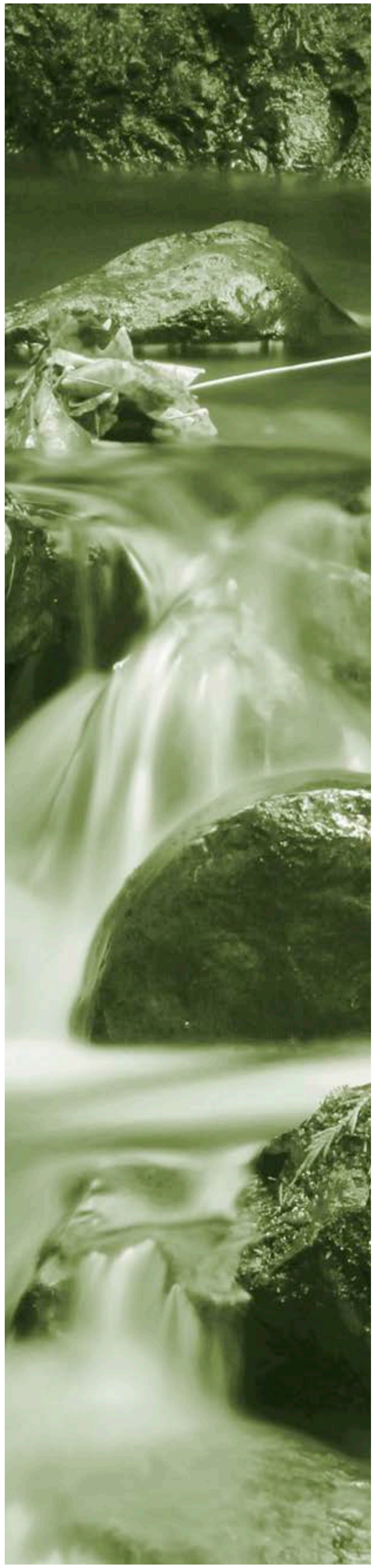


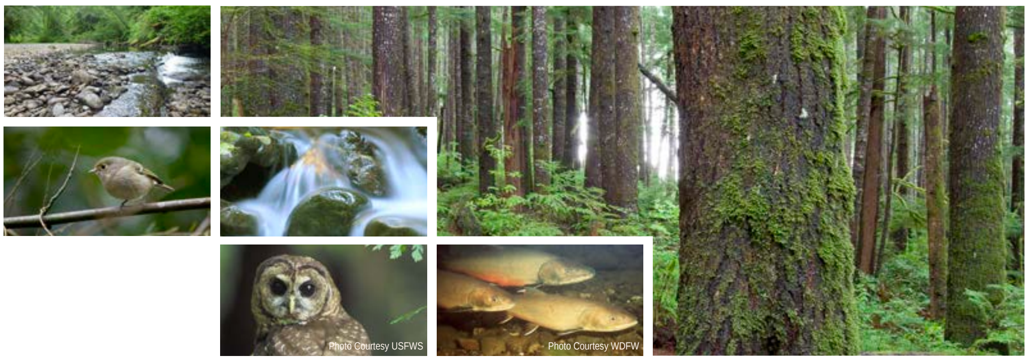
Chapter 3

Environmental Analysis

In This Chapter

Chapter 3

Environmental Analysis



This chapter contains information about the affected environment, the environmental analysis approach, the harvest schedule analyzed, and the potential environmental impacts of the alternatives being considered. “Forest Conditions and Management” covers the forest as a whole. Individual topics such as “Water Quality” and “Northern Spotted Owls” are covered in separate sections.

Affected Environment

Physical Attributes and Vegetation Zones

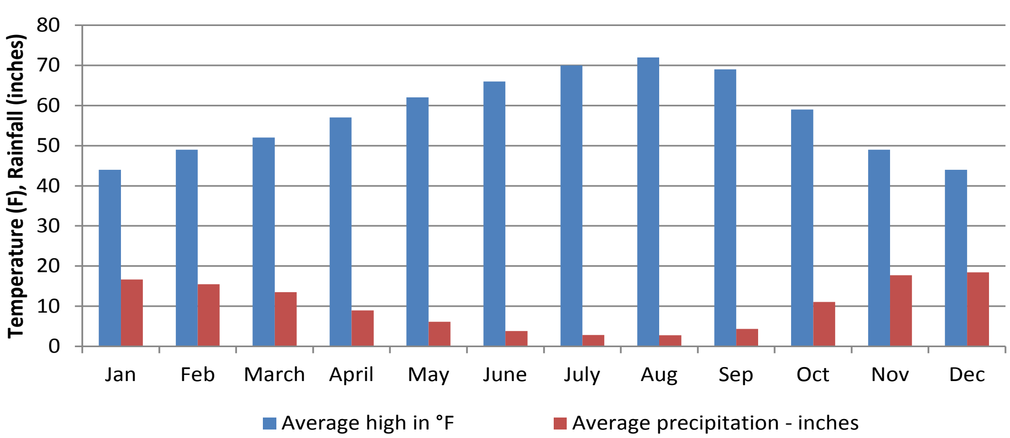
The OESF is a primarily forested area on the Olympic Peninsula ranging in elevation from 0 to 7,952 feet. Vegetation zones[1] in the OESF are shown on Map 3-1. There are three major vegetation zones on state trust lands in the OESF: western hemlock (43 percent of state trust lands), Sitka spruce (33 percent of state trust lands), and Pacific silver fir (24 percent of state trust lands).

Climate

Seasonal rainfall of between 80 to 180 inches per year is a notable climatic feature of the OESF. The climate is maritime (strongly influenced by the Pacific Ocean) with relatively dry summers and significant precipitation during the winter. Most precipitation falls as rain (refer to Chart 3-1).

Map 3-1. Vegetation Zones in the OESF

Chart 3-1. Average Monthly Temperature and Rainfall for Forks, Washington



Fire

Fire occurrence on the Olympic Peninsula is closely tied to climate and climatic history. Some periods have had many stand-replacing fires, others almost none, and some may have had high fire frequency but low fire intensity.[2]

Past fire patterns are correlated with vegetation zones. An analysis of reconstructed fire patterns on the Olympic Peninsula shows that fewer acres burned within the Sitka spruce, silver fir, and mountain hemlock zones than in the western hemlock or subalpine fir zones. During the last 340 years, only 30 percent of the Pacific silver fir or mountain hemlock zones burned, while 128 percent of the western hemlock zone burned (some areas more than once) (Henderson and others 1989). The fire return interval (time between fires) for the Sitka spruce zone was 900 years; mountain hemlock, 844 years; Pacific silver fir, 629 years; western hemlock, 234 years; and subalpine fir, 208 years (Henderson and others 1989).

Wind

Wind is the most prevalent natural disturbance regime in coastal Sitka spruce forests and in higher Pacific silver fir and alpine forests, where moist conditions generally limit fire spread (Agee 1993). In the last century, hurricane-force winds have hit the coast every 20 years on average. The historical record shows 14 storms of hurricane-force winds on the coast in the past 200 years; two storms had winds in excess of 150 miles per hour (Henderson and others 1989, Mass 2008). Selected examples: the hurricane-force winds of the Great Olympic Blowdown on January 29, 1921 (the "21 Blow") felled an estimated 20 percent of the timber along the entire coastline of the Olympic Peninsula—eight times more timber than was felled by the 1980 eruption of Mount St. Helens (Mass 2005). The Columbus Day Storm (October 12, 1962) was one of the most damaging to hit the Pacific Northwest. Hurricane-force winds along the coast blew down an estimated 15 billion board feet of timber in Washington and Oregon (Mass 2005). And the Inauguration Day windstorm of January 20, 1993 brought winds over 80 miles per hour to the Washington coast and winds over 100 miles per hour to exposed sites in the coastal mountains and the Cascades (Mass 2005).

Rivers and Streams

Major river systems that run through the OESF include the Queets, Clearwater, Hoh, Bogachiel, Calawah, Sol Duc, Quillayute, Dickey, Ozette, Sekiu, Hoko, Clallam, and Pysht rivers (refer to Map 3-2). Headwaters for the Queets and Hoh rivers are on Mount Olympus in Olympic National Park. A number of smaller coastal rivers, containing important salmon habitat, enter the Pacific Ocean along the west and north coasts of the OESF. These rivers include the Kalaloch, Cedar, Mosquito, Goodman, Sooes, and Deep Creek.

According to DNR's GIS database, there are 10,730 miles of streams in the OESF, 2,785 miles of which are located on state trust lands (Table 3-1). Steep, erodible terrain and heavy annual precipitation promote an abundance of small streams (Type 4 and Type 5 streams).[3] Stream density (reported as miles of stream per square mile of land area) is particularly high in U-shaped glacial valleys such as the Hoh, Bogachiel, and Sol Duc drainages.

Map 3-2. Major River Systems in the OESF

Table 3-1. Stream Length (Miles) by Ownership in the OESF

Water type	Stream miles						
	DNR	Other state	Federal	Municipal	Tribal	Private[a]	Total
1	138	7	192	0	29	347	714
2	50	1	47	0	61	118	277
3	450	1	104	1	89	726	1,370
4	389	0	91	1	109	521	1,111
5[3]	1,712	3	2,060	1	486	1,812	6,073
9	46	0	895	0	121	123	1,185
TOTAL	**2,785**	**12**	**3,388**	**2**	**895**	**3,648**	**10,730**

[a]Includes industrial forestland, agricultural lands, and residential, industrial, and commercial lands.

Wetlands

In Western Washington, the combination of high rainfall and soil layers that restrict water movement results in wetlands. Wetlands are found in the coastal lowlands and valley bottoms of the major river systems in the OESF, including the lower Queets, Clearwater, Kalaloch, Hoh, Mosquito, Goodman, Bogachiel, Quillayute, Dickey, and Ozette rivers and their tributaries. Bogs, a special type of wetland that accumulates peat, are generally rare across Washington but are found in the OESF because of its geological and glacial history. Table 3-2 shows the estimated extent of wetlands in each watershed administrative unit in the OESF that has greater than 20 percent state trust lands (refer to "Administrative Designations" in this section for a description of watershed administrative units).

Table 3-2. Estimated Extent of Wetlands in Each OESF Watershed Administrative Unit

Watershed administrative unit	Acres	Percent of state trust lands as wetlands
Bogachiel	112	1.0%
Cedar	66	1.5%
Clallam River	217	2.1%
East Fork Dickey	318	2.8%
Goodman Mosquito	141	1.1%
Hoko	94	0.8%
Kalaloch Ridge	12	0.2%
Lower Clearwater	179	0.9%
Lower Dickey	173	2.2%
Lower Hoh River	383	5.0%
Lower Queets River	461	2.9%
Middle Hoh	596	1.5%
Quillayute River	132	1.8%
Sol Duc Lowlands	220	4.8%
Sol Duc Valley	262	1.8%
Upper Clearwater	226	0.4%
TOTAL	**3,615**	**<1%**

Administrative Designations

Deferrals and Operable Areas

As discussed under "DNR's Management Approach: Integrated Management" in Chapter 2, deferrals are areas that are not currently available for timber harvest per current policy or other reasons. Deferrals account for 40 percent, or 107,320 acres, of state trust lands in the OESF. An additional 3,512 acres in the OESF are designated permanently as natural area preserves and natural resources conservation areas, which are not considered state trust lands. DNR included these areas in totals used throughout this RDEIS because they contribute toward the objectives of DNR's 1997 *Habitat Conservation Plan* conservation strategies. Together, deferrals, natural area preserves, and natural resource conservation areas account for 43 percent of DNR-managed land in the OESF. For the remainder of this document, all of these areas will be referred to as deferrals or deferred areas. The remaining 57 percent (146,734 acres) is considered operable, or available for harvest, according to current policies (including conservation strategies) and laws. Table 3-3 shows the number of acres of deferrals and operable areas in each landscape in the OESF (landscapes will be described later in this section). Totals in Table 3-3 exclude acres of non-forested areas such as administrative sites, roads, and water bodies.

Table 3-3. Long-Term Deferrals and Operable Acres of DNR-Managed Land in the OESF, by Landscape

Landscape	Deferred	Operable	TOTAL
Clallam	3,684 (21%)	13,592 (79%)	17,276
Clearwater	32,179 (58%)	23,024 (42%)	55,203
Coppermine	9,000 (47%)	10,246 (53%)	19,246
Dickodochtedar	8,294 (30%)	19,753 (70%)	28,047
Goodman	9,763 (41%)	14,036 (59%)	23,799
Kalaloch	7,973 (44%)	10,149 (56%)	18,122
Queets	9,245 (44%)	11,562 (56%)	20,807
Reade Hill	4,396 (52%)	4,083 (48%)	8,479
Sekiu	1,804 (18%)	8,210 (82%)	10,014
Sol Duc	5,781 (30%)	13,365 (70%)	19,146
Willy Huel	18,714 (50%)	18,714 (50%)	37,428
All landscapes	**110,832 (43%)**	**146,734 (57%)**	**257,566**

Spatial Scales Used in the OESF

DNR uses three different spatial scales to plan and manage state trust lands in the OESF. In descending order of size, these scales are landscapes, watershed administrative units, and Type 3 watersheds.[4] Each scale is defined primarily along hydrologic boundaries. The scales are illustrated in Figure 3-1.

Figure 3-1. Spatial Scales Used to Plan and Manage State Trust Lands in the OESF

LANDSCAPE

To assist in planning and managing state trust lands in the OESF, DNR divided the OESF into 11 administrative areas called landscapes. There are 11 landscapes in the OESF: Clallam, Clearwater, Coppermine, Dickodochtedar, Goodman, Kalaloch, Queets, Reade Hill, Sekiu, Sol Duc, and Willy Huel (refer to Map 3-3). Table 3-4 shows the total number of acres of state trust lands in each landscape. Totals in Table 3-4 exclude acres of non-forested areas such as administrative sites, roads, and water bodies.

Map 3-3. Landscapes in the OESF

Table 3-4. Landscapes in the OESF

Landscape	Acres of state trust lands	Landscape	Acres of state trust lands
Clallam	17,276	Queets	20,807
Clearwater	55,203	Reade Hill	8,479
Coppermine	19,246	Sekiu	10,014
Dickodochtedar	28,047	Sol Duc	19,146
Goodman	23,799	Willy Huel	37,428
Kalaloch	18,122		
TOTAL (All Landscapes)			**257,566**

WATERSHED ADMINISTRATIVE UNIT

As established by WAC 222-22-020, Washington is divided into watershed administrative units. The boundaries of these units are defined based on hydrology and geomorphology by DNR in cooperation with Ecology, Washington Department of Fish and Wildlife (WDFW), affected tribes, local governments, forest landowners, and the public. The boundaries are mainly along drainage divides (ridges), with some along rivers and other DNR management boundaries.

There are 31 watershed administrative units in the OESF. Only watershed administrative units containing at least 20 percent state trust lands by area (refer to Table 3-5) were selected for analysis in this RDEIS. Twenty percent is the minimum ownership threshold at which DNR believes its management practices influence the environmental conditions of a watershed.[5] Of the 31 watershed administrative units, 16 exceed this threshold. Collectively, these 16 watershed administrative units represent approximately 90 percent, or 232,038 acres, of state trust lands in the OESF. The watershed administrative unit scale has been used in other DNR documents and deemed appropriate for an environmental analysis (DNR 2004, 2010). Totals in Table 3-5 exclude acres of non-forested areas such as administrative sites, roads, and water bodies. Watershed administrative units are shown on Map 3-4.

Table 3-5. Watershed Administrative Units with Greater Than 20 Percent State Trust Lands by Area

Watershed administrative unit	Acres of state trust lands	Watershed administrative unit	Acres of state trust lands
Bogachiel	11,267	Lower Dickey	7,377
Cedar	4,208	Lower Hoh River	7,120
Clallam River	10,161	Lower Queets River	14,961
East Fork Dickey	10,975	Middle Hoh	37,289
Goodman Mosquito	13,449	Quillayute River	6,187
Hoko	10,636	Sol Duc Lowlands	4,448
Kalaloch Ridge	5,753	Sol Duc Valley	13,481
Lower Clearwater	19,815	Upper Clearwater	54,911
TOTAL (All watershed administrative units)			**232,038**

Map 3-4. Watershed Administrative Units in the OESF

TYPE 3 WATERSHED

Watershed administrative units are divided into smaller units, Type 3 watersheds (refer to Map 3-5). A Type 3 watershed is a watershed that drains a Type 3 stream.

There are 594 Type 3 watersheds in the OESF; of those, 493 contain greater than 20 percent state trust lands by area. Table 3-6 shows the Type 3 watersheds located within the 16 watershed administrative units described in the previous section. The riparian analysis (p. 3-45) examines potential environmental impacts at the Type 3 watershed scale.[6] Totals in Table 3-6 exclude acres of non-forested areas such as administrative sites, roads, and water bodies.

Map 3-5. Type 3 Watersheds in the OESF

Table 3-6. Number of Type 3 Watersheds in Selected OESF Watershed Administrative Units with Greater Than 20 Percent State Trust Lands by Area[a]

Watershed administrative unit	Total number of Type 3 watersheds	Type 3 watersheds with greater than 20 percent state trust lands
Bogachiel	32	19
Cedar	11	9
Clallam River	32	22
East Fork Dickey	24	18
Goodman Mosquito	39	25

Table 3-6, Continued. Number of Type 3 Watersheds in Selected OESF Watershed Administrative Units with Greater Than 20 Percent State Trust Lands by Area[a]

Watershed administrative unit	Total number of Type 3 watersheds	Type 3 watersheds with greater than 20 percent state trust lands
Hoko	39	16
Kalaloch Ridge	15	12
Lower Clearwater	50	32
Lower Dickey	35	21
Lower Hoh River	30	15
Lower Queets River	26	12
Middle Hoh	75	66
Quillayute River	14	8
Sol Duc Lowlands	18	10
Sol Duc Valley	29	20
Upper Clearwater	75	75

[a]Data source: 2010 Large Data Overlay; includes slivers of Type 3 watersheds that are not included in the State of the Forest files.

Analysis Approach

This RDEIS is not meant to be a site-specific analysis of the potential environmental impacts of specific management activities such as individual timber sales or the construction of specific sections of roads. As explained in Chapter 1, this RDEIS is an analysis of a non-project action (development and implementation of a forest land plan). Non-project actions include the adoption of plans, policies, programs, or regulations that contain standards controlling the use of the environment, or that regulate or guide future on-the-ground actions. Future management actions depend, in part, on the decisions made during this planning process, but no specific on-the-ground activities are designed as part of this process. As described in Chapter 1, the site-specific impacts of proposed, specific management activities are analyzed at the time they are proposed.

What Topic Areas Does This Analysis Include?

Forest conditions as a whole are analyzed in "Forest Conditions and Management," p. 3-21. In this RDEIS, DNR also provides detailed analysis for the following topics: soils, riparian, water quality, fish, wildlife, northern spotted owls, and climate change.

How Is Each Topic Analyzed?

All analysis in this RDEIS has been performed using the best available scientific information and techniques.[7] To analyze each topic, DNR uses criteria and indicators. Criteria are broad concepts, such as forest health or functioning riparian habitat. Indicators are the specific, quantitative means by which the criteria are measured. For example, the indicator stand density (crowding of forest stands) is used to measure the criterion forest health, and the indicator stream shade is used to measure the criterion functioning riparian habitat. Each criterion may have one or more indicators. This approach is based on the Montréal Process, which was established to advance the development of internationally agreed-upon criteria and indicators for the conservation and sustainable management of temperate and boreal forests (Montréal Process 1995).

DNR used its expertise, existing scientific information, and current data to select the criteria and indicators that would best describe the potential environmental impacts of the two alternatives. Each topic area (such as "Northern Spotted Owls," "Riparian," and "Water Quality") has its own set of criteria and indicators. The criteria and indicators used to address the forest as a whole are described in "Forest Conditions and Management" later in this chapter.

Overlapping Indicators

Forests are complex, interrelated natural systems. Few indicators will apply to only one topic in this RDEIS; many will overlap. For example, the amount of stream shade provided by the riparian forest affects both water quality and fish.

DNR analyzes each overlapping indicator in the section to which it most logically applies. Stream shade, for example, is analyzed in "Riparian." Subsequent sections which use these indicators, such as "Water Quality," include a brief summary of the indicator and additional information about that indicator specific to the topic being discussed.

Additional indicators could have been used to evaluate the criteria. However, DNR used its expertise to determine which indicators were best to use with the scientific data that is currently available from Ecology, USFS, DNR, and other sources. DNR believes that the selected indicators are sufficient to understand how the criteria are affected.

How Are the Indicators Analyzed?

DNR'S FOREST ESTATE MODEL

This environmental analysis is based primarily on the outputs of the forest estate model (plus consideration of mitigation through current management practices, as will be described later in this section). To deepen its understanding of the potential environmental impacts affecting particular topic areas, DNR also developed computer models for northern spotted owl territories and habitat, windthrow, and each riparian indicator. Each model was developed using data from the forest estate model and other data and information. For more information on northern spotted owl territory and habitat models, refer to Appendix I, and for more information on riparian and windthrow models, refer to Appendix G.

In Chapter 2, DNR explained that the forest estate model will be used to implement the Landscape Alternative *only*; the model will *not* be used to implement the No Action Alternative. However, in order to assess the potential environmental impacts of the two alternatives for this RDEIS, **it was necessary to run the forest estate model for *both* alternatives.**

For each alternative, the model determines the optimal solution of when, where, and by what harvest method to harvest forest stands to meet multiple management objectives. This solution is expressed as a harvest schedule. The harvest schedule projects the types, locations, and timings of harvests across state trust lands in the OESF over the 100-year analysis period (reported in decade intervals). For this RDEIS, with the exception of road-related indicators, **DNR analyzes, for each alternative, the potential environmental impacts of implementing the harvest schedule across state trust lands in the OESF. DNR analyzes harvests exactly as modeled, with no modifications.**

The model also provides a state of the forest file, which is a forecast of forest conditions that are projected to occur as a result of implementing the harvest schedule under each alternative. For some indicators, DNR uses the state of the forest file as well as the territory, habitat, windthrow, and riparian indicator models to identify trends of change in forest ecosystems—for example, an increase or decrease in the risk to forest health posed by overcrowded forest stands. DNR uses these trends to identify potential environmental impacts.

Using the forest estate model for an environmental analysis has certain advantages. For example, the model enables DNR to forecast future forest conditions that may result from each alternative over a long period to a level of detail not possible by other means. This forecast enables DNR to perform an objective, quantitative, repeatable analysis of the potential environmental impacts of the alternatives.

However, there are caveats. Even the best model can only approximate future conditions, as natural systems are highly complex with numerous interrelated factors. In addition, because of small differences between modeled and actual conditions, harvests may not be implemented exactly as modeled. Despite these caveats, DNR believes that its model is more than sufficient to identify potential environmental impacts at the spatial scale at which these impacts are analyzed. For more information about the advantages and caveats of using a forest estate model for an environmental analysis, refer to Chapter 4, p. 4-10.

THREE TYPES OF INDICATORS

In this RDEIS, DNR uses three types of indicators: those that measure the frequency and intensity of projected harvest activities, those that measure changes to forest conditions that may result from those activities, and those that measure the road network:

- **Frequency and intensity of projected harvest activities**: For these indicators, DNR analyzes the frequency and intensity of harvest activities that are projected to occur under either alternative over the next 100 years. For example, for the indicator "harvest methods and number of forest stand entries," DNR identifies combinations of projected harvest activities that could result in potential high impacts, such as three stand replacement harvests of the same stand over the 100-year analysis period.

- **Forest conditions**: For these indicators, DNR compares current forest conditions to the forest conditions that are projected to result from implementing either alternative. For example, for the indicator "northern spotted owl habitat," DNR considered whether, as compared to current conditions, the number of acres of habitat is projected to increase, decrease, or remain the same over time under each alternative.

- **Road network**: These indicators measure the location and extent of the current road network. Because DNR does not anticipate major changes to the road network over the next 100 years, results are based on current conditions. Refer to "Water Quality," p. 3-115 for more information.

ANALYSIS PROCESS

Step One: Assigning Potential Low, Medium, or High Impact Ratings

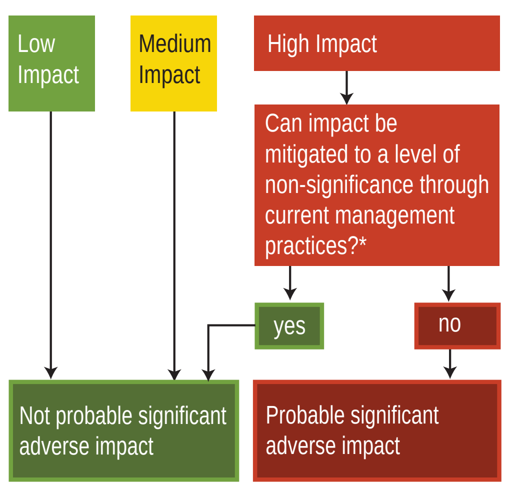
In this RDEIS, DNR first quantifies potential environmental impacts for each indicator as low, medium, or high using parameters defined for each indicator. The exact meaning of each term (low, medium, high) is specific to each indicator. For example, some low and medium impacts are potentially beneficial (an improvement in conditions), while others are potentially adverse but not significant. For this analysis, only potential high impacts are considered potentially significant impacts.

It is important to understand that **DNR first assigns potential low, medium, or high impact ratings by analyzing management activities *exactly* as they were modeled or mapped, without considering current management practices that are expected to mitigate potential high impacts**. For example, DNR first analyzes potential impacts from roads based on a straightforward assessment of the mapped size and location of the road network. In this step, DNR assumes that all roads that have not been certified as abandoned[8] can contribute sediment to streams, even though some of these roads have been mitigated already or will be mitigated in the future through current management practices to prevent the delivery of sediment from roads to stream channels (mitigation of the road network through current management practices is discussed in "Water Quality" on p. 3-131). **Mitigation is not considered until the second step of DNR's analysis process.**

Step Two: Determining if Impacts are Probable Significant Adverse

In this step, DNR considers the full range of its current management practices to identify specific programs, rules, procedures, or other measures that are expected to mitigate a potential high impact to a level of non-significance. If an impact will be mitigated, it is not considered probable significant adverse (refer to Figure 3-2). For each indicator, DNR describes the specific management practice(s) that will be used to mitigate a potential high impact. DNR may also determine if a potential high impact is significant based on the role the indicator plays in ecological function.

Figure 3-2. Determining Impacts for Each Indicator



*DNR may also consider the indicator's role in ecological function to determine significance

If a potential high impact will not be mitigated through current management practices, and the indicator plays an important role in ecological function, the potential high impact is considered probable significant adverse. For these indicators, DNR describes possible mitigation. Unlike mitigation through current management practices, possible mitigation is something that DNR may do to reduce a potential high impact to a lower level. It is suggested, not required. Although DNR may adopt possible mitigation in the future, DNR is not committed to implementing it at this time. Possible mitigation includes site-specific mitigation that foresters may suggest to further reduce potential impacts at the time of an individual management activity. Site-specific mitigation is considered under SEPA as part of the SEPA review for each activity. Possible mitigation is mentioned but not analyzed in this RDEIS.

For each topic, DNR provides a detailed explanation of how each indicator is measured; the thresholds used to measure it; the specific meaning of low, medium and high in the context of that indicator; the mitigation that applies to that indicator; and the final determination of whether the impact is a probable significant adverse impact. To assist the reader, DNR uses color-coded symbols in tables throughout this RDEIS. A green circle indicates a potential low impact, a yellow diamond indicates a potential medium impact, and a red square indicates a potential high impact.

What Spatial Scales Does DNR Use for Each Indicator?

DNR analyzed each indicator at the spatial scale that it considers most meaningful. For example, peak flow (an indicator for functioning riparian habitat) is analyzed at the scale of the Type 3 watershed, while carbon sequestration (an indicator for climate change) is analyzed at the scale of state trust lands in the OESF. Scales are chosen based on existing literature, available data, and professional judgment. In some cases, multiple scales are used to provide a more comprehensive understanding of potential impacts. Table 3-7 lists the scales used for indicators under each topic.

Table 3-7. Scale of Analysis by Topic

Topic	Scale of analysis
Forest Conditions and Management	State trust lands in the OESF, landscape; results at watershed administrative unit and Type 3 watershed scale are presented in Appendix E
Riparian	Type 3 watershed, stream reach
Soils	Landscape, watershed administrative unit
Water Quality	Landscape, Type 3 watershed
Fish	Stream reaches that are considered essential habitat for certain species of fish[a]
Wildlife	State trust lands in the OESF
Northern Spotted Owls	State trust lands in the OESF, landscape
Climate	State trust lands in the OESF

[a]The term essential habitat is used solely for the purpose of conducting this environmental impact analysis and does not connote or imply DNR policy direction.

Natural Disturbance

In this RDEIS, DNR does not analyze the potential environmental impacts of stochastic (random), large-scale natural disturbances such as major fires or windstorms because DNR is unable to predict or model the local likelihood of these disturbances. In addition, DNR is unable to model future, site-specific, small-scale natural disturbance events as it is impossible to predict their location or severity. Instead, these smaller natural disturbances are accounted for within the forest estate model in a generalized fashion in the growth and mortality estimates for trees within forest stands over time.

Natural disturbances such as fire, windthrow, naturally occurring landslides, and other events can lead to openings in forests, loss of standing volume, alterations in the shape and depth of streams, and other changes. **DNR does not imply that all changes in forest ecosystems are negative, nor does DNR imply that management activities are the only source of disturbance in the forest.** Disturbance is part of a forest's natural lifecycle, and forests are constantly changing.

Harvest Schedule Analyzed

Following, DNR describes the harvest schedule analyzed in this RDEIS under each alternative in terms of the total area harvested, the number of forest stand entries, the acres of harvest per decade, the harvest methods, and harvest volumes. The differences between the harvest schedules are due to the differences between the alternatives; those differences are described in Chapter 2. For a description of how the alternatives were modeled, refer to Appendix D.

Is DNR Proposing to Change the Sustainable Harvest Level Through This Planning Process?

DNR is *not* proposing to change the current sustainable harvest level for state trust lands in the OESF through this planning process. As explained under "DNR's Planning Process," the sustainable harvest level for state trust lands in the OESF is a policy-level decision that will be determined through a separate planning process.

However, the harvest schedule analyzed in this RDEIS for both alternatives represents a harvest level that is higher than the current sustainable harvest level of 576 million board feet per decade. When DNR modeled the two alternatives for this environmental analysis, DNR did not constrain the model to any pre-determined harvest level. In other words, the model was not required to adhere to any specific harvest level. DNR made this decision for the following reasons:

- A primary purpose of forest land planning is to determine if the sustainable harvest level can be met. An effective way to answer this question is to run the model without a harvest level constraint, and then compare the resulting harvest level to the current sustainable harvest level.
- DNR is near the end of the current sustainable harvest decade and the new sustainable harvest level has not been calculated. To impose the current sustainable harvest

level on the model would require DNR to assume that the level will not change; to impose a lower or higher level on the model would require DNR to speculate on what a future level might be. DNR believes both choices to be speculative and inappropriate.

- By running the model without a harvest level constraint, DNR was able to determine the harvest schedule that would result from applying the management strategies and procedures unique to each alternative. Had the model been constrained to the current sustainable harvest level, the harvest schedules for the alternatives would have been very similar, which would have masked the differences between them.

Regardless of which alternative is chosen in this planning process, the sustainable harvest level for the OESF will remain at 576 million board feet for the current decade.

Total Area Harvested

As explained under "Deferred and Operable Areas" earlier in this chapter, 57 percent, or 146,734 acres, of DNR-managed lands in the OESF are considered operable, meaning they are available for harvest activities under either alternative according to current policies and laws. However, within the operable area, the total number of acres on which harvest activities are *scheduled to occur* will differ under each alternative due to the procedures and management strategies that are unique to each alternative. Under the Landscape Alternative, the total area harvested, or harvest footprint, is 141,321 acres according to model results. Under the No Action Alternative, the total area harvested is 138,948 acres, or 2,373 acres less than the Landscape Alternative.

Acres Harvested Per Decade

Table 3-8 shows the number of acres scheduled to be harvested per decade under each alternative. With the exception of decades 1 and 6, in each decade more acres are scheduled for harvest under the Landscape Alternative than under the No Action Alternative. Note that acres overlap between the decades: acres harvested in one decade may be harvested again in a subsequent decade.

Table 3-8. Acres Harvested Per Decade Under Each Alternative, by Decade

Decade	No Action Alternative	Landscape Alternative
1	31,466	30,568
2	22,878	26,843
3	28,473	31,468
4	35,722	38,049
5	38,077	48,293
6	45,935	44,676
7	38,665	40,382
8	39,565	46,895
9	43,000	49,220
10	25,963	26,098

Number of Forest Stand Entries

Each harvest of a forest stand, whether that harvest is a variable density thinning or a variable retention harvest, is called a forest stand entry. For example, a forest stand that is not harvested at all during the 100-year analysis period has no forest stand entries. A forest stand that receives two thinning harvests and a variable retention harvest over 100 years has three forest stand entries.

According to model results, forest stand entries are projected to be more frequent under the Landscape Alternative than under the No Action Alternative. For example, under the Landscape Alternative, nearly 12,000 more acres are scheduled to receive three or more forest stand entries than under the No Action Alternative (for more information on forest stand entries, refer to "Forest Conditions and Management" on p. 3-22).

Harvest Methods

Charts 3-2 and 3-3 show the number of acres of variable retention harvest and variable density thinning that are scheduled under each alternative. Considering all decades together, the Landscape Alternative is projected to have 15 percent more acres of variable density thinning and 8 percent more acres of variable retention harvest than the No Action Alternative.

