air temperature are required, and buffers of up to 787 feet are required for protection of humidity. Ledwith (1996) demonstrated that buffer widths of at least 100 feet between clearcuts and streams in northern California significantly reduce air temperature and increase relative humidity. Other studies have reported that 100-foot wide buffers between clearcuts and streams are sufficient to retain adequate shade on streams to maintain suitable stream temperatures for amphibians (Brown and Krygier, 1970; Brazier and Brown, 1973; Steinblums et al., 1984). Retaining buffer strips of at least 100 feet can help maintain woody debris recruitment (Bottom et al., 1983; Harmon et al., 1986; VanSickle and Gregory, 1990).

FEMAT (1993) recommends a buffer width of 170 feet in western Washington (which is equal to one site potential tree height) to provide complete protection for sediment filtration. This width was chosen because: (1) it meets the requirements of buffer widths recommended in the literature (Johnson and Ryba, 1992); and (2) it is consistent with the width chosen for the EBAI model (see Appendix D – Riparian Habitat). This is the distance that was assumed to be the baseline target for this analysis of that aspect of amphibian microhabitat requirements. Target widths for other microclimatic parameters are chosen from Brosotske and others (1993) and Chen (1991) (see above). Target guidelines for downed wood are difficult to determine. Amphibian species such as western red-backed salamander and ensatina are more closely associated with downed woody debris than are the target amphibian species. Nonetheless, at least one study recommends course woody debris retention in the range of 100-300 cubic meters per hectare to provide adequate cover for terrestrial salamanders (Butts and McComb, 2000).

Unique Habitats Important to the Target Amphibian Species

Many unique habitats in the landscape provide refugia for the target amphibian species. These include stream junctions, talus, downed woody debris, seeps, and springs. These unique habitats were chosen as evaluation criteria because (1) some of them are addressed separately in the proposed alternatives and (2) some of the target amphibian species are more closely associated with unique habitats than the background riparian zone. These components are evaluated according to how much and how well they are protected under the proposed alternatives. In addition to the unique habitats listed above, protection of wetlands was also chosen as an evaluation criterion for the effects of the alternatives. Although none of the six target amphibian species is directly associated with wetland habitats, wetland buffers and other protection measures can provide indirect protection for nearby unique habitats that may support populations of these species.

Other Riparian-Associated Species

The third criterion that was chosen for evaluating the potential impacts of the proposed alternatives on wildlife was the potential effects on other riparian-associated species in Washington. This criterion was limited primarily to species with special status (see Table 3.8-1). This criterion was chosen because so many species, other than the target amphibian species, use riparian areas for some portion of their life cycle. This criterion is evaluated qualitatively with regard to how well the protections proposed in Alternative 2 and 3 compare to existing FPRs.

3.8.3.2 Analysis of Alternatives

Microhabitat Variables and Target Amphibians

The first evaluation criterion was the potential protection afforded to microhabitat variables, including microclimatic variables, sedimentation, and downed wood, by the proposed alternatives.

ALTERNATIVE 1

Under Alternative 1 the current FPRs would be maintained. Current FPRs protect microhabitat variables only indirectly through various riparian prescriptions. The primary prescription that is currently directly applicable to the maintenance of suitable microhabitat conditions for amphibians is the stream-shade requirement, which provides enough shade on Type 1, 2 or 3 streams to maintain stream temperatures at either 16 and 18 degrees Celsius, depending on the classification of the stream and the elevation of the site (Forest Practices Board Manual M-5). In general, riparian buffers on Type 1 and 2 streams are between 25 and 100 feet wide, buffers on Type 3 streams are between 25 and 50 feet wide, while Type 4 and 5 streams generally have no protected buffer requirements (see Section 3.5).

Alternative 1 would result in high risk for most amphibian habitat variables along Type 1-3 streams and very high risk along Type 4 and 5 streams.

Based on recommended riparian widths, the RMZs provided for Alternative 1 for Type 1-3 waters, which range between 25 and 100 feet, do not maintain complete microclimatic conditions, downed woody debris recruitment, and sediment filtration. RMZs are not currently required on Type 4 and 5 streams, except under special circumstances; therefore maintenance of the microhabitat variables important to amphibians will not occur on these headwater streams. These conclusions are supported by the results of the EBAI analysis (see Section 3.4 and Appendix D), which concludes that Alternative 1 produces an EBAI for LWD of less than 30 percent of the recommended EBAI for complete protection of LWD recruitment potential for both fish-bearing and nonfish-bearing streams in both eastern and western Washington. Because the buffer requirements for LWD recruitment are more stringent than buffer requirements for protection of other riparian functions (i.e. - downed wood), the EBAI can also be used to compare relative protection for those parameters as well (see Appendix D). The EBAI for sediment filtration under Alternative 1 is 62 percent of the recommended EBAI for complete protection. This result is explained primarily by the lack of riparian protection, and thus sediment filtration, along Type 4 and 5 streams. Rashin et al. (1999) demonstrated that BMPs were ineffective without RMZs on Type 4 and 5 streams. Sullivan et al. (1990) demonstrated that current FPRs result in significant increases in air temperature in riparian areas.

There are some practices in the current FPRs that can mitigate for some of the lack of maintenance of these parameters and limit the effects of timber harvest on microhabitat, particularly some that apply to sediment delivery. These include: (1) clearcuts can be a maximum of 240 acres; (2) yarding in RMZs must minimize damage to vegetation; (3) sidecast along skid trails is limited to above the 50-year floodplain; (4) no more than 30 percent volume removal every 10 years within 200 feet of a designated shoreline (usually Type 1 waters); (5) riparian leave tree requirements are greater when stream substrate is gravel or cobble; and (6) hardwood to conifer ratios must be maintained.

ALTERNATIVE 2

Alternative 2 would be expected to improve the microclimate along streams by requiring a variety of more restrictive buffers compared to Alternative 1. These include a minimum no-harvest zone of 50 feet (i.e., the core zone), and selective harvest zones (with two options) up to a total of 200 feet beyond the bankfull width or CMZ of all Type S and F streams on the westside (depending on site class), and a minimum no-harvest zone of 30 feet and selective harvest zones up to a total of 130 feet beyond the bankfull width or CMZ of all Type S and F streams on the eastside. Furthermore, and perhaps more importantly for amphibians, Alternative 2 provides a variety of protective measures for Type N streams, which are primarily the streams that are Type 4 and 5 streams under Alternative 1.

These additional prescriptions include: (1) a 30-foot equipment limitation zone on all perennial and intermittent Type N streams; (2) a 50-foot no-harvest buffer applied on either side of all perennial Type N streams for the length of the stream up to 500 feet upstream of its intersection with a Type S or F stream; and (3) a 56-foot radius buffer patch surrounding the intersection of two or more perennial Type N streams. In addition to these prescriptions, a variety of protective buffers must be used by landowners to protect sensitive sites. These include: (1) no harvest within 50 feet of a soil zone perennially saturated from a headwall or side-slope seep and (2) no harvest within 50 feet of side-slope spring. Overall, at least 50 percent of the total length of Type N_p waters would receive 50-foot buffers.

Alternative 2 would result in moderate risk of effects on amphibian microhabitat variables, especially along Type S and F streams in areas with high site classes, although proposed buffer widths would still be below optimum. Microhabitat variables would be well below optimum along nonfish-bearing streams with buffers and all habitat variables would lack protection along nonfish-bearing streams without buffers.

As described in Section 3.4 (Riparian Habitat), both options of Alternative 2 would provide improved LWD recruitment, particularly for fish-bearing streams. Under Alternative 2, the EBAI for sediment filtration (see Figure 3.2-2) is approximately 80 percent of the maximum protection for sediment filtration (see Section 3.2.3.2). Notably, the proposed arrangement of expanded linear buffers combined with nodes to protect sensitive areas of headwater streams under Alternative 2 is similar to the standardized buffer approach recommended by the WDFW to protect riparian features and functions important to torrent salamanders, Dunn's salamander, and Van Dyke's salamander (Larsen, 1997).