Chart 3-2. Acres of Modeled Variable Density Thinning Under the No Action and Landscape Alternatives, by Decade

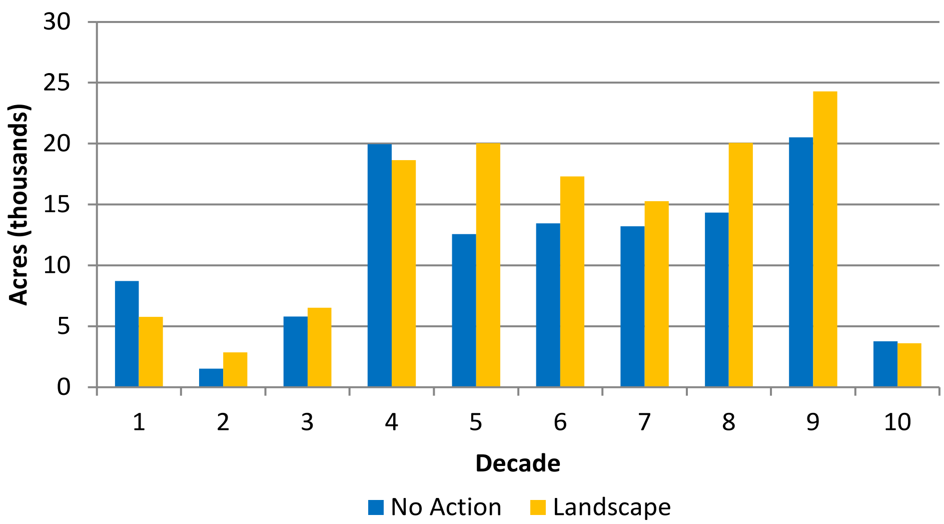
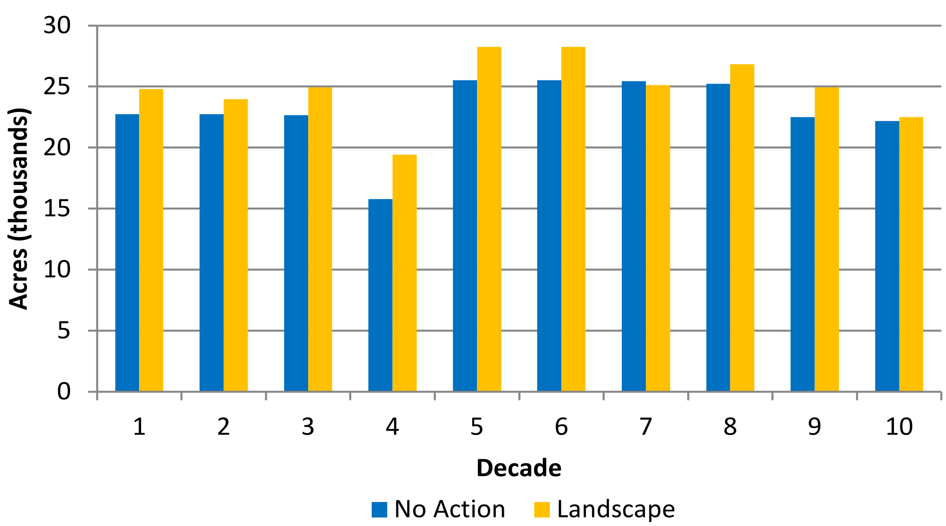


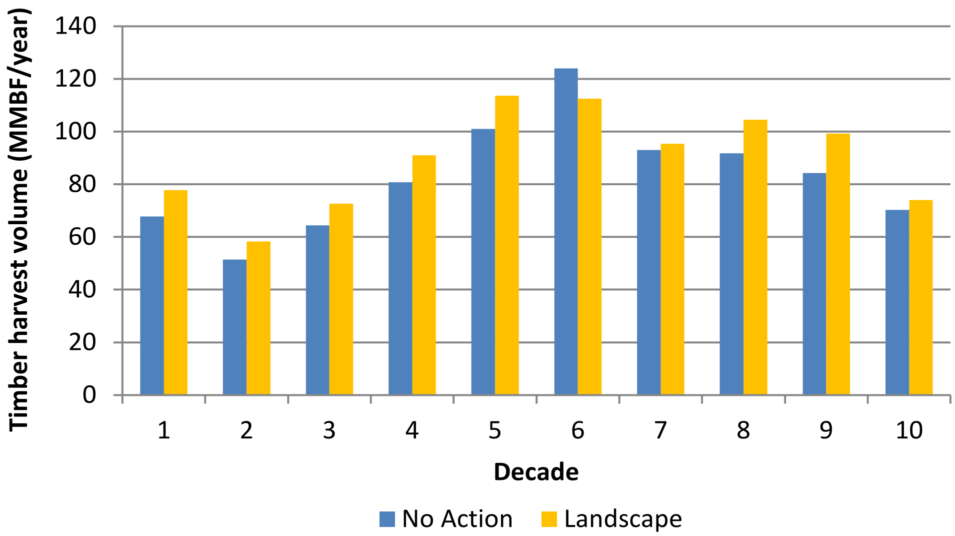
Chart 3-3. Acres of Modeled Variable Retention Harvest Under the No Action and Landscape Alternatives, by Decade



Harvest Volume

Chart 3-4 shows the projected harvest volume under both alternatives. As explained previously, these harvest volumes are an output of DNR's forest estate model, which was not constrained by the current sustainable harvest level. As a reminder, DNR is *not* proposing to change the current sustainable harvest level through this planning process.

Chart 3-4. Timber Harvest Volume (Millions of Board Feet Per Year [MMBF]) Projected by the Forest Estate Model Under Each Alternative, by Decade



This information is presented for the benefit of stakeholders and other interested readers. However, harvest volume is not a focus of this RDEIS because, when considered alone, harvest volume does not adequately describe either the differences between the alternatives or their respective potential environmental impacts. For example, a similar harvest volume under each alternative could have different impact levels depending on the frequency of harvest entries, the proximity of the harvests to streams, and other factors.

For that reason, DNR uses indicators that are more descriptive of potential impacts. The indicators DNR uses examine how often and by what method an area is projected to be harvested, the forest conditions that are projected to result from those harvests, and how the projected harvests may affect soils, water quality, riparian function, fish, and wildlife. All of these topics are discussed in this chapter.

How Is the Analysis Organized?

The remainder of Chapter 3 contains separate sections for "Forest Conditions and Management," "Riparian," "Soils," Water Quality," "Fish," "Wildlife," "Northern Spotted Owls," "and "Climate Change." The sections are generally structured as follows:

- A brief introduction to the topic;
- A description of the criteria and indicators used in the analysis, including information on how the indicators are measured;
- Current conditions for each indicator—in some sections, current conditions and results are discussed together;
- Results—in this section, DNR presents an analysis of the potential environmental impacts of the two management alternatives for each indicator;
- A summary table of potential environmental impacts by indicator; and
- Additional information pertinent to the topic.

Section Notes

1. Vegetation zones are areas with similar environmental attributes such as soils, climate, and elevation, and are defined by the dominant tree species in the absence of wildfire, windstorms, harvest practices, or other disturbances.
2. Many fires affecting a small area.
3. DNR uses a numerical system (one through five) to categorize streams based on physical characteristics such as stream width, steepness, and whether or not fish are present. Type 1 streams are the largest; Type 5 streams are the smallest. Type 9 streams are "unclassified" and refer to streams that are currently mapped, but lack sufficient data to determine the correct water type. Only Type 1, 2 and 3 streams are considered fish-bearing. DNR and the Federal Services have agreed that the Washington Forest Practices Board Emergency Rules (stream typing), November 1996 (WAC 222-16-031 [water typing interim]) meet the intent of DNR's 1997 *Habitat Conservation Plan*. A comparison of DNR's water typing system is provided in the rules (WAC 222-16-031).

   The current DNR GIS stream layer is believed to underestimate the number of Type 5 streams. Mapping standards and methodology vary according to ownership, which results in marked differences in mapped headwater stream density.
4. DNR also used a much smaller scale, the stream reach, to understand what is occurring at the Type 3 watershed level; refer to "Riparian," p. 3-47 for more information.
5. The use of a 20 percent threshold followed recommendations from federal watershed monitoring programs (Reeves and others 2004, Gallo and others 2005). Reeves and others recommended using a minimum 25 percent ownership threshold for the inclusion of a given watershed in the monitoring program. As described by Gallo and others (2005), this 25 percent threshold was selected to avoid sampling watersheds in which "the contribution of federal lands to the condition of the watershed was insignificant." A more stringent 20 percent threshold was used in this analysis.
6. Washington's current Forest Practices Board Manual refers to the Type 3 watershed as a sub-area of a watershed administrative unit, and recognizes the Type 3 watershed as a scale at which watershed analysis (WAC 222-22) can be conducted.
7. For a definition of "best available science" reference WAC 365-195-905.
8. Under the forest practices rules (WAC 222-24-52(3)), a road is considered abandoned if: (a) roads are outsloped, water barred, or otherwise left in a condition suitable to control erosion and maintain water movement within wetlands and natural drainages; (b) ditches are left in a suitable condition to reduce erosion; (c) the road is blocked so that four-wheel highway vehicles cannot pass the point of closure at the time of abandonment; (d) water crossing structures and fills on all typed waters are removed, except where DNR determines other measures would provide adequate protection to public resources; and (e) DNR has determined that the road is abandoned.

Forest Conditions and Management

What Is Important About Forests?

When managed sustainably, forests provide a wide range of essential economic, social, and environmental goods and services for the benefit of current and future generations (Montréal Process 1995). Sustainably-managed forests have a mix of forest conditions, including high-quality trees available for harvest and diverse habitats for native species such as northern spotted owls, marbled murrelets, and salmon (DNR 1997).

What Are the Criteria for Forest Conditions?

The criteria for evaluating forest conditions are **forest sustainability**, **forest structural complexity**, and **forest health**. These criteria are a subset of the internationally recognized criteria for sustainable forestry used in the Montréal Process. The criteria used in the Montréal Process form a common understanding within and across countries of what is meant by sustainable forest management.

What Are the Indicators for Forest Conditions?

Each criterion is analyzed using one or more indicators. The criterion forest sustainability is analyzed using the indicators **forest biomass** and **harvest methods and number of forest stand entries**. The criterion forest structural complexity is analyzed using the indicators **stand development stages**, and the criterion forest health is analyzed using the indicator **stand density**. These indicators were selected based on DNR's expertise, existing scientific information, and current data. Information about each criterion and indicator is presented in the following section.

Descriptions of Criteria and Indicators

Criterion: Forest Sustainability

For this RDEIS, forest sustainability is defined as the management of forests to provide harvesting on a continuing basis without major curtailment or cessation of harvest (RCW 79.10.310). This definition reflects DNR's responsibility as a trust lands manager, which is to manage state trust lands to provide perpetual income for current and future trust beneficiaries (DNR 2006). Forest sustainability is measured by considering the amount of wood available in the forest (forest biomass) and the type and frequency of harvest (harvest methods and number of forest stand entries) that is projected to occur over the 100-year analysis period.

INDICATOR: FOREST BIOMASS

Forests contain trees of all ages and often of many different species. To meet its fiduciary responsibilities, DNR makes trees available for harvest when they mature. The harvested trees are replaced with seedlings as a way to constantly renew the forest.

Forest biomass is measured in total standing volume (Smith and others 2003), which is the amount of wood standing in the forest, excluding snags (standing dead trees). Total standing volume increases over time when tree growth exceeds tree mortality and removal. When a forest is sustainably managed, the amount of total standing volume removed through harvest should not exceed the amount of total standing volume remaining. A drop in total standing volume over time due to harvest is not considered sustainable.

For this indicator (forest biomass), DNR uses the forest estate model to determine if the total standing volume is projected to increase, stay the same, or decrease as a result of harvests projected under each alternative. The total standing volume also has implications for carbon sequestration (storage) (refer to "Climate Change," p. 3-223).

INDICATOR: HARVEST METHODS AND NUMBER OF FOREST STAND ENTRIES

The types of harvest methods used on state trust lands in the OESF are described in Text Box 3-1. The analysis for the harvest methods and number of forest stand entries indicator is a three-step process:

- **Step one**—Determine the percentage of state trust lands in each landscape with potential high impacts. Potential high impacts are based on the projected number of forest stand entries, as will be explained later in this section.
- **Step two**—Assign a potential low, medium, or high impact rating to each landscape based on the percentage of state trust lands in that landscape with potential high impacts.
- **Step three**—Assign a potential low, medium, or high impact rating to this indicator based on the percentage of state trust lands in all landscapes with potential high impacts.

Additional information on harvest methods can be found in Appendix A (draft forest land plan), Chapter 3. Following, DNR explains each step in analyzing this indicator.

Text Box 3-1. Examples of Harvest Methods

Variable Retention Harvest

Variable retention harvests are stand-replacement harvests in which “leave trees” (trees that are not harvested), snags, large logs, and other structural features are retained between one harvest and the next. These features provide the structural diversity across the landscape that is increasingly being recognized as important for biodiversity (Lindenmayer and Franklin 2002). Variable retention harvests are distinctly different from “clearcuts,” in which large areas are harvested (over 100 acres) and most or all of the existing forest is removed. Clearcuts leave little or no structural diversity (Franklin and others 2002).


Variable retention harvest

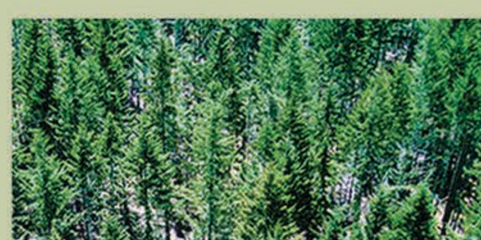

Variable retention harvest


Variable retention harvest

Thinning

Thinning is normally done to reduce stand density and allow the remaining trees to become larger. In uniform thinning, trees are evenly removed throughout the stand. In variable density thinning, some areas are lightly thinned (“skips”) while other areas are more heavily harvested (“gaps”) to create variations in stand density and canopy cover (Lindenmayer and Franklin 2002).


Variable density thinning


Uniform thinning

Step One: Determine the Percentage of Each Landscape with Potential High Impacts

Each harvest of a forest stand is called a forest stand entry. Repeated forest stand entries can affect many elements of the environment, such as soils (Elliot and others 1999). DNR considers certain combinations of forest stand entries to be a potential high impact. Examples include three variable retention harvests, or two variable retention harvests and two thinnings, of the same stand over the 100-year analysis period.

Using the outputs of the forest estate model and the methodology shown in Figure 3-3, DNR determines the percentage of state trust lands in each landscape that is projected to receive combinations of forest stand entries that DNR considers a potential high impact.

Figure 3-3. Method for Determining the Number of Acres in Each Landscape With Potential High Impacts

This chart is completed for each of the 11 landscapes.

In the boxes with green circles, DNR enters the number of acres of state trust lands in this landscape on which the projected combination of variable retention harvest and thinning over the 100-year analysis period may have potential low impacts

In the boxes with red squares, DNR enters the number of acres of state trust lands in this landscape on which the projected combination of variable retention harvest and thinning over the 100-year analysis period may have potential high impacts

		Variable retention harvest entries			
		0 entries	1 entry	2 entries	3 entries
Thinning Entries	0 entries	acres	acres	acres	acres
	1 entry	acres	acres	acres	acres
	2 entries	acres	acres	acres	acres
	3 entries	acres	acres	acres	
	4 or more	acres			
Acres and percent of total area with potential high impacts					acres (percent)

Key: Low impact | Medium impact | High impact

In the boxes with yellow diamonds, DNR enters the number of acres of state trust lands in this landscape on which the projected combination of variable retention harvest and thinning over the 100-year analysis period may have potential medium impacts.

This analysis is primarily concerned with potential high impacts. DNR adds all of the acres in the red boxes, then divides that total by the total number of acres in the landscape. This calculation determines what percentage of the landscape may have potential high impacts.

Step Two: Assign a Potential Low, Medium, or High Impact Rating to Each Landscape

DNR assigns each landscape a potential low, medium, or high impact rating based on the percentage of state trust lands in that landscape with potential high impacts. DNR uses the following thresholds:

- If less than 10 percent of state trust lands in the landscape have potential high impacts, the potential environmental impact for that landscape is low.
- If 10 to 20 percent of state trust lands in the landscape have potential high impacts, the potential environmental impact for that landscape is medium.
- If more than 20 percent of state trust lands in the landscape have potential high impacts, the potential environmental impact for that landscape is high.

Step Three: Assign a Potential Low, Medium, or High Impact Rating to This Indicator

In this step, DNR determines the total number of acres of state trust lands in all landscapes with potential high impacts. DNR then uses the thresholds identified in step 2 to assign a potential low, medium, or high impact rating to this indicator. As described in the introduction to this chapter, DNR assigns potential low, medium, or high impact ratings by analyzing management activities exactly as they were modeled, without considering current management practices that are expected to mitigate potential high impacts.

DNR's threshold for potential high impacts is based on experience, professional judgment, and the assumption that repeated forest stand entries may affect soils. Studies on the impacts of repeated forest stand entries in the forests of the Pacific Northwest are lacking, in part due to the relatively short histories of timber harvesting and research on the effects of timber harvesting in those forests. DNR analyzes the potential environmental impacts of forest stand entries on soils in greater detail in "Soils," p. 3-91.

Criterion: Forest Structural Complexity

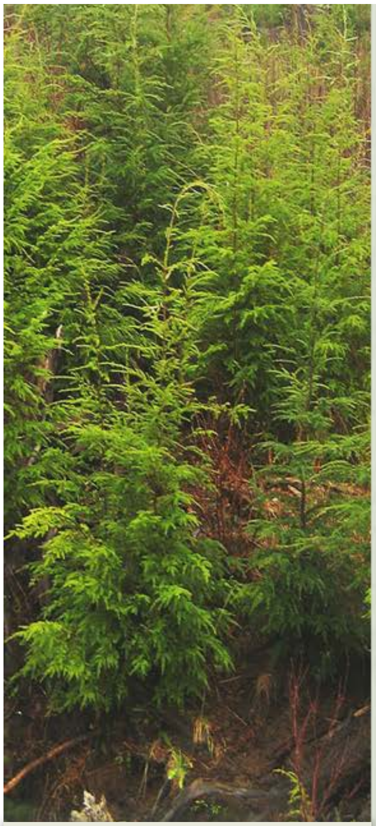
Forest structure is the physical structure of a stand of trees such as the number of canopy layers, tree width and height, and the presence or absence of snags and down wood. A forest stand's structure can range from simple (one canopy, no understory) to complex (multiple canopy layers, snags, down wood, and other features). This criterion is measured using stand development stages.

INDICATOR: STAND DEVELOPMENT STAGES

As trees grow from planted seedlings after a harvest or regenerate on their own after natural disturbances, forest stands move in and out of stand development stages (refer to Text Box 3-2). Each stand development stage is characterized by a set of measurable physical attributes The forest classification system for state trust lands in the OESF is based on many scientific publications (Carey 2007, Van Pelt 2007, Franklin and others 2002, Carey and others 1996, Oliver and Larson 1996, DNR 2004). For this analysis, nine stand development stages were consolidated to five, as shown in Text Box 3-2.

Classifications of stand development stages are somewhat arbitrary as these stages are continuous rather than a series of discrete stages (Franklin and others 2002). It is also possible for individual stands to skip a developmental stage (Franklin and others 2002). Despite these caveats, it is still valuable to classify stands by their stand development stage as a way to understand the overall condition of the forest.

Text Box 3-2. Stand Development Stages



Ecosystem Initiation

Death or removal of overstory trees by wildfire, windstorm, insects, disease, or timber harvest leads to the establishment of a new forest ecosystem (Carey and others 1996). Establishment and occupation of the site by vegetation are the main ecological process taking place (Carey 2007).

Competitive Exclusion

This stage, as used in this analysis, contains forest stands in the following subcategories: Sapling Exclusion, Pole Exclusion, and Large Tree Exclusion (forest stand development stages adopted from Carey and others 1996). The main characteristic of this stand development stage is that trees fully occupy the site. Competition for light, water, nutrients, and space is the key ecological process in this stage (Carey 2003).

Understory Development

As overstory trees die, fall down, or are harvested,canopy gaps are created. In these gaps, an understory of trees, ferns, and shrubs develops. In this stage, there is little diversification of plant communities.

Text Box 3-2, Continued. Stand Development Stages

Biomass Accumulation

For this RDEIS analysis, DNR considers Biomass Accumulation roughly equivalent to the Maturation stand development stage defined by Franklin and others (2002). Forest stands in this stand development stage contain numerous large, overstory trees that continue to rapidly add woody biomass (grow larger in diameter). Forests in this stage fully occupy the site, and competition between trees is moderate. Franklin and others (2002) and Carey (2003) consider woody biomass production the key ecological process in this stage. Tree heights are expected to be equal to or greater than 85 feet. In this stage, forest stands lack the large snag and/or down woody debris and understory diversity that characterizes later stages.

Structurally Complex

Forest stands classified as Structurally Complex contain stands in the Niche Diversification and Fully Functional stand development stages. Forests contain live, dead, and fallen trees of various sizes, including decomposing, fallen trees or "nurse logs" on which trees and other vegetation grows. These stands have a diversity of plant communities on the forest floor. Multiple canopies of trees are present, and large and small trees have a variety of diameters and heights. The added complexity provides for the life requirements of diverse vertebrates, invertebrates, fungi, and plants.

A stand's structure can result from a number of influences, including harvest, natural growth, natural disturbance, or a combination of influences. Harvest methods, for example, can change a forest stand's trajectory into and out of its existing stand development stage:

- Thinning can move a stand currently in the Competitive Exclusion stage (Photo A) into the Understory Development stage (Photo B). Forests that are not thinned or affected by natural disturbance can remain in the Competitive Exclusion stage for many decades.

- Variable retention harvests often result in a forest stand being reclassified temporarily to the Ecosystem Initiation stage; these stands then begin moving through the next stages of stand development. When a variable retention harvest is performed, snags, unique trees, down woody debris, and other structural features can be retained to help enhance structural complexity across the landscape (Franklin and others 2002).

Photo A.
Forest Stand in Competitive Exclusion Stage

Photo B.
Thinned Forest Stand Transitioning Into Understory Development Stage

Stands in both photos (A and B) are the same age.

For this indicator (stand development stages), DNR considers how the proportion of stand development stages across state trust lands in the OESF is projected to change over the 100-year analysis period. A shift over time (100-year analysis period) toward more complex stand development stages, particularly a reduction in the Competitive Exclusion stage and an increase in the Structurally Complex stage, is considered a potential low impact. Conversely, a shift toward less complex stand development stages, such as an increase in the Competitive Exclusion stage, is considered a potential high impact.

DNR is not implying a goal of achieving uniform conditions on state trust lands in the OESF, in which most acres are in one or two specific stand development stages. A diversity of stand development stages provides a range of ecological conditions that support both ecological values and revenue production. Instead, this indicator considers how the proportion of stand development stages on state trust lands changes over time because those changes may affect the forest ecosystem.

For example, an increase in structural complexity may benefit wildlife. While each stand development stage has specific structures, such as large trees, down wood, or snags, which can benefit certain wildlife guilds (a wildlife guild is a group of species that has similar habitat requirements for foraging, breeding, or shelter), the early stand development stages, such as Ecosystem Initiation, and later stages, such as Structurally Complex, can support the greatest diversity and abundance of wildlife species (Johnson and O'Neil 2001, Carey 2003).

A decrease in Competitive Exclusion may benefit forest health (refer to "Forest Health" in this section). Refer to Appendix M for maps of projected stand development stages over the 100-year analysis period.

Criterion: Forest Health

Forest health is the perceived condition of a forest, including forest age, structure, composition, function, vigor, presence of unusual levels of insects or disease, and resilience to disturbance (adapted from definition by the Society of American Foresters).

INDICATOR: STAND DENSITY

Stand density[1] is the degree of crowding of individual trees within the portion of an area actually stocked with trees (Smith and Baily 1964). Stand density indicates the level of inter-tree competition, which can affect tree mortality. DNR uses a measure of stand density called Curtis' Relative Density (Curtis 1982; refer to Text Box 3-3) to compare stand density at different points in time. For simplicity, the remainder of this RDEIS refers to Curtis' Relative Density as relative density.

DNR defines stands as overstocked and forest health at increased risk if a) stands have a single canopy, and b) relative density is greater than 75, regardless of tree species. Overstocked conditions are most prevalent in the Competitive Exclusion stand development stage, but stands in the Biomass Accumulation stage can also become overstocked because trees fully occupy the site and accumulate biomass rapidly (grow taller and larger in diameter). Similar to Competitive Exclusion stands, Biomass Accumulation stands can develop with a single closed canopy that suppresses or eliminates light-dependent understory plants.

Stands in the Understory Development or Structurally Complex stages with high relative density are not considered overstocked because they have multiple canopy layers. In single canopy stands, trees of roughly the same age compete directly with each other for resources (sunlight, moisture, growing space, and nutrients). However, multiple-canopy

Text Box 3-3. Curtis' Relative Density

Relative density (RD) represents how the density of a given stand relates to the theoretical maximum density for a particular tree species. RD is calculated by taking the stand basal area (BA) and dividing it by the square root of its quadratic mean diameter (QMD).

$RD=BA/\sqrt{QMD}$

Where:

BA is the cross-sectional area of all tree stems for a given diameter range in a forest stand.

QMD is the tree of average basal area within the same stand and diameter range. QMD may be obtained by dividing the stand basal area by the number of trees per acre, then finding the diameter of this tree.

stands have trees of different ages, sizes, and species. Although these trees compete with each other, their needs are different so competition is not as direct. High relative density in these stands is a natural part of the stand's progression and is not considered a significant risk for forest health.

As stand density increases, competition for essential resources such as sunlight, moisture, nutrients, and growing space also increases. Although not universally true, trees with less room to grow (refer to Figure 3-4) tend to be less able to withstand attack from insects, pathogens and parasites (Safranyik and others 1998). Destructive forest insects kill substantial portions of standing volumes when epidemic levels occur in local areas. The range of acceptable stand densities varies somewhat by a species' shade tolerance, but for this analysis, DNR uses a relative density of 75 as the threshold for overstocked conditions (refer to Appendix E for additional discussion of how relative density affects certain tree species differently).

Many studies have emphasized the need to reduce forest health risks in overstocked stands by thinning to reduce competition between trees (Powell and others 2001, Kohm and Franklin 1997, Curtis and others 1998). Although stands can naturally self-thin over time, stands with high relative densities can remain in this condition for decades if tree competition is not reduced by thinning or natural disturbance such as wind or wildfire.

For this indicator (stand density), DNR considers whether the number of acres of forest in a high forest health risk category (stands in the Competitive Exclusion or Biomass Accumulation stage with a relative density over 75) is projected to increase or decrease over the 100-year analysis period according to model results.

Figure 3-4. Relationship Between Stand Density and Insect and Disease Impacts (Adapted from Powell 1994)

Criteria and Indicators: Summary

Table 3-9 summarizes the criteria and indicators and how they are measured.

Table 3-9. Criteria and Indicators for Forest Conditions and How They Are Measured

Criteron/Indicator	**How the indicator is measured**	**Potential environmental impacts**
Forest sustainability/ Forest biomass	The change in standing wood volume on state trust lands in the OESF; a decrease in the standing volume in operable areas (places where harvest may occur) is considered unsustainable.	**Low:** Forest growth (biomass) exceeds harvest removals. **Medium:** Forest growth equals harvest removals. **High:** Harvest removals exceed forest growth.
Forest sustainability Harvest methods and number of forest stand entries	The percentage of state trust lands in the OESF with a potential for high impacts from harvest activities, calculated using the method described in Figure 3-3.	**Low:** Less than 10 percent of state trust lands has potential high impacts. **Medium:** 10 to 20 percent of state trust lands has potential high impacts. **High:** Over 20 percent of state trust lands has potential high impacts.
Forest structural complexity/ Stand development stages	The proportion of state trust lands in the OESF in each stand development stage.	**Low:** The proportion of state trust lands in each stand development stage shifts toward more complex stages. **Medium:** The proportion of state trust lands in each stand development stage remains the same. **High:** The proportion of state trust lands in each stand development stage shifts toward less complex stages.
Forest health / Stand density	The number of acres of state trust lands in the OESF in a high forest health risk category (stands in the Competitive Exclusion and Biomass Accumulation stages with a relative density of 75 or greater).	**Low:** The number of acres of state trust lands in a high health risk category decreases. **High:** The number of acres of state trust lands in a high health risk category increases.

Riparian Versus Upland Land Classifications

DNR classifies state trust lands as either "riparian" or "uplands" in the forest estate model. These classifications are used for only one topic in this RDEIS: forest conditions and management. DNR uses these classifications here to provide a better understanding of forest conditions and potential environmental impacts. Table 3-10 shows the number of acres of state trust lands within each classification in each of the 11 landscapes of the OESF. The riparian land classification should not be confused with either the "area of influence" concept that will be presented in "Riparian" or the interior-core buffer concept presented in Chapter 2.

Table 3-10. Acres of State Trust Lands in the OESF by Landscape and Land Classification

Landscape	Land classification		
	Riparian	Uplands	Total
Clallam	3,831 (22%)	13,445 (78%)	17,276
Clearwater	19,990 (36%)	35,213 (64%)	55,203
Coppermine	6,383 (33%)	12,862 (67%)	19,246
Dickodochtedar	4,876 (17%)	23,171 (83%)	28,047
Goodman	4,686 (20%)	19,113 (80%)	23,799
Kalaloch	5,231 (29%)	12,891 (71%)	18,122
Queets	3,254 (16%)	17,552 (84%)	20,807
Reade Hill	2,468 (29%)	6,011 (71%)	8,479
Sekiu	1,938 (19%)	8,076 (81%)	10,014
Sol Duc	3,892 (20%)	15,254 (80%)	19,146
Willy Huel	12,981 (35%)	24,446 (65%)	37,428
TOTAL	69,532 (27%)	188,034 (73%)	257,566

Current Conditions

Current conditions on state trust lands in the OESF are the result of past forest stand entries, natural forest development, and past natural disturbances (wind, fire, landslides). The following section describes current conditions in the context of the three criteria (forest sustainability, forest structural complexity, and forest health).

Criterion: Forest Sustainability

INDICATOR: FOREST BIOMASS

As discussed previously, forest biomass will increase over time as long as tree growth exceeds tree mortality and harvest removal. DNR analyzes biomass using total standing volume, which is determined using DNR's forest inventory database. The current total standing volume on state trust lands in the OESF is shown in Table 3-11 for operable areas (areas where stands are available for harvest) and deferred areas.

Table 3-11. Current Total Standing Volume by Landscape on State Trust Lands in the OESF (Billions of Board Feet[a])

Landscape	Deferred	Operable	Total board feet
Clallam	0.15	0.40	0.55
Clearwater	0.88	0.25	1.13
Coppermine	0.23	0.12	0.35

Table 3-11, Continued. Current Total Standing Volume by Landscape on State Trust Lands in the OESF (Billions of Board Feet[a])

Landscape	Deferred	Operable	Total board feet
Dickodochtedar	0.32	0.35	0.68
Goodman	0.35	0.21	0.57
Kalaloch	0.24	0.13	0.37
Queets	0.33	0.13	0.46
Reade Hill	0.21	0.10	0.31
Sekiu	0.03	0.13	0.16
Sol Duc	0.23	0.36	0.59
Willy Huel	0.52	0.25	0.78
TOTAL	**3.5**	**2.44**	**5.94**

[a]A board foot is a unit of cubic measure for lumber, equal to 1 foot square by 1 inch thick.

Table 3-12 shows the current total standing volume on state trust lands classified as riparian and uplands. One third of the current total standing volume is located on lands classified as riparian, mainly because of the substantial number of riparian areas in the OESF.

Table 3-12. Current Total Standing Volume on State Trust Lands in the OESF (Billions of Board Feet)

Land class	Deferred	Operable	Total board feet
Riparian	1.5	0.2	1.7
Uplands	2	2.2	4.2
TOTAL	**3.5**	**2.4**	**5.9**

Unpredictable natural events, such as catastrophic winds, can result in major changes to the existing standing volume. An analysis of these events is beyond the scope of this RDEIS.

INDICATOR: HARVEST METHODS AND NUMBER OF FOREST STAND ENTRIES

For this indicator, DNR analyzes the potential environmental impacts of forest stand entries that are projected to occur on state trust lands in the OESF over the next 100 years. A general discussion of forest stand entries over the past 100 years can be found in Chapter 4, p. 4-2. As mentioned previously, current conditions on state trust lands in the OESF are a result of past forest stand entries, natural forest development, and past natural disturbances. Refer to the indicators forest biomass, stand development stages, and stand density for more information on the current condition of forest stands on state trust lands in the OESF.

Criterion: Forest Structural Complexity

INDICATOR: STAND DEVELOPMENT STAGES

The current distribution of stand development stages on state trust lands in the OESF is shown in Chart 3-5. Of state trust lands in the OESF, 54 percent are in the Competitive Exclusion stage; DNR attributes this condition to harvesting in the 1970s and 1980s.[2] Of the remainder, 29 percent are in the Understory Development stage, 11 percent are in the Structurally Complex stage, 4 percent are in the Ecosystem Initiation stage, and 2 percent are in the Biomass Accumulation stage.

Chart 3-5. Current Stand Development Stages on State Trust Lands in the OESF

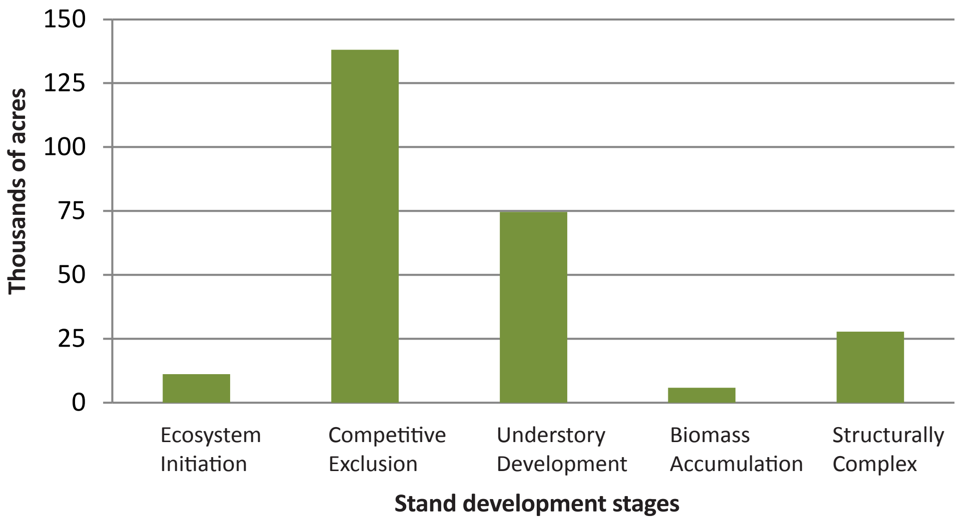
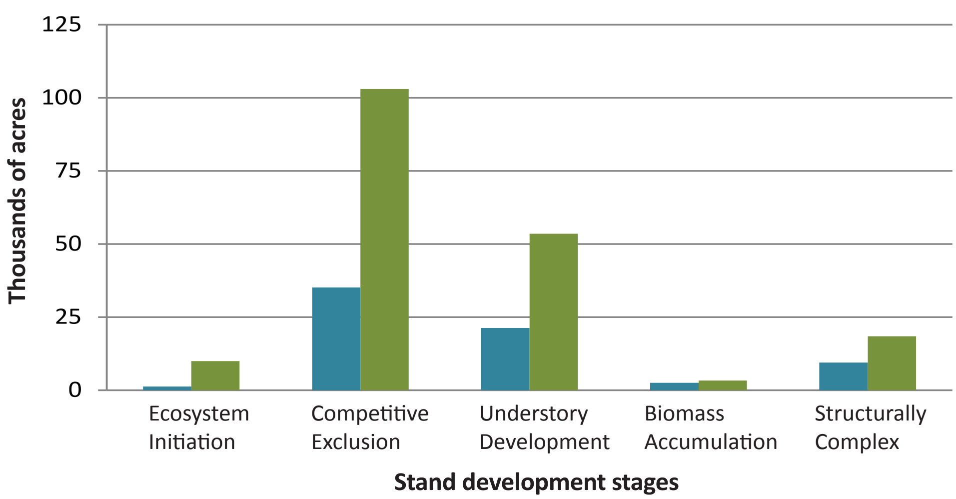


Chart 3-6 shows the current distribution of stand development stages in each land classification (riparian and uplands). In either classification, the largest percentage of state trust lands is in the Competitive Exclusion stand development stage, followed by Understory Development and Structurally Complex.

Chart 3-6. Current Stand Development Stages on State Trust Lands in the OESF Classified as Uplands and Riparian



Within 70 to 100 years, DNR intends to achieve "older" forest structures across 10-15 percent of each habitat conservation planning unit, including the OESF (DNR 2006). Older forest structures are represented by forest stands in the Structurally Complex stand development stage. Table 3-13 shows that state trust lands in the OESF have already met this goal. For information on stand development stages by landscape and watershed administrative unit, refer to Appendix E.

Table 3-13. Current Distribution of Stand Development Stages on State Trust Lands in the OESF

Stand development stage and current percentage	Stand development stage	Acres	Percent of state trust lands
Ecosystem Initiation (4%)	Ecosystem Initiation	11,149	4%
Competitive Exclusion (54%)	Sapling Exclusion	16,055	6%
	Pole Exclusion	71,685	28%
	Large Tree Exclusion	50,354	20%
Understory Development (29%)	Understory Re-initiation	54,920	21%
	Developed Understory	19,762	8%
Biomass Accumulation (2%)	Biomass Accumulation	5,804	2%
Structurally Complex (11%)	Niche Diversification	15,971	6%
	Fully Functional	11,866	5%
TOTAL		**257,566**	**100%**

Criterion: Forest Health

INDICATOR: STAND DENSITY

Stand density can affect tree growth and mortality. As explained previously, the Competitive Exclusion and Biomass Accumulation stages are the most susceptible to forest health impacts from increasing stand density.

Chart 3-5 and Chart 3-6 (presented earlier in this section) show the current stand development stages on state trust lands in the OESF. The majority of forest stands are in the Competitive Exclusion and Understory Development stages. This trend is similar across state trust lands in each of the 11 landscapes and most watershed administrative units (refer to Appendix E) in the OESF.

A total of 138,094 acres of state trust lands in the OESF are in the Competitive Exclusion stand development stage and 5,804 acres are in the Biomass Accumulation stages (refer to Table 3-13). Of these acres, only 20,866 acres have a relative density greater than 75 and therefore are considered to be in the high risk category for forest health. A breakdown by landscape for deferred and operable areas is provided in Table 3-14.