In contrast to Alternative 1, total buffer widths for site classes I and II approach or exceed the minimum buffer widths recommended for microclimatic parameters, at least on Type S and F streams. However, the no-harvest zones are not wide enough to allow microclimatic conditions to reach unharvested levels in the inner and outer zones. Protection of microclimate parameters along Type N streams would likely make it easier to maintain suitable amphibian habitat in Type S and F streams. Corn and Bury (1989) found that uncut timber upstream from logged stands promoted amphibian diversity in those areas. However, full maintenance of suitable microclimatic conditions along Type N streams may not be achieved, since these streams would be protected with a 50-foot no-cut buffer at most, which is much smaller than the 147-foot buffer recommended by the literature for complete protection.

Microclimatic conditions would be maintained through 100-foot wide no-harvest buffers that are proposed for Type S and F streams greater than 10 feet wide under Option 2. Option 2 under Alternative 2 leaves substantially more trees per acre in the inner and outer zones than Option 1. Although the proposed buffers would likely protect in-stream microclimatic conditions on site class I and II, Type S and F streams (which would benefit the highly aquatic torrent salamanders), microclimatic conditions in the terrestrial environment would approach upland levels as the outer edge of the buffers are approached. This means that the buffer itself would not maintain ideal conditions. Semlitsch (1997) recommends a buffer zone of over 500 feet in width as more ecologically realistic to protect important terrestrial habitat. Similarly, Dodd and Cade (1997) argue that regulatory buffers should consider the many types of amphibian migratory patterns in upland habitats in order to preserve habitat critical to all stages of the amphibians' life cycle.

Alternative 2 recommends the following downed wood guidelines associated with salvage logging in RMZs in western Washington:

Logs with a Solid Core	< 1 Foot Diameter	1-2 Foot Diameter	> 2 Foot Diameter	Total
Number of logs/acre	85	83	26	194

These guidelines may be translated to a downed wood retention range of between approximately 122 and 407 cubic meters per hectare assuming the following: (1) median diameters for each category above are .5, 1.5, and 2.5 feet; (2) logs are either 6 feet or 20 feet long. These amounts cover the entire range recommended in the literature. Therefore, the minimum amount of downed wood required to be left outside the core zone of RMZs in western Washington is adequate for amphibians. This parameter would be expected to have relatively minor effects on the highly aquatic torrent salamanders, and more significant effects on the other more terrestrial salamanders and frogs.

Overall, compared to Alternative 1, the changes to FPRs proposed under Alternative 2 would be expected to maintain suitable microclimatic, downed wood, and sediment delivery conditions for highly aquatic amphibians along site class I and II, Type S and F streams. This alternative would also significantly improve these same microhabitat conditions along other Type S and F streams, as well as along Type N streams. This improvement is due in part to the water typing changes proposed in Alternative 2. These changes include changing many streams that are currently classified as Type 4 streams to Type F streams, based on their gradient (see Appendix C). Microhabitat conditions in these higher site class streams and in the terrestrial habitat of the buffers would not be maintained at optimum levels for the target amphibian species. This would require wider buffers on Type N streams and buffering greater lengths of these streams than are currently proposed under Alternative 2. Although the design of this alternative (and the WDFW recommendations) would result in substantially better protection for both individual amphibians and amphibian populations compared to Alternative 1, the proposed buffers would not provide the optimum amount of protection.

ALTERNATIVE 3

Alternative 3 proposes similar riparian buffers on all streams on both the eastside and westside. The minimum buffer width is based on stream gradient. Streams with 0 to 20 percent gradient receive a 200-foot minimum width, 20 to 30 percent receive 100 feet, and greater than 30 percent receive 70 feet. Thinning would be allowed within these buffers, but only for the purpose of improving riparian function and after the landowner went through the appropriate SEPA procedures. Additional buffers are provided for BHZs and CDZs. CDZs are the areas within 30 feet of the lateral extent of an expected channelized landslide.

According to EBAI analyses, Alternative 3 would provide over 90 percent of the recommended protection for LWD recruitment and sediment filtration on all streams (see Section 3.5 and Appendix C). This result is logical since the proposed buffers on streams

Alternative 3 would result in low risk of effects on amphibian microhabitat variables, especially along lower gradient streams, although proposed buffer widths would still be below optimum for some variables. Along high gradient streams microhabitat variables would be well below optimum, but all would have some protection.

less than 20 percent gradient exceed the 170-foot buffer width requirement for sediment delivery and all Type N streams are consistently protected to some degree. Alternative 3 would protect approximately five times more acreage in affected lands with buffers compared with Alternative 2. Alternative 3 would also provide wide enough buffers on low-gradient streams to create some terrestrial habitat with microclimatic conditions suitable for amphibians, unlike either Alternative 1 or Alternative 2. For example, a 200-foot buffer would be wide enough to provide temperature and moisture conditions approximately 30 feet beyond the banks of the streams that would be suitable for the target amphibian species. This aspect of Alternative 3 is particularly important for the more terrestrial amphibians, such as the tailed frog and Van Dyke's salamander. Furthermore, Alternative 3 would provide additional buffers for beaver habitat. Since this buffer can apply on almost any small basin, low-gradient stream in the state, many streams could potentially have additional buffers added to them due to this provision of Alternative 3.

Based on the expanded primary buffers and additional buffers, Alternative 3 would be expected to provide the most positive benefits to amphibians through protection of sediment delivery, downed wood, and microclimate. However, it would be expected that some variables, such as air temperature and humidity, would still not be completely protected under the rules proposed for Alternative 3.

Unique Habitats and Target Amphibians

Scientists have identified several unique habitat features in the landscape that are of particular importance to the successful maintenance of healthy amphibian populations. These include stream junctions, Type N streams (under Alternatives 2 and 3), talus, and other refugia. This section analyzes the potential protection provided for these features by the proposed alternatives. Some of these features (e.g., stream junctions, Type N streams) are often associated with wetlands. Measures designed to protect wetland habitats can thus provide indirect protection to unique habitats that support the target amphibians. Therefore, this section also analyzes the wetland protection measures of the proposed alternatives.

ALTERNATIVE 1

Headwater streams, seeps, springs, and talus receive little or no direct protection under current FPRs. Protection of these unique habitats is largely indirect, occurring only to the extent that these habitats are associated with wetlands.

Current FPRs delineate Type A and B wetlands. Type A wetlands are non-forested wetlands with open water. Type B wetlands are non-forested wetlands lacking open water. The third category is forested wetlands. Current FPRs do not provide protection for wetlands smaller than 0.25 acre. The average buffer currently provided for any wetland is 100 feet. This buffer is provided only on Type A wetlands larger than 5 acres in size. Smaller Type A wetlands and Type B wetlands larger than 5 acres receive a 50-foot average buffer. Type B wetlands between 0.5 and 5 acres have an average buffer of 25 feet. Type B wetlands between 0.25 and 0.5 acres receive no buffer.

Alternative 1 would provide high risk of impacts to refugia and unique habitats for target amphibians.

These buffers are much smaller than those recommended in the literature. Semlitsch (1997) recommended buffers of over 500 feet around wetlands based on studies of pond-breeding salamanders in numerous studies from the Midwest and East. This large buffer was meant to encompass the terrestrial movements of 95 percent of the populations studied. Some of the more terrestrial of the target amphibian species, such as the tailed frog, Dunn's salamander, and Van Dyke's salamander, can spend considerable amounts of time in upland areas adjacent to riparian areas, usually within 150 – 300 feet from the stream (Gomez and Anthony, 1996). Thus, current RMZs do not protect all habitat used by these amphibians in their daily movements.

ALTERNATIVE 2

Alternative 2 would provide low to moderate risk of impacts to refugia and unique habitats for target amphibians.

Measures proposed under Alternative 2 would provide more protection to unique habitats than Alternative 1. The increased RMZs along Type S and F streams would increase the amount of protection for streamside unique habitats. Furthermore, and perhaps more importantly for amphibians, Alternative 2 would provide a variety of protective measures for Type N streams. Under existing FPRs, most such streams are classified as Type 4 or 5 and receive little or no protection. The torrent salamanders in particular, would benefit from protection of rock and cobble in the splash zone of Type N streams. These protective measures are described above for Alternative 2 under the "Microhabitat Variables and Target Amphibians" subsection. The lack of protection for isolated refugia such as talus would still allow some negative impacts to the more terrestrial amphibians (e.g., Dunn's and Van Dyke's salamanders, and tailed frogs) from future timber harvest.

Wetland buffers under Alternative 2 would not be significantly different from Alternative 1. However, increased RMZs would protect additional acres of wetlands in the affected lands (see Tables 3.5-3 and 3.5-4).

ALTERNATIVE 3

Alternative 3 provides the highest potential benefits for amphibians based on its proposed protection for refugia. It provides the widest potential buffers on riparian areas, ranging from 70-foot buffers on steep gradient (>30%) streams to 200-foot buffers on low gradient (<20%) streams. It also proposes the largest buffers on wetlands, including 200-foot buffers on Type A wetlands greater than 5 acres, 100-foot buffers on Type B wetlands, and snag and canopy retention standards on non-forested wetlands. These buffers are proposed as managed buffers, which means that they are intended to allow thinning where it is beneficial to the proper functioning of the riparian or wetland area (see Chapter 2).

Alternative 3 would provide low risk of impacts to refugia and unique habitats for target amphibians.

These proposed buffers would provide protection to most of the important refugia used by torrent salamanders in the landscape, such as the splash zone of Type N streams. It would also provide enough buffer on isolated wetlands (200 feet for Type A) to protect much of daily movements of salamanders and tailed frogs living in that environment. Despite these improvements, Alternative 3 would still not provide buffers wide enough to maintain all of the habitat requirements of amphibians using the refugia (Dodd and Cade, 1998; Semlitsch, 1998).

Other Riparian Species

The third criterion is the potential protection from the proposed alternatives for other riparian- associated wildlife species.

ALTERNATIVE 1

Current FPRs provide a variety of protections to wildlife species, particularly for species that are state or federally listed as threatened and endangered. These critical habitat prescriptions are listed in Section WAC 222-16-080 of the existing FPRs. Table 3.8-1 lists wildlife species in Washington that have some special status (e.g., state or federal listed, species of concern, or high profile species) and are considered strongly associated with riparian areas for breeding and/or foraging. This table is not meant to be inclusive of all wildlife species in Washington that are associated with riparian areas. As discussed earlier, over 85 percent of Washington's native fauna use riparian areas for some portion of their life cycles. Instead, Table 3.8-1 is limited to species with some special status. Nonetheless, this table provides a general indication of the wide variety of species that could be affected by the proposed alternatives.

Alternative 1 would provide high risk of impacts on other riparian species.

Alternative 1 would do nothing to benefit these other riparian-associated species beyond existing FPRs. Some of the species, such as the Oregon spotted frog, western pond turtle, and Columbian white-tailed deer have extremely limited distributions. While this makes them very vulnerable to extinction, it is unlikely that private forest practices are going to impact these species significantly because site-specific management plans are in place for most of the extant populations (McAllister and Leonard, 1997; Larsen, 1997). Some of the more widely distributed species, including Cascades frog and the red-legged frog, use aquatic and riparian habitats for breeding, but are usually found in more upland habitats for the rest of their life cycle. Current riparian buffers are most likely inadequate for some of these other amphibian and reptile species. Western pond turtles may require buffers well over 1,000 feet in width to accommodate their upland breeding habitat (Holland, 1994). The northern leopard frog is distributed mainly in the shrub-steppe vegetation zone of southeastern Washington, so it would not be significantly affected by existing or proposed FPRs (McAllister et al., 1999). Finally, many of these species are likely to occur in small, temporary wetlands, many of which are not currently protected if they are less than 0.5-acre in size. Cascades frogs can be very abundant in small, isolated high elevation wetlands (Larsen, 1997). As recommended by Dodd and Cade (1998), buffers of over 600 feet may be necessary to adequately protect all the habitat required for the migratory patterns of amphibians in these small wetlands.

As for many of the bird species listed in Table 3.8-1, current RMZ prescriptions do not attempt to protect all of the habitat requirements of these species. The bald eagle receives specific protections for its critical habitat requirements due to its federal threatened status. These special provisions protect large buffers around known nest sites. As for the other avian species, Alternative 1 would do little to minimize negative impacts to these species from human activities. For instance, 100-foot buffers along streams occupied by nesting harlequin ducks are recommended because that is the necessary distance to recruit large woody debris for loafing (Larsen, 1997). Even larger buffers (164 feet) have been recommended to protect suitable nesting habitat (Cassirer and Groves, 1990). Buffers up to 600 feet wide have been recommended for cavity-nesting ducks and pileated woodpeckers (Larsen, 1997).

Similar to the birds mentioned above, the mammals listed on Table 3.8-1 require very large buffers. Some studies have recommended riparian buffers of 100m (328 feet) to protect the area of optimum foraging and cover habitat for mink and beaver (Melquist et al., 1981; Allen, 1983; Knutson and Naef, 1997).

ALTERNATIVE 2

Alternative 2 would provide low to moderate risk of impacts on other riparian species.

Compared to existing conditions, Alternative 2 would be expected to improve habitat for other riparian-associated species in Washington in four mains ways : 1) Alternative 2 would substantially increase the acreage of riparian habitat protected by no-harvest buffers (see Figures 3.4-7 and 3.4-8); 2) it would increase the amount of riparian habitat protected by selective harvest buffers and equipment limitation zones (see Figures 3.4-7 and 3.4-8); 3) it would provide protection for riparian habitat along headwater (Type N) streams, which generally receive no buffers under Alternative 1; and 4) it would provide improved wetland protection due to better mapping techniques and protection of seeps and springs connected to Type N streams (see Section 3.5, Wetlands). These measures would have benefits for riparian-associated species, but the extent of the benefits is unknown.

ALTERNATIVE 3

Alternative 3 would provide low risk of impacts on other riparian species.

Compared to existing conditions, Alternative 3 would have the most positive benefits for other riparian-associated species in Washington. Similar to Alternative 2, they would benefit in four main ways : (1) Alternative 3 would substantially increase the acreage of riparian habitat protected by no-harvest buffers (see Figures 3.4-7 and 3.4-8); 2) it would provide protection for riparian habitat along streams with gradients greater than 30 percent, which generally received no buffers under Alternative 1; and 3) it would provide improved wetland protection due to improved mapping techniques and protection of seeps and springs connected to Type N streams (see Section 3.4, Wetlands). These proposed measures would have benefits for riparian-associated species, but the extent of the benefits is unknown. Nevertheless, Alternative 3 would provide the most protection and potential habitat improvement for other riparian-associated species of any of the alternatives.

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3.9 FIRE

3.9.1 Introduction

Fire has been an integral part of the forest environment for thousands of years. The likelihood of a fire initiation and the extent and severity of the resulting fire are affected by the vegetation and other fuel on the site. This section discusses the frequency of fire in the forests of Washington, the common causes of those fires, and the effects on future fires likely to result from each of the alternatives.

3.9.2 Affected Environment

Forest fires have occurred in the area that now makes up the state of Washington for millions of years. The most common natural cause of these fires is lightning. Areas east of the Cascade Crest average 10 to 15 thunderstorms per year while areas west of the Crest average 5 per year. Most of the forested areas of Washington experience between 1 and 6 lightning fires per 100,000 acres each year. However, lightning fires are more common in some areas in Okanogan, Ferry, and Chelan Counties (Agee, 1993). When conditions are dry and fuel is abundant, these lightning fires can burn large areas. One lightning fire in Chelan County, the1994 Tyee Fire, burned over 140,000 acres and cost millions of dollars to suppress.