Table 3-14. Current Acres of State Trust Lands in the OESF in the High Risk Category for Forest Health (Competitive Exclusion or Biomass Accumulation Stands With Relative Density Greater Than 75)

Landscape	Deferred	Operable	TOTAL
Clallam (17,276)	646	2,456	3,102
Clearwater (19,246)	1,113	793	1,906
Coppermine (28,047)	108	177	285
Dickodochtedar (28,047)	333	3,014	3,347
Goodman (23,799)	615	2,273	2,888
Kalaloch (18,122)	336	727	1,063
Queets (20,807)	49	59	108
Reade Hill (8,479)	197	561	758
Sekiu (10,014)	58	511	569
Sol Duc (19,146)	682	2,699	3,381
Willy Huel (37,428)	2,864	595	3,459
TOTAL	7,001	13,865	20,866

Results

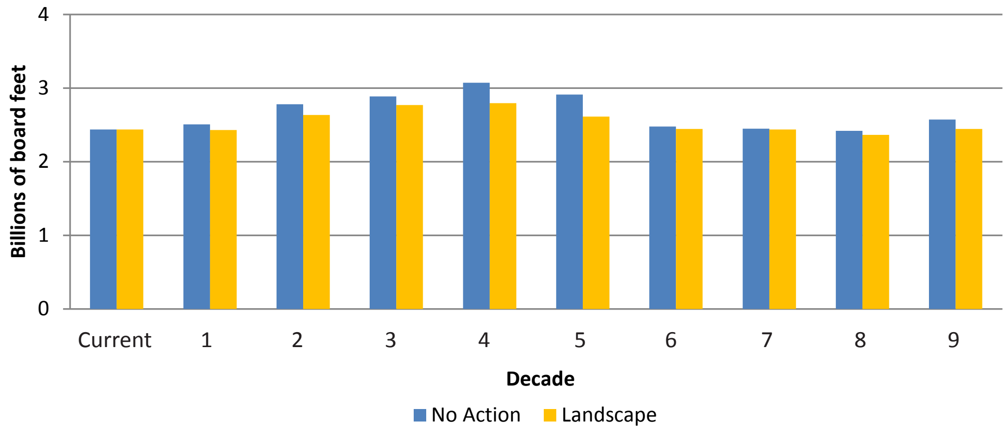
In the following section, DNR presents results at the spatial scales of all state trust lands in the OESF, landscapes, or both. Results at the spatial scale of watershed administrative units (those with greater than 20 percent state trust lands) and Type 3 watersheds are presented in Appendix E.

Criterion: Forest Sustainability

INDICATOR: FOREST BIOMASS

As shown in Chart 3-7, over the 100-year analysis period, the amount of total standing volume in operable areas is projected to increase over the first four decades, and then decline slightly under both alternatives to current levels. If DNR considers the total standing volume of operable acres alone, forest growth would equal harvest removals and the potential impact would be medium for either alternative.

Chart 3-7. Projected Change in Total Standing Volume (Board Feet) on State Trust Lands in Operable Areas, by Alternative



However, DNR also considers the total standing volume on deferred areas. Chart 3-8 compares the current projected total standing volume on deferred acres under both alternatives. As shown, standing volume on deferred areas is projected to increase over the 100-year analysis period.

Chart 3-8. Projected Change in Total Standing Volume (Board Feet) on State Trust Lands in Deferred Areas, by Alternative

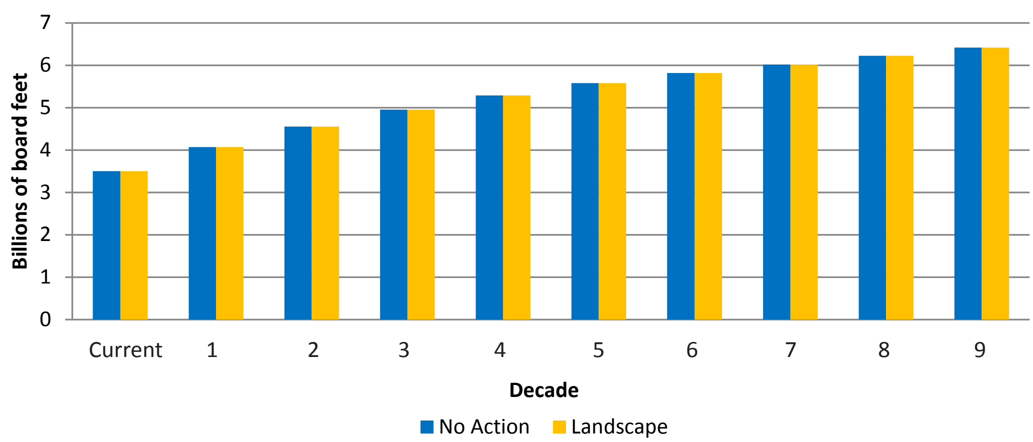
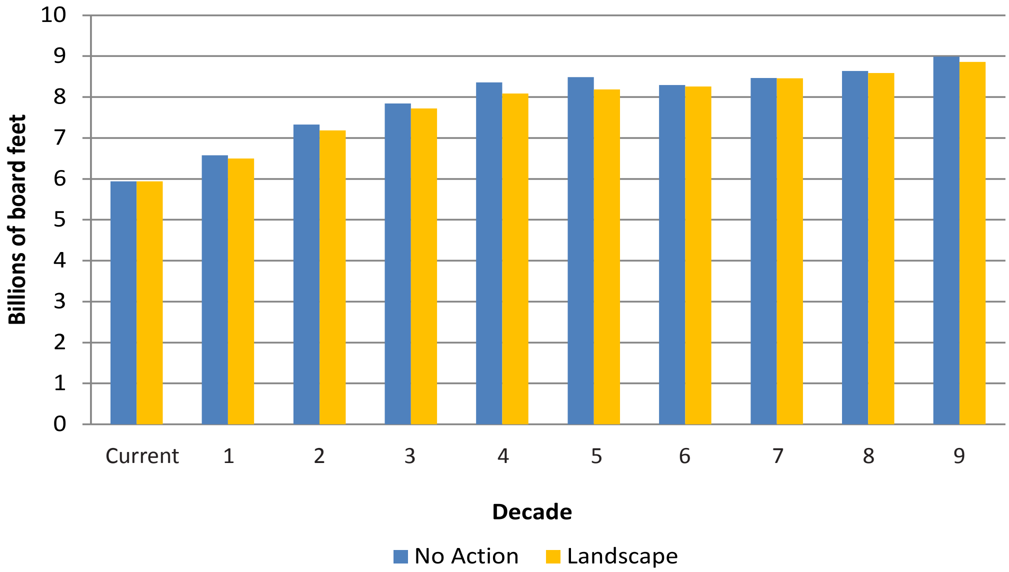


Chart 3-9 on p. 3-38 shows the total standing volume on deferred and operable acres together. Under both alternatives, the total standing volume on state trust lands (deferred and operable together) in the OESF is projected to increase over the 100-year analysis period.

Chart 3-9. Projected Change in Total Standing Volume (Board Feet) on State Trust Lands in Deferred and Operable Areas, by Alternative



Because total standing volume continually increases (Chart 3-9), the potential environmental impact of either alternative for this indicator is considered **low**. DNR has not identified probable significant adverse environmental impacts from either alternative for this indicator.

INDICATOR: HARVEST METHODS AND NUMBER OF FOREST STAND ENTRIES

As explained previously, DNR first determines the percentage of state trust lands in each landscape with potential high impacts. Potential high impacts are defined as certain combinations of thinning and variable retention harvest of the same stand over the 100-year analysis period (refer to Figure 3-3).

DNR then assigns a potential low, medium, or high impact rating to each landscape based on the percentage of state trust lands in that landscape with potential high impacts. Finally, DNR assigns a potential low, medium, or high impact rating to this indicator based on the percentage of state trust lands in all landscapes with potential high impacts (refer to sidebar).

- If less than 10 percent of state trust lands have potential high impacts, the potential environmental impact is low.
- If 10 to 20 percent of state trust lands have potential high impacts, the potential environmental impact is medium.
- If more than 20 percent of state trust lands have potential high impacts, the potential environmental impact is high.

Table 3-15 on p. 3-39 shows the percentage (and number of acres) of state trust lands in each landscape projected to have potential high impacts.

DNR's analysis shows that under the No Action Alternative, less than 20 percent of state trust lands in any given landscape have potential high impacts. Therefore, the potential environmental impacts for all landscapes under the No Action Alternative are considered low or medium.

Under the Landscape Alternative, 22 percent of state trust lands in the Clallam landscape have potential high impacts. Therefore, the potential environmental impact for the Clallam landscape is high. The potential environmental impacts for state trust lands in all other landscapes under the Landscape Alternative are considered low or medium (refer to Appendix E for the number of forest stand entries and methods for each landscape by alternative, and refer to "Harvest Schedule Analyzed" on p. 3-16 for more information about proposed harvests under each alternative).

Table 3-15. Projected Percent of State Trust Lands in Each Landscape with Potential High Impacts, by Alternative

Landscape	Percent of total area with potential high impacts	
	No Action Alternative	Landscape Alternative
Clallam (17,276)	17% (2,896) ◇	22% (3,739) ■
Clearwater (55,203)	7% (3,653) ●	9% (4,695) ●
Coppermine (19,246)	8% (1,619) ●	12% (2,227) ◇
Dickodochtedar (28,047)	13% (3,622) ◇	17% (4,826) ◇
Goodman (23,799)	10% (2,312) ◇	15% (3,646) ◇
Kalaloch (18,122)	8% (1,526) ●	12% (2,200) ◇
Queets (20,807)	17% (3,451) ◇	20% (4,232) ◇
Reade Hill (8,479)	7% (570) ●	11% (938) ◇
Sekiu (10,014)	10% (990) ◇	15% (1,514) ◇
Sol Duc (19,146)	12% (2,383) ◇	19% (3,559) ◇
Willy Huel (37,428)	1% (490) ●	<1% (30) ●
TOTAL	**9% (23,512)** ●	**12% (31,606)** ◇

● Low impact ◇ Medium impact ■ High impact

Considering all landscapes together, under the No Action Alternative, only 9 percent (23,512 acres) of state trust lands in the OESF have potential high impacts. Therefore, the potential environmental impact for the No Action Alternative for this indicator is considered **low.** Under the Landscape Alternative, only 12 percent (31,606 acres) of state trust lands in the OESF have potential high impacts. Therefore, the potential environmental impact for the Landscape Alternative for this indicator is considered **medium**. DNR has not identified probable significant adverse environmental impacts from either alternative for this indicator.

Possible mitigation could reduce potential high impacts on state trust lands in the Clallam landscape to a lower level. For example, DNR may eliminate combinations of thinning and variable retention harvests that are causing a high impact by lengthening the harvest rotation (time between harvests) in this landscape. As described in the introduction to this chapter, possible mitigation is something DNR may or may not implement. Although DNR may adopt possible mitigation in the future, DNR is not committed to implementing it at this time.

Criterion: Forest Structural Complexity

INDICATOR: STAND DEVELOPMENT STAGES

Currently, over half of state trust lands in the OESF are in the Competitive Exclusion stand development stage. Using a forest estate model, DNR projected the shift, over time, in the proportion of state trust lands in each stand development stage under each alternative. DNR projects a decrease in the number of acres in the Competitive Exclusion stage and a corresponding increase in the number of acres in the Understory Development and Structurally Complex stages (refer to Chart 3-10 and Chart 3-11). The number of acres in Ecosystem Initiation is projected to remain relatively constant. Trends are similar for each of the landscapes under both alternatives (refer to Appendix E).

The reduction in Competitive Exclusion may be partly due to planned harvest activities in these stands. Harvests performed to reduce competition in Competitive Exclusion stands may transition them into the Understory Development stage.

Currently, few acres of state trust lands are in the Biomass Accumulation stage. Over time under both alternatives, this stand development stage is projected to decline. Stands in the Biomass Accumulation stage may move into the Structurally Complex stage through natural processes, or they may be harvested and replanted, which moves them into the Ecosystem Initiation stage.

Chart 3-10. Projected Stand Development Stages on State Trust Lands, No Action Alternative

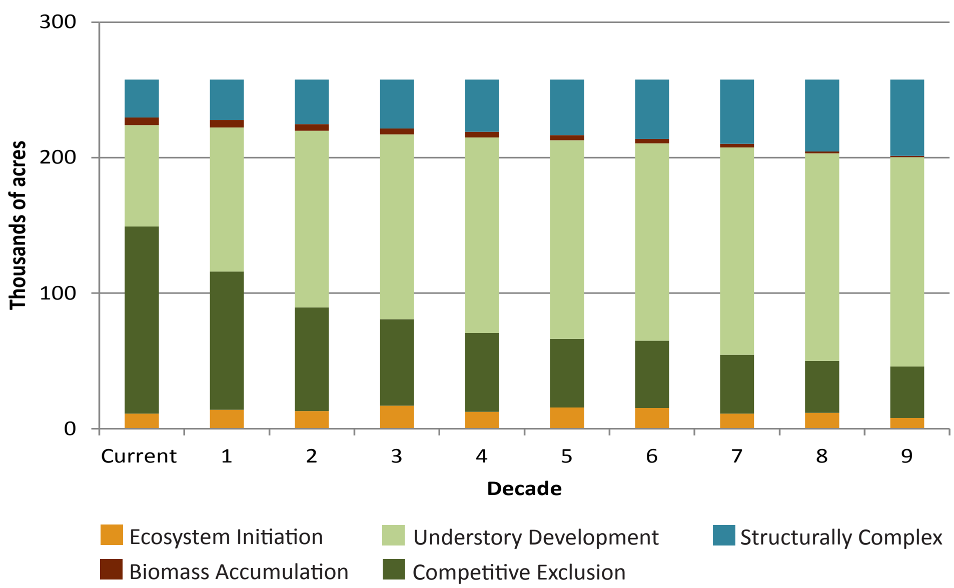
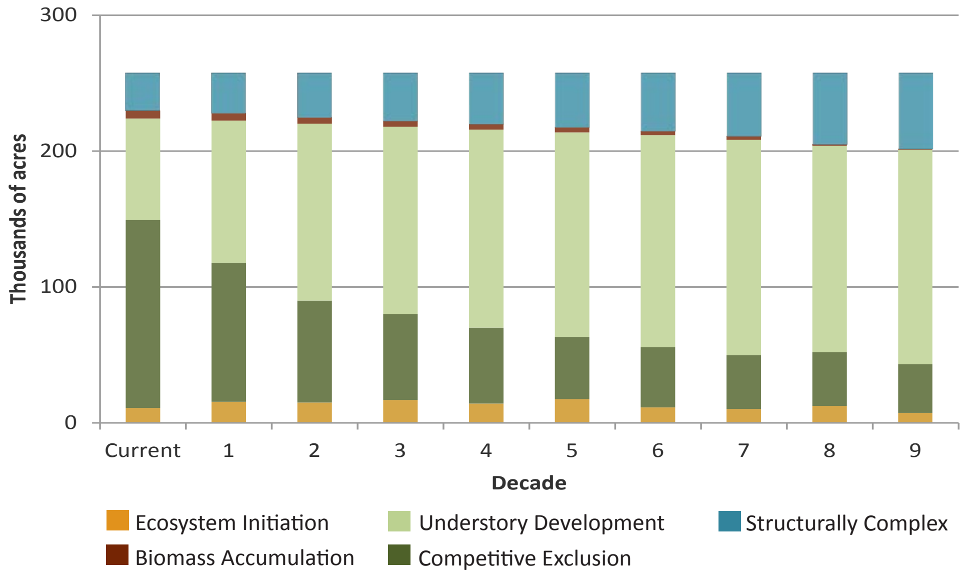


Chart 3-11. Projected Stand Development Stages on State Trust Lands, Landscape Alternative



On lands classified as riparian, under both alternatives, DNR projects a decrease in the number of acres in the Competitive Exclusion stage and a corresponding increase in the number of acres in the Understory Development and Structurally Complex stages. DNR also projects a slight decrease in the Biomass Accumulation stage (refer to Chart 3-12 and Chart 3-13). These results are largely due to the riparian conservation strategy. Under this strategy, DNR applies interior-core buffers and exterior buffers (where needed) along streams on state trust lands in the OESF (refer to Chapter 2, p. 2-16). DNR projects that most riparian areas will gradually shift toward more complex stages. The development of structural complexity in riparian areas on state trust lands in the OESF was anticipated in the 1997 *Habitat Conservation Plan*.

Chart 3-12. Projected Stand Development Stages on State Trust Lands Classified as Riparian, No Action Alternative

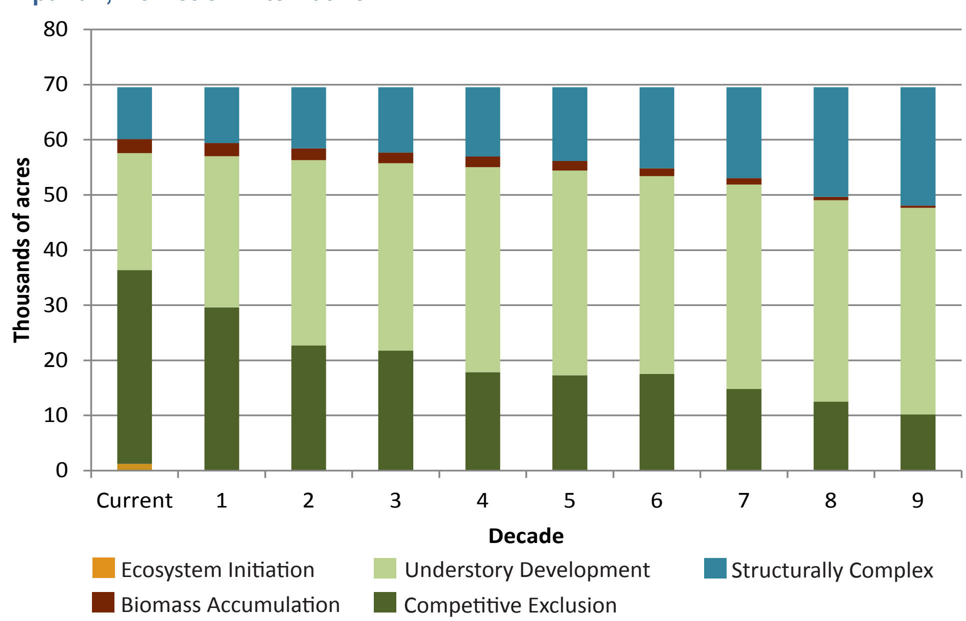
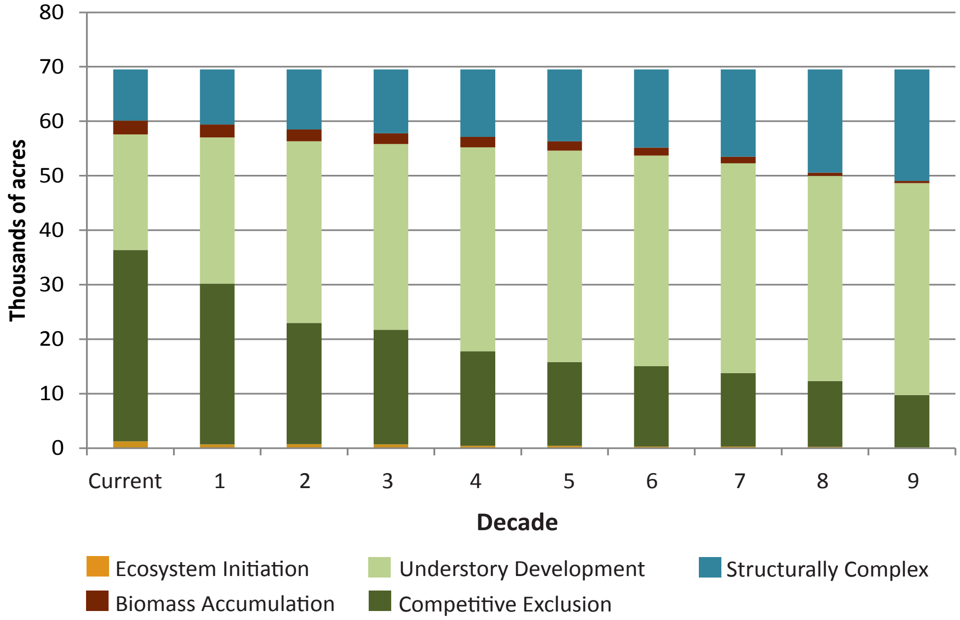


Chart 3-13. Projected Stand Development Stages on State Trust Lands Classified as Riparian, Landscape Alternative



The potential environmental impact of either alternative for this indicator is considered **low**, since the distribution of stand development stages on state trust lands is projected to shift toward more complex stages. In particular, the number of acres in the Competitive Exclusion stage is projected to decrease and the number of acres in the Structurally Complex stage is projected to increase. DNR considers an increase in structural complexity a benefit to wildlife (refer to "Wildlife," p. 3-187). Developing and maintaining structural complexity in managed stands is important to any forest management program that intends to maintain forest biodiversity and ecosystem processes (Lindenmayer and Franklin 2002). DNR has not identified probable significant adverse environmental impacts from either alternative for this indicator.

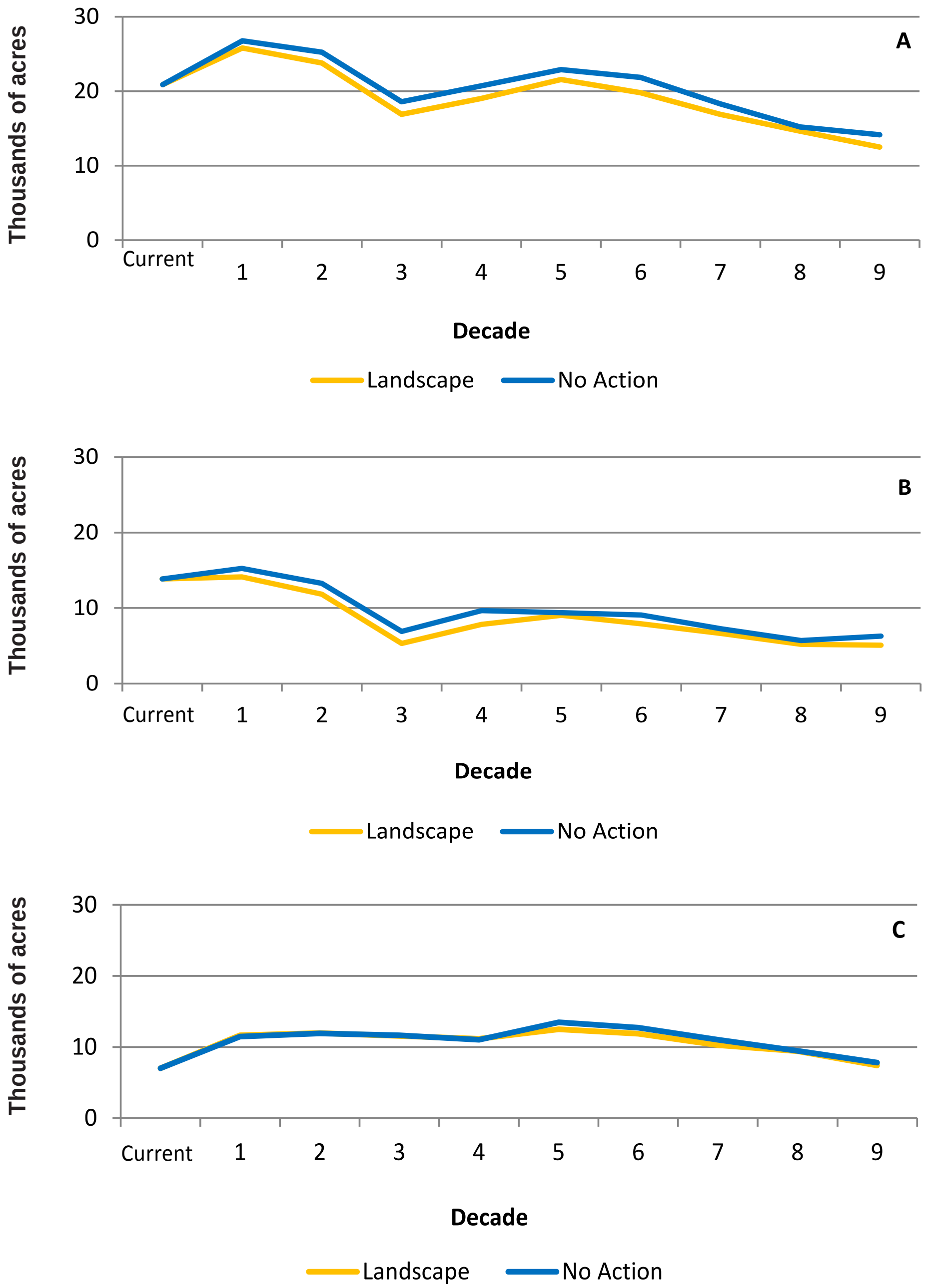
Criterion: Forest Health

INDICATOR: STAND DENSITY

Forest stands in the Competitive Exclusion and Biomass Accumulation stand development stages with a relative density greater than 75 are considered to be in a high forest health risk category. Chart 3-14 (a through c) shows the trend for forest health at three spatial scales: all state trust lands, operable areas, and deferred areas.

When considering operable areas only (Chart 3-14 [b]), the number of acres of state trust lands in a high forest health risk category is projected to decrease over the long term according to model results. This transition is largely the result of harvest and assumes stand density will be reduced by thinning. This trend is true for both alternatives and represents a beneficial environmental impact—a reduction in the potential risk to forest health posed by large areas of overstocked stands.

Chart 3-14. Projected Acres with High Forest Health Risk for a) All State Trust Lands, b) Operable Areas on State Trust Lands, and c) Deferred Areas on State Trust Lands



For deferred areas (Chart 3-14 [c]), over the first 50 years of the analysis period the number of acres of state trust lands in a high risk category is projected to increase from approximately 6,500 acres to 12,000 acres under the Landscape Alternative and to 13,000 acres under the No Action Alternative. This increase is due to natural growth of forest stands; in the absence of harvest or natural disturbance, these stands may increase in relative density to 75 and higher. Relative density is projected to decline to near-current levels by the end of the analysis period as these stands transition slowly, through natural processes, from Competitive Exclusion to more complex stages (refer to Figure 3-5).

Declines could also be caused by natural disturbance events such as fire or catastrophic wind, which were not modeled as part of this analysis.

Figure 3-5. Natural Transition From Competitive Exclusion to More Complex Stand Development Stages

Differentiations in the crown, stem breakage, and tree mortality create small gaps in the stand, allowing the understory to develop naturally.

When considering all state trust lands (operable and deferred – Chart 3-14 [a]), the number of acres in a high forest health risk category is projected to decrease under both alternatives. Therefore, the potential environmental impact of either alternative for this indicator is considered **low**. DNR has not identified probable significant adverse environmental impacts from either alternative for this indicator.

Summary of Potential Impacts

Table 3-16 provides an overview of the potential environmental impacts on forest conditions when all of the criteria and indicators are considered. For this analysis, only potential high impacts are considered potentially significant impacts. DNR has not identified probable significant adverse environmental impacts from either alternative for any indicator for this topic.

Table 3-16. Summary of Potential Impacts on Forest Conditions, by Alternative

Criteria	Indicators	No Action Alternative	Landscape Alternative
Forest sustainability	Forest biomass	Low ●	Low ●
	Harvest methods and number of forest stand entries	Low ●	Medium ◆
Forest structural complexity	Stand development stages	Low ●	Low ●
Forest health	Stand density	Low ●	Low ●

● **Low impact** ◆ **Medium impact**

Section Notes

1. Stand density can be the number of trees or the amount of basal area, wood volume, leaf cover, or a variety of other parameters (Curtis 1970, Ernst and Knapp 1985). Stocking is the proportion of any measurement of stand density to a standard expressed in the same units. In other words, stand density is what actually exists, whereas stocking is how what is there relates to an established standard of what ought to be there (Smith and others 1997).
2. DNR policy in the 1970s and 1980s mandated that the oldest timber be harvested first (Commission on Old Growth Alternatives for Washington's Forest Trust Lands, 1989).

Riparian

What Are Riparian Areas, and Why Are They Important?

A riparian area is where aquatic and terrestrial ecosystems interact. It includes surface waters such as rivers, streams, lakes, ponds, and wetlands, and the adjacent forests and groundwater zones that connect the water to the surrounding land.

Riparian areas provide habitat for numerous species of plants and wildlife. In addition, riparian areas influence stream conditions such as water quality, quantity (Cleaverly and others 2000), temperature (Brown and Krygier 1970), and nutrient concentrations (Tabbacchi and others 1998), and are a major source of sediment and organic materials (Triska and others 1982, Gregory and others 1991).

What Is the Criterion for Riparian Areas?

The criterion for riparian areas is functioning riparian habitat. Functioning riparian habitat supports viable populations of salmon and other species that are dependent on in-stream and riparian environments.

What Are the Indicators for Riparian Areas?

The indicators used to assess the criterion are **large woody debris recruitment**, **peak flow**, **stream shade**, **fine sediment delivery**, **leaf and needle litter recruitment**, and **riparian microclimate**. An additional indicator, the **composite watershed score**, combines these indicators to assess the health of the riparian system as a whole. These indicators were selected based on DNR's expertise, existing scientific information, and current data. Information about the significance of each indicator is presented in the following section. DNR incorporated an additional indicator, **coarse sediment delivery**, into the composite watershed score. (Refer to Appendix G for more information on this indicator.)

In-stream data such as the amount and distribution of large woody debris, the presence and amount of leaf and needle litter in the stream, stream temperature, and sedimentation (settling and accumulation of sediment on the streambed) is not available in a comprehensive or readily usable form for all streams in the OESF. Therefore, DNR used surrogates to assess current and future conditions for each indicator. For example, as a surrogate for the number and size of logs in each stream reach, DNR assesses the characteristics of the riparian forest and its potential to provide large woody debris to the stream channel. DNR uses the potential of the riparian forest to provide stream shade and leaf and needle litter as surrogates for stream temperature and stream nutrients, respectively; the potential delivery of fine sediment from the road network as a surrogate for sedimentation or turbidity (water cloudiness); and hydrologic maturity within each watershed as a surrogate for peak flow (hydrologic maturity will be discussed later in this chapter).

Overlapping Indicators

As discussed in the introduction to this chapter, few indicators apply to only one topic in this RDEIS; many overlap. For example, stream shade is used as an indicator in "Water Quality," p. 3-115, and large woody debris recruitment, peak flow, stream shade, and fine sediment delivery are used as indicators in "Fish," p. 3-137 In addition, DNR analyzed the potential for coarse sediment delivery in "Soils," p. 3-91 using the indicators landslide potential and potential road failure.

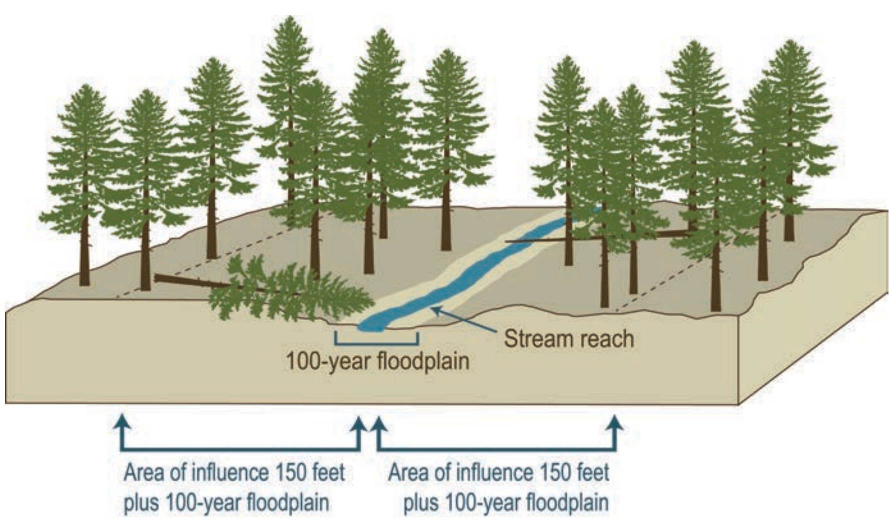
How Are the Indicators Analyzed?

Area of Influence

DNR bases its riparian analysis on an "area of influence," the area in which each indicator is expected to have an influence on the stream channel (refer to Figure 3-6). DNR uses areas of influence in this analysis to better understand how DNR's management activities will affect riparian and watershed conditions over the 100-year analysis period.

The area of influence is different for each indicator and is based on DNR's review of current scientific literature. The widths of areas of influence can vary widely. For example, large woody debris recruitment generally takes place within the 100-year floodplain plus 150 feet, or approximately one tree height (McDade and others 1990, Forest Ecosystem Management Assessment Team [FEMAT] 1993), while the area of influence for peak

Figure 3-6. Area of Influence for Large Woody Debris Recruitment



flow is the entire Type 3 watershed (a Type 3 watershed is a watershed that drains a Type 3 stream[1] (refer to "Spatial Scales Used in the OESF" in this section).

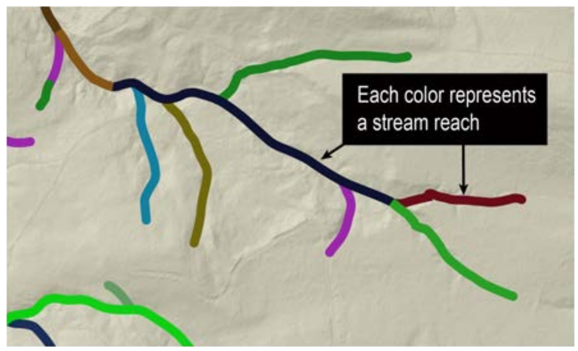
Analysis Methodology

For this analysis, DNR calculates **stream reach scores** and **watershed scores** for each indicator. Scores are developed using sophisticated computer modeling techniques which are described in detail in Appendix G. DNR built a separate model for each indicator, including for the composite watershed score. These models were built using outputs of the forest estate model.

STREAM REACH SCORES

The basis of the analysis is a stream reach (refer to Figure 3-7). A stream reach is a section of stream with consistent channel and floodplain characteristics, such as gradient (how steep the stream is) or confinement (how much a stream channel can move within its valley). Stream reaches are typically a few hundred feet in length, and one stream may have numerous reaches. Stream reaches are important because many riparian species interact with the environment at the reach scale, and because many ecological processes create or maintain habitat at this scale.

Figure 3-7. Example of Stream Reaches



For all indicators except stream shade, reaches are given a score based on two factors: the potential of their surrounding area of influence to provide riparian function, and their sensitivity, or expected stream channel response to that function. For example, at a given point in time, the area of influence for a given stream reach may have little or no potential to provide large woody debris to the stream channel (low potential). For that same stream reach, large woody debris may be critical to maintaining the shape of the channel, providing habitat features such as pools, trapping sediment, and protecting stream banks (high sensitivity). For most indicators, sensitivity is based on gradient and confinement.

DNR considers both potential and sensitivity when assigning reach scores. Impacts are highest (high score) along sensitive reaches with low potential, and lowest (low score) along less sensitive reaches with high potential. In other words, when the function is critical, and the area of influence is not likely to provide it, the score is high; the reverse is also true. A complete description of how sensitivity and potential ratings are derived and combined can be found in Appendix G. The methodology used for analyzing stream shade is described later in this section.

WATERSHED SCORES

To understand what is happening at a larger spatial scale, DNR combines the stream reach scores for every reach in a Type 3 watershed into a watershed score (refer to Figure 3-8). This process is completed for each indicator.