In the cool, moist climate of western Washington, climatic conditions, fuel accumulation, and lightning ignition combine to result in extensive stand-replacement fires on an average of once every 230 years (though this varies from as often as every 150 years in drier areas to several hundred years in wetter areas). These fires were generally intense; often 50 to 100 years would pass before these burns became fully restocked with native conifers (Franklin et al., 1981). On the eastside, Ponderosa pine forests historically have had extensive fires every 15 years on average, mixed conifer forests an average of every 50 years, and the moister, high elevation forests experience fire only about once every 500 years (Agee, 1993). Often the more frequent fires on the eastside represented understory burns that maintained the canopy, or at least a portion of the canopy.

Lightning fires, which usually start as the result of lightning strikes in large trees or snags, account for approximately 37 percent of the forest fires in Washington. Less than 1 percent are caused by spontaneous combustion or other natural causes (Agee, 1993). The remaining fires are caused by humans, and are due to campfire escapes, industrial activity, other accidents, or are intentionally set.

Fire suppression efforts over the past century have had a substantial effect on existing vegetation in many areas of the state, particularly on the east side. Fuel levels are high in many parts of eastern Washington, because the frequent understory fires that once burned these areas and kept fuel levels in check have been aggressively suppressed. As a result, fires are now often more intense and difficult to suppress.

3.9.3 Environmental Effects

By maintaining standing trees and snags in RMZs, surrounded by dead fuel on the ground as the result of logging operations, all alternatives contribute to the risk of a wildfire occurring. The extent of the risk is likely to be greater in those alternatives that leave more standing trees and snags and more down woody debris. These can act as lightning rods and increase the likelihood of a fire start, as well as enhance its spread after it has started. The risk is likely to be greater in areas where fire is more common due to climatic and topographic factors. In other words, a fire is more likely to begin in a wide riparian buffer in a ponderosa pine forest on a south-facing slope in Chelan County than in a narrow buffer in a western hemlock forest on a north-facing slope in Whatcom County.

Once a fire begins, its rate of spread, and the difficulty that fire fighters will have controlling it, are related to the amount and type of fuel and to weather and topographic conditions. Weather and topographic conditions would not be effected by the proposed alternatives, but fuels would be affected. Alternatives that leave more wood on the ground (large woody debris), especially in conjunction with standing trees and snags, are more likely to support fire spread than alternatives that leave less. Dead limbs and logs on the ground, especially large logs, increase the intensity of the fire. Heavier fuel on the ground means a hotter fire that burns for a longer period of time. This volatilizes nitrogen, a nutrient often deficient in forest soils, and can cause greater soil damage, resulting in increased soil erosion (Biswell, 1989). It can also lead to an increase of herbaceous vegetation and shrubs that compete with tree seedlings (Saveland and Bunting, 1988). Standing snags and large logs on the ground can also increase the fires spread by 'spotting', throwing burning embers large distances. Alternatives that leave more fuel are likely to have a greater risk than alternatives that leave less. Again, the risk is greater in dryer areas than in wetter ones.

Intense or stand replacement fires are considered to have negative effects on riparian functions and aquatic systems because of elimination of shade, potential for increased erosion and sediment inputs, and other factors. Therefore, optimum conditions are considered to be those that will maintain riparian functions while minimizing the potential for intense, stand-replacement fires.

3.9.3.1 Alternative 1

Present conditions would continue. No buffers would be left on Type 4 and 5 streams and relatively few leave trees and snags would be left in buffers on Type 1, 2, and 3 streams. Approximately two large logs would be left per acre. From 25 to 100 or more leave trees would be left on each side per 1,000 linear feet in RMZs between 25 and 100 feet wide. Some leave-trees would likely blow down, increasing the amount of large woody debris.

With Alternative 1, risk of fire initiation and spread would be similar to current conditions. The risk of intense, stand replacement fires would be relatively low.

The risk of a fire occurring, its rate of spread and intensity would not change compared with current conditions. The risk of intensive, stand replacement fires in the managed riparian zones would be relatively low.

3.9.3.2 Alternative 2

With Alternative 2, the risk of fire initiation and spread would be slightly higher than under Alternative 1. The risk of intense, stand replacement fires would be higher than for Alternative 1, but still relatively low.

A no-harvest buffer, ranging from 50 feet to 100 feet on each side of fish-bearing streams would be left on the westside and 30 feet wide on each side of streams on the eastside. These buffers may contain snags as well as live trees. Trees would also be left in the inner and outer zones of the RMZs on fish-bearing streams as well. Alternative 2 also has minimum requirements on the east side for down wood to be left behind in the inner and outer zones after harvest. It has additional requirements for down wood in cases where salvage logging inside the inner or outer zone is permitted, for both the east side and west side. In addition, some trees would likely blow down, especially in the outer portions of the RMZ, adding to the amount of large down wood. The thinning regime that is prescribed for the eastside is designed to mimic pre-settlement conditions (i.e., the period before fire was intensively suppressed) over a 50-year period. However, the amount of down wood being left under this alternative on the eastside is considerably higher than under Alternative 1 and may be well above the levels that existed under pre-settlement conditions.

Compared to Alternative 1, the increased amount of standing and down wood on the eastside would increase the risk of fire initiation and increase the likelihood that any fire that does start will burn hotter and for a longer time. The size of the fire would also likely be greater than under Alternative 1. However, the narrower no-cut buffers and the thinning regime within the inner and outer zones would help maintain eastside stands more like stands under a natural fire regime. On the cooler, moister westside, little increased risk is expected.

3.9.3.3 Alternative 3

With Alternative 3, the risk of fire initiation and spread would be moderately higher than under Alternative 1, and slightly higher than under Alternative 2. The potential for intense, stand-replacement fires would be highest and would increase over time under this alternative.

A no-harvest buffer from 70 to 170 feet wide on both sides of streams would be left on the westside and from 30 to 100 feet on the eastside. These wider buffers would contain more trees and snags than either of the other alternatives and all existing down woody debris would be retained. In addition, some trees are likely to blow down, especially in the outer portions of the buffer, adding to the amount of large woody debris. The increased amount of standing and down wood is likely to increase the likelihood of a fire starting and increase the likelihood that the fire will burn hotter and for a longer time, than under Alternative 1 or under Alternative 2. The size and intensity of the fire are also likely to be greater than under those alternatives, especially compared to Alternative 1. The potential for intense, stand replacement fires would be highest under this alternative and would increase over time because of the lack of thinning or understory burning within the riparian zone, which would reduce fuels.

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3.10 CULTURAL RESOURCES

3.10.1 Introduction

Cultural resources are archaeological and historic sites and artifacts and traditional religious, ceremonial and social uses and activities of affected Indian tribes (WAC 222-16-010) (see Glossary for other related definitions). Affected Indian tribes are federally recognized tribes that request in writing from DNR, information on forest practices applications and notification filed on specific areas. Cultural resources are important to our understanding of culture, history, heritage, and relationships to the land. One measure of significance for cultural resources is listing or eligibility for listing on the National Register of Historic Places.

DNR and the Washington forest practices rules aim to protect cultural resources from impacts of timber harvesting and related activities on private and state lands. The Washington Office of Archaeology and Historic Preservation (OAHP) is the state's link in the National Historic Preservation Program, and works closely with federal and state agencies, tribal nations, local governments, businesses, and individuals to meet both federal and state responsibilities for cultural resource protection. OAHP maintains the Washington State Inventory of Cultural Resources.

3.10.2 Affected Environment

A discussion of the prehistory, history, and ethnography for the entire state of Washington is necessarily broad and simplified. Site-specific prehistoric, historic, and ethnographic overviews may be developed for specific forest practices.