Scores are placed into three categories: low impact condition (0 to 33), medium impact condition (34 to 66), and high impact condition (67 to 100).[2] Results are graphed (refer to Figure 3-9) at four points

Figure 3-8. Stream Reach and Watershed Scores Computed for Each Indicator

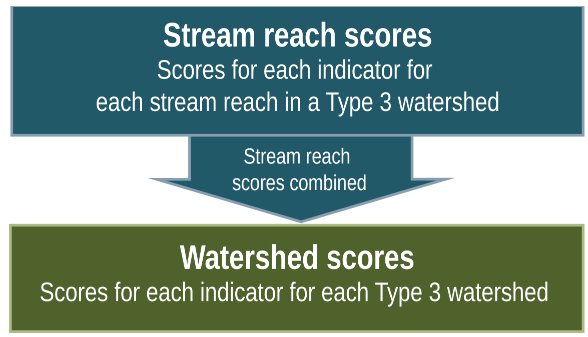
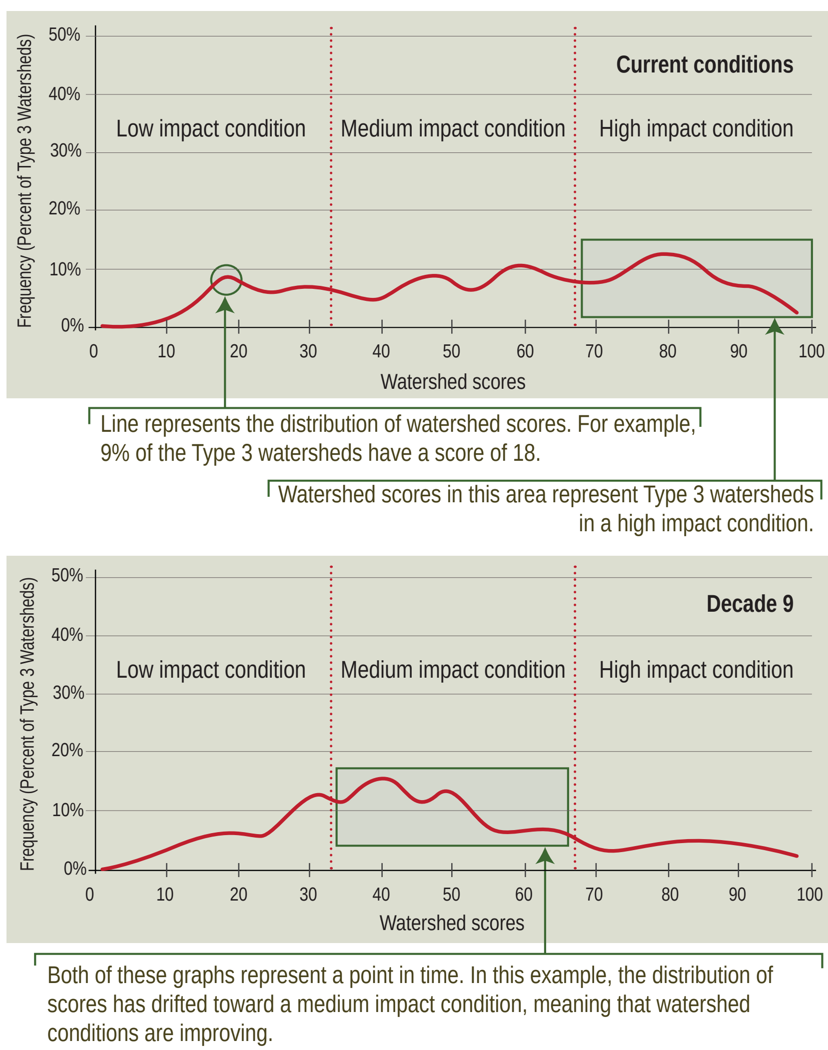


Figure 3-9. Example of a Distribution of Watershed Scores



in time: Decade 0 (current condition), Decade 1 (short-term trends), Decade 6 (mid-term trends), and Decade 9 (long-term trends). Each point in time gives DNR an indication of whether most Type 3 watersheds fall in a low, medium, or high impact condition. Note: these are potential low, medium, and high impact conditions. Results are based on projections generated by computer models using the best available science.

DNR compares the current, short-, mid-, and long-term graphs to determine how the distribution of scores shifts over time. For instance, scores may shift from a medium to a low impact condition or vice versa (refer to Figure 3-9). This analysis is repeated for each indicator for both alternatives. DNR uses this analysis to infer how the two management alternatives affect riparian habitat function.

It is important to note that **a range of watershed conditions is desirable**. A key principle of managing riparian ecosystems for habitat complexity is to focus on natural processes and variability, rather than attempting to maintain or engineer a desired set of conditions through time (Lugo and others 1999, Dale and others 2000 as cited in Bisson and Wondzell 2009). DNR is not working toward a set threshold for the number of watersheds in a low impact condition. Rather, DNR's objective is to achieve a range of conditions that provide habitat variability and complexity.

OWNERSHIP

There are 594 Type 3 watersheds in the OESF. Only the watersheds in which DNR manages at least 20 percent of the land area are evaluated (423 out of 594 watersheds).[3] Streams not located on state trust lands were not included in this analysis unless their area of influence extends onto state trust lands.

Descriptions of the Indicators

Indicator: Large Woody Debris Recruitment

Large woody debris recruitment refers to logs, pieces of logs, root wads, or large chunks of wood falling into stream channels. While the definition of "large" can vary according to context (a log may provide a certain level of ecological function when it falls into a small stream; the same size log may not provide as much benefit in a large river), many biologists define large woody debris as having a minimum diameter of 4 inches and measuring 6 feet in length (Schuett-Hames and others 1999).

Large woody debris is an important habitat component for fish and other aquatic organisms (Swanson and others 1976, Harmon and others 1986, Bisson and others 1987, Maser and others 1988, Naiman and others 1992, Samuelsson and others 1994). Trees and other large pieces of wood that fall into streams help trap and retain sediment (Keller and Swanson 1979, Sedell and others 1988), change the shape and steepness of the stream (Ralph and others 1994), slow fast-moving water (DNR 1997), release nutrients slowly as they decompose (Cummins 1974), and provide fish and amphibians places to hide from predators (Bisson and others 1987, Bilby and Ward 1989).

The area of influence[4] for large woody debris recruitment is the 100-year floodplain plus an additional 150 feet (approximately one tree height). Factors affecting large woody debris recruitment include the relative density of the forest, tree size, tree species, and the distance of trees from the floodplain (McDade and others 1990, FEMAT 1993).

Indicator: Peak Flow

The term "peak flow" refers to periods of high stream flow or maximum discharge, usually associated with storm events. In the Pacific Northwest, peak flow often coincides with winter storms in which rain falls on top of an existing snow pack (Pentec Environmental, Inc. 1997). These events are commonly known as rain-on-snow events.

Peak flows can affect stream channels and in-stream habitat because of the large amount and high velocity of water moving through the stream. For example, some streambeds are composed of sand and gravel which may be lifted or scoured during peak flow events. Salmon prefer to lay their eggs in gravel streambeds, which can be damaged by scouring peak flows. Also, stream channels can shift, leaving gravel streambeds—and salmon eggs—dry. (For more information, refer to "Fish," p. 3-143.)

Peak flow is assessed by measuring the proportion of hydrologically immature forests in a watershed.

- **Hydrologically immature forests** are young (less than 25 years old) and sparse (relative density[5] less than 25). These forests lack a dense forest canopy and therefore contribute more to peak flow—for example, more snow accumulates on the forest floor, and that snow melts rapidly, sending more water into streams (DNR 2004).

  Land use practices that reduce vegetative cover or increase soil compaction, such as timber harvesting and road building, can alter hydrologic processes and increase peak flow. For example, the deeper snow packs found in harvested areas hold more water and melt faster when rain falls on them (Grant and others 2008), which leads to higher stream flows. The effect is more pronounced in larger openings (Harr and McCorison 1979). Removing trees also decreases plant transpiration (the release of water vapor from plants), which leads to increased soil moisture and water runoff in harvested areas (Grant and others 2008).

  The effect of harvest on peak flow can be complex and sometimes counteracting. For example, although snow packs are deeper in harvested areas, they are also subject to increased sublimation (evaporating without melting) from the wind, especially at higher elevations (Storck and others 2002 as cited in Grant and others 2008).

- **Hydrologically mature forests** have a higher relative density, meaning there is a denser canopy to intercept snowfall and often more vegetation to absorb or slow water. Much of the snow caught in the canopy melts and evaporates or sublimates and thus does not reach the stream (Grant and others 2008). Also, trees dissipate heat by long wave radiation, which can melt the snow pack under a forest canopy. Therefore, snow packs in hydrologically mature forests are not as deep. These forests contribute less to peak flow during storm events.

- **Areas without vegetation**, such as roads, are also considered hydrologically immature. Rain may flow over the top of the road instead of being absorbed into the road surface.

The area of influence for this indicator is the Type 3 watershed. DNR considers whether harvests projected to occur in a Type 3 watershed will lower hydrologic maturity to a level that can cause an increase in peak flow.

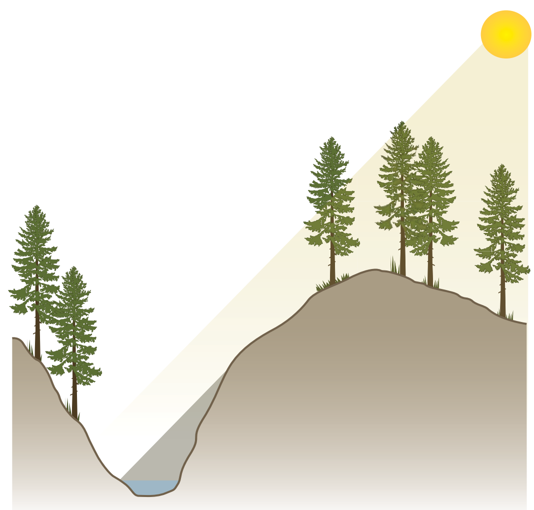
Indicator: Stream Shade

Stream shade refers to the extent to which incoming sunlight is blocked on its way to the stream channel. Stream shade is considered one of the primary factors influencing stream temperature (Brown 1969). Stream temperature influences water chemistry, which can affect the amount of oxygen present to support aquatic life. Also, all aquatic organisms have a temperature range outside of which they cannot exist.

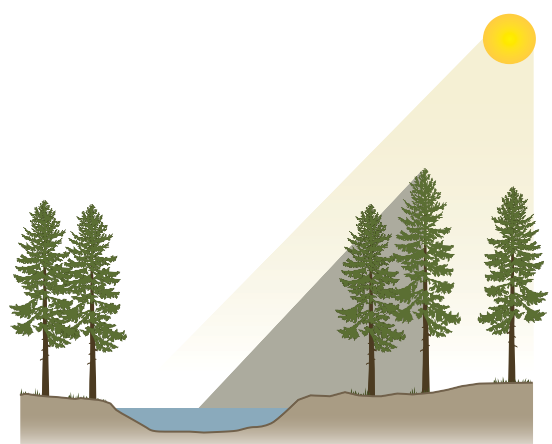
Factors that affect shading include stream size, stream orientation, local topography, tree species, tree height, stand density, and elevation (DNR 2004). For example, streams at higher elevations require less shade to maintain cool water temperatures (Sullivan and others 1990) than streams at lower elevations. In addition, at higher elevations, terrain is steeper, stream channels tend to be narrower and more confined, and the topography itself is more likely to provide shade (Figure 3-10). At lower elevations, streams tend to occupy flatter terrain and are less likely to be shaded by topography. As well, wide, low-elevation streams are generally more open to the sky and naturally shade-limited.

Stream shade is measured by using a computer model that projects how sunlight decreases as it passes through riparian forests or is blocked by surrounding terrain. The model for this indicator measures the potential amount

Figure 3-10. Stream Shade in Steep Versus Flat Terrain



At higher elevations, terrain is steeper, stream channels are more confined, and the topography itself is more likely to provide shade.



At lower elevations, streams occupy flatter terrain and are less likely to be shaded by topography. In addition, wide, low-elevation streams are more open to the sky and naturally shade-limited.

of shade at the midpoint of each stream reach at hourly intervals on the hottest day of the year (July 31).[6] For this RDEIS analysis, each stream reach is assigned a target shade level[7] based on the amount of shade necessary to maintain stream temperatures within acceptable levels (adapted from WAC 222-30-040) and the maximum amount of shade available, given the orientation and width of the stream channel.

The area of influence is the area through which sunlight passes on its way to the stream. To determine potential impacts, DNR compares the target shade level for each stream reach to the amount of shade that would be present after management activities have taken place.

Indicator: Fine Sediment Delivery

The term fine sediment refers to small soil particles, such as sand, silt, or clay, generally less than about 1/16th of an inch in diameter. Fine sediment is generated from the interaction of water and exposed soil (for example, unpaved roads or soils exposed by harvest activities or natural processes such as stream bank erosion). There are several ways that fine sediment can be delivered to the riparian system, including through the erosion of stream banks (Megahan 1982 and Scrivener 1988 as cited in DNR 1996), landslides (Cederholm and Reid 1987), water flowing across the land surface (a process called overland flow) (Comerford and others 1992 as cited in DNR 1997), or improperly designed road-associated features such as ditches and culverts that drain either too near, or into, the stream channel (DNR 1997). A past study in the Clearwater landscape found that roads which were neither mitigated nor brought up to modern design standards at the time of the study were a major source of management-related stream sediment (Cederholm and Reid 1987). For information on mitigation of roads through current management practices and the percentage of projects already completed, refer to “Water Quality” p. 3-131

Increased levels of fine sediment (for example, from management-related activities) can have detrimental effects on both water quality and aquatic habitat. Sediment that settles in streams or stays suspended in the water column can reduce salmon survival (Hicks and others 1991). Fine sediment deposited in areas where salmon spawn can decrease the survival of eggs and young hatchlings by reducing the availability of oxygen, and muddy, sediment-filled water can cause stress to juvenile salmon during the summer (Cederholm and Reid 1987). Increased levels of fine sediment can also reduce populations of small aquatic insects, an important food source for salmon (Cederholm and Reid 1987). (For additional discussion of sediment and its effects on fish, refer to “Fish,” p. 3-144.)

The area of influence for fine sediment delivery is all roads (on state trust lands and non-state trust lands) that are located within 300 feet of a stream or water body in each Type 3 watershed. DNR based this distance on the methodology of Potyondy and Geier (2011). DNR analyzes traffic on **all roads (roads on state trust lands and non-state trust lands)** in the OESF because traffic associated with harvest activities may run on roads built and maintained by DNR or on roads built and maintained by other landowners.

DNR assessed the potential delivery of fine sediment from the road network (refer to Text Box 3-4) using traffic impact scores. The role of traffic in increasing road sediment

Text Box 3-4. OESF Road Network

The **road network in the OESF** ranges from temporary gravel roads used for a single timber sale and then abandoned, to roads that are paved, permanent, and used year-round. Roads are categorized according to the following:

- **Status**, such as active (in use), closed (could be temporarily closed, but not now in use), decommissioned (made impassable to vehicle traffic, expected to be reconstructed in the future), or abandoned (not expected to be reused in the future with all drainage facilities removed); and
- **Surface type**, such as asphalt, chip seal, crushed aggregate, or unpaved.

Most roads on state trust lands in the OESF are active and unpaved. This type of roads has the greatest potential to generate and deliver sediment to streams and other water bodies (causing turbidity) unless improvements are made (Potyondy and Geier 2011, Elliot and others 2009, Croke and Hairsine 2006) (refer to Appendix C for miles of road by status and surface type).

production is well-recognized (Luce and Black 2001, Reid and Dunne 1984). Traffic impact scores are based on the following factors:

- **Road surface type:** Road traffic generates sediment through surface erosion, which occurs only on unpaved roads. Paved roads are not scored as having an impact.
- **Proximity of roads to streams or other water bodies:** DNR uses GIS tools to determine the proximity of roads to water bodies. Roads that are closer to the stream receive a higher score (higher impact) than those farther away. Roads greater than 300 feet from a water body are not scored as having an impact.
- **Projected traffic levels:** DNR considers the number of times per day a log truck will drive over each segment of road to transport harvested timber to market. DNR includes log truck traffic associated with projected harvests on all ownerships in a Type 3 watershed (state trust lands as well as federal, tribal, and private lands). Projected traffic levels for other ownerships are based on a review of past reports of timber harvest volumes and assumptions about harvest intensity relative to DNR's projected management activities; these projected traffic levels are held constant, meaning they do not vary from one decade to the next. Recreational and other uses are not included in the analysis because information about recreational and other traffic levels in the OESF is not available. Traffic levels are determined based on the methods of Dubé and others (2004). (For additional information, refer to Appendix C.)

For this analysis, DNR assumes the extent of the road network in the OESF will remain essentially unchanged under both alternatives throughout the 100-year analysis period.[8]

DNR does not expect a substantial reduction of the road network because roads are essential to working forests. Although DNR has abandoned some of its roads, very little additional road abandonment is identified in current plans. Nor does DNR expect a substantial expansion of its road network, although some new roads may be needed. It is too speculative to estimate their locations or number of miles; the exact locations and lengths of roads cannot be determined until a harvest is planned and a site assessment is performed. (For more information about the accomplishment of road maintenance and abandonment plans, refer to the summaries in Appendix C; for more information on the methodology used to calculate traffic scores, refer to Appendix C.)

SEPARATE FINE SEDIMENT ANALYSES

In this RDEIS, fine sediment delivery is also analyzed in "Fish" and "Water Quality." Each analysis of fine sediment delivery is performed at a spatial scale appropriate to the topic, and consequently the analyses will have different results.

Here in "Riparian" as well as in "Fish," DNR analyzes fine sediment delivery potential using traffic impact scores, as described in the preceding section. Fine sediment delivery potential is coupled with the sensitivity of the stream channel to fine sediment delivery, as described previously.

In "Water Quality," DNR analyzes potential only; DNR does not consider sensitivity. DNR's indicators for water quality are based on Ecology's water quality standards. Those standards are primarily concerned with whether or not an impact is occurring (in this case, turbidity caused by delivery of fine sediment), regardless of the sensitivity of the stream channel to fine sediment input. For that reason, for its water quality analysis, DNR considered potential only. Fine sediment delivery potential in "Water Quality" is analyzed with four separate road-related indicators. In addition to traffic impact scores, these indicators are road density, stream crossing density, and the proximity of roads to streams and other water bodies.

Indicator: Leaf and Needle Litter Recruitment

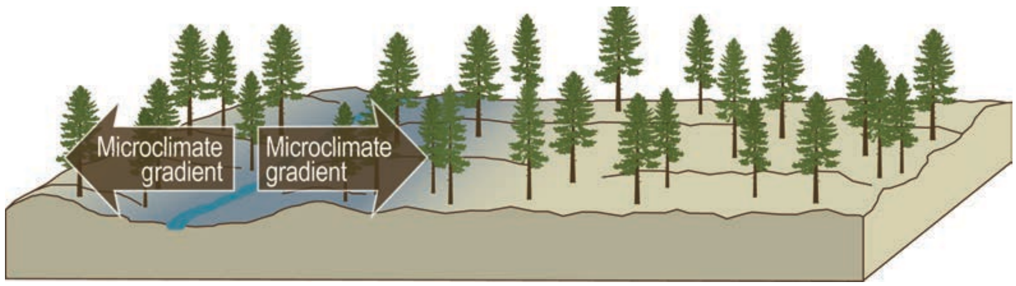
Leaf and needle litter refers to fine organic materials, such as leaves and tree needles, which grow in the forest canopy and fall to the ground or into stream channels. Leaf and needle litter supply nutrients to streams; these nutrients are needed by the small aquatic insects (Richardson 1992) that are an important food source for fish and other aquatic species. Leaf and needle litter recruitment is especially important in small, headwater streams where it can provide the greatest share of total metabolic energy for the stream community (Richardson 1992).

The area of influence for leaf and needle litter is the 100-year floodplain plus an additional 150 feet (FEMAT 1993). Factors which influence leaf and needle litter recruitment include the relative density of the adjacent forest, the distance of trees from the stream, and the size and species of trees. Many hardwoods provide leaf litter that has higher nutrient value and is more readily broken down than the needle litter provided by conifers (Bisson and Wondzell 2009).

Indicator: Riparian Microclimate

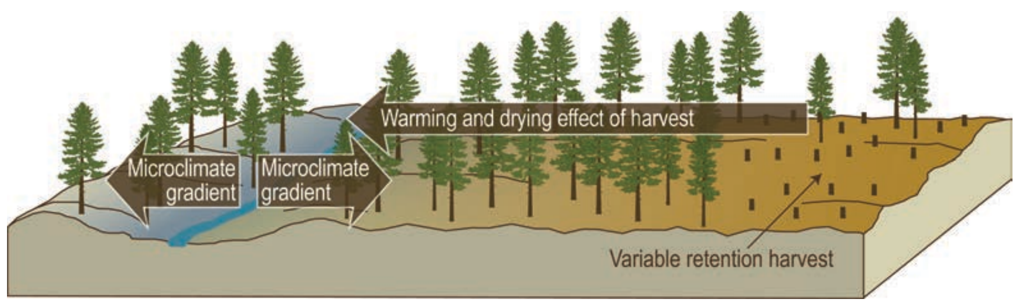
Streams are known to influence climatic conditions in the surrounding forest (Meehan 1991, Naiman 1992, Maridet and others 1998 as cited in Naiman and others 2005). Air and soil temperatures near streams are cooler, and the humidity is higher next to the stream than it is in the interior forest. The effect dissipates as one moves further from the stream. This phenomenon is known as the riparian microclimate gradient (refer to Figure 3-11). A microclimate is a localized climate zone.

Figure 3-11. Riparian Microclimate Gradient



Removing or altering vegetation, such as harvesting timber, in or near riparian areas can influence microclimatic conditions (Spence and others 1996). Harvested areas are exposed to increased sunlight, which heats the soil and warms and dries the air (refer to Figure 3-12). Many riparian-associated plant and animal species require cool, moist, relatively stable conditions for survival and reproduction. Vegetation removal may affect these species adversely (Brosofske and others 1997).

Figure 3-12. Effects of Harvests on Riparian Microclimate Gradient

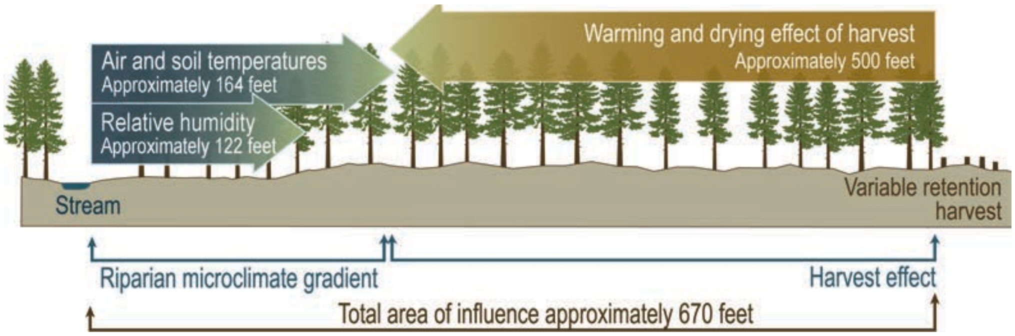


The area of influence for microclimate is derived by adding the approximate width of the riparian microclimate gradient and the approximate width of the harvest effects.

- Studies by Brosofske and others (1997) have demonstrated that streams exert a cooling effect on both soil and air temperatures at distances of up to 164 feet from the stream. In addition, they noted increased relative humidity at distances up to 122 feet from the stream.
- The heating and drying effects of harvest can extend up to three tree heights (more than 500 feet) into the surrounding unharvested areas (Chen 1991, Chen and others 1995, FEMAT 1993).

Thus the total area of influence is approximately 670 feet from the stream bank, including the 100-year floodplain (refer to Figure 3-13).

Figure 3-13. Riparian Microclimate Area of Influence

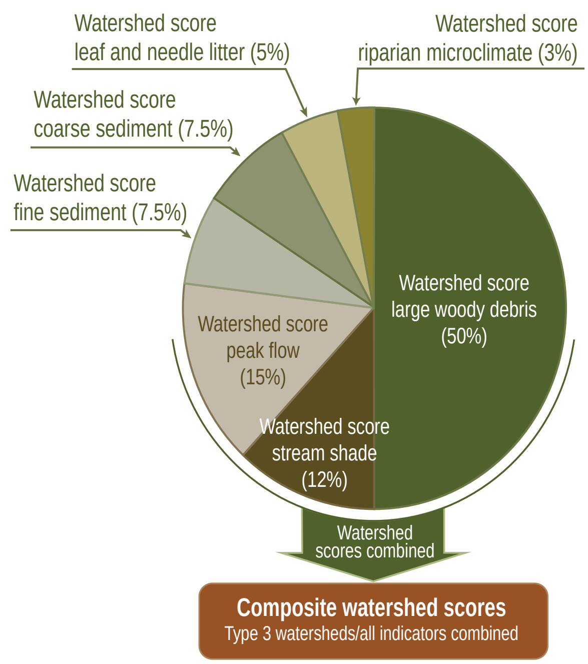


In the riparian microclimate model, DNR modeled how daytime air temperature, soil temperature, and relative humidity within the riparian microclimate gradient may change as a result of nearby harvests. Only daytime conditions were evaluated, since that is when the greatest impacts of harvest are expected to occur.

Indicator: Composite Watershed Score

Each of the indicators corresponds to an ecosystem process that takes place in and around riparian areas. While it is meaningful to assess each indicator individually, it is the numerous interactions between them that best describe the riparian ecosystem as a whole. To approximate the complexity and interactions of these indicators, DNR uses a computer model (refer to Appendix G) to create composite watershed scores for each Type 3 watershed (refer to Figure 3-14). The composite watershed score is calculated by combining the watershed scores for each indicator into a single score.

Figure 3-14. Composite Watershed Score



Indicators are not equal in their contribution to functioning riparian habitat; some are more important than others. Indicators are assigned a weighting factor based on DNR's professional judgment as informed by scientific literature (Reeves and others 2004, Gallo and others 2005). The net contributions of the indicators to the composite watershed score are as follows:

- Large woody debris recruitment – 50 percent
- Peak flow – 15 percent
- Stream shade – 12 percent
- Fine sediment delivery – 7.5 percent
- Coarse sediment delivery – 7.5 percent
- Leaf and needle litter recruitment – 5 percent
- Riparian microclimate –3 percent

For information on the incorporation of coarse sediment delivery into the composite watershed score, refer to Appendix G. Similar to watershed scores, composite watershed scores are graphed, reported at decades 0, 1, 6, and 9, and compared to determine how the distribution of scores shifts over time.

Criteria and Indicators: Summary

Table 3-17 summarizes the criteria and indicators and how they are measured.

Table 3-17. Criteria and Indicators for Riparian Areas and How They Are Measured

Criterion/ Indicator	How the indicator is measured	Potential environmental impacts
Functioning riparian habitat/ Large woody debris recruitment	Characteristics of the riparian forest, such as relative density and the size and species of trees, and distance of trees from the floodplain. **Area of influence:** 100-year floodplain plus an additional 150 feet **Contribution to overall riparian impact score (importance):** 50 percent **Assessment area:** All streams that cross state trust lands within Type 3 watersheds that contain at least 20 percent state trust lands	**Low:** Distribution of watershed scores shifts toward a low impact condition, with most scores in a low impact condition. **Medium:** Distribution of watershed scores and most watersheds remain in a medium impact condition, or scores shift from a medium to a low or high impact condition but most scores remain in a medium impact condition. **High:** Distribution of watershed scores shifts toward a high impact condition, with most scores in a high impact condition.

Table 3-17, Continued. Criteria and Indicators for Riparian Areas and How They Are Measured

Criterion/ Indicator	**How the indicator is measured**	**Potential environmental impacts**
Functioning riparian habitat/ Peak flow	Hydrologic maturity of a Type 3 watershed. **Area of influence:** Type 3 watershed **Contribution to overall riparian impact score (importance):** 15 percent **Assessment area:** All streams, regardless of ownership, within Type 3 watersheds that contain at least 20 percent state trust lands	**Low:** Distribution of watershed scores shifts toward a low impact condition, with most scores in a low impact condition. **Medium:** Distribution of watershed scores and most watersheds remain in a medium impact condition, or scores shift from a medium to a low or high impact condition but most scores remain in a medium impact condition. **High:** Distribution of watershed scores shifts toward a high impact condition, and/or most are in a high impact condition.
Functioning riparian habitat/ Stream shade	Topography, stream orientation, and characteristics of the riparian forest, including canopy closure and tree height. **Area of influence**: Area through which sunlight passes on its way to the stream; shade measured at hourly intervals on the hottest day of the year (July 31) **Contribution to overall riparian impact score (importance)**: 12 percent **Assessment area**: All streams that cross state trust lands within Type 3 watersheds that contain at least 20 percent state trust lands	**Low**: Distribution of watershed scores shifts toward a low impact condition, with most scores in a low impact condition. **Medium**: Distribution of watershed scores and most watersheds remain in a medium impact condition, or scores shift from a medium to a low or high impact condition but most scores remain in a medium impact condition. **High**: Distribution of watershed scores shifts toward a high impact condition, with most scores in a high impact condition.

Table 3-17, Continued. Criteria and Indicators for Riparian Areas and How They Are Measured

Criterion/ Indicator	**How the indicator is measured**	**Potential environmental impacts**
Functioning riparian habitat/ Fine sediment delivery	Characteristics of the road network, such as proximity of roads to streams and water bodies, surface type (paved or unpaved), and traffic levels, measured using traffic impact scores. **Area of influence:** All roads (on state trust lands and non-state trust lands) that are located within 300 feet of a stream or water body in each Type 3 watershed **Contribution to overall riparian impact score (importance):** 7.5 percent **Assessment area:** All streams, regardless of ownership, within Type 3 watersheds that contain at least 20 percent state trust lands	**Low**: Distribution of watershed scores shifts toward a low impact condition, with most scores in a low impact condition. **Medium**: Distribution of watershed scores and most watersheds remain in a medium impact condition, or scores shift from a medium to a low or high impact condition but most scores remain in a medium impact condition. **High**: Distribution of watershed scores shifts toward a high impact condition, with most scores in a high impact condition.
Functioning riparian habitat/ Leaf and needle litter recruitment	Characteristics of the riparian forest, such as relative density and the size and species of trees, and distance of trees from stream. **Area of Influence:** 100-year floodplain plus an additional 150 feet **Contribution to overall riparian impact score (importance)**: 5 percent **Assessment area**: All streams that cross state trust lands within Type 3 watersheds that contain at least 20 percent state trust lands	**Low**: Distribution of watershed scores shifts toward a low impact condition, with most scores in a low impact condition. **Medium**: Distribution of watershed scores and most watersheds remain in a medium impact condition, or scores shift from a medium to a low or high impact condition but most scores remain in a medium impact condition. **High**: Distribution of watershed scores shifts toward a high impact condition, with most scores in a high impact condition.

Table 3-17, Continued. Criteria and Indicators for Riparian Areas and How They Are Measured

Criterion/ Indicator	**How the indicator is measured**	**Potential environmental impacts**
Functioning riparian habitat/ Riparian microclimate	Changes to daytime air temperature, soil temperature, and relative humidity as a result of nearby harvests. **Area of influence**: Within 670 feet of the stream bank **Contribution to overall riparian score (importance)**: 3 percent **Assessment area**: All streams that cross state trust lands within Type 3 watersheds that contain at least 20 percent state trust lands	**Low**: Distribution of watershed scores shifts toward a low impact condition, with most scores in a low impact condition. **Medium**: Distribution of watershed scores and most watersheds remain in a medium impact condition, or scores shift from a medium to a low or high impact condition but most scores remain in a medium impact condition. **High**: Distribution of watershed scores shifts toward a high impact condition, with most scores in a high impact condition.
Functioning riparian habitat/ Composite watershed score	Combination of Type 3 watershed impact scores for all indicators.	**Low**: Distribution of composite watershed scores shifts toward a low impact condition, with most scores in a low impact condition. **Medium**: Distribution of composite watershed scores and most watersheds remain in a medium impact condition, or scores shift from a medium to a low or high impact condition but most scores remain in a medium impact condition. **High**: Distribution of composite watershed scores shifts toward a high impact condition, with most scores in a high impact condition.

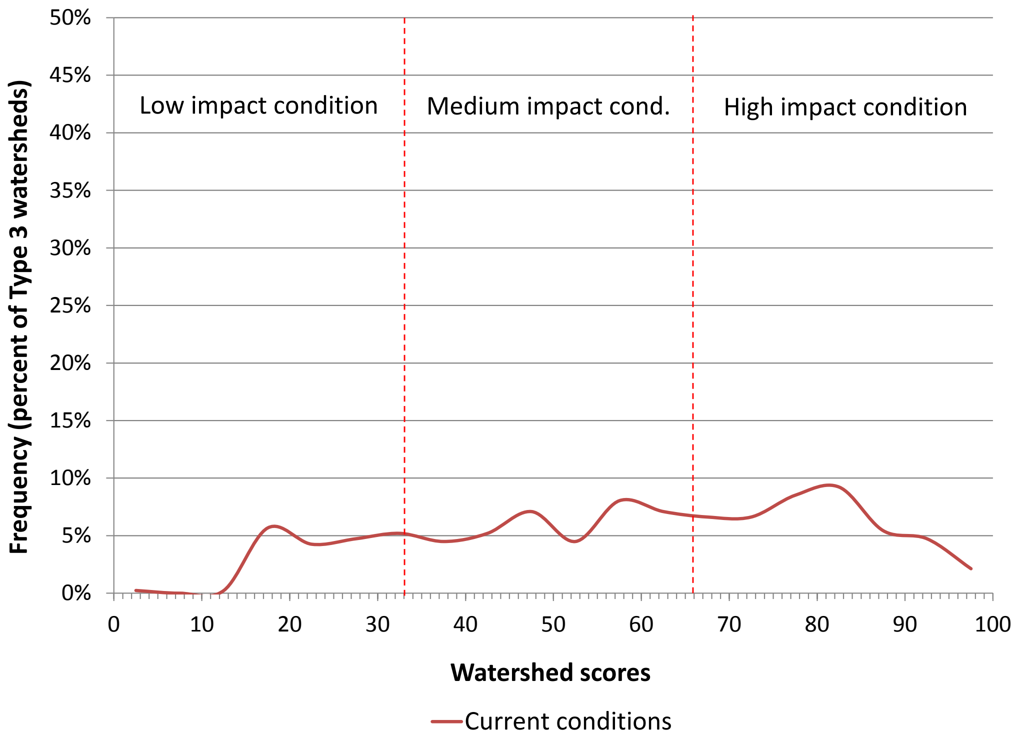
Current Conditions

As described previously, current conditions for each indicator are presented as a distribution of scores. For a list of the individual and composite scores for each Type 3 watershed, refer to Appendix G. Scores are developed using sophisticated computer modeling techniques which are described in detail in Appendix G. DNR built a separate model for each indicator, including the composite watershed score.

Indicator: Large Woody Debris Recruitment

The distribution of watershed scores for large woody debris is shown in Chart 3-15. Currently, 18 percent of Type 3 watersheds are in a low impact condition, 40 percent are in a medium impact condition, and 41 percent are in a high impact condition.

Chart 3-15. Current Distribution of Watershed Scores for Large Woody Debris Recruitment



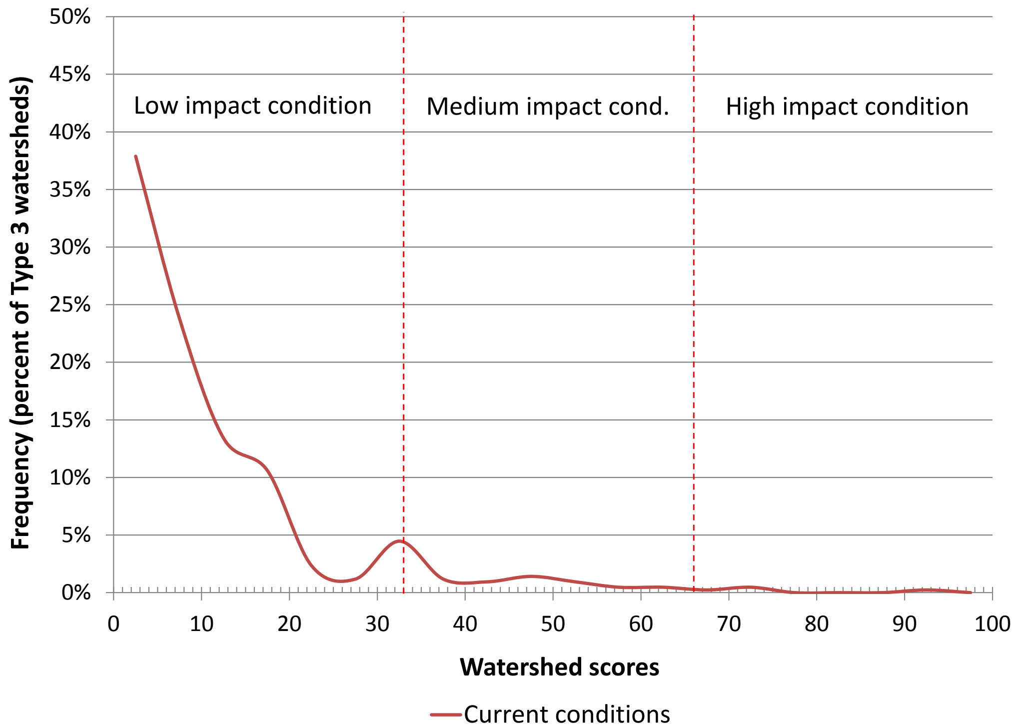
The current condition of large woody debris recruitment is primarily the result of timber harvests that occurred prior to implementation of the 1997 *Habitat Conservation Plan*. Between 1970 and 1990, approximately half of the forest within the area of influence for large woody debris was clearcut. (Today, DNR uses variable retention harvest; refer to Text Box 3-1 on p. 3-23.) While regrowth has occurred, 43 percent of these areas are currently in the Competitive Exclusion stand development stage. (For a description of stand development stages, refer to Text Box 3-2, p. 3-26).

Stands in the Competitive Exclusion stage often lack the large trees, snags, multiple canopy layers, and significant large woody debris found in more structurally complex forests (Bigley and Deisenhofer 2006). The woody debris these forests provide currently consists of small diameter pieces, which decay faster, are less stable in the stream channel, and are less likely to influence in-stream habitat.

Indicator: Peak Flow

The distribution of watershed scores for peak flow is shown in Chart 3-16. Currently, 92 percent of Type 3 watersheds are in a low impact condition, 7 percent are in a medium impact condition, and 1 percent are in a high impact condition.

Chart 3-16. Current Distribution of Watershed Scores for Peak Flow



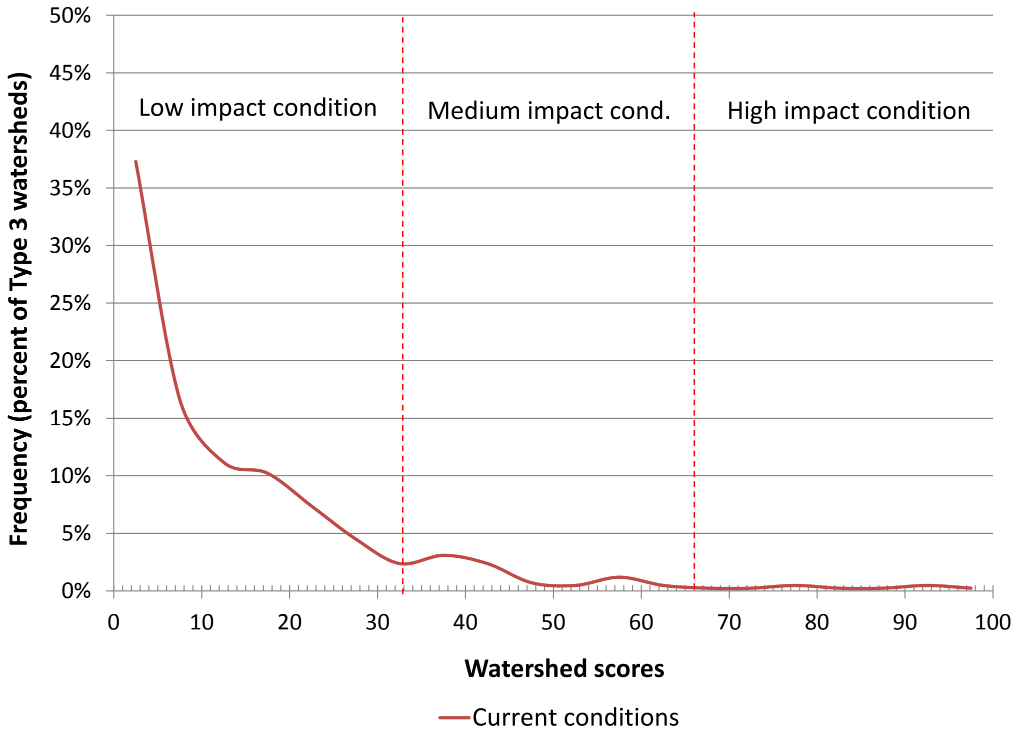
Currently, the proportion of hydrologically immature forests remains sufficiently low to prevent or minimize changes in peak flow. On average, hydrologically immature forests comprise less than approximately 25 percent of each Type 3 watershed. A large percentage of a watershed must be classified as hydrologically immature before changes to peak flow can be detected.

Studies by Grant and others (2008) have shown that peak flow response to harvest varies by hydrologic zones (areas defined by the dominant precipitation type). These studies found that changes to peak flow become detectable only when more than 40 percent of a watershed is harvested in the rain-dominated zone, and more than 20 percent of the watershed is harvested in the rain-on-snow zone. Most watersheds are currently below this threshold.

Indicator: Stream Shade

The distribution of watershed scores for shade is shown in Chart 3-17. Currently, 89 percent of Type 3 watersheds are in a low impact condition, 9 percent are in a medium impact condition, and 2 percent are in a high impact condition.

Chart 3-17. Current Distribution of Watershed Scores for Stream Shade



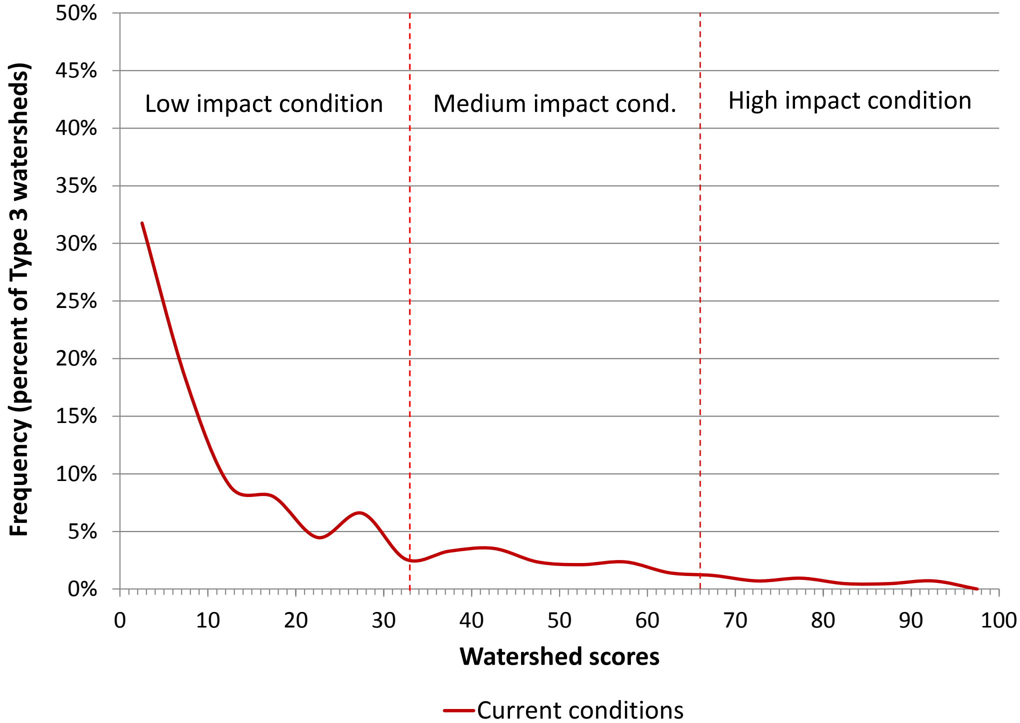
The current distribution of watershed scores for shade shows that most (approximately 68 percent) stream reaches are at or above their shade targets. An additional 11 percent of streams have nearly achieved their shade target (meaning they are within 10 percent). Current shade levels are a result of many factors, including topography, stream orientation, stream width, forest conditions, and past and current harvests.

Indicator: Fine Sediment Delivery

As explained previously, for this indicator DNR considers both fine sediment delivery potential and the sensitivity, or expected channel response, to the delivery of fine sediment. Fine sediment delivery potential is determined using traffic impact scores, which are based on road surface type, the proximity of roads to streams or other water bodies, and the level of log-truck traffic that may result from future harvests in the Type 3 watershed on all ownerships (state trust lands as well as federal, tribal, and private lands).

Instead of current conditions, DNR reports results based on the first decade's worth of harvest activities under the No Action Alternative. In the first decade, 80 percent of Type 3 watersheds are in a low impact condition, 16 percent are in a medium impact condition, and 4 percent are in a high impact condition (refer to Chart 3-18).

Chart 3-18. Distribution of Watershed Scores for Fine Sediment Delivery Based on the First Decade of Harvest Activities Under the No Action Alternative



Indicator: Leaf and Needle Litter Recruitment

The distribution of watershed scores for leaf and needle litter recruitment is shown in Chart 3-19. Currently, 3 percent of Type 3 watersheds are in a low impact condition, 15 percent are in a medium impact condition, and 82 percent are in a high impact condition.

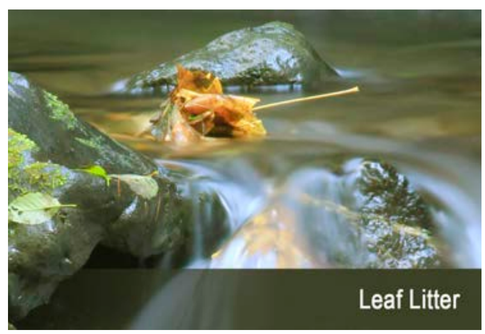
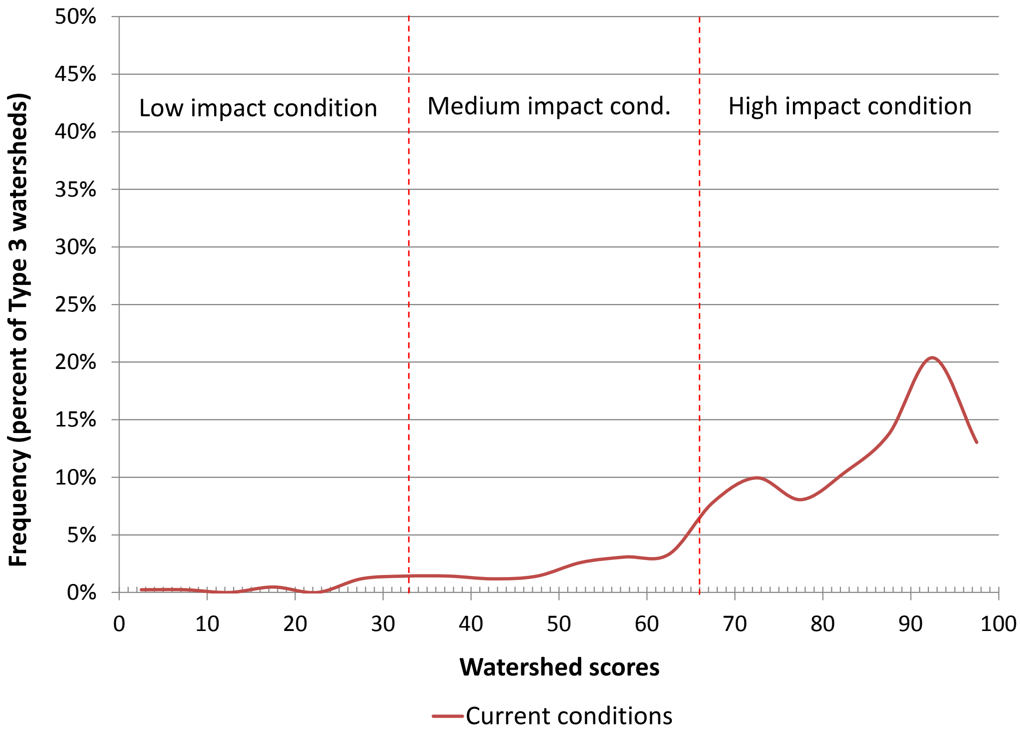


Chart 3-19. Current Distribution of Watershed Scores for Leaf and Needle Litter Recruitment



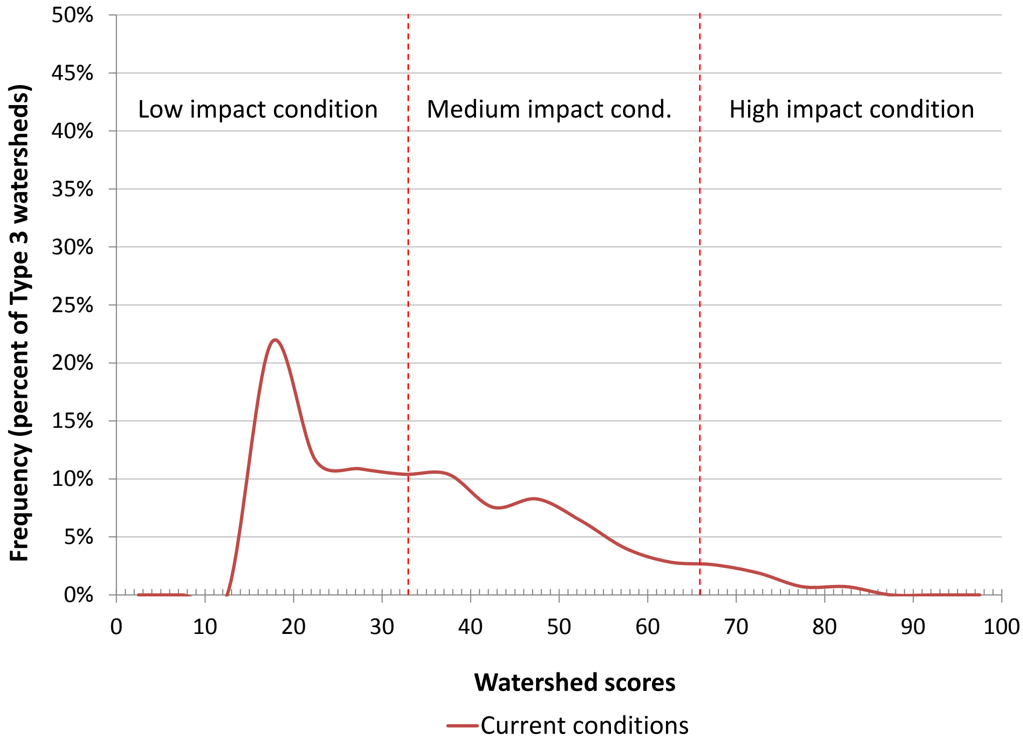
The high impact condition of many Type 3 watersheds is due to a combination of factors: the high sensitivity of headwater streams (Type 4 and Type 5 streams) to leaf and needle litter input, the abundance of these streams on state trust lands in the OESF, past harvests along Type 4 streams, and past and current harvests along Type 5 streams on stable ground.

Per DNR's current policies, procedures, and forest practice rules, interior-core buffers are applied to Type 1 through Type 4 streams, and to Type 5 streams on potentially unstable ground. Interior-core buffers are not applied to Type 5 streams on stable ground. On these streams, DNR applies only an equipment limitation zone, which is an area along the stream where heavy equipment use is limited to maintain bank stability and integrity. Refer to Chapter 2, p. 2-16 for a discussion of the application of interior-core buffers under both management alternatives.

Indicator: Riparian Microclimate

The distribution of watershed scores for riparian microclimate is shown in Chart 3-20. Currently, 50 percent of Type 3 watersheds are in a low impact condition, 44 percent are in a medium impact condition, and 6 percent are in a high impact condition.

Chart 3-20. Current Distribution of Watershed Scores for Riparian Microclimate



Variable retention harvest methods have the most influence on this indicator; harvests within 670 feet of the stream bank may affect riparian microclimate conditions. However, studies have shown these effects to be temporary.

- In the Oregon Coast Range, where plant growth is rapid, in 10 years the vegetation in a newly regenerated area can often grow as high as the base of tree crowns in riparian buffers. Side light and air movement quickly become limited, and microclimate conditions more like those of a continuous forest are reestablished (Hibbs and Bower 2001).

- Summers (1982) found that shade recovery to old-growth levels occurred within about 10 years in the Sitka spruce zone, 14 years in the Oregon Coast Range western hemlock zone, and about 20 years in the Cascade Mountain western hemlock zone. However, shade recovery was slower in higher elevation Pacific silver fir forests in the Cascade Mountains, and was only 50 percent complete after 20 years (Brown and Krygier 1970, Harris 1977, Feller 1981, and Harr and Fredriksen 1988 as cited in Moore and others 2005). Recovery took longer in some cases and was not detected in others.

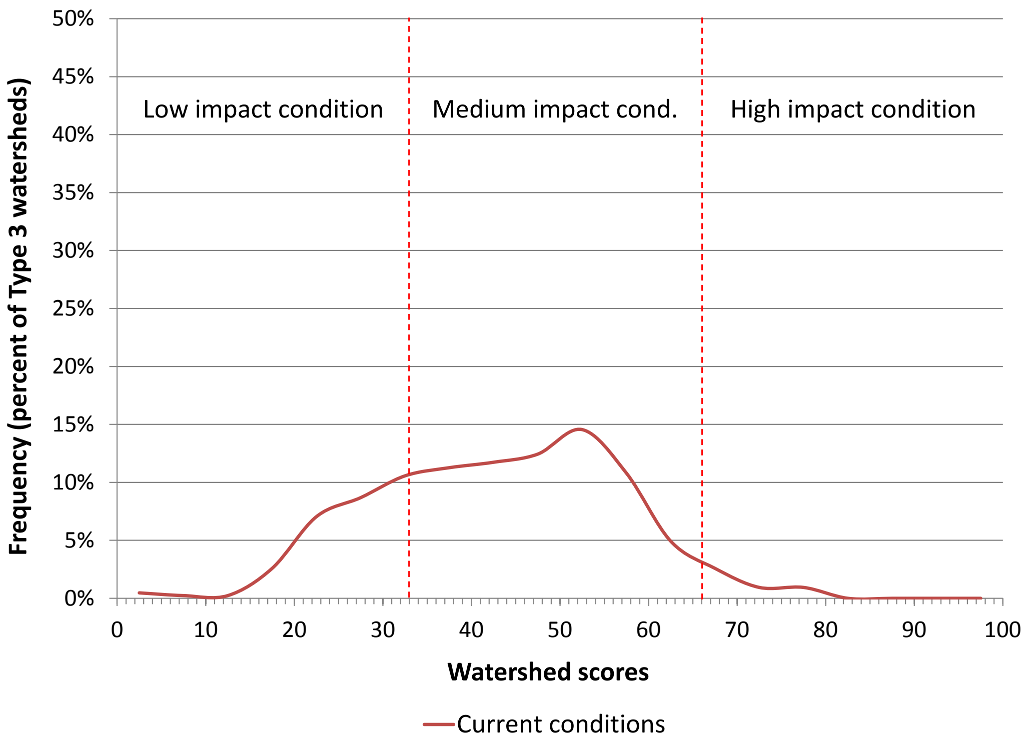
Based on a review of the available literature, DNR modeled microclimate effects as declining 50 percent in 10 years and disappearing in 20 years.

Most likely, most watersheds are currently in a low or medium impact condition for microclimate because the amount of variable retention harvest within the microclimate area of influence has declined over the last 20 years. In addition, microclimate gradients have had enough time to recover from past variable retention harvests.

Indicator: Composite Watershed Score

The distribution of composite watershed scores is shown in Chart 3-21. Currently, 24 percent of Type 3 watersheds are in a low impact condition, 72 percent are in a medium impact condition, and 4 percent are in a high impact condition.

Chart 3-21. Current Distribution of Composite Watershed Scores



Past harvest practices affected a large proportion of the OESF. As a result, many of these areas are currently in the early stages of forest development. These stages are less capable of providing the full suite of riparian functions, which is reflected by most watersheds currently being in a medium impact condition.

Results

As described previously, results for each indicator are presented as a distribution of scores and are based on model results. For a list of the individual and composite scores for each Type 3 watershed, refer to Appendix G. Scores are developed using sophisticated computer modeling techniques which are described in detail in Appendix G. DNR built a separate model for each indicator, including the composite watershed score.

Indicator: Large Woody Debris Recruitment

Chart 3-22 through Chart 3-24 show the distribution of watershed scores for large woody debris for decades 1, 6, and 9, representing short-, mid-, and long-term trends.

Chart 3-22. Distribution of Watershed Scores for Large Woody Debris, Decade 1

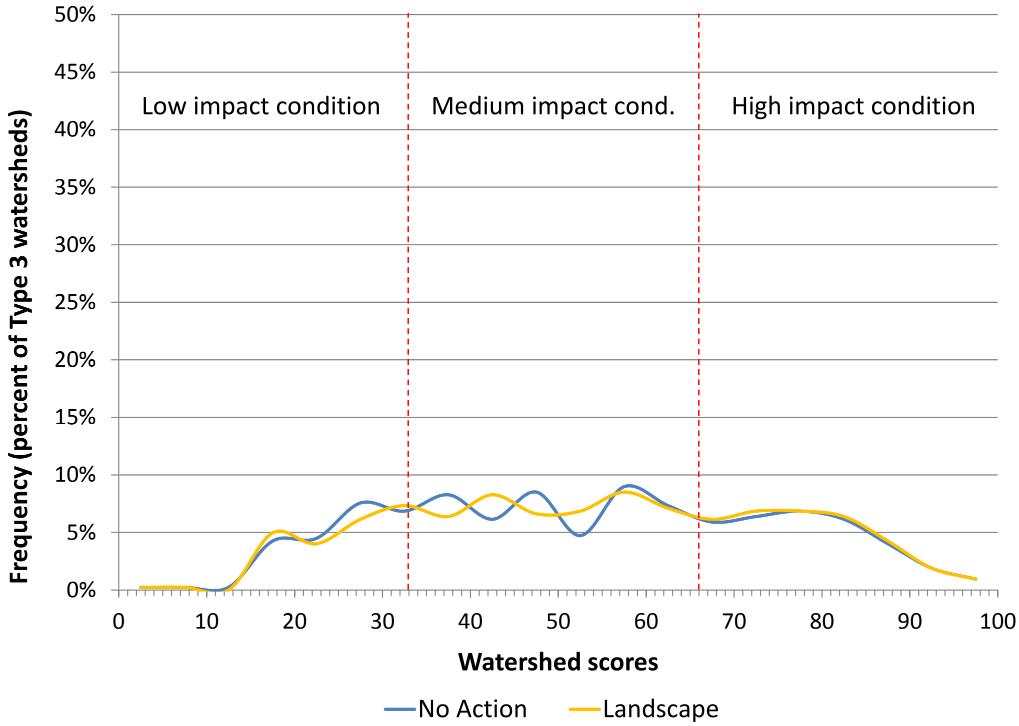


Chart 3-23. Distribution of Watershed Scores for Large Woody Debris, Decade 6

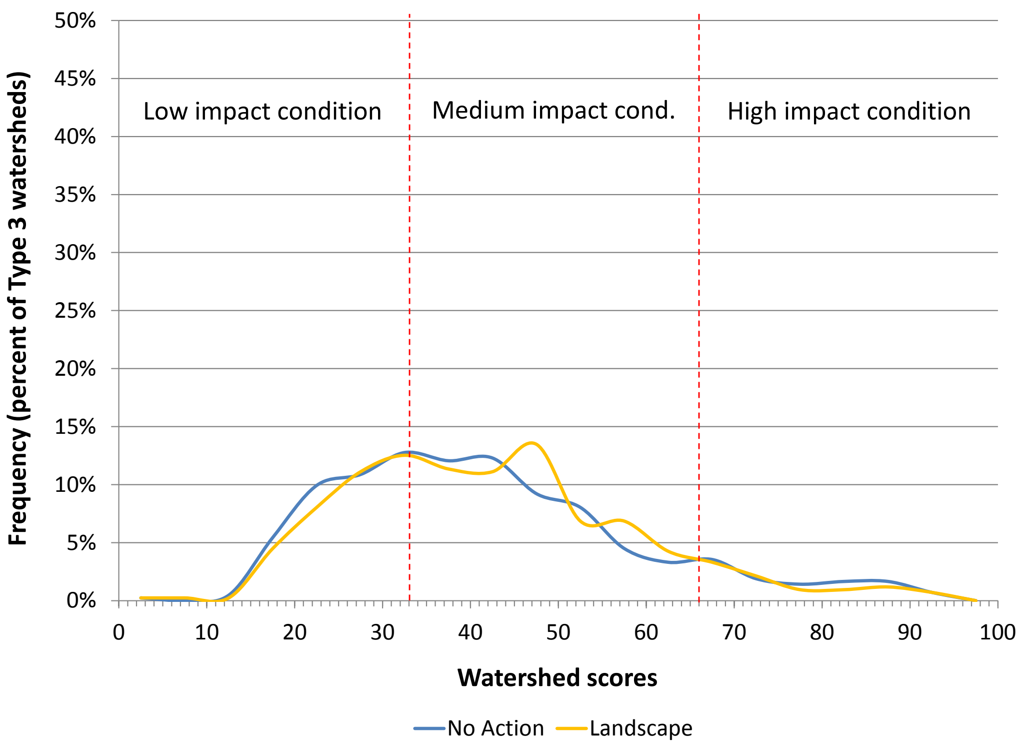
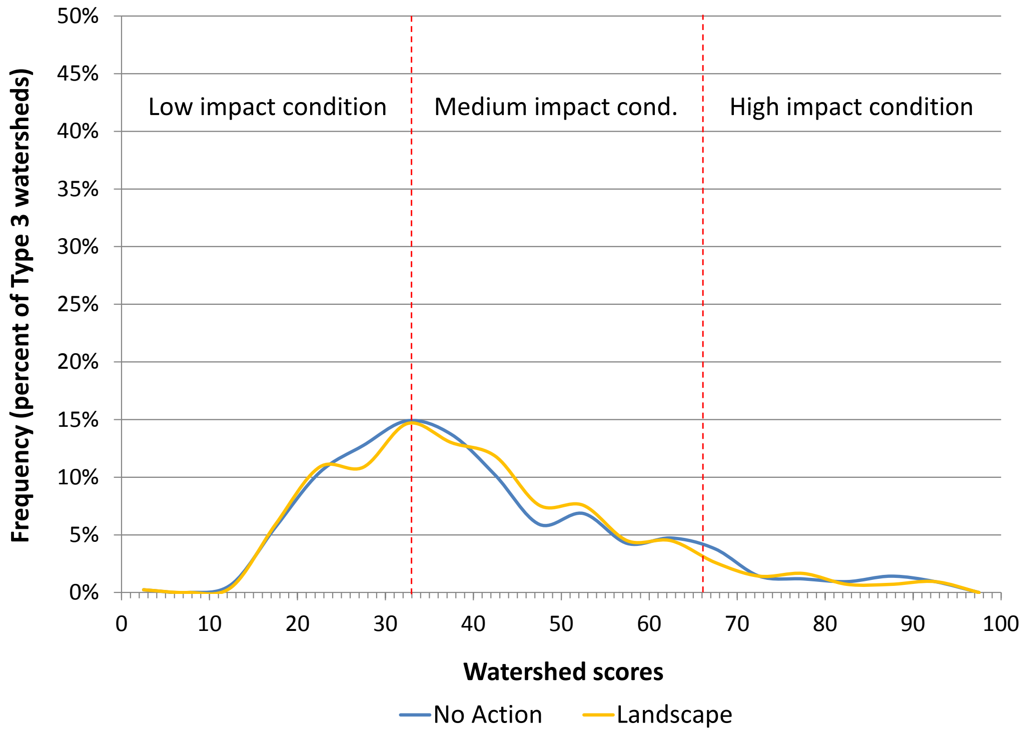


Chart 3-24. Distribution of Watershed Scores for Large Woody Debris, Decade 9



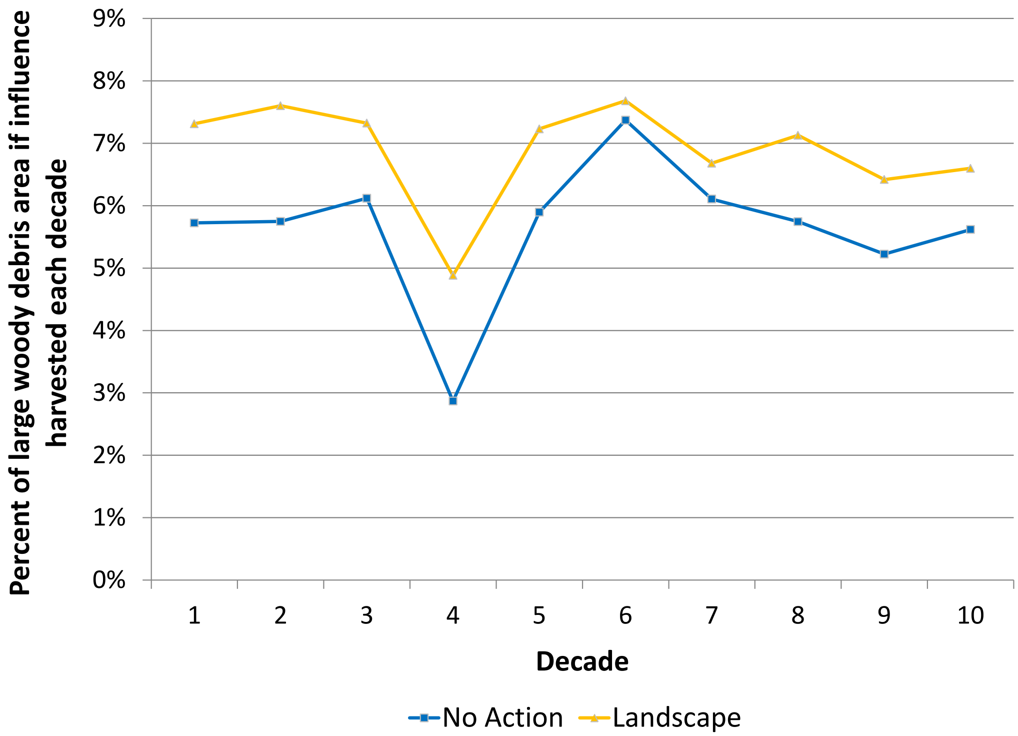
The distribution of impact scores is nearly identical for both alternatives and steadily moves toward an improved condition (lower impact). Most watersheds remain in a medium impact condition for the duration of the analysis period. These results can be attributed to a combination of factors, including natural forest growth, past harvest activities, and future harvest activities.

- **Natural forest growth and past harvest activities**: Fifty-seven percent of the area of influence for large woody debris is currently deferred from harvest, meaning these areas are not currently available or scheduled for harvest per current policy or other reasons. Forty-three percent of the area of influence is currently in the Competitive Exclusion stand development stage. In the absence of harvest or natural disturbance, forest stands can remain in the Competitive Exclusion stage for decades. For example, an analysis of the outputs of DNR's forest estate model shows that, on average, in the absence of management, stands currently in the Competitive Exclusion stage remain so for 50 years or more.

  During the Competitive Exclusion stage, stand density, or the extent to which an area is occupied by trees, typically reaches its maximum. Competition for limited resources, such as light, nutrients, and growing space, is high. Many trees in the stand may decline in growth and eventually die as competition intensifies (Franklin and others 2007). While some forest stand-level parameters such as basal area[9] or standing volume increase at their maximum rate during the Competitive Exclusion stage because of the sheer number of trees, the growth of individual trees is generally depressed. Conditions for large woody debris therefore will improve over time through natural processes, but the change will be slow. By the end of the analysis period, many watersheds will be in a medium impact condition under both alternatives.

- **Future harvest activities – variable retention harvest**: The management alternatives propose similar levels of variable retention harvests within the large woody debris area of influence. From decade to decade, the projected level of harvest varies but does not exceed 8 percent of the area of influence (Chart 3-25). Large woody debris recruitment is projected to improve gradually across the distribution of watersheds at this level of harvest.

Chart 3-25. Projected Amount of Variable Retention Harvests Within the Area of Influence for Large Woody Debris, by Alternative



- **Future harvest activities – thinning**: Thinning can reduce competition between trees for resources. Trees respond to thinning with accelerated growth, which eventually leads to higher-quality large woody debris. While there may be a short-term reduction in large woody debris recruitment immediately after harvest, the long-term recruitment potential is expected to benefit from thinning (Bigley and Deisenhofer 2006).

The differences between the extent and intensity of harvests projected for the alternatives are not large enough to result in appreciably dissimilar effects on large woody debris recruitment. Changes in large woody debris recruitment over time are nearly identical for the alternatives.

The potential environmental impact of either alternative for this indicator is considered **medium**. The distribution of impact scores moves steadily toward an improved condition (lower impact), but most watersheds remain in a medium impact condition because it takes considerable time for trees to grow large enough to contribute large woody debris. DNR has not identified probable significant adverse environmental impacts from either alternative for this indicator.

Indicator: Peak Flow

Under both alternatives, the distribution of watershed scores remains relatively stable (Chart 3-26 through Chart 3-28). Most watersheds are in a low impact condition for peak flow. Trends are subtle, and the alternatives track in a similar fashion.