Evidence for prehistoric human occupation of Washington state extends back at least 12,000 years, and is found at sites throughout the state. General trends in prehistoric settlement and subsistence have been constructed from these sites. From 12,000 to 8,000 years ago, the climate throughout Washington was much cooler and wetter than it is presently. Occupants of this area during this period had a subsistence strategy that was based primarily on hunting of large mammals, and collection of fish, shellfish, plants, and other resources. The climate shifted and a warmer and drier period ensued, eventually reaching conditions similar to the present about 4,500 years ago. Subsistence and settlement patterns adapted to the changes in climate and resource availability. By 3,000 years ago, and up to the time of European contact (the historic or ethnographic period), the area was characterized by large semi-permanent winter villages, seasonal forays to the uplands and occupation of seasonal camps, fully developed food processing and storage technologies, and complex trade and travel networks from the Pacific Coast to the Columbia Plateau.

Ethnographic records paint a picture of the lifestyles of people who occupied Washington before Europeans arrived. Physical barriers, such as mountain ranges and rivers, defined tribal territories and resulted in unique adaptations to varied environmental conditions. However, the social organization of Indian groups was probably considerably more complex and fluid than indicated by present-day tribal designations. While some of the recognized tribes in Washington are similar to their aboriginal composition, others are confederations of bands and tribes created in the mid-19th century in conjunction with the making of treaties with the U.S. Government, or in the 20th century for government administration. Ethnographic records indicate that Indian groups came together at certain times of the year to hunt, fish, and gather specific types of resources or participate in social and ceremonial gatherings, and then dispersed. Exogamy, marriage outside of the kinship group, was practiced widely, creating complex social networks with kin ties beyond the village, and facilitating trade and travel.

Western Washington was a relatively lush world, with abundant riverine and marine resources. Among the western Washington Indians, salmon was a major source of food and the focus of ceremonial and social life. Wood was used to construct canoes and houses, including large communal longhouses, and cedar bark and other plants were used to make clothing, baskets, and other objects. The seasonal subsistence pattern for many of these groups involved gathering at villages in the lower river valleys during the winter and moving in dispersed groups to take advantage of seasonally available upland animal and plant resources during the rest of the year. The most basic social unit was the extended family, which stayed together during seasonal migrations to resource procurement areas. A unique feature of some coastal Indian cultures was the potlatch, a grand feast at which the host earned prestige and political power by giving away their possessions to the guests.

Eastern Washington was characterized by a more arid climate and more sparsely scattered resources. People living on the Columbia Plateau also relied upon salmon as a major food source, supplementing this with rabbit, deer, and elk, as well as roots, berries, and nuts, and following a seasonal subsistence cycle. The basic social unit of the Plateau Indians was the highly mobile band, which was well adapted to hunting, fishing, and gathering more widely dispersed resources. Shelters were built from poles and animal skins or woven mats, or pithouses were dug partially below ground. Caves and natural rock shelters also provided protection from the elements. Sweathouses played an important part in Plateau culture and were used in purification rituals. Europeans introduced the horse in the late 1700s, profoundly altering the economic and social organization of these groups by facilitating travel and trade over much greater distances.

Arrival of Europeans, beginning in the late 18th century, significantly disrupted the health, social organization, and culture of the Indians who occupied the area as well as the natural resources of the area. The earliest European explorations of Washington were by fur trappers and traders. The Hudson's Bay Company, other trading companies, and the U.S.

Government established forts throughout Washington (hostilities between Europeans and Indians peaked in the1850s and 1860s with the so-called Indian Wars). In the mid-1800s, the U.S. Government made a number of treaties with the Washington Indians. In the treaties, Indians ceded title to their lands in exchange for certain reserved rights and protections, and opened the land to settlement. The federal government also sponsored several expeditions to explore transportation routes between eastern and western Washington. In 1887, the completion of the transcontinental Northern Pacific Railroad through the Cascades opened the new State of Washington for trade to the east. Timber companies, ranchers, and farmers now had a faster, cheaper way of getting their products to markets in the east. Work on the railroads attracted large numbers of Europeans and Asians, and the booming logging, milling, and agricultural industries attracted thousands more. Discoveries of gold and coal in the Cascades in the mid to late-1800s and additional gold and silver finds to the east in Idaho territory contributed to the growth in the economy and population of Washington. Large-scale irrigation, reservoir, and hydroelectric projects were developed, particularly east of the Cascades, beginning around the turn of the 20th century.

Settlement and development have altered or destroyed numerous cultural resources of Washington (including cultural resources on forest lands). Passage of cultural resource protection laws has led to improved identification and management of these resources in recent years. Although the locations of many sites with archaeological or historic value are now known, many sites are unknown and are still sometimes altered or destroyed by actions associated with development or resource extraction.

3.10.3 Environmental Effects

3.10.3.1 Alternative 1

> Under Alternative 1, protection of cultural resources is afforded through the forest practices application process; little incidental protection of undiscovered resources is provided in RMZs and WMZs.

Although there is no requirement to conduct systematic cultural resource surveys on forest lands under the existing forest practices rules associated with Alternative 1, these rules do protect previously recorded cultural resources in several ways. A Class IV-Special or Class III application must be filed with DNR for forest practices on lands containing cultural resources. DNR notifies affected Indian tribes of all applications of concern to the tribes, including those involving cultural resources identified by the tribes. DNR provides OAHP with copies of all applications and notifications for forest practices to be conducted on lands known to contain historic or archaeological resources. In addition, DNR may consult with OAHP (and tribes) on the significance of cultural resources within a project area. Affected Indian tribes may forward plans for protection of cultural resources to the OAHP, but OAHP is not generally called into meetings with landowners.

A Class IV–Special application for forest practices must be filed with DNR for forest practices on lands containing archaeological or historic sites registered with OAHP, or containing sites with evidence of Native American cairns, graves, or glyptic records, as provided for in chapters 27.44 and 27.53 RCW. The DNR consults with affected Indian tribes to help identify such sites. Class IV-Special applications must include an environmental checklist in compliance with SEPA. DNR may require additional information or a detailed environmental statement. Under SEPA authority, DNR can then deny the Class IV-special application, accept the application unconditionally, or condition the application with mitigation measures to protect cultural resources.

According to the FPRs, a Class III application must be filed with DNR for forest practices on lands containing cultural resources which are listed on or are eligible for listing on the National Register of Historic Places, or have been identified to the DNR as being of interest to an affected Indian tribe. In practice, however, National Register-eligible or –listed sites are automatically registered with OAHP; therefore, the presence of such sites automatically triggers a Class IV-Special application, rather than a Class III.

Under a Class III application, the landowner meets with the affected tribes with the objective of agreeing on a plan for protecting the archaeological and cultural values of the resource. If the landowner and affected Indian tribes come to an agreement, then the landowner may voluntarily add the mitigation measures to the application for cultural resources protection. In this case, then the DNR will enforce the terms of the permit. If an agreement regarding mitigation measures is not reached, or if there is no landowner, the provisions protecting cultural resources under 27.44 and 27.53 RCW still apply, but the DNR has no authority to enforce these provisions.

Protection identified for riparian areas, wetlands, and unstable slopes under Alternative 1 also provides incidental protection to undiscovered historic and archaeological sites by limiting or excluding forest practices in these areas. The amount of protection to these areas is addressed in Section 3.4.

3.10.3.2 Alternative 2

> Under Alternative 2, protection of cultural resources is afforded through the forest practices application process. In addition, a cultural resource module is added to watershed analysis and substantial incidental protection of undiscovered resources is provided in RMZs and WMZs.

Alternative 2 would include the same regulatory protections for cultural resources that are provided under Alternative 1, and would provide additional protection. Alternative 2 would add a cultural resource module to the state watershed analysis process, to take effect within 2 years, which would make it more likely that cultural resources would be identified and considered in watershed analysis and planning. DNR would ultimately be responsible for conducting the analysis of watersheds, but individual landowners may opt to conduct their own analyses to speed the environmental review process.

In addition, Alternative 2 would require much larger RMZs and more protection of land with unstable slopes compared to Alternative 1 (see Figures 3.4-7 and 3.4-8). This could provide additional incidental protection to certain types of undiscovered cultural resources (e.g., archaeological sites) along streams. Most of the larger RMZs are located along Type S and F streams and rivers (large and medium-sized streams and rivers that contain salmon and other fish populations). Protection of wetlands and adjacent areas would be at a level similar to that provided under Alternative 1.

Under Alternative 3, cultural resource protection would be virtually the same as under Alternative 2, except for greater incidental protection due to wider RMZs and WMZs and specific protection of culturally important plants in the riparian zones during pesticide applications.

3.10.3.3 Alternative 3

Alternative 3 would include the same regulatory protections for cultural resources provided under Alternatives 1 and 2, but the buffer widths in RMZs would be larger than those provided under Alternative 2, and Alternative 3 has the potential, therefore, to provide greater incidental protection to undiscovered cultural resources over a larger area along streams (see Figures 3.4-7 and 3.4-8). Like Alternative 2, Alternative 3 would incorporate a cultural resource module in watershed analysis planning. Alternative 3 also provides for the protection of culturally significant plants from pesticide applications, an additional protection that is not included under Alternatives 1 or 2.

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Chapter 3

3.11 CUMULATIVE EFFECTS

The cumulative impacts of the rule proposal and the alternatives are addressed in the previous sections in terms of how application of the rule changes would cumulatively effect the different resource areas subject to forest practices rules. This section also addresses the cumulative effect of rule changes on a watershed scale and also considers the cumulative effect on a broader landscape scale, when added to management on non-federal forest land covered by HCPs, federal forest land, watershed planning, and other state and federal programs.

3.11.1 Watershed Cumulative Effects

Cumulative effects are defined in the forest practices rules as "the changes to the environment caused by the interaction of natural ecosystem processes with the effects of two or more forest practices" (WAC 222-16-010). Multiple forest practices include all possible combinations of forest practices including those occurring on the same site over time, or widely dispersed within the forest, occurring simultaneously or in a sequential manner (Geppert et al. 1984). The alternatives each address cumulative effects within a watershed, but to different degrees.

3.11.1.1 Alternative 1

Under Alternative 1, cumulative effects would be addressed in watersheds that undergo watershed analysis. However, cumulative impacts would occur in other watersheds, especially those with high levels of past harvest or other disturbances.

Under Alternative 1, the forest practices rules in general (WAC 222) address cumulative effects by establishing minimum standards for all forest practices. In addition, cumulative watershed effects are addressed directly by a number of specific rules (see WAC 222-12-046). The primary specific rule that address cumulative effects is watershed analysis. A number of other rules including those dealing with Class IV-Special applications, road maintenance and abandonment plans, harvest unit size, green-up, and separation requirements, further restrictions on the size of clear-cuts in rain-on-snow zones, and adaptive management, also address it.

Ideally, watershed analysis (chapter 222-22 WAC) would be an effective way of evaluating cumulative effects and modifying forest practices in watersheds where it has been conducted. However, a small minority of watersheds have been analyzed to date (see

Appendix H). In addition, many watershed analyses started have not been completed because negotiations during the prescription phase have stalled, primarily over riparian issues (M. Hunter, WDFW, personal communication, January 19, 2001). On occasion, prescriptions have also varied widely, even for adjacent watersheds with similar situations (M. Hunter, WDFW, personal communication, January 19, 2001). Much of this variability has resulted from the negotiating abilities of the parties preparing the prescriptions (M. Hunter, WDFW, personal communication, January 19, 2001). Other deficiencies in watershed analysis, as implemented in the past, have been outlined in Collins and Pess, 1997a and 1997b). Overall, watershed analysis has been an effective tool for understanding watershed conditions and their relationship with forest practices, but has been less effective at implementing prescriptions designed to prevent cumulative effects.

Forest practices which have a potential for substantial impact on the environment are classified as Class IV-Special or Class IV-General by WAC 222-16-050 and receive an evaluation as to whether or not a detailed environmental statement under SEPA must be prepared. Thus, cumulative effects are considered through the SEPA process, when the individual forest practices that triggered SEPA have potential for substantial impact.

Cumulative effects are also addressed when the Department of Natural Resources requires a road maintenance and abandonment plan for a drainage or road system where damage to public resources is occurring or has potential to occur (WAC 222-24-050). They are also addressed by harvest unit size and separation requirements that restrict the size of clear-cuts and the harvesting of units adjacent to young stands (WAC 222-30-025). Restrictions can also be placed on the size of clear-cuts in the significant rain-on-snow zone, if the Department determines that, based on local evidence, peak flows have resulted in damage to public resources (WAC 222-22-100).

Adaptive management (WAC 222-08-035 and 222-12-045) is a process that also addresses cumulative effects. However, the adaptive management process under Alternative 1 is relatively informal and does not address cumulative effects on a watershed basis, except over the long term. Watershed analysis has historically been, and would continue to be, one of the primary sources of feedback on the effectiveness of forest practices rules for use in adaptive management, under Alternative 1.

As noted in previous sections, the standards established by the current forest practices rules (Alternative 1) are generally insufficient to avoid resource impacts, particularly when evaluated in a cumulative sense with other forest practices. An exception to this is when watershed analysis is implemented and is used to modify and implement effective prescriptions and other practices that address cumulative effects. However, watershed analysis is voluntary and has only been implemented on a minority of watersheds to date.

3.11.1.2 Alternative 2

Under Alternative 2, the forest practices rules in general address cumulative effects by establishing minimum standards for all forest practices. A number of additional rules also address cumulative effects including: those dealing with Class IV-special applications, road maintenance and abandonment plans, harvest unit size and separation requirements,

> Under Alternative 2, cumulative effects would be addressed in watersheds that undergo watershed analysis, but only to a limited degree since riparian and other prescriptions would not be modified and fewer watershed analyses would be conducted. It is not clear that the rules under Alternative 2 are sufficiently protective to prevent cumulative effects in watersheds containing high levels of past harvest or other disturbances.

further restrictions on the size of clear-cuts in rain-on-snow zones, and adaptive management.

Watershed analysis could still be used to assess cumulative effects. However, implementation is voluntary for landowners and riparian prescriptions designed for the conditions observed in the watershed would no longer be a required product (See Appendix H). In addition, the mass wasting module and surface erosion prescriptive phase would be phased out when the unstable slope hazard map and road maintenance and abandonment plans become available. Cultural resources and restoration modules will be developed and added to the watershed analysis methodology. Consequently, the cost of conducting the assessment phase would increase, but most benefits to a private landowner from the prescriptive phase would be lost. Therefore, it appears that watershed analysis would be conducted less frequently in the future under Alternative 2 because of reduced incentive and higher costs to private landowners.

Forest practices which have a potential for substantial impact on the environment would continue to be classified as Class IV-Special or Class IV-General and receive an evaluation as to whether or not a detailed environmental statement under SEPA must be prepared. In Alternative 2, the SEPA process is more defined by guidelines to ensure a comprehensive review of potential effects of proposed forest practices. A variety of forest practices may trigger a Class IV-Special application including (among others, see chapter 222-16 WAC):

- Certain types of pesticide use including use within a Type A or B wetland;
- Timber harvest, or construction of roads, landings, gravel pits, rock quarries, or spoil disposal areas:
    - on potentially unstable slopes or landforms;
    - in high avalanche hazard areas if no watershed analysis has been conducted; or
    - in archaeological or historic sites.

Thus, cumulative effects are considered through the SEPA process, when the individual forest practices that triggered SEPA have potential for substantial impact.