Chart 3-26. Distribution of Watershed Scores for Peak Flow, Decade 1

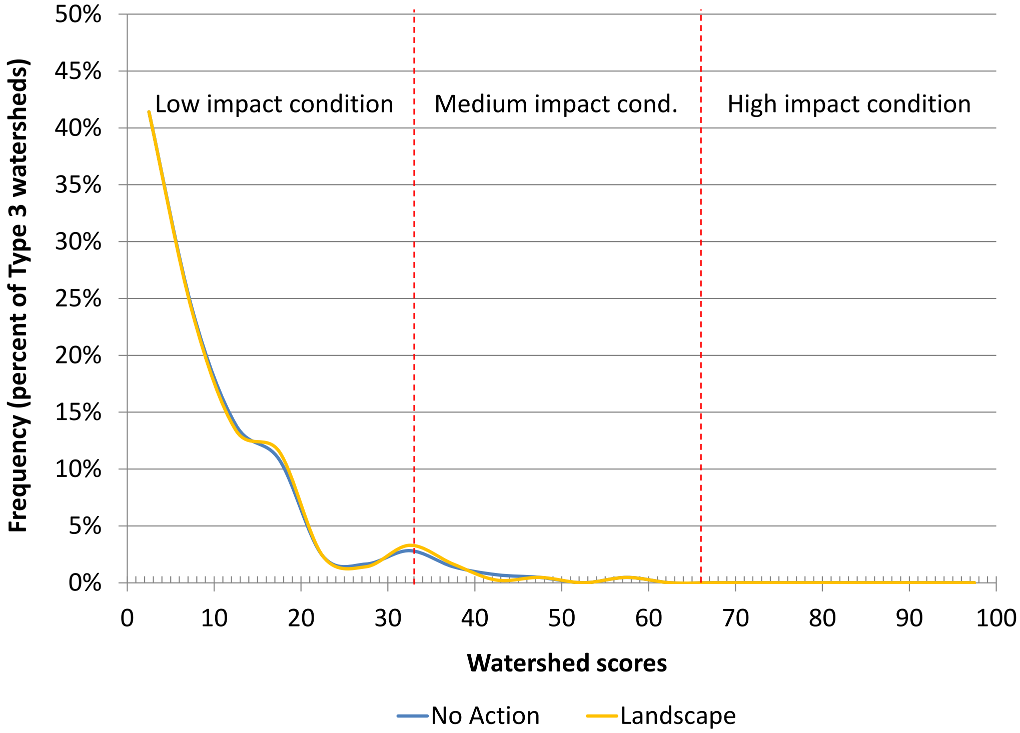


Chart 3-27. Distribution of Watershed Scores for Peak Flow, Decade 6

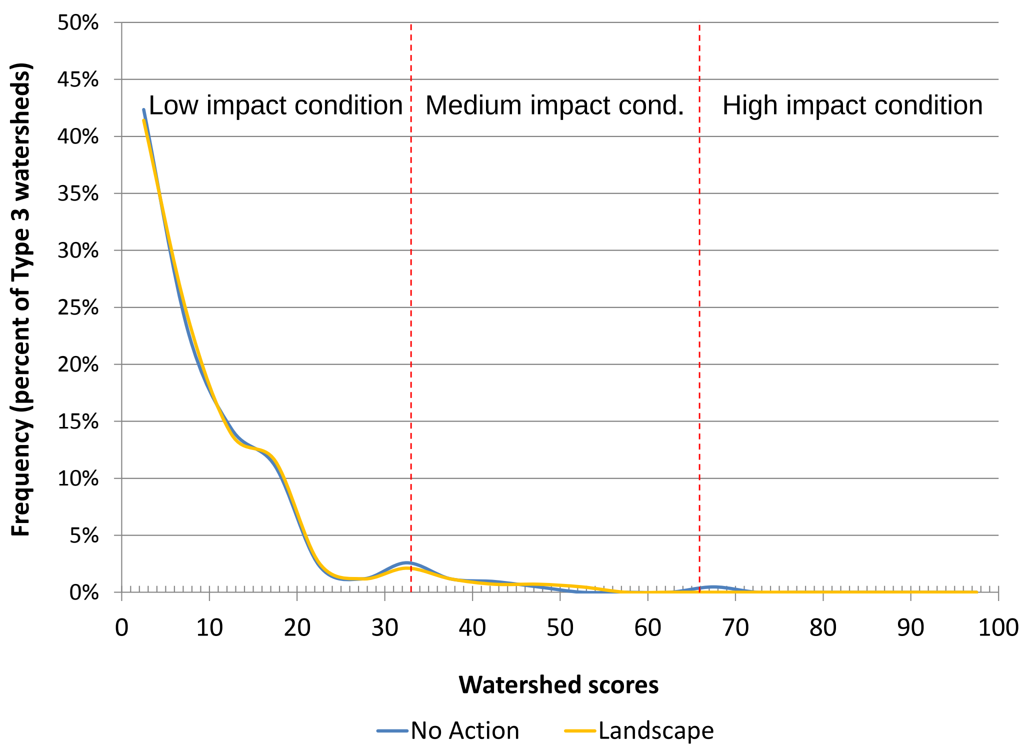
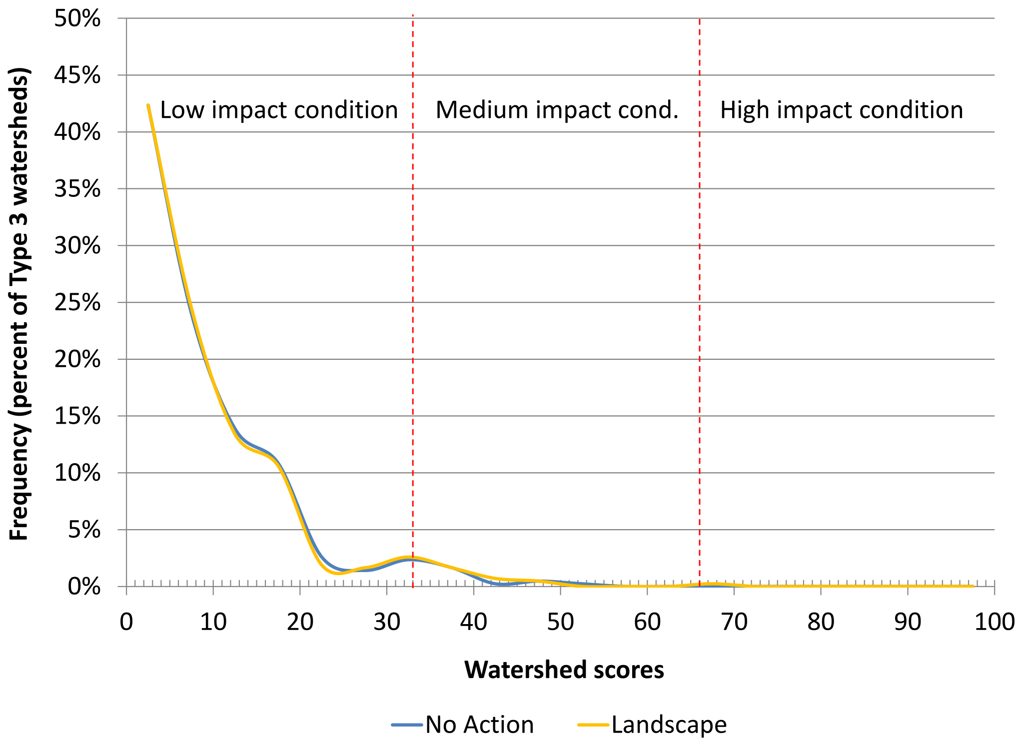


Chart 3-28. Distribution of Watershed Scores for Peak Flow, Decade 9



Peak flow is influenced by the proportion of hydrologically immature areas within a watershed. Under both alternatives, the amount of hydrologically immature forests remains sufficiently low to prevent or minimize changes in peak flow. On average, in each decade, hydrologically immature forests comprise less than approximately 25 percent of each Type 3 watershed.

The potential environmental impact of either alternative for this indicator is considered **low.** Most watersheds are in a low impact condition and the number of watersheds in a low impact condition is projected to increase slightly over time. DNR has not identified probable significant adverse environmental impacts from either alternative for this indicator.

Indicator: Stream Shade

The distribution of watershed scores for stream shade is shown in Chart 3-29 through Chart 3-31. The alternatives show a nearly identical trend of low impact conditions for stream shade. Under both alternatives, the distribution of scores remains relatively stable.

Chart 3-29. Distribution of Watershed Scores for Stream Shade, Decade 1

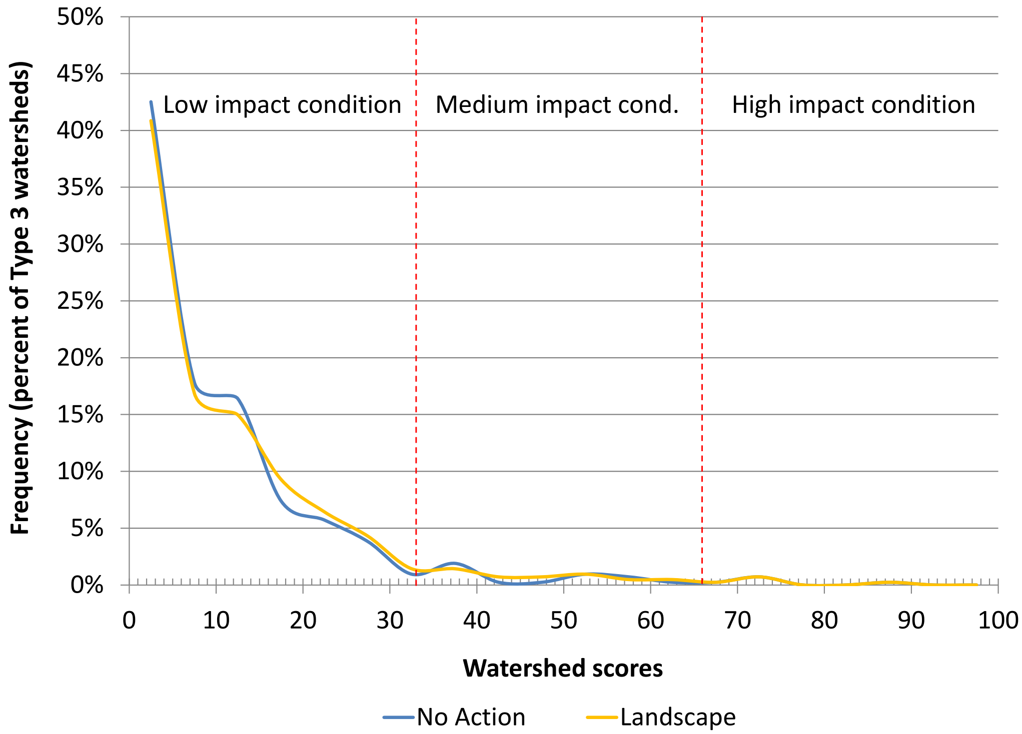


Chart 3-30. Distribution of Watershed Scores for Stream Shade, Decade 6

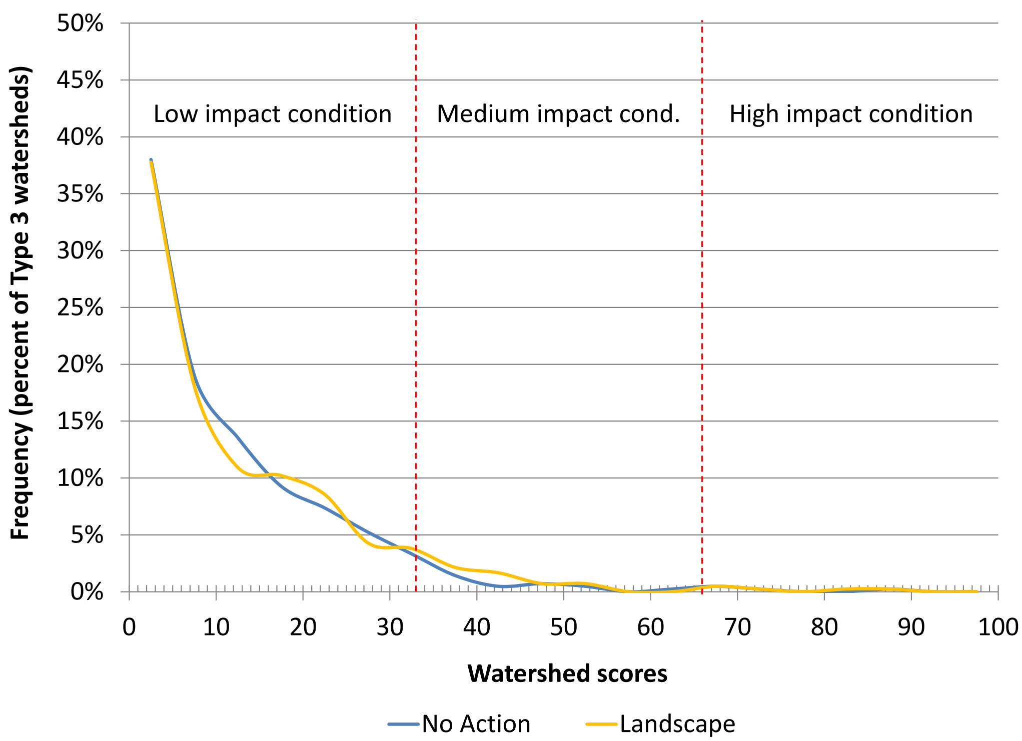
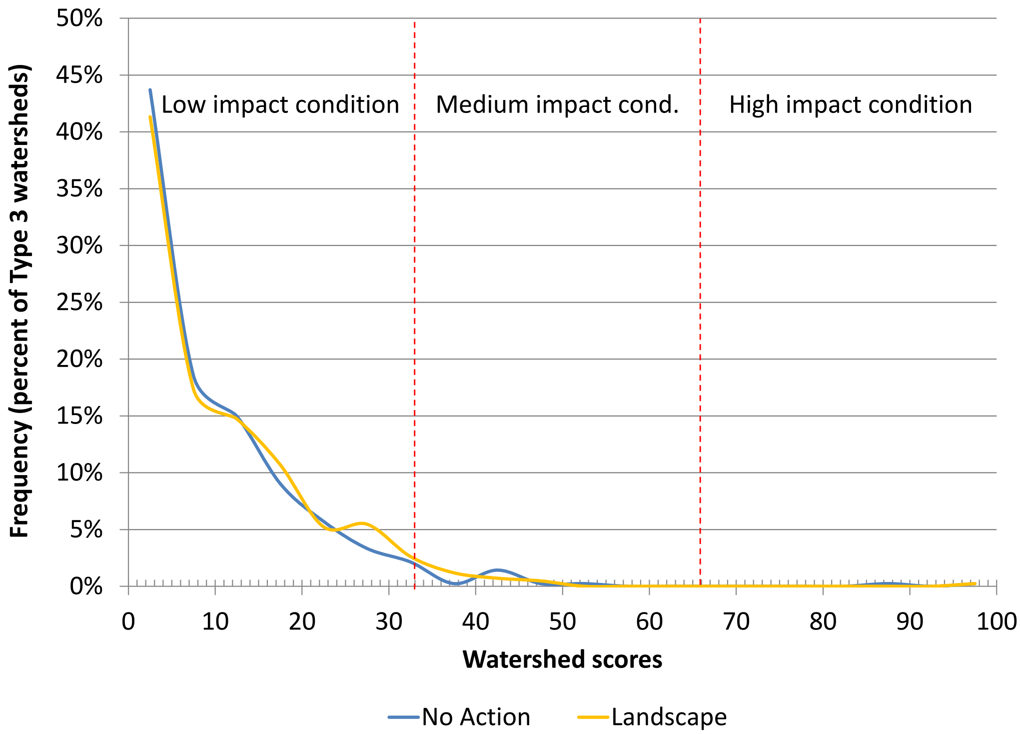


Chart 3-31. Distribution of Watershed Scores for Stream Shade, Decade 9



The relative stability of shade scores over the 100-year analysis period is due to a combination of factors.

- **Harvest activities – variable retention harvest**: Variable retention harvest may reduce shade levels along Type 5 streams on stable ground because DNR does not apply interior-core buffers to these streams. However, these streams tend to be found at higher elevations where temperatures are cooler, the terrain is more likely to provide shade, and the target shade level necessary to maintain cooler water temperatures is lower.
- **Harvest activities – thinning**: Chan and others (2004) found substantial reductions in shade only when harvest reduced relative density below 30. For less intensive thinnings, they found light levels to be similar to those in unthinned forests. Since DNR does not thin below a relative density of 35, thinning is not expected to impact shade substantially.
- **Physical characteristics**: The amount of stream shade can be affected by the shape of the surrounding terrain, the orientation of the stream channel, and the width of the stream itself. These factors will not change over time, nor will they be affected by DNR management activities.
- **Natural forest growth**: Fifty-seven percent of the first 150 feet of the area of influence is currently deferred from harvest. In these areas, changes in stream shade will be due solely to natural growth and disturbance. Forty-three percent of the first 150 feet of the area of influence is currently in the Competitive Exclusion stand development stage, with crowded canopies and high shade levels. Changes will occur in these areas, but the shift will be slow.

The differences between the extent and intensity of harvests projected to occur under the alternatives are not large enough to result in appreciably dissimilar effects on stream shade. Changes in stream shade over time are nearly identical for the alternatives (Chart 3-29 through Chart 3-31).

The potential environmental impact of either alternative for this indicator is considered **low**. Most Type 3 watersheds remain in a low impact condition. DNR has not identified probable significant adverse environmental impacts from either alternative for this indicator.

Indicator: Fine Sediment Delivery

The distribution of watershed scores for fine sediment delivery is shown in Chart 3-32 through Chart 3-34. The alternatives show a nearly identical trend of low impact conditions for fine sediment delivery. Under both alternatives, the distribution of scores remains relatively stable.

Chart 3-32. Distribution of Watershed Scores for Fine Sediment Delivery, Decade 1

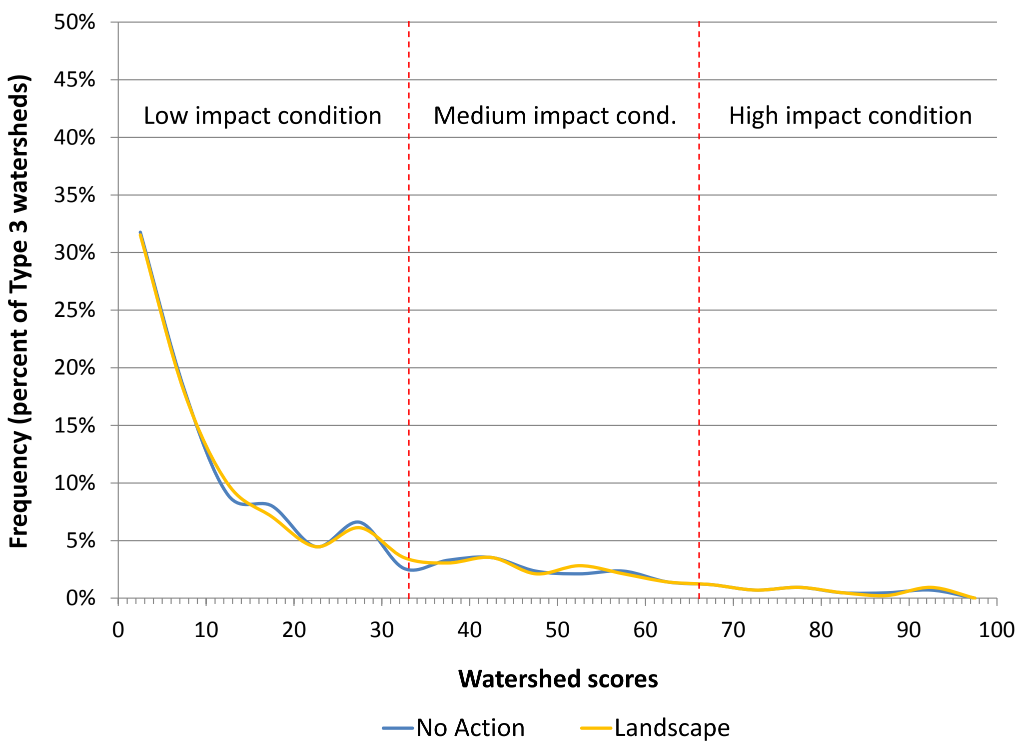


Chart 3-33. Distribution of Watershed Scores for Fine Sediment Delivery, Decade 6

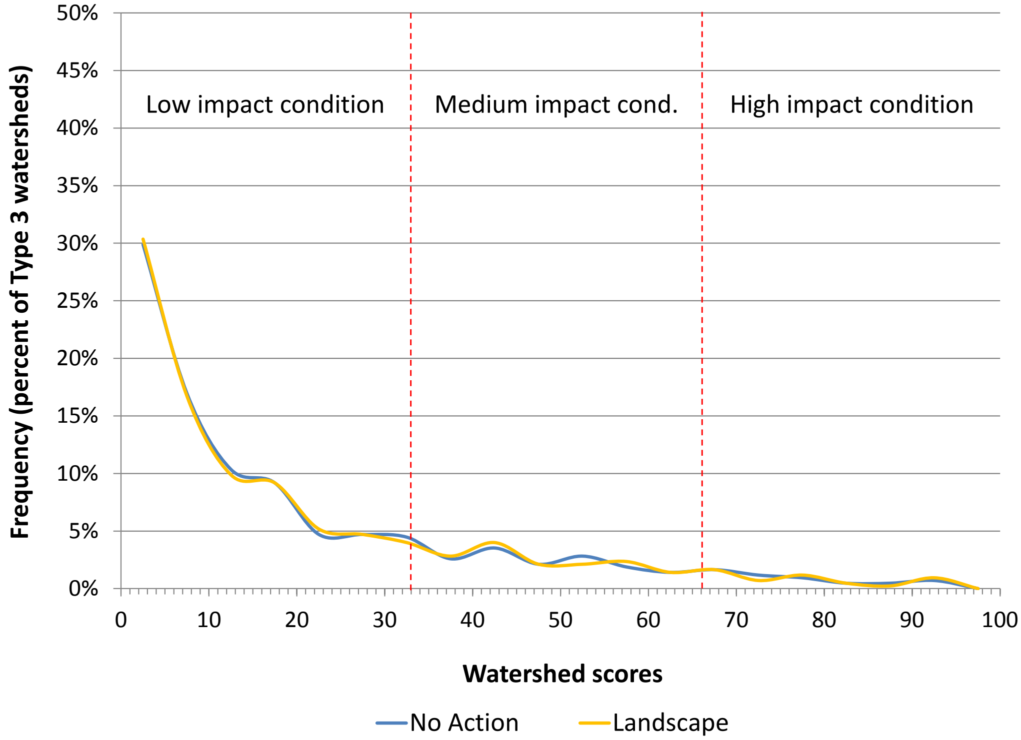
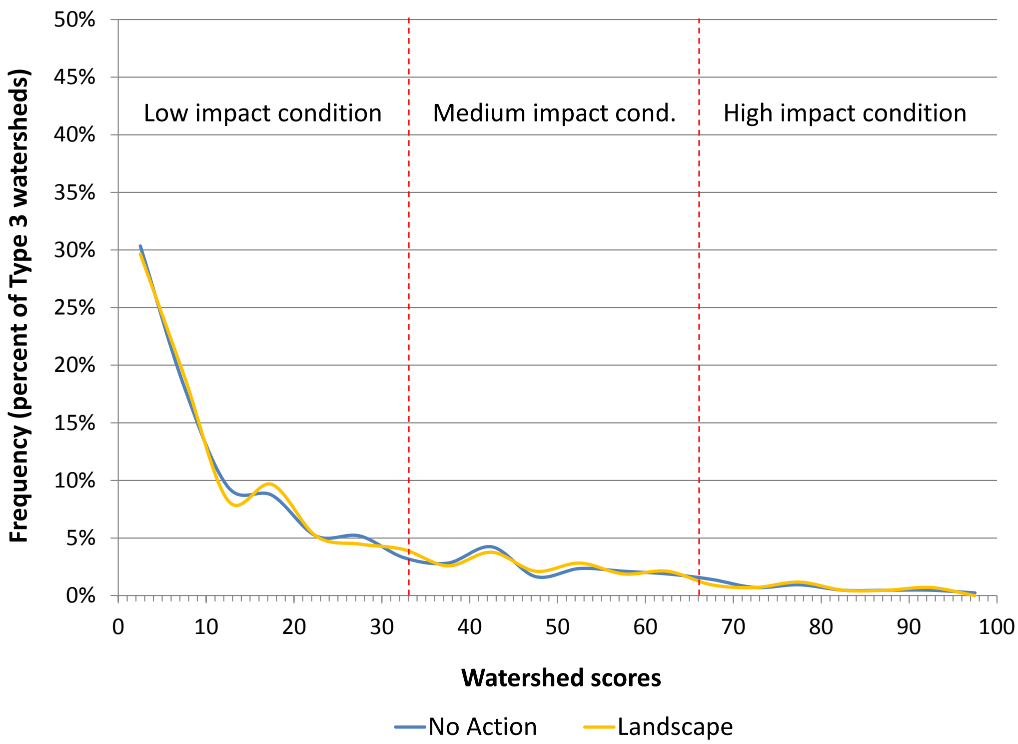


Chart 3-34. Distribution of Watershed Scores for Fine Sediment Delivery, Decade 9



DNR considers both the fine sediment delivery potential and the sensitivity, or expected channel response, to the delivery of fine sediment. DNR determines the fine sediment delivery potential using traffic impact scores, which are based on road surface type, proximity of roads to streams or other water bodies, and the level of log-truck traffic that may result from future harvests in the Type 3 watershed on all ownerships (state trust lands as well as federal, tribal, and private lands).

As explained previously, the projected traffic levels for other ownerships are held constant, meaning they do not vary from one decade to the next. Because these levels do not change, and because projected traffic levels from DNR harvests vary little from one decade to the next, traffic impact scores are relatively stable. In addition, the differences between the extent and intensity of harvests projected to occur under the alternatives are not large enough to result in appreciably dissimilar effects on fine sediment delivery. Changes in fine sediment delivery over time are nearly identical for the No Action and Landscape alternatives.

While individual stream reaches may be rated as highly sensitive at the watershed level, most stream reaches are relatively insensitive to the delivery of fine sediment. By length, approximately 78 percent of all streams on state trust lands in the OESF are assigned a low sensitivity rating. For these reaches, fine sediment is stored only temporarily and most fine sediment is transported through with little impact.

The potential environmental impact of either alternative for this indicator is considered **low**. Most Type 3 watersheds remain in a low impact condition. DNR has not identified probable significant adverse environmental impacts from either alternative for this indicator.

Indicator: Leaf and Needle Litter Recruitment

The distribution of watershed scores for leaf and needle litter recruitment are shown in Chart 3-35 through Chart 3-37. Under both alternatives, the distribution of scores moves toward a lower impact condition, although the trend is subtle. The rate of recovery is slow and many watersheds remain in a high impact condition during the entire analysis period. Differences between the alternatives are small.

Chart 3-35. Distribution of Watershed Scores for Leaf and Needle Litter Recruitment, Decade 1

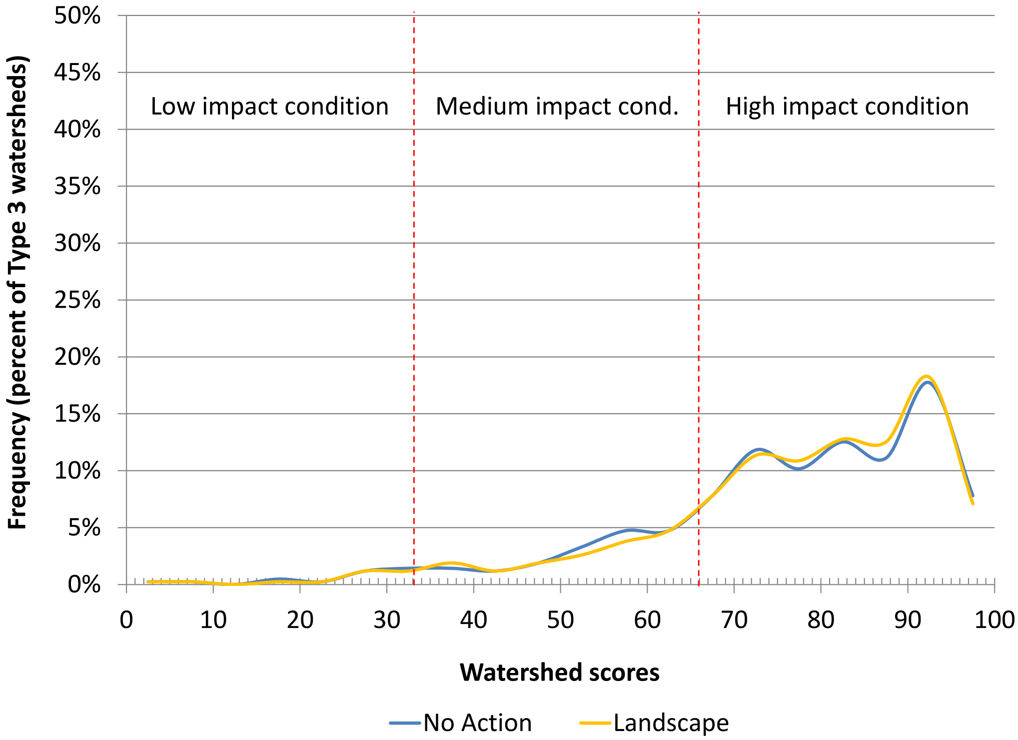


Chart 3-36. Distribution of Watershed Scores for Leaf and Needle Litter Recruitment, Decade 6

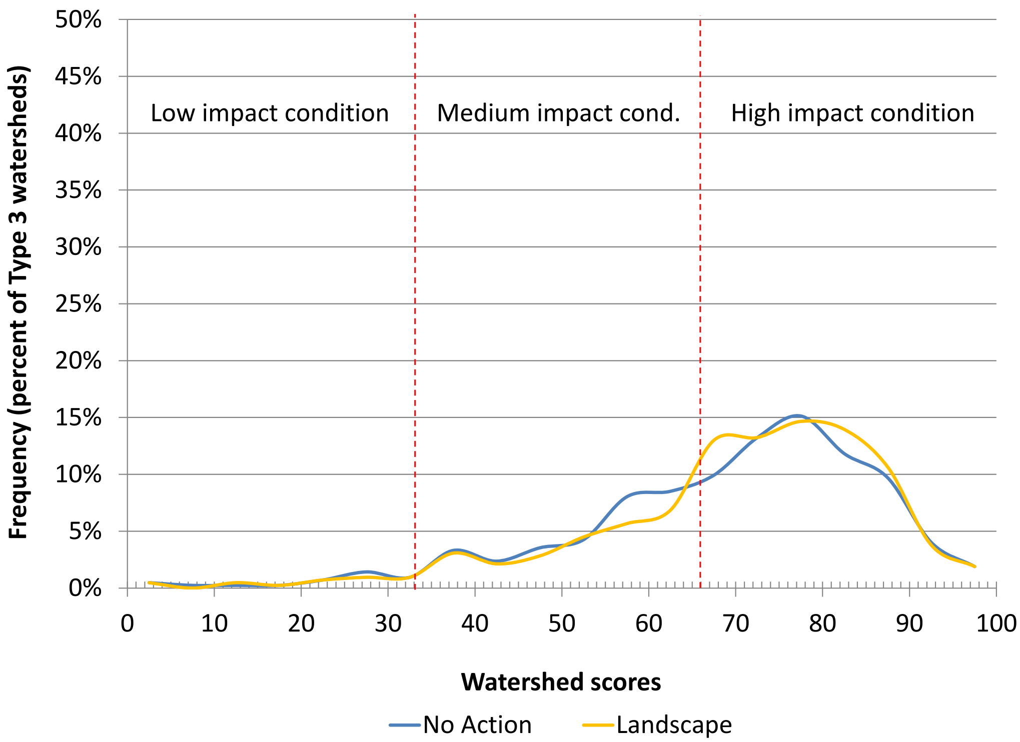
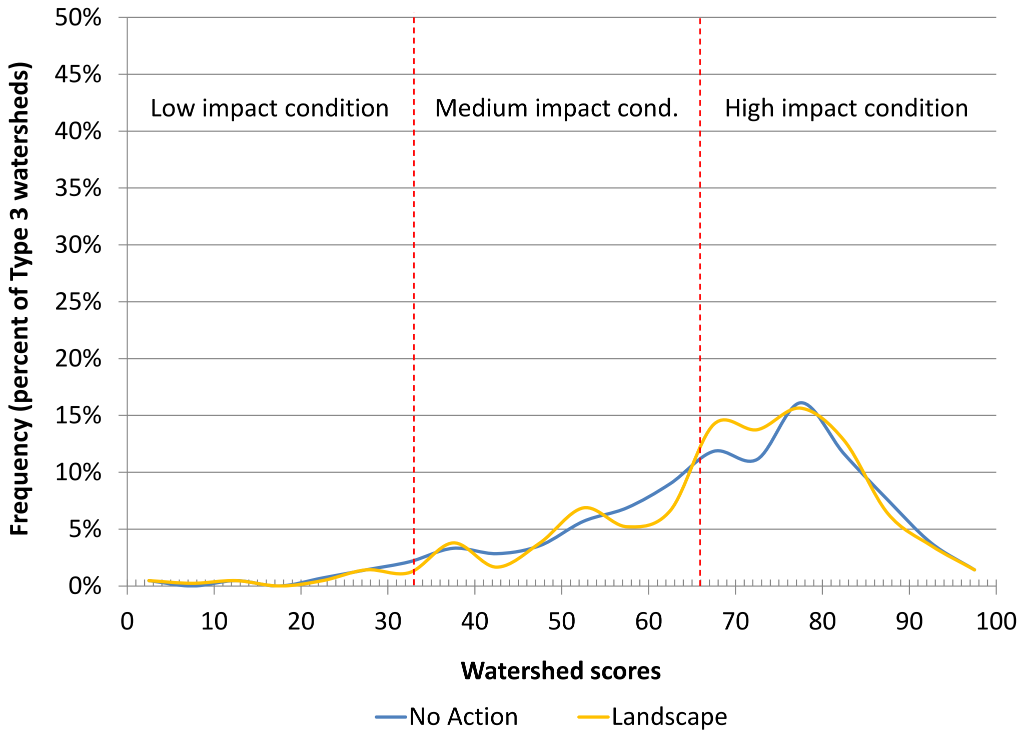


Chart 3-37. Distribution of Watershed Scores for Leaf and Needle Litter Recruitment, Decade 9



Management activities, natural disturbances, and natural forest growth can all influence forest conditions, and therefore can influence leaf and needle litter recruitment.

- **Harvest activities – variable retention harvest**: As mentioned previously, leaf and needle litter recruitment is important in small, headwater streams (Type 4 and Type 5 streams). These streams account for most of the total stream miles on state trust lands in the OESF. They are also the most dependent on leaf and needle litter input as the basis of their aquatic food webs.

  Variable retention harvest may reduce leaf and needle litter recruitment along Type 5 streams on stable ground because DNR does not apply interior-core buffers to these streams. The amount of variable retention harvest along these streams may be a primary reason why impacts remain high throughout the analysis period.

- **Harvest activities – thinning**: Thinning can reduce competition for resources and trees respond to thinning with accelerated growth. However, any prompt acceleration in growth is largely from an increase in water and nutrients supplied by the roots. The amount of foliage (the source of leaf and needle litter) does not increase until there has been enough time for the canopy to enlarge (Smith 1986), so change can be slow.

- **Natural forest growth in deferred areas**: Fifty-seven percent of the area of influence for leaf and needle litter recruitment is currently deferred from harvest. Forty-three percent of this area is in the Competitive Exclusion stand development stage.

A lack of light moves the canopy upward over time; trees growing in Competitive Exclusion stands therefore have no lower branches. The change can be surprisingly rapid. Even the largest and most vigorous trees usually develop canopies that are too short and narrow in proportion to their total height (Smith 1986). The result is an atrophied canopy that provides less leaf and needle litter to the stream.

- **Hardwood versus conifer**: The forest practices rules stress the importance of conifers for their longevity, resistance to breakage, and contribution to in-stream habitat. However, many hardwoods provide leaf litter that is higher in nutrients and more easily broken down than conifer needle litter (Bisson and Wondzell 2009).

The differences between the extent and intensity of harvests projected to occur under the alternatives are not large enough to result in appreciably dissimilar effects on leaf and needle litter recruitment. Changes in leaf and needle litter recruitment over time are nearly identical for the No Action and Landscape alternatives.

The potential environmental impact of either alternative for this indicator is considered **high**. While the distribution of impact scores gradually moves toward an improved condition, the rate of recovery is slow and most watersheds remain in a high impact condition for the entire analysis period. Impacts are considered probable and adverse. However, leaf and needle litter recruitment's contribution to riparian function is not significant: it is only 5 percent of the composite watershed score. Therefore, DNR has not identified significant impacts from either alternative for this indicator.

For this analysis, DNR took the conservative approach of not considering the potential contribution of leaf litter from the forest understory (such as shrubs) because the research and data that is available about it is limited. Including the forest understory in this analysis could result in a lower impact rating, particularly since the forest understory may develop rapidly after a stand-replacement harvest.

No policies, procedures, or laws currently apply to leaf and needle litter recruitment. The Board is committed to continually reviewing the implementation of its policies. In the event that science provides new information about leaf and needle litter recruitment, the Board will take that information into consideration when future policy decisions are made.

Indicator: Riparian Microclimate

The distribution of watershed scores is shown in Chart 3-38 through Chart 3-40. Under both alternatives, the distribution of scores moves toward a higher impact condition. Approximately 45 percent of watersheds are currently in a medium impact condition; this proportion increases over time to approximately 63 percent by Decade 9 under both alternatives.