Cumulative effects are also addressed because of the requirement under this alternative for road maintenance and abandonment plans and their implementation by 2015. These plans should address the cumulative impacts within a watershed associated with roads over the next 15 years. Cumulative effects would continue to be addressed by harvest unit size and separation requirements that restrict the size of clear-cuts and the harvesting of units adjacent to young stands. Restrictions could also still be placed on the size of clear-cuts in the significant rain-on-snow zone, if the Department determines that, based on local evidence, peak flows have resulted in damage to public resources.

Over the long term, the adaptive management process under Alternative 2 would result in cumulative effects being more fully addressed. The program includes effectiveness monitoring for prescriptions that is expected to be focused in representative watersheds throughout the state (M. Hunter, WDFW, personal communication, January 19, 2001).

This process is formal, includes review by an independent scientific committee, and a mechanism for resolving disputes when stakeholders cannot reach consensus. The adaptive management program is expected to be productive over the long term.

> There is uncertainty regarding the effects of the lack of RMZ buffers on many Type N streams under Alternative 2. This uncertainty is increased in watersheds with a high level of recent past harvest, because cumulative effects may not be addressed.

As noted in previous sections, the standards established by the rules of Alternative 2 generally have a low to moderate level of risk for not adequately avoiding resource impacts; however, there is a high degree of uncertainty associated with the effectiveness of certain rules. This uncertainty is generally related to the lack of RMZ buffers on many Type N_p and all Type N_s streams. The uncertainty relates to issues regarding effects on sediment delivery to fish streams, LWD and leaf/needle litter recruitment from non-fish to fish streams, and the effects of shade reduction and microclimate changes on non-fish stream temperatures and their ultimate effect on fish stream temperatures. In addition, there is some concern over the sufficiency of eastside RMZs on Type S and F waters for providing LWD. These are areas that deserve emphasis with adaptive management. However, adaptive management is a relatively long-term process and the issues identified are of concern in the short term in watersheds that have experienced a high degree of past timber harvest, contain significantly degraded fish habitat, or contain temperature or sediment-impaired streams. The lack of any consistently applied rules under Alternative 2 for assessing current watershed condition increases the level of resource risk relative to these uncertain issues.

3.11.1.3 Alternative 3

> Alternative 3 would also address cumulative effects to a limited degree through watershed analysis and through additional rules related to cumulative harvest in ROS zones and road densities. Also, the riparian rules would be substantially more protective than under Alternatives 1 or 2.

As for Alternatives 1 and 2, Alternative 3 would address cumulative effects by establishing minimum standards for all forest practices. In addition, cumulative watershed effects are addressed directly by watershed analysis. A number of specific rules, including those addressed by Alternative 2, also address cumulative effects. Two additional cumulative effects measures would also be included: no net increase in road density and restrictions on cumulative harvest in rain-on-snow zones.

Forest practices would continue to be conditioned through the forest practices application process (with Class IV-special applications), through restrictions on harvest unit size, through watershed analysis (although it would likely be implemented with less frequency than at present and without the riparian module), and through adaptive management (over the long term). Cumulative effects would also be addressed because of the requirement under this alternative for road maintenance and abandonment plans and their implementation by 2010. These plans should address the cumulative impacts within a watershed associated with roads over the next 10 years. In addition, road-related cumulative effects would also be reduced by the restriction on increasing road densities. Finally, restrictions on the cumulative harvest within the rain-on-snow zone of a watershed would be implemented.

The standards established by the rules of Alternative 3 are generally more protective than those under either Alternative 1 or 2. In most cases, they are sufficiently protective to substantially reduce the uncertainty associated with risk to aquatic resources that is associated with some aspects of Alternative 2. However, in the short term, watersheds that have experienced a high degree of past timber harvest, contain significantly degraded fish habitat, or contain temperature or sediment-impaired streams, may still need additional protection. Without a consistent general assessment of current watershed condition prior to conducting forest practices in these watersheds and implementation of additional protection measures where needed, the level of resource risk is increased.

3.11.2 Landscape-level Cumulative Effects

The changes to forest practice rules that are proposed under Alternatives 2 and 3 have been developed through more than 10 years of TFW discussions and research. These changes are just one aspect of far-reaching regulatory, policy, and land-use management changes that are occurring in Washington as a response to ESA listings for Pacific Salmon and trout, CWA listings for water quality impaired streams, and a general understanding that current forest practice rules (Alternative 1) are inadequate to protect aquatic and riparian resources. Plans are being developed at all levels of government throughout Washington to maintain and recover populations of the listed species, improve water quality, and address water quantity issues.

3.11.2.1 Habitat Conservation Plans

HCPs outline mechanisms for conserving and monitoring listed species and mitigating for their losses incidental to otherwise lawful practices.

ESA Section 10 provides for Incidental Take Permits and Habitat Conservation Plans that provide regulatory protection from the ESA Take Prohibition (Section 9) for a period of usually 30 to 50 years, but sometimes more. Incidental take occurs when it results during otherwise lawful practices. The HCPs outline mechanisms for conserving and monitoring listed species and mitigating for their losses. Incidental Take Permits quantify an acceptable amount of take that will not jeopardize the existence of the listed species and permit-holders are not at risk of Section 9 violations so long as take remains below the permit levels. Many HCPs have been prepared in the Pacific Northwest region by government and private entities since implementation of the ESA. Most of the HCPs prepared in Washington address issues concerning multiple listed wildlife and/or aquatic species. Some of the HCPs and their issues that have been completed or are in progress in Washington include:

- Mid-Columbia Public Utility Districts - Hydroelectric;
- Washington State DNR – Forestlands;
- Plum Creek I-90 HCP and Native Fish HCP – Forestlands;
- Murray Pacific HCP – Forestlands
- City of Seattle Cedar River – Forestlands and Drinking Water Supply;
- International Paper (formerly Champion Pacific Timberlands) - Forestlands;
- City of Tacoma – Forestlands and Hydroelectric;
- Longview Fibre - Forestlands;
- Rayonier - Forestlands;
- Crown Pacific - Forestlands;
- Port Blakely - Forestlands;
- West Fork Timber Co. (formerly Murray Pacific) - Forestlands;

- Simpson Timber Company - Forestlands;
- Lewis County Programmatic – Non-Industrial Tree Farms;
- King County - Wastewater Treatment; and
- Foster Creek Conservation District – Ranching and Agriculture.

The WDFW is considering an HCP for Hydraulic Project Approvals, but other options are also being considered for meeting ESA requirements. Many of the HCPs that have been implemented in forested areas have larger riparian buffers and other conservation measures for listed species than existing forest practices rules. For instance, the DNR HCP requires the state to use a riparian conservation strategy on all of its ownership which has as one of its goals to protect the breeding, foraging, and resting habitats of the Dunn's salamander, Van Dyke's salamander, and tailed frog through the application of minimum 100-foot wide buffers on Type 1, 2, 3, and 4 streams. This strategy is enhanced in the Olympic Experimental Forest Planning Unit, which borders the western edge of Olympic National Forest. Many of the HCPs for private forestlands require watershed analysis, habitat reserves, or a number of other special features that benefit aquatic and riparian systems.

3.11.2.2 The Northwest Forest Plan

Implementation of the Northwest Forest Plan (NFP) has particular relevance to alternatives evaluated in this EIS because state and private forestlands are often adjacent to, or exist as inholdings within Federal ownership. In addition, Federal ownership affected by the Forest Plan includes up to about one-third of the land base of the EIS regions in the western half of Washington. The NFP has management strategies designed specifically for aquatic and riparian species.

Protection of aquatic and riparian species under the NFP is part of the Aquatic Conservation Strategy (ACS) and Survey and Manage Protocols (USDA et al., 1994). Components of the ACS include Riparian Reserves, protection of Key Watersheds, Watershed Analysis, and Watershed Restoration. Riparian Reserves on federal lands within the range of the Northern Spotted Owl are a minimum of 100 feet (seasonal streams) to 300 feet (fish-bearing streams) in width on either side of a stream. Consequently, streams on most federal lands within Washington have more protection for aquatic and riparian-associated wildlife than any of the alternatives considered in this EIS. Notably, a majority of federal lands are located along the Cascade Crest and northern Olympic Peninsula. Consequently, on a broad-scale federal lands include a higher proportion of low order, nonfish-bearing streams compared to state and private forest lands. Survey and Manage protocols require individuals applying to conduct activity on federal lands to survey for a wide variety of wildlife species, including many amphibians, and subsequently manage for those species if they are discovered in the vicinity of a proposed project.

The Aquatic Conservation Strategy implemented under the NW Forest Plan on federal lands will complement the strategies considered under Alternatives 2 and 3.

The current size of stream buffers on federal lands should not be construed to mean that streams on federal lands are currently in better condition than streams on private lands. In fact, historic forest practices, including harvest of riparian trees, on federal lands have also contributed significantly to stream conditions that have affected the status and listing of Pacific salmon and trout in the region. However, as the ACS is implemented in the long-term, stream protection strategies on federal lands will complement the strategies considered under Alternatives 2 and 3, particularly in watersheds with substantial amounts of federal and private mixed ownership. Under Alternative 1, maintenance of properly functioning streams and recovery of degraded streams may not be possible in forested watersheds with high proportions of private ownership.

3.11.2.3 Watershed Planning

Development of watershed plans that address water quantity, water quality, fish habitat, and instream flows are in progress in many areas of the state.

Watershed planning is an option that state, local, and tribal governments may pursue as a result of the Watershed Planning Act (House Bill 2514). The goals of the plans are to assess the status of water resources, and to address water quantity issues including mechanisms for accommodating competing water resource needs. In addition, the plans may address water quality, habitat, or proposals for setting or revising instream flows. Although plans are optional, they must meet requirements outlined in HB 2514 to obtain state funding. The plans can include a single or multiple watershed resource inventory area (WRIA). Watershed Plans have been initiated for more than half of the WRIAs. None of the plans have been completed. Most of the plans in development will include all of the optional components, but this is not universal.

3.11.2.4 Other State and Federal Programs

Numerous other federal management activities and policies will also influence the overall success of recovering listed species. These include:

- Management of the Federal Columbia River Hydroelectric System (Corps of Engineers, Bureau of Reclamation, Bonneville Power Administration, and the Northwest Power Planning Council);
- Implementation of the Pacific Salmon Treaty;
- Implementation of the Northwest Forest Plan (NFP, US Forest Service and Bureau of Land Management);
- National Parks and Wilderness Areas;
- Re-licensing of private hydroelectric facilities (Federal Energy Regulatory Commission);
- Water quality enforcement (Environmental Protection Agency); and
- Permitting of flood control, wetland development, and dredging projects (Corps of Engineers).

Under Section 7 of the ESA, all activities that require direct federal management activities or obtain federal funding that might affect listed species require consultation with the NMFS or FWS. These activities usually require a Biological Assessment by the consulting agency and a Biological Opinion by NMFS or FWS if the activity will have an adverse effect.

Numerous state and federal programs under development will complement new forest practices rules.

Water quality programs by the Environmental Protection Agency and Washington's Department of Ecology will complement new forest practice rules. Over 600 water bodies of the state do not meet water quality standards and are listed as Clean Water Act Section 303(d) water quality impaired streams. These agencies have a Memorandum of Understanding concerning implementation of the state's Total Maximum Daily Load

(TMDL) program for addressing non-point source stressors to water quality. Prescriptions implemented on private forestlands under this program will complement water quality protections present in FPRs.

Governor Locke and the Joint Natural Resources Cabinet have developed a plan called the "Statewide Strategy to Recover Salmon" (Washington State JNRC, 1999). Improvements to forest practices rules is just one component to the plan's 13 basic elements. The other 12 components include the following:

- Agricultural practices
- Urban stormwater issues
- Land-use practices
- Hydropower
- Commercial and recreational fish harvest
- Hatcheries
- Water quantity
- Water quality
- Enforcement of existing laws
- Education
- Monitoring
- Integration of stream corridor guidelines

The primary agencies and organizations the Governor has targeted for implementing the plan include the following (WDFW, 1999):

- Department of Fish and Wildlife
- Department of Ecology
- Department of Natural Resources
- Department of Agriculture
- Conservation Commission
- Timber, Fish, and Wildlife
- Department of Community, Trade, and Economic Development
- Tribal Governments
- City and County Government and Agencies

It is important to understand that all of the elements of the Governor's Salmon Plan, the local and county plans, and many of the various habitat conservation plans are still in development. It is reasonable to believe that many these programs will be implemented within the next one to five years. However, it is unclear what precisely will be included in all of the different programs. Consequently, it is not possible to accurately describe details of all of the cumulative effects that may result from the alternatives evaluated in this EIS and other programs.

One of the more complete components is the Wild Salmonid Policy developed by the WDFW and Western Washington Treaty Tribes in 1997. However, the Wild Salmonid Policy (WSP) is designed as a living document that will be updated as the available science improves. Under the WSP, numerous policies related to salmonid habitat, aquaculture, harvest, and other issues were developed to guide existing and future management. Included in the policy were riparian management prescriptions for forested areas that were specifically described as interim until they were replaced by prescriptions agreed to under the Forest and Fish Report.

In part, it is the intent that the development of the different strategic elements in the Governor's Salmon Plan will result in regulations, permit processes, and other formalized programs that will be reviewed, approved by the NMFS and/or FWS, and then included as part of their ESA Section 4(d) rules. The 4(d) rules allow the Services (NMFS and FWS) to implement limitations to take prohibitions under Section 9 of the ESA. "Take" includes killing or injuring listed species, and harm or harassment due to habitat destruction or other activities. The 4(d) rules describe which kinds of activities, when implemented according to approved guidelines, will not result in take of the listed species. Under the 4(d) rules recently published by the NMFS (65 FR 42422, , 65 FR 170,and 64 FR 73479), the Forests and Fish Report was specifically cited as an example of forest practices rule changes that would limit take prohibitions. In other words, as long as forest practices rules were implemented under prescriptions at least as protective as strategies described in the Forests and Fish Report, then forest practices activities could continue without fear of violating the ESA. The USFWS has not adopted a 4(d) rule for bull trout or sea-run cutthroat trout, however, the Forest and Fish Report includes assurances that such a rule for bull trout would be adopted by July 1, 2001.

3.11.2.5 Conclusion

In combination, the various programs and plans described above, reflect a significant wide-spread effort and financial commitment to improve water quality, put listed species on a positive trend towards recovery, and provide substantial protection for other aquatic and riparian-associated species. For the most part, the strategies and programs are complementary and reflect different land management goals and activities that are needed to maintain economic viability in the region and meet legal and environmental responsibilities under the ESA and CWA. From the perspective of cumulative effects, Alternative 1 is unlikely to meet the level of protection needed for the forest practices industry to play its part in the recovery process. In contrast, both Alternatives 2 and 3 provide significant additional protection that complements other activities in the region. Alternative 3 has more certainty for achieving adequate protection to resources in the short-term because the proposed prescriptions are more conservative than Alternative 2.. Specific adjustments could be made to Alternative 2 that would increase short-term certainty, particularly with regard to cumulative watershed measures (see Section 3.11.1.2). Both Alternatives 2 and 3 incorporate adaptive management in their approach, which is a cornerstone to nearly all of the plans, policies, and programs mentioned above. Consequently, in the long-term both alternatives should result in adequate protection levels and plans under development reflect a significant wide-spread effort to put listed species on a positive trend towards recovery.

that would result in improvements in water quality, the opportunity for recovery of listed species, and improved habitat for aquatic/riparian fish and wildlife.

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