Chart 3-38. Distribution of Watershed Scores for Riparian Microclimate, Decade 1

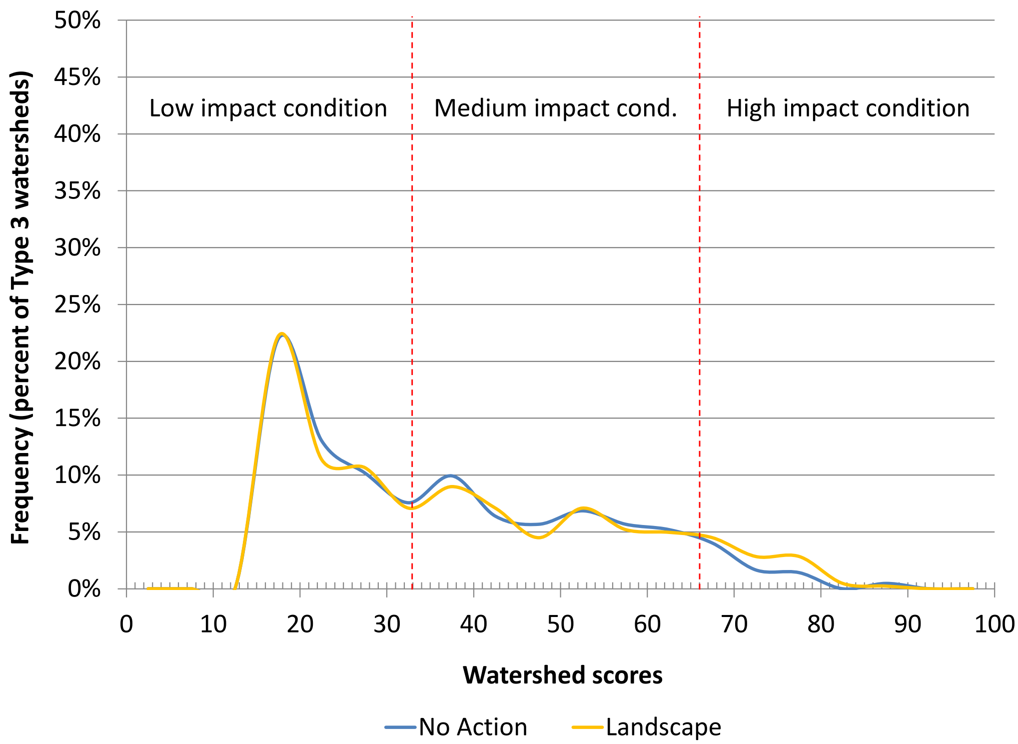


Chart 3-39. Distribution of Watershed Scores for Riparian Microclimate, Decade 6

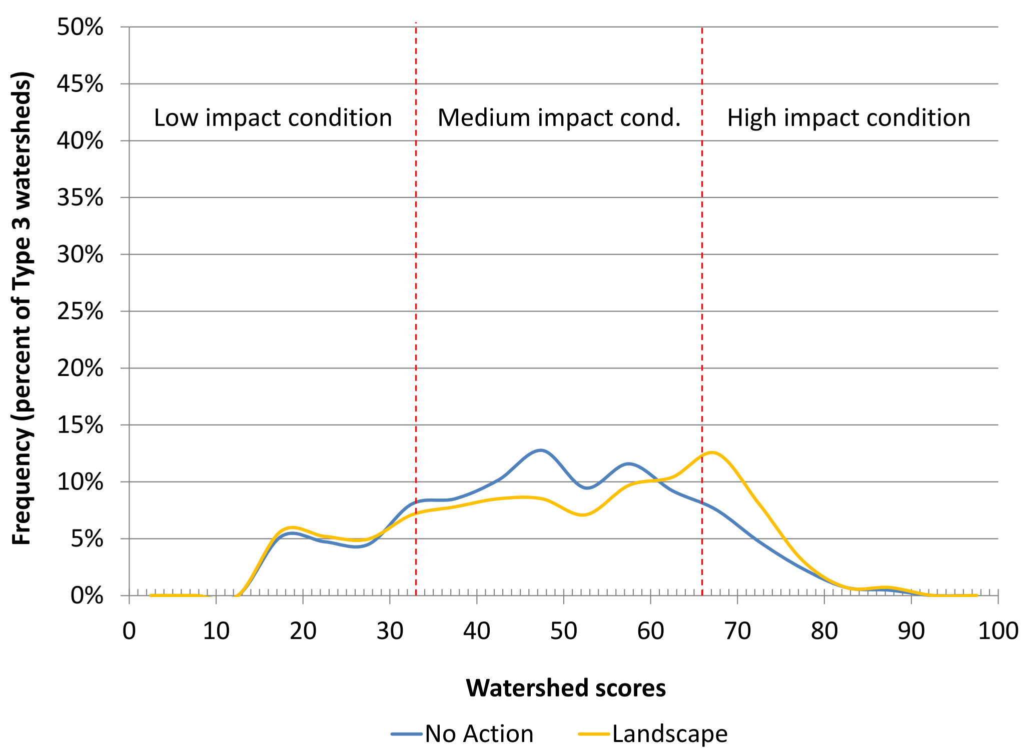
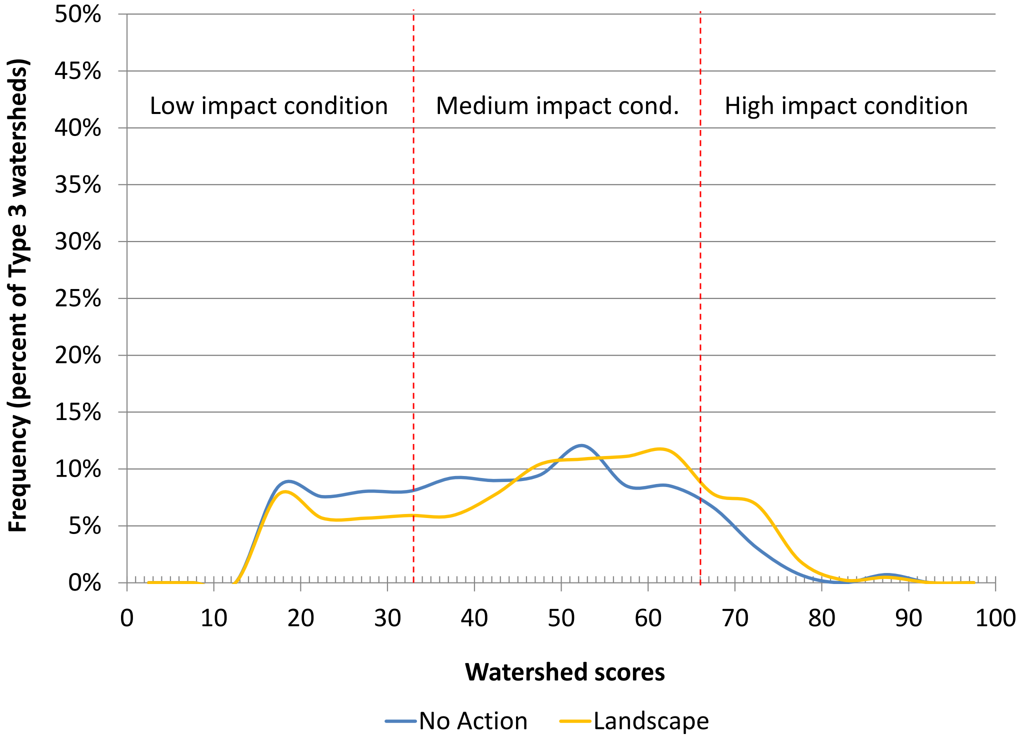


Chart 3-40. Distribution of Watershed Scores for Riparian Microclimate, Decade 9

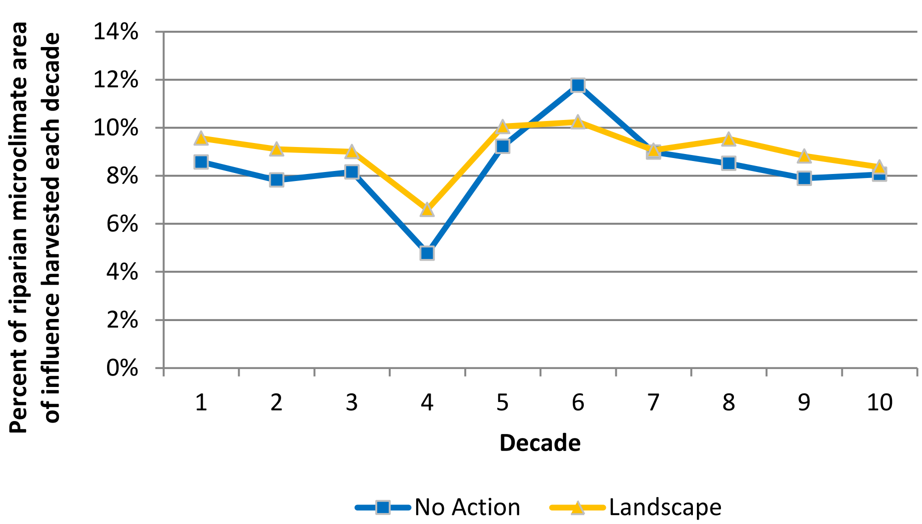


Riparian microclimate results are due primarily to the effects of variable retention harvest.

- **Harvest activities – variable retention harvest**: This analysis measures how the cool, moist conditions found near streams are modified by the warmer, drier conditions found in or near variable retention harvests (refer to Figure 3-12).

  Chart 3-41 shows a summary of projected variable retention harvests that are close enough to the stream to influence riparian microclimate. This chart includes all regeneration harvests within the area of influence (within 670 feet of the stream bank).

Chart 3-41. Variable Retention Harvests in the Riparian Microclimate Area of Influence



The extent of harvests under the Landscape Alternative is higher in all decades, with the exception of Decade 6. However, the differences in the extent of harvests projected to occur under the alternatives are not large enough to result in appreciably dissimilar effects on riparian microclimate.

- **Harvest activities – thinning**: The effects of thinning on microclimate were not analyzed, because DNR's review of scientific literature found that thinning has no effect on riparian microclimate. For example, Olson and Chan (2005) examined the effects of thinning along headwater streams in western Oregon and found that thinning did not affect soil temperature within the riparian forest. Changes in gradients were observed for air temperature and relative humidity, but riparian buffers as narrow as 56 feet mitigated microclimate changes associated with thinning (Olson and Chan 2005).

The potential environmental impact of either alternative for this indicator is considered **medium**. The distribution of impact scores moves steadily toward a higher impact condition, but most watersheds remain in a medium impact condition. Also, microclimate is only 3 percent of the composite watershed score. DNR has not identified probable significant adverse environmental impacts from either alternative for this indicator.

No policies, procedures, or laws currently apply to riparian microclimate. The Board is committed to continually reviewing the implementation of its policies. In the event that science provides new information about riparian microclimate, the Board will consider that information when future policy decisions are made.

Indicator: Composite Watershed Score

The distribution of composite watershed scores over time (Chart 3-42 through Chart 3-44) indicates a gradual improvement in riparian function. Results are similar for both alternatives.

Chart 3-42. Distribution of Composite Watershed Scores, Decade 1

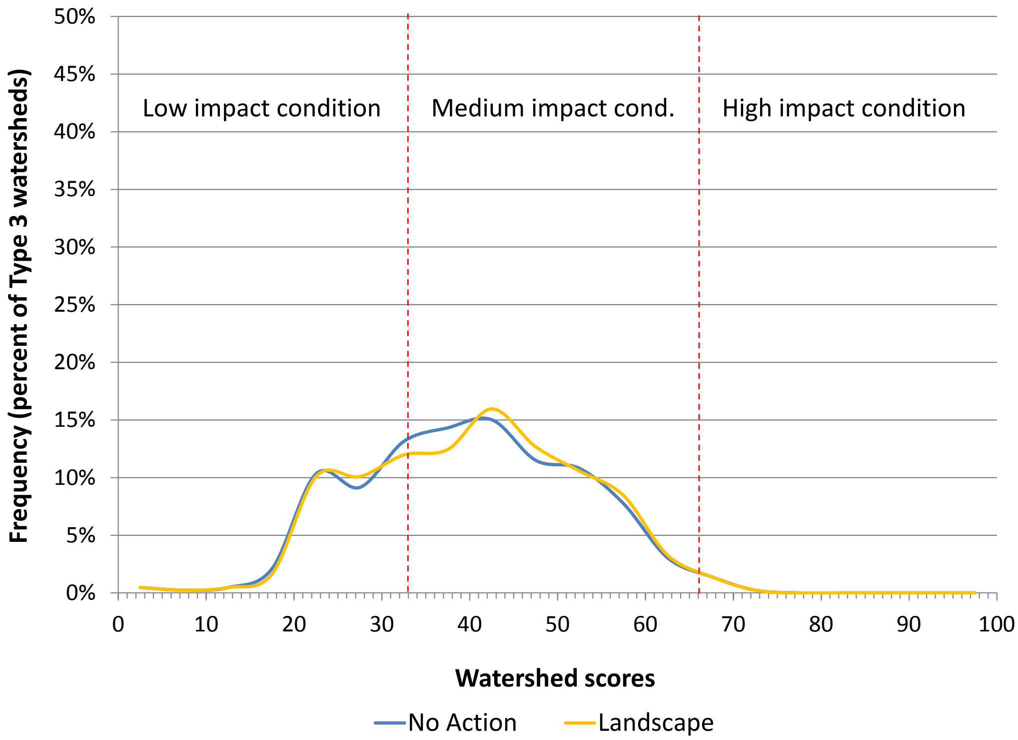


Chart 3-43. Distribution of Composite Watershed Scores, Decade 6

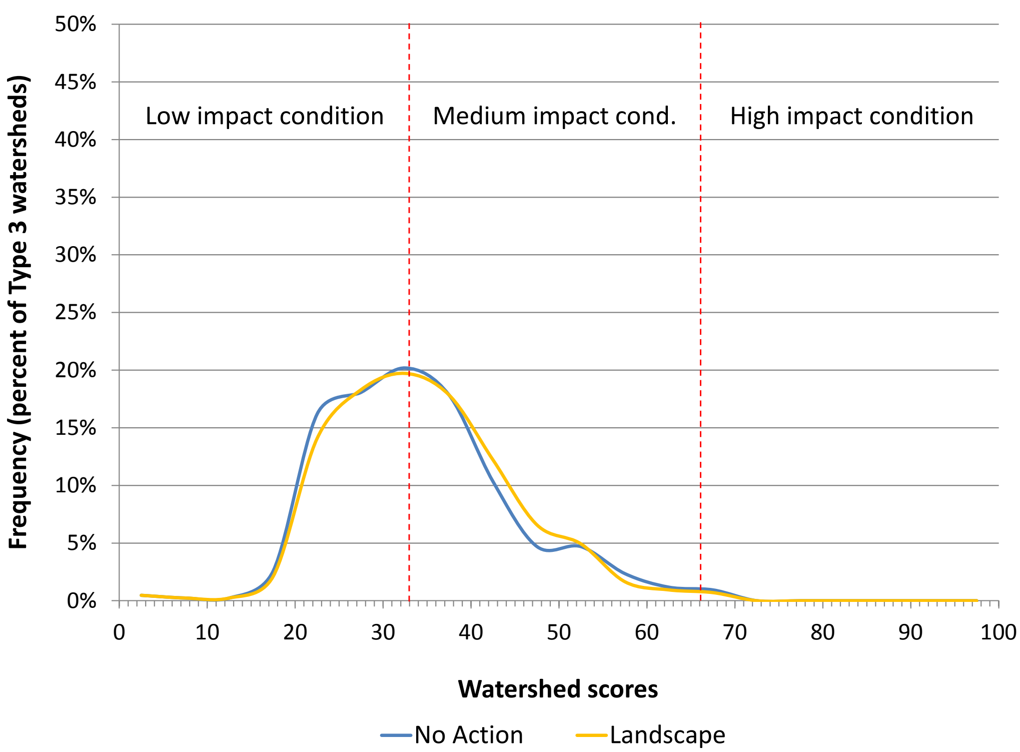
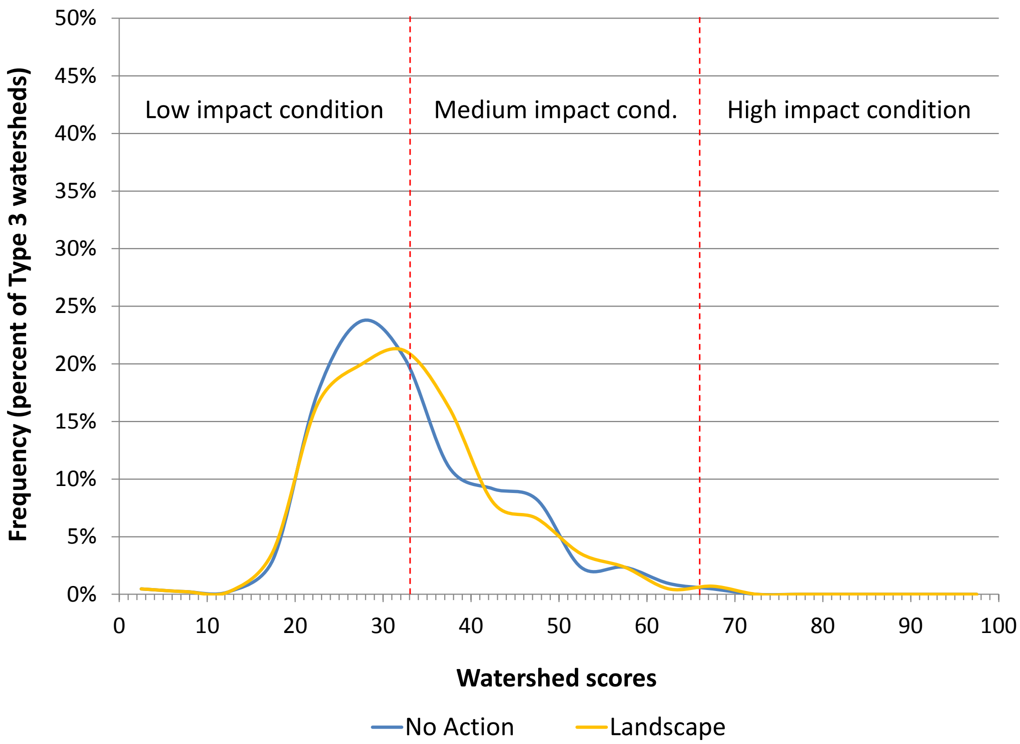


Chart 3-44. Distribution of Composite Watershed Scores, Decade 9



The potential environmental impact of either alternative for this indicator is considered **medium**. The distribution of impact scores moves steadily toward an improved condition, but most watersheds remain in a medium impact condition. DNR has not identified probable significant adverse environmental impacts from either alternative for this indicator.

Summary of Potential Impacts

Table 3-18 provides an overview of the potential environmental impacts on riparian areas when the criterion and all of the indicators are considered. For this analysis, only high impacts are considered potentially significant impacts. DNR has not identified probable significant adverse environmental impacts from either alternative for large woody debris recruitment, peak flow, stream shade, riparian microclimate, or the composite watershed score.

For the indicator leaf and needle litter recruitment, DNR considers impacts to be probable and adverse but not significant because the contribution of leaf and needle litter recruitment to riparian function is relatively minor: it is only 5 percent of the composite watershed score.

Table 3-18. Summary of Potential Impacts on Riparian Areas, by Alternative

Criterion	Indicators	No Action Alternative	Landscape Alternative
Functioning riparian habitat	Large woody debris recruitment	Medium ◊	Medium ◊
	Peak flow	Low ●	Low ●
	Stream shade	Low ●	Low ●
	Fine sediment delivery	Low ●	Low ●
	Leaf and needle litter recruitment	High ■	High ■
	Riparian microclimate	Medium ◊	Medium ◊
	Composite watershed score	Medium ◊	Medium ◊

● **Low impact** ◊ **Medium impact** ■ **High impact**

Considered but Not Analyzed

Wetlands

Wetlands are areas that are inundated or saturated with surface or groundwater often enough, or for long enough periods during the year, to support vegetation that is typically adapted to life in saturated soil conditions.

Wetlands in forested landscapes such as the OESF include freshwater marshes, swamps, bogs (refer to photo), fens, seeps, wet meadows, and shallow ponds. Wetlands can be forested or dominated by smaller vegetation such as shrubs, herbs, mosses, grasses, or grass-like plants. Wetlands can be seasonal, wet for only part of the year, or permanent (wet all year). They can be either isolated from or connected to other surface water bodies, such as ponds, lakes, rivers, and streams.

Cedar Bog in the OESF
Bogs are a type of wetland that accumulates peat.

Wetlands provide habitat for amphibians and aquatic invertebrates and rearing habitat for coho salmon. Birds use wetlands for nesting and feeding, and wetlands provide connectivity for wildlife movement and refuge during seasonal fluctuations (DNR 2004, p. 4-132). Wetlands also augment stream flow during the summer, moderate peak flows during storm events, and provide habitat for plants and animals (Sheldon and others 2005, Adamus and others 1991).

According to the 2006 *Policy for Sustainable Forests*, DNR will allow no net loss of acreage or function of naturally occurring wetlands. Forested and non-forested wetlands are protected with buffers or special management considerations; in these areas, forest management activities such as timber harvest and road building are prohibited or limited.

The implementation of existing policy and laws protects existing wetlands. Existing policies require field identification of wetlands. The site-specific assessment of conditions required for each timber sale under DNR's current wetland management procedure for the OESF (refer to Appendix F), is expected to identify and avoid or minimize potential impacts to wetlands to a level of non-significance before an activity can take place on the ground. Therefore, this RDEIS does not include an analysis of wetlands.

Analyzed and Addressed Through Implementation

Windthrow in Interior-Core Buffers

Windthrow is the blowing over or breaking of trees by the wind. Windthrow of entire trees occurs when wind overcomes the tree's rooting strength in the soil and tips over the tree, its root ball, and some amount of root-attached soil (Coutts 1986). Wind also may break the bole, or trunk, of the tree (referred to as stem breakage), resulting in trees with broken tops.

Windthrow along forest edges is a normal occurrence, but is known to increase after timber harvesting activities expose previously interior forest stands to the direct effects of the wind (Harris 1989). Windthrow in riparian forests is a special concern in the OESF because of the alignment of the major river valleys with the prevailing winds, the fully saturated soils during the winter months, and the forest edge effects associated with variable retention harvest.

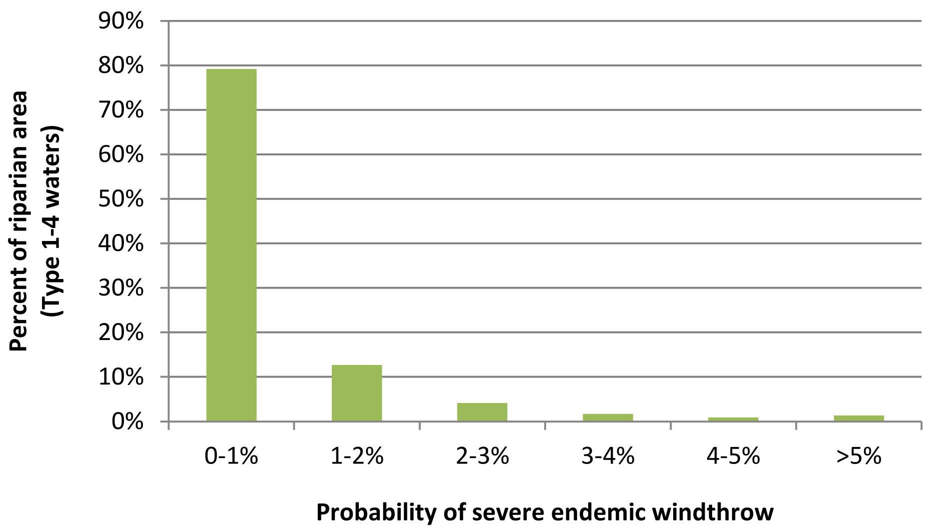
DNR uses interior-core buffers to maintain a range of ecosystem functions. Windthrow may compromise some of these functions and enhance others (Sullivan and others 1987, Grizzel and Wolff 1998). For example, windthrow in interior-core buffers may decrease stream shade or destabilize stream banks, but enhance in-stream habitat complexity by providing large woody debris to the stream channel (large woody debris is an important component of habitat for fish; refer to "Fish," p. 3-142). In certain locations, windthrow likely is the most significant mechanism by which large woody debris is recruited to the stream channel (Grizzel and Wolff 1998).

Under the Landscape Alternative, windthrow in interior-core buffers will be addressed by implementing the OESF riparian conservation strategy (refer to Chapter 2, p. 2-16). DNR's goal is to maintain the integrity of riparian forests and the functions they provide by protecting them from severe endemic winds. DNR uses a combination of remote reconnaissance, field assessments, and a windthrow probability model (Mitchell and Lanquaye-Opoku 2007) especially designed and calibrated for use on the Olympic Peninsula to identify segments of interior-core buffers that are most susceptible to severe endemic windthrow.[10] Exterior buffers will be placed on all segments of interior-core buffers for which the probability of severe endemic windthrow is deemed unacceptable. Under the

OESF riparian procedure, DNR defines the acceptable level of probability as 5 percent. All segments of interior-core buffers with a 5 percent or greater chance of experiencing severe endemic windthrow will be protected with an exterior buffer; those with a less than 5 percent chance will not.

An analysis of the variable retention harvests projected to occur under the Landscape Alternative reveals that, for most riparian areas, the probability of severe endemic windthrow is very low (refer to Chart 3-45). Assuming a 5 percent level of probability, only approximately 1 percent of the interior-core buffers for Type 1 through Type 4 streams on state trust lands in the OESF will require an exterior buffer. At this level of probability, a total of only 26 acres of severe endemic windthrow is expected in riparian areas in the first decade of implementing the Landscape Alternative, according to model results.

Chart 3-45. Probability of Severe Endemic Windthrow Along Type 1 Through Type 4 Streams



As explained in Chapter 2, under the No Action Alternative, exterior buffers are placed on all segments of interior-core buffers.

DNR has not identified probable significant adverse environmental impacts for either alternative from windthrow. The site-specific assessment of conditions and the implementation of windthrow probability modeling are expected to identify and avoid or minimize potential windthrow impacts to riparian areas on state trust lands in the OESF.

For additional detail on the windthrow probability model, an assessment of the consequences of windthrow, and the determination of windthrow probability, refer to Appendix A (draft forest land plan).

Section Notes

1. DNR uses a numerical system (one through five) to categorize streams based on physical characteristics such as stream width, steepness, and whether or not fish are present. Type 1 streams are the largest; Type 5 streams are the smallest. Type 9 streams are "unclassified" and refer to streams that are currently mapped, but lack sufficient data to determine the correct water type. Only Type 1, 2 and 3 streams are considered fish-bearing. DNR and the Federal Services have agreed that the Washington Forest Practices Board Emergency Rules (stream typing), November 1996 (WAC 222-16-031 [water typing interim]) meet the intent of DNR's 1997 *Habitat Conservation Plan*. A comparison of DNR's water typing system is provided in the rules (WAC 222-16-031).
2. As each individual parameter is evaluated, its calculated value is converted to a common scale of 0 to 100 using a mathematical construct known as a "fuzzy curve." Fuzzy curves allow the aggregation of multiple parameters, measured using disparate units, which otherwise would be difficult to compare. The shape and breakpoints for each curve determine how each value is normalized. Fuzzy curves for each parameter were adapted from multiple sources, including available literature (Gallo and others 2005), watershed analysis methods (DNR 1997), or consultation with DNR scientific staff. For additional information, refer to Appendix G. For this analysis, the parameters used to determine the composite watershed score are the seven riparian indicators.
3. This ownership threshold is used to identify areas where DNR manages enough of the watershed that its management practices could influence watershed conditions. The use of such a threshold followed recommendations from federal watershed monitoring programs (Reeves and others 2004, Gallo and others 2005).
4. Streams are dynamic. Many studies to date that make recommendations for the recruitment of large woody debris have not considered how stream channels migrate over time (Murphy and Koski 1989, Robison and Beschta 1990, McDade and others 1990, Washington Forest Practices Board [WFPB] 1994 as cited in DNR 1997). To account for lateral stream migration across the floodplain, recruitment to the floodplain was considered equivalent to the recruitment to the stream channel. Large woody debris in the floodplain provides riparian function during flood events (DNR 1997), and in time, may eventually become in-stream large woody debris as streams migrate. Therefore, the area of influence includes the floodplain itself plus an additional 150 feet. For this analysis, the width of the 100-year floodplain was defined by stream type, measured outward horizontally from the center of the stream channel along both sides of the stream: 150 feet along each side of Type 1 streams (300 feet total), 30 feet along each side of Type 2 streams (60 feet total), 15 feet along each side of Type 3 streams (30 feet total), 3.75 feet along each side of Type 4 streams (7.5 feet total), and 0 feet for Type 5 and Type 9 streams. DNR analyzed the additional 150 feet (approximately one tree height) beyond the edge of the 100-year floodplain because this area is expected to provide the largest share of large woody debris, based on FEMAT (1993) and McDade and others (1990). For a detailed description of how the area of influence for large woody debris as calculated, refer to Appendix G.
5. Refer to "Forest Conditions and Management" for a discussion on relative density.
6. Based on a review of approximately 30 years of daily average temperature records for the Clearwater, Quinault, and Forks weather stations archived by the NOAA Western Regional Climate Center, July 31 is the hottest day of the year and therefore the one in which thermal loading to the stream is expected to be at a maximum.
7. The target shade level is intended solely for the purpose of conducting this environmental impact analysis, and does not connote or imply DNR policy direction.
8. In the event that, during the statewide sustainable calculation, a change in the harvest level would require an increase in road density, DNR would first analyze the impacts of a higher road density through the sustainable harvest calculation process.
9. In forestry, the term basal area describes the sum of the cross-sectional area of all trees in a stand, measured at breast height. It is generally expressed as square feet per acre.
10. Windthrow can be termed endemic or catastrophic. Endemic windthrow results from routine peak winds with short return intervals (less than 5 years between events). Endemic windthrow is strongly influenced by site conditions and silvicultural practices, and can therefore be predicted (Lanquaye 2003). Catastrophic windthrow results from winds with longer return periods (typically greater than

20 years between events) and is strongly influenced by wind speed, wind direction, and local topographic features. DNR is unable to predict the local likelihood of catastrophic windthrow from stand and site conditions (Zielke and others 2010). DNR cannot and does not protect against catastrophic windthrow.

For this analysis, severe endemic windthrow is defined as windthrow in which 90 percent of an area will experience 50 percent canopy loss (Mitchell and Lanquaye-Opoku 2007). This threshold was selected since it represents a level of canopy loss in excess of that which would occur under the riparian silvicultural prescriptions permitted in DNR's 2006 Riparian Forest Restoration Strategy. Windthrow that results in canopy loss below this severity threshold is not considered to have a significant, adverse impact to riparian function.

Soils

Why Is Soil Important?

Soil is the foundation of a healthy forest. Soil anchors roots, supplies water to plants and trees, and provides air to plant roots and minerals for plant nutrition (Kohnke and Franzmeier 1995). Soil conditions, such as soil productivity, influence how large trees grow. Soil also recycles organic matter and provides habitat for numerous insects and fungi.

What Is the Criterion for Soils?

The criterion for soils is **soil conservation**. Since soil is the basis of plant growth, soil conservation is vital to maintaining functioning and productive forest ecosystems.

What Are the Indicators for Soils?

The indicators used to analyze the criterion are **soil compaction**, **soil erosion**, **soil displacement**, **soil productivity**, **landslide potential**, and **potential road failure**. Landslide potential and potential road failure measure the potential for the delivery of coarse sediment to streams. These indicators were selected based on DNR's expertise, existing scientific information, and current data.

How Are the Indicators Analyzed?

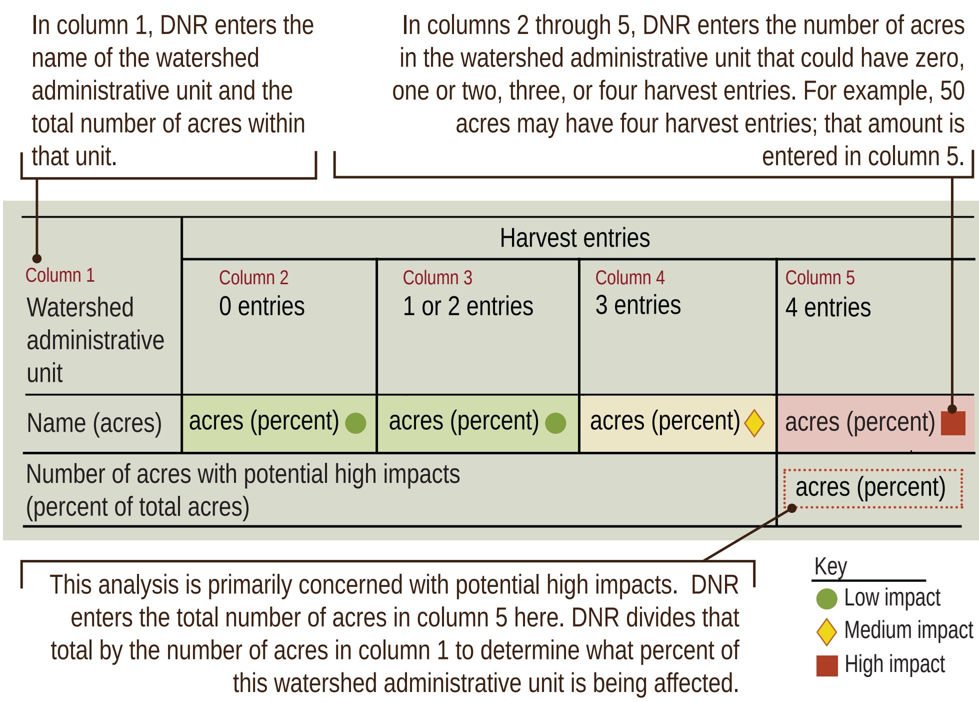
For this analysis, DNR is concerned with the potential environmental impacts of multiple forest stand entries on soils that, because of their physical properties or underlying geology, have a high likelihood of compaction, erosion, displacement, or landslides, or that are the least productive. For all indicators except potential road failure, DNR first maps the extent and location of these soils using a GIS process and a tool known as zonal statistics (for more information on this process and zonal statistics, refer to Appendix H). DNR then measures each indicator using a three-step process as will be explained in this section.

DNR measures all indicators except potential road failure at the scale of the watershed administrative unit. Only watershed administrative units in which DNR manages at least 20 percent of the land base are included.[1] Potential road failure is analyzed at the landscape scale; refer to "potential road failure" in this section for the methodology used to measure that indicator.

Step One: Determine the Percentage of Each Landscape with Potential High Impacts

Using the forest estate model and the methodology in Figure 3-15, DNR determines the percentage of state trust lands in each watershed administrative unit that is projected to have potential high impacts. DNR considers a potential high impact to be four or more harvest entries (variable retention harvest or thinning) on soils with a high likelihood of compaction, erosion, displacement, or landslides, or that are the least productive, over 100 years.

Figure 3-15. Method for Determining the Number of Acres with Potential High Impacts in Each Watershed Administrative Unit



Step Two: Assign a Low, Medium, or High Impact Rating to Each Watershed Administrative Unit

DNR assigns each watershed administrative unit a potential low, medium, or high impact rating based on the percentage of that watershed administrative unit with potential high impacts. DNR uses the following thresholds:

- If less than 10 percent of state trust lands in the watershed administrative unit have potential high impacts, the potential environmental impact for that watershed administrative unit is low.
- If 10 to 20 percent of state trust lands in the watershed administrative unit have potential high impacts, the potential environmental impact for that watershed administrative unit is medium.

- If more than 20 percent of state trust lands in the watershed administrative unit have potential high impacts, the potential environmental impact for that watershed administrative unit is high.

Step Three: Assign a Potential Low, Medium, or High Impact Rating to This Indicator

In this step, DNR determines the total number of acres of state trust lands in all watershed administrative units with potential high impacts. DNR then uses the thresholds identified in step 2 to assign a potential low, medium, or high impact rating to this indicator. As described in the introduction to this chapter, DNR assigns potential low, medium, or high impact ratings by analyzing management activities *exactly* as they were modeled, without considering current management practices that are expected to mitigate potential high impacts.

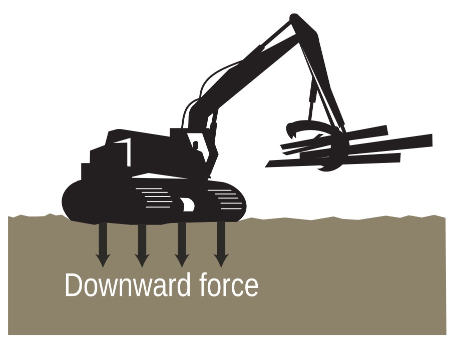
DNR's threshold for potential high impacts is based on experience, professional judgment, and the assumption that repeated harvest entries may affect soils. Studies on the impacts of repeated harvest entries in the forests of the Pacific Northwest are lacking, in part due to the relatively short histories of timber harvesting and research on the effects of timber harvesting in those forests.

Descriptions of Indicators

Indicator: Soil Compaction

Soil compaction is the loss of void space (the space between particles of soil) within the soil caused by an external force, such as the weight of heavy machinery or the impact of trees hitting the ground (refer to Figure 3-16). Void space is essential for plant survival and productivity because water and air enter the soil through void spaces, and because tree roots absorb water, carbon dioxide, and nutrients through void spaces to sustain growth.

Figure 3-16. Soil Compaction; Feller Buncher Shown



Soil compaction, particularly in the uppermost 2 to 4 inches of the soil, can impede root growth (Heilman 1981) and decrease the overall productivity of the soil (Cafferata 1992; Grier and others 1989). However, Ares and others (2007) have shown that high levels of compaction do not substantially affect tree growth in newly planted stands because compaction can help control competing vegetation and increase the availability of water, leading to lower mortality and increases in tree trunk height and width.

Soils may be prone to compaction because of the shape, size, and composition of their individual particles. Also, some types of soils, such as glacially derived and organic soils, are more prone to compaction than others,[2] even those containing a variety of particle shapes and sizes (Henderson and others 1989). For this indicator, DNR determines how often harvest activities are projected to occur on soils with a high likelihood of compaction.

Indicator: Soil Erosion

Soil erosion is the movement of soil particles through particle detachment, transport, and deposition (Megahan 1991). Soil erosion can reduce the capacity of a particular site to grow timber. Eroded soils can be deposited in downslope streams, lakes, and wetlands, degrading water quality and aquatic habitat. Soil erosion can be caused by natural processes such as gravity, water, wind, freeze-thaw cycles, or other forces that detach or move particles, or by human activities such as road building and timber harvesting.

Some types of soils may be prone to erosion because of their texture, structure, or porosity.[3] Other factors include the steepness of the slope, the presence or absence of vegetation, or the climate where the soil is located. For this indicator, DNR determines how often harvest activities are projected to occur on soils that have a high likelihood of erosion and are located on steep slopes (greater than 60 percent). Soil erosion is considered a separate process from landslides, which are discussed later in this section.

Indicator: Soil Displacement

Soil displacement is the localized movement of soil from an external force applied to the soil surface. This movement is not just downward (as in compaction), but sideways or horizontal, creating ridges and furrows in the soil (refer to Figure 3-17). Ridges and furrows can intercept shallow groundwater, concentrate surface water flow, and potentially initiate rill and gully erosion[4] (Lal 2005).

Figure 3-17. Soil Displacement; Skidder Shown

Soils may be prone to displacement because of texture, particle size, or moisture content.[5] The most common cause of soil displacement is harvesting using heavy ground-based equipment such as skidders, bulldozers, or excavators. Displacement is most pronounced on sites where trees are moved with ground based equipment or by cable without full suspension.[6] Further displacement may occur after the harvest during site preparation.[7] Over the last three years on state trust lands in the OESF, DNR used ground-based equipment on two thirds of harvests and cables on one third.

For this indicator, DNR determines how often harvest activities are projected to occur on soils with a high likelihood of displacement.

Indicator: Soil Productivity

Soil productivity is the capacity of the soil to support plant growth. Conservation of both the body and fertility of soil is the key to soil productivity. The body of soil can be damaged by surface erosion or displacement, landslides, compaction, and other physical impacts from activities such as road building or timber harvesting. The fertility of soil can be damaged by short harvest rotations, particularly on poor soils. Different soil types and their properties are important factors in determining the rooting depth of a tree (Crow 2005). Poor soils result in slow-growing trees and can be more prone to compaction.

In forested environments, productivity often is expressed as an index of the actual or potential tree growth for a given site. This expression, known as site index, is a species-specific measure of the average height of trees in a forest stand at a specific age (typically 50 or 100 years). Site indices are commonly grouped into site classes (1 through 5), with Site Class 1 having the most productive soils and Site Class 5 having the least productive soils. For this indicator, DNR determines how often harvest activities are projected to occur on the least productive soils, those on Site Class 5. This analysis is based on the assumption that repeated harvest entries may reduce soil productivity. Studies on the impacts of repeated harvest entries on soils in the forests of the Pacific Northwest are lacking, however, in part due to the relatively short histories of timber harvesting in the Pacific Northwest and research on the effects of timber harvesting in those forests.

Indicator: Landslide Potential

Landslides are the dislodgement or downslope movement of loose soil and rocks driven by gravity (Cruden and Varnes 1996, Nelson 2003). In contrast to erosion, which involves individual soil particles, landslides involve the movement of a large mass of soil. Landslides can be shallow-rapid or deep-seated. Deep-seated landslides have slip planes far beneath the surface and generally move very slowly, sometimes only inches to feet per year (a slip plane is the surface along which the landslide occurs). Shallow-rapid landslides have slip planes relatively close to the surface. These landslides move quickly, sometimes faster than 30 miles per hour (refer to Text Box 3-5).

Landslides are a natural process and occur throughout the OESF. Landslides can be caused by storms, prolonged rainfall, or rain-on-snow events, when rain falls on an existing snow pack. Other causes include earthquakes or streams undercutting an unstable slope. Human activities, such as tree harvesting or road building, may increase the likelihood of landslides by exposing soils to rainfall, especially if no mitigation is implemented.

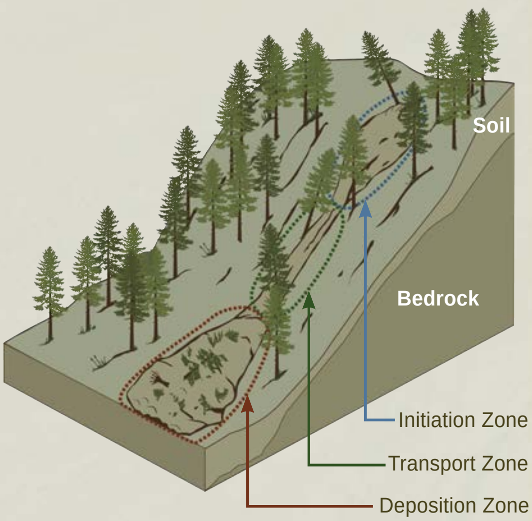
Underlying geology can affect landslide formation. In the OESF, analysis has shown that landslides are often associated with certain geologic units,[8] such as areas dominated by basalt or marine sediments (Sarikhan and others 2008, 2009). These geologic units have a much higher historic rate of landslides[9] than other units.

Landslides can reduce the ability of a particular site to grow timber because of a loss of soil. Landslides can also degrade water quality and fish habitat by delivering coarse sediment into down-slope streams, lakes, and wetlands.

Potentially unstable slopes are identified using a slope stability model, which rates slope instability using criteria such as steepness and landform, specifically the presence of convergent slopes.[10] Areas identified as potentially unstable with a high level of risk are deferred from harvest.[11] These areas are not included in this analysis.

Text Box 3-5. Shallow-Rapid and Deep-Seated Landslides

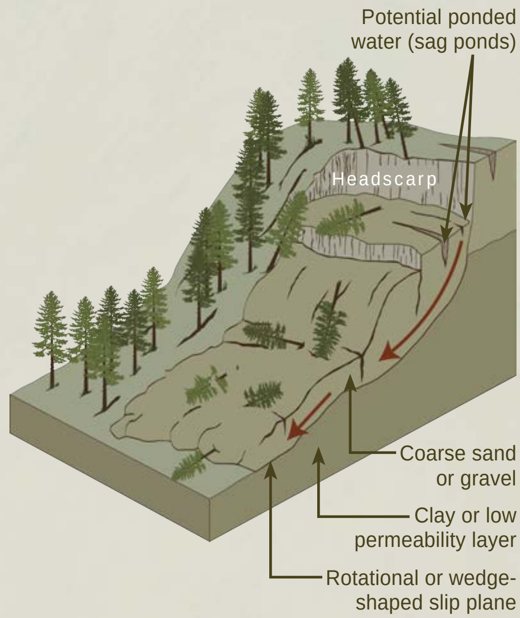
Shallow-Rapid Landslides



The slip plane of a **shallow-rapid landslide** is relatively close to the ground surface (a slip plane is the surface along which a landslide occurs, refer to figure, above). These landslides move relatively quickly, sometimes over 30 miles per hour (Cruden and Varnes 1996), and can travel a mile or more from their point of initiation. Shallow-rapid landslides can severely impact streams, roads, bridges, and other structures within their path of travel.

Shallow-rapid landslides generally originate in steep terrain and are typically triggered by intense rain storms or rain-on-snow events, though they can also result from stream undercutting and large magnitude earthquakes. During storms, large amounts of water enter the soil. If the water pressure forcing the soil particles apart exceeds the soil's capacity to stick together, the soil's structure fails and a shallow-rapid landslide results.

Deep-Seated Landslides



A **deep-seated landslide** is the movement of a large mass of soil in which the slip plane is located far below the ground (refer to figure, above). Deep-seated landslides move slowly, only inches to feet per year, and their absolute age is often unknown (Salo and Cundy 1987).

Most often, deep-seated landslides form when water percolates through mechanically weak soils, such as sand or gravel, and becomes perched on top of stronger soils, such as clay, creating an area of weakness. These landslides are often triggered by seasonal fluctuations in precipitation, stream undercutting, or large-magnitude earthquakes.

Deep-seated landslides may appear intact and can be covered with large, mature trees. They are characterized by broken ground, extensive water seepage, ponded water, ground cracks, and deformed trees, and range in size from less than an acre to many hundreds of acres.

Drawings modified from Varnes 1978

DNR has taken the conservative approach of identifying any additional areas (areas not already identified in the forest estate model) which may be potentially unstable because of underlying geology or slope steepness—specifically, those areas that have soils on top of marine sediment or basalt geologic units and that are steeply (over 70 percent) sloped.[12] To determine potential environmental impacts, DNR analyzes the number of forest stand entries which are projected to occur on these areas.

Indicator: Potential Road Failure

Road failure is the collapse of a roadbed. Roads may fail for many reasons, including drainage, design, construction, and maintenance (NOAA Fisheries and USFWS 2006), changes in surface erosion and runoff (MacDonald and Coe 2008), the stability of the ground on which they are built, or a combination of factors. When roads fail, they can trigger a landslide that may cause a loss of soil productivity and deliver coarse sediment to streams. Too much coarse sediment can affect salmon adversely by burying them and their nests (known as "redds") or flushing them downstream.

The OESF road network includes roads that were built on potentially unstable slopes as early as the 1930s, when the understanding of how slope failures occur was still evolving. In addition, these roads were built before the forest practices rules were enacted in 1974. The rules include regulations for constructing and maintaining roads to prevent road-related landslides and limit the delivery of sediment and surface runoff to streams. (The rules were written to implement the Forest Practices Act and have been amended several times since 1974.) Many of these roads have been mitigated to current standards, as will be discussed under "Results" in this section.

For this indicator, in each of the 11 landscapes, DNR analyzes the percentage of the road network that is located on potentially unstable slopes. DNR then considers all landscapes together to determine if the potential environmental impact is low, medium, or high.

In this analysis, DNR has taken the conservative approach of including all roads built on potentially unstable slopes, including roads that have been mitigated to current standards. Using GIS tools, DNR overlays the mapped road network on mapped potentially unstable slopes to determine what percentage of the road network may be vulnerable.

Criterion and Indicators: Summary

Table 3-19 summarizes the criterion and indicators and how they are measured.

Table 3-19. Criterion and Indictors for Soils and How They Are Measured

Criterion/Indicator	**How the indicator is measured**	**Potential environmental impacts**
Soil conservation/ Soil compaction	Number of forest stand entries (variable retention harvest or thinning) on soils that have a high likelihood of compaction; measured using the methodology in Figure 3-15.	**Low**: Less than 10 percent of state trust lands have potential high impacts. **Medium**: 10 to 20 percent of state trust lands have potential high impacts. **High**: Over 20 percent of state trust lands have potential high impacts.
Soil conservation/ Soil erosion	Number of forest stand entries (variable retention harvest or thinning) on soils that have a high likelihood of erosion and are located on steep slopes (above 60 percent); measured using the methodology in Figure 3-15.	**Low**: Less than 10 percent of state trust lands have potential high impacts. **Medium**: 10 to 20 percent of state trust lands have potential high impacts. **High**: Over 20 percent of state trust lands have potential high impacts.
Soil conservation/ Soil displacement	Number of forest stand entries (variable retention harvest or thinning) on soils that have a high likelihood of displacement; measured using the methodology in Figure 3-15.	**Low**: Less than 10 percent of state trust lands have potential high impacts. **Medium**: 10 to 20 percent of state trust lands have potential high impacts. **High**: Over 20 percent of state trust lands have potential high impacts.
Soil conservation/ Soil productivity	Number of forest stand entries (variable retention harvest or thinning) on Site Class 5 soils; measured using the methodology in Figure 3-15.	**Low**: Less than 10 percent of state trust lands haves potential high impacts. **Medium**: 10 to 20 percent of state trust lands have potential high impacts. **High**: Over 20 percent of state trust lands have potential high impacts.
Soil conservation/ Landslide potential	Number of forest stand entries (variable retention harvest or thinning) on soils that have a high likelihood of landslides; measured using the methodology in Figure 3-15.	**Low**: Less than 10 percent of state trust lands have potential high impacts. **Medium**: 10 to 20 percent state trust lands have potential high impacts. **High**: Over 20 percent of state trust lands have potential high impacts.

Table 3-19, Continued. Criterion and Indictors for Soils and How They Are Measured

Criterion/Indicator	How the indicator is measured	Potential environmental impacts
Soil conservation/ Potential road failure	Percentage of the road network built on potentially unstable slopes.	**Low:** Less than 5 percent of road network in a landscape is located on potentially unstable slopes. **Medium:** 5 to 10 percent of road network in a landscape is located on potentially unstable slopes. **High:** Over 10 percent of road network in a landscape is located on potentially unstable slopes.

Current Conditions

Following, DNR provides information on the number of acres of soils on state trust lands in each watershed administrative unit that have a high likelihood of compaction, erosion, displacement, or landslides, or that are classified in certain site classes.

Indicator: Soil Compaction

As shown in Table 3-20, all watershed administrative units have soils with a high likelihood of compaction. For example, in the Bogachiel watershed administrative unit, those soils are found on 7,757 acres, or 69 percent, of state trust lands in that watershed administrative unit. Percentages range from 27 percent (Lower Clearwater) to 97 percent (Cedar).

Table 3-20. Acres and Percent of State Trust Lands in Each Watershed Administrative Unit With Soils That Have a High Likelihood of Compaction

Watershed administrative unit (acres of state trust lands)	Acres (percent)
Bogachiel (11,267)	7,757 (69%)
Cedar (4,208)	4,066 (97%)
Clallam River (10,161)	8,549 (84%)
East Fork Dickey (10,975)	9,146 (83%)
Goodman Mosquito (13,449)	10,815 (80%)
Hoko (10,636)	9,638 (91%)
Kalaloch Ridge (5,753)	5,555 (97%)
Lower Clearwater (19,815)	5,312 (27%)
Lower Dickey (7,377)	6,414 (87%)
Lower Hoh River (7,120)	6,182 (87%)

Table 3-20, Continued. Acres and Percent of State Trust Lands in Each Watershed Administrative Unit With Soils That Have a High Likelihood of Compaction

Watershed administrative unit (acres of state trust lands)	Acres (percent)
Lower Queets River (14,961)	12,481 (83%)
Middle Hoh (37,289)	15,155 (41%)
Quillayute River (6,187)	5,138 (83%)
Sol Duc Lowlands (4,448)	3,087 (69%)
Sol Duc Valley (13,481)	9,216 (68%)
Upper Clearwater (54,911)	26,759 (49%)

Indicator: Soil Erosion

Table 3-21 shows the acres of state trust lands in each watershed administrative unit that have soils with a high likelihood of erosion. Many watershed administrative units contain less than 1 percent of these soils. Others, such as the Middle Hoh, have 27 percent.

Table 3-21. Acres and Percent of State Trust Lands in Each Watershed Administrative Unit With Soils That Have a High Likelihood of Erosion

Watershed administrative unit (acres of state trust lands)	Acres (percent)
Bogachiel (11,267)	169 (2%)
Cedar (4,208)	15 (<1%)
Clallam River (10,161)	684 (7%)
East Fork Dickey (10,975)	23 (<1%)
Goodman Mosquito (13,449)	52 (<1%)
Hoko (10,636)	1,217 (11%)
Kalaloch Ridge (5,753)	258 (4%)
Lower Clearwater (19,815)	2 (<1%)
Lower Dickey (7,377)	3 (<1%)
Lower Hoh River (7,120)	11 (<1%)
Lower Queets River (14,961)	5 (<1%)
Middle Hoh (37,289)	9,921 (27%)
Quillayute River (6,187)	2 (<1%)
Sol Duc Lowlands (4,448)	46 (1%)
Sol Duc Valley (13,481)	647 (5%)
Upper Clearwater (54,911)	13,055 (24%)

Indicator: Soil Displacement

Table 3-22 shows the acres of state trust lands in each watershed administrative unit that have soils with a high likelihood of displacement. Some watershed administrative units, such as Sol Duc Lowlands, have only 2 percent, while others, such as Kalaloch Ridge, have as much as 84 percent.

Table 3-22. Acres and Percent of State Trust Lands in Each Watershed Administrative Unit With Soils That Have a High Likelihood of Displacement

Watershed administrative unit (acres of state trust lands)	Acres (percent)
Bogachiel (11,267)	2,027 (18%)
Cedar (4,208)	1,244 (30%)
Clallam River (10,161)	6,113 (60%)
East Fork Dickey (10,975)	1,365 (12%)
Goodman Mosquito (13,449)	3,281 (24%)
Hoko (10,636)	7,377 (69%)
Kalaloch Ridge (5,753)	4,851 (84%)
Lower Clearwater (19,815)	3,035 (15%)
Lower Dickey (7,377)	748 (10%)
Lower Hoh River (7,120)	1,499 (21%)
Lower Queets River (14,961)	2,217 (15%)
Middle Hoh (37,289)	15,870 (43%)
Quillayute River (6,187)	552 (9%)
Sol Duc Lowlands (4,448)	89 (2%)
Sol Duc Valley (13,481)	3,943 (29%)
Upper Clearwater (54,911)	33,769 (61%)

Indicator: Soil Productivity

Table 3-23 shows the site classes for state trust lands in each watershed administrative unit, and Table 3-24 shows the site classes for all state trust lands in the OESF. Most areas of state trust lands in the OESF are classified as Site Class 3 or Site Class 4 (site class is determined by DNR's forest inventory). On state trust lands where an inventory was not conducted, DNR inferred that soils are either Site Class 3 or Site Class 4 based on tree growth from other areas with the same soil classification.

Table 3-23. Site Classes for State Trust Lands in Each Watershed Administrative Unit, in Acres

Watershed administrative unit (acres of state trust lands)	Site class					
	1	2	3	4	3 and 4	5
Bogachiel (11,267)	580	1,298	2,746	743	5,790	110
Cedar (4,208)	0	1,302	897	75	1,568	366
Clallam River (10,161)	240	2,477	4,063	871	2,505	5
East Fork Dickey (10,975)	710	1,625	4,018	470	4,118	33
Goodman Mosquito (13,449)	359	613	4,004	1,017	7,261	194
Hoko (10,636)	495	2,157	3,897	1,447	2,449	191
Kalaloch Ridge (5,753)	19	1,560	1,728	467	1,979	0
Lower Clearwater (19,815)	1,749	3,346	6,714	1,194	6,514	298
Lower Dickey (7,377)	0	490	2,182	744	3,370	591
Lower Hoh River (7,120)	0	579	604	87	5,447	401
Lower Queets River (14,961)	359	2,302	3,150	1,854	7,212	83
Middle Hoh (37,289)	69	547	2,603	3,554	30,277	239
Quillayute River (6,187)	224	1,405	1,955	296	2,280	27
Sol Duc Lowlands (4,448)	135	353	1,317	347	2,297	0
Sol Duc Valley (13,481)	230	1,953	5,313	1,797	4,125	63
Upper Clearwater (54,911)	748	4,316	13,430	13,473	22,931	13

Table 3-24. Site Classes for State Trust Lands, in Acres

Site class	Acres (percent[a]) of State Trust Lands
1	8,199 (3 %)
2	32,059 (12 %)
3	66,273 (26%)
4	32,053 (12%)
3 and 4	116,127 (45%)
5	2,856 (1%)
TOTAL	257,566

[a]Does not equal 100 percent because of rounding.

Indicator: Landslide Potential

Table 3-25 shows the acres of state trust lands in each watershed administrative unit that have soils with a high likelihood of landslides. Ten watershed administrative units have 1 percent or less; no watershed administrative unit has more than 17 percent.

Table 3-25. Acres and Percent of State Trust Lands in Each Watershed Administrative Unit With Soils That Have a High Likelihood of Landslides

Watershed administrative unit (acres of state trust lands)	Acres (percent)
Bogachiel (11,267)	68 (1%)
Cedar (4,208)	5 (<1%)
Clallam River (10,161)	259 (3%)
East Fork Dickey (10,975)	6 (<1%)
Goodman Mosquito (13,449)	21 (<1%)
Hoko (10,636)	525 (5%)
Kalaloch Ridge (5,753)	102 (2%)
Lower Clearwater (19,815)	98 (<1%)
Lower Dickey (7,377)	0
Lower Hoh River (7,120)	9 (<1%)
Lower Queets River (14,961)	2 (<1%)
Middle Hoh (37,289)	6,285 (17%)
Quillayute River (6,187)	8 (<1%)
Sol Duc Lowlands (4,448)	18 (1%)
Sol Duc Valley (13,481)	227 (5%)
Upper Clearwater (54,911)	8,499 (15%)

Indicator: Potential Road Failure

The road network in the OESF ranges from roads that are temporary, gravel, and used for a single timber sale and then abandoned, to roads that are paved, permanent, and used year-round. Most roads on state trust lands in the OESF are active (currently in use) and unpaved. For this analysis, DNR included all roads on state trust lands (1,800 miles of road) except roads that have been certified as abandoned.[13]

For this analysis, DNR assumes the extent of the road network in the OESF will remain essentially unchanged under both alternatives throughout the 100-year analysis period.[14] DNR does not expect a substantial reduction of the road network because roads are essential to working forests. Although DNR has abandoned some of its roads, very little additional road abandonment is identified in current plans. Nor does DNR expect a substantial expansion of its road network, although some new roads may be needed. It is too speculative to estimate their locations or number of miles; the exact locations and lengths of roads cannot be determined until a harvest is planned and a site assessment is performed. (For more information about the accomplishment of road maintenance and abandonment plans, refer to the summaries in Appendix C; for more information on the methodology used to calculate traffic scores, refer to Appendix C.)

Because DNR assumes the road network will not change, DNR bases its results for this indicator on the current condition of the road network. Therefore, current conditions and results are the same and are presented in the following section. Also, although there may be small differences in new road construction between the two alternatives, DNR assumes the road network will be essentially the same under both alternatives and therefore does not present the results for this indicator by alternative.

Results

As explained previously, for all indicators except potential road failure, DNR first determines the percentage of state trust lands in each watershed administrative unit that is projected to have potential high impacts. DNR considers a potential high impact to be four or more harvest entries (variable retention harvest or thinning) on soils with a high likelihood of compaction, erosion, displacement, or landslides, or that are the least productive, over 100 years.

- If less than 10 percent of state trust lands have potential high impacts, the potential environmental impact is low.
- If 10 to 20 percent of state trust lands have potential high impacts, the potential environmental impact is medium.
- If more than 20 percent of state trust lands have potential high impacts, the potential environmental impact is high.

DNR then assigns a low, medium, or high impact rating to each watershed administrative unit based on the percentage of state trust lands in that watershed administrative unit with potential high impacts. Finally, DNR assigns a low, medium, or high impact rating to this indicator based on the percentage of state trust lands in all watershed administrative units with potential high impacts.

Indicator: Soil Compaction

Soils with a high likelihood of compaction are found on a significant portion of state trust lands in the OESF (refer to Table 3-20). Yet, there are relatively few instances of four or more forest stand entries occurring on these soils over the 100-year analysis period.

Under either alternative, 20 percent or less of state trust lands in any given watershed administrative unit has potential high impacts (refer to Table 3-26). Therefore, potential environmental impacts for all watershed administrative units under either alternative are low or medium.

Table 3-26. Percent and Acres of State Trust Lands in Each Watershed Unit Projected to Have Potential High Impacts From Compaction, by Alternative

Watershed administrative unit (acres of state trust lands)	Percent (acres) of state trust lands with potential high impacts	
	No Action Alternative	Landscape Alternative
Bogachiel (11,267)	5% (601) ●	10% (1,074) ◇
Cedar (4,208)	15% (619) ◇	19% (804) ◇
Clallam River (10,161)	14% (1,444) ◇	16% (1,600) ◇
East Fork Dickey (10,975)	11% (1,233) ◇	19% (2,057) ◇

Table 3-26, Continued. Percent and Acres of State Trust Lands in Each Watershed Unit Projected to Have Potential High Impacts From Compaction, by Alternative

Watershed administrative unit (acres of state trust lands)	Percent (acres) of state trust lands with potential high impacts	
	No Action Alternative	Landscape Alternative
Goodman Mosquito (13,449)	5% (670) ●	8% (1,101) ●
Hoko (10,636)	13% (1,382) ◇	17% (1,848) ◇
Kalaloch Ridge (5,753)	8% (475) ●	13% (747) ◇
Lower Clearwater (19,815)	8% (1,578) ●	11% (2,143) ◇
Lower Dickey (7,377)	5% (395) ●	10% (756) ◇
Lower Hoh River (7,120)	4% (287) ●	4% (315) ●
Lower Queets River (14,961)	10% (1,424) ◇	14% (2,074) ◇
Middle Hoh (37,289)	1% (384) ●	<1% (42) ●
Quillayute River (6,187)	11% (702) ◇	20% (1,225) ◇
Sol Duc Lowlands (4,448)	7% (293) ●	10% (441) ◇
Sol Duc Valley (13,481)	11% (1,549) ◇	14% (1,868) ◇
Upper Clearwater (54,911)	4% (2,467) ●	6% (3,114) ●
TOTAL (232,038)	7% (15,503) ●	9% (21,209) ●

● Low impact ◇ Medium impact

Considering all watershed administrative units together, under the No Action Alternative, only 7 percent (15,503 acres) of state trust lands in the OESF have potential high impacts, and under the Landscape Alternative, only 9 percent (21,209 acres) of state trust lands in the OESF have potential high impacts. Therefore, the potential environmental impact for either alternative for this indicator is considered **medium**. DNR has not identified probable significant adverse environmental impacts from either alternative for this indicator.

Indicator: Soil Erosion

Soils with a high likelihood of erosion make up varying percentages of state trust lands in each watershed administrative unit. Many watershed administrative units have less than 1 percent, others as much as 27 percent (refer to Table 3-21). However, very few instances of four or more forest stand entries occur over the 100-year analysis period on soils that are both prone to erosion and located on steep (greater than 60 percent) slopes. Under either alternative, 1 percent or less of state trust lands in any given watershed administrative unit has potential high impacts. Therefore, potential environmental impacts for all watershed administrative units under either alternative are low (Table 3-27).

Table 3-27. Percent and Acres of State Trust Lands in Each Watershed Unit Projected to Have Potential High Impacts From Erosion, by Alternative

Watershed administrative unit (acres of state trust lands)	Percent (acres) of state trust lands with potential high impacts	
	No Action Alternative	Landscape Alternative
Bogachiel (11,267)	<1% (3) ●	<1% (3) ●
Cedar (4,208)	<1% (8) ●	<1% (8) ●
Clallam River (10,161)	0 ●	0 ●
East Fork Dickey (10,975)	0 ●	0 ●
Goodman Mosquito (13,449)	<1% (10) ●	<1% (10) ●
Hoko (10,636)	0 ●	0 ●
Kalaloch Ridge (5,753)	<1% (8) ●	<1% (8) ●
Lower Clearwater (19,815)	<1% (2) ●	<1% (2) ●
Lower Dickey (7,377)	0 ●	0 ●
Lower Hoh River (7,120)	<1% (1) ●	<1% (1) ●
Lower Queets River (14,961)	0 ●	0 ●
Middle Hoh (37,289)	0 ●	0 ●
Quillayute River (6,187)	<1% (1) ●	<1% (1) ●
Sol Duc Lowlands (4,448)	0 ●	0 ●
Sol Duc Valley (13,481)	0 ●	0 ●
Upper Clearwater (54,911)	1% (545) ●	1% (549) ●
TOTAL (232,038)	<1% (578) ●	<1% (582) ●

● Low impact

Considering all watershed administrative units together, under either alternative, less than 1 percent (578 acres under the No Action Alternative, 582 acres under the Landscape Alternative) of state trust lands in the OESF have potential high impacts. Therefore, the potential environmental impact for either alternative for this indicator is considered **low**. DNR has not identified probable significant adverse environmental impacts from either alternative for this indicator.

Indicator: Soil Displacement

Soils with a high likelihood of displacement make up varying percentages of state trust lands in each watershed administrative unit. Some have as little as 2 percent, others as much as 84 percent (refer to Table 3-22).

Under both alternatives, three watershed administrative units (Clallam River, East Fork Dickey, Hoko) have potential high impacts on more than 20 percent of state trust lands; the potential environmental impacts for these units is high (Table 3-28). Potential environmental impacts for all other watershed administrative units are low or medium.

Table 3-28. Percent and Acres of State Trust Lands in Each Watershed Unit Projected to Have Potential High Impacts from Displacement, by Alternative

Watershed administrative unit (acres of state trust lands)	Percent (acres) of state trust lands with potential high impacts	
	No Action Alternative	Landscape Alternative
Bogachiel (11,267)	6% (621) ●	5% (618) ●
Cedar (4,208)	19% (787) ◇	19% (787) ◇
Clallam River (10,161)	31% (3,200) ■	31% (3,198) ■
East Fork Dickey (10,975)	6% (634) ●	6% (632) ●
Goodman Mosquito (13,449)	11% (1,534) ◇	11% (1,538) ◇
Hoko (10,636)	43% (4,592) ■	43% (4,588) ■
Kalaloch Ridge (5,753)	29% (1,669) ■	29% (1,670) ■
Lower Clearwater (19,815)	5% (909) ●	6% (1,233) ●
Lower Dickey (7,377)	6% (454) ●	6% (454) ●
Lower Hoh River (7,120)	10% (686) ◇	10% (686) ◇
Lower Queets River (14,961)	4% (621) ●	4% (621) ●
Middle Hoh (37,289)	7% (2,742) ●	7% (2,742) ●
Quillayute River (6,187)	4% (250) ●	4% (250) ●
Sol Duc Lowlands (4,448)	1% (61) ●	1% (61) ●
Sol Duc Valley (13,481)	19% (2,603) ◇	19% (2,602) ◇
Upper Clearwater (54,911)	19% (10,460) ◇	19% (10,462) ◇
TOTAL (232,038)	14% (31,823) ◇	14% (32,142) ◇

● Low impact ◇ Medium impact ■ High impact

Considering all watershed administrative units together, under both alternatives, 14 percent (31,823 acres under the No Action Alternative and 32,142 acres under the Landscape Alternative) of state trust lands in the OESF have potential high impacts. Therefore, the potential environmental impact for either alternative for this indicator is considered **medium**. DNR has not identified probable significant adverse environmental impacts from either alternative for this indicator.

Possible mitigation could reduce potential high impacts within the Clallam, Hoko, and Kalaloch Ridge watershed administrative units to a lower level. As described in the introduction to this chapter, possible mitigation includes site-specific mitigation that foresters may suggest to further reduce potential impacts at the time of an individual management activity. For example, DNR may use suspended cables to move trees to landings or otherwise limit heavy machinery movement on exposed soils with a high likelihood of displacement. Site-specific mitigation is considered under SEPA as part of the SEPA review for each activity.

Indicator: Soil Productivity

There are only 2,856 total acres of the least productive soils (Site Class 5) on state trust lands in the OESF. There are less than 591 acres of these soils on state trust lands in any given watershed administrative unit (refer to Table 3-23). The occurrence of four or more forest stand entries on Site Class 5 soils on state trust lands is therefore low. Under either alternative, potential impacts are low in all watersheds (refer to Table 3-29).

Table 3-29. Percent and Acres of State Trust Lands in Each Watershed Unit Projected to Have Potential High Impacts to Soil Productivity, by Alternative

Watershed administrative unit (acres of state trust lands)	Percent (acres) of state trust lands with potential high impacts	
	No Action Alternative	Landscape Alternative
Bogachiel (11,267)	<1% (91) ●	<1% (91) ●
Cedar (4,208)	4% (182) ●	4% (186) ●
Clallam River (10,161)	<1% (3) ●	<1% (3) ●
East Fork Dickey (10,975)	<1% (22) ●	<1% (22) ●
Goodman Mosquito (13,449)	1% (150) ●	1% (152) ●
Hoko (10,636)	1% (157) ●	1% (158) ●
Kalaloch Ridge (5,753)	0 ●	0 ●
Lower Clearwater (19,815)	1% (133) ●	1% (87) ●
Lower Dickey (7,377)	6% (425) ●	6% (425) ●
Lower Hoh River (7,120)	0 ●	0 ●
Lower Queets River (14,961)	<1% (56) ●	<1% (56) ●
Middle Hoh (37,289)	<1% (81) ●	<1% (82) ●
Quillayute River (6,187)	0 ●	0 ●
Sol Duc Lowlands (4,448)	0 ●	0 ●
Sol Duc Valley (13,481)	1% (43) ●	1% (43) ●
Upper Clearwater (54,911)	<1% (8) ●	<1% (8) ●
TOTAL (232,038)	1% (1,351) ●	1% (1,313) ●

● **Low impact**

Table 3-30 shows the total acres of harvest that are projected to occur on all site classes on state trust lands in the OESF over the 100-year analysis period. DNR projects that only 1,201 acres of Site Class 5 soils under the No Action Alternative and 1,228 acres of Site Class 5 soils under the Landscape Alternative will be harvested.

Table 3-30. Total Acres of Harvest (Variable Retention Harvest or Variable Density Thinning) Projected Over 100 Years on Site Class 1 Through Site Class 5 Soils on State Trust Lands in the OESF

Site class	No Action Alternative	Landscape Alternative
1	3,820	3,853
2	17,169	17,411
3	34,748	35,206
3 and 4	42,987	43,909
4	13,814	14,005
5	1,201	1,228

Considering all watershed administrative units together, under either alternative, less than 1 percent (1,351 acres under the No Action Alternative, 1,313 acres under Landscape Alternative) of state trust lands in the OESF have potential high impacts. Therefore, the potential environmental impact for either alternative for this indicator is considered **low**. DNR has not identified probable significant adverse environmental impacts from either alternative for this indicator.

Indicator: Landslide Potential

Few watershed administrative units have soils with a high likelihood of landslides (soils on top of marine sediment or basalt geologic units on slopes of 70 percent or greater). With the exception of the Middle Hoh and the Upper Clearwater, these soils made up less than 5 percent of state trust lands in any given watershed administrative unit (refer to Table 3-25). This relative scarcity of potentially unstable areas is reflected in the results for this indicator. Under either alternative, 3 percent or less of state trust lands in any given watershed administrative unit has potential high impacts. Thus, potential environmental impacts for all watershed administrative units under either alternative are low (refer to Table 3-31).

Table 3-31. Percent and Acres of State Trust Lands in Each Watershed Unit Projected to Have Potential High Impacts for Landslide Potential, by Alternative

Watershed administrative unit (acres of state trust lands)	Percent (acres) of state trust lands with potential high impacts	
	No Action Alternative	Landscape Alternative
Bogachiel (11,267)	<1% (10) ●	<1% (10) ●
Cedar (4,208)	<1% (3) ●	<1% (3) ●
Clallam River (10,161)	1% (127) ●	1% (127) ●

Table 3-31, Continued. Percent and Acres of State Trust Lands in Each Watershed Unit Projected to Have Potential High Impacts for Landslide Potential, by Alternative

Watershed administrative unit (acres of state trust lands)	Percent (acres) of state trust lands with potential high impacts	
	No Action Alternative	Landscape Alternative
East Fork Dickey (10,975)	<1% (4) ●	<1% (4) ●
Goodman Mosquito (13,449)	<1% (6) ●	<1% (6) ●
Hoko (10,636)	3% (272) ●	3% (273) ●
Kalaloch Ridge (5,753)	<1% (1) ●	<1% (1) ●
Lower Clearwater (19,815)	<1% (12) ●	<1% (26) ●
Lower Dickey (7,377)	0 ●	0 ●
Lower Hoh River (7,120)	<1% (2) ●	<1% (2) ●
Lower Queets River (14,961)	0 ●	0 ●
Middle Hoh (37,289)	2% (655) ●	2% (655) ●
Quillayute River (6,187)	0 ●	0 ●
Sol Duc Lowlands (4,448)	<1% (4) ●	<1% (4) ●
Sol Duc Valley (13,481)	1% (103) ●	1% (103) ●
Upper Clearwater (54,911)	3% (1422) ●	3% (1423) ●
TOTAL (232,038)	1% (2,621) ●	1% (2,637) ●

● Low impact

Considering all watershed administrative units together, under either alternative less than 1 percent (2,621 acres under the No Action Alternative, 2,637 acres under Landscape Alternative) of state trust lands in the OESF have potential high impacts. Therefore, the potential environmental impact for either alternative for this indicator is considered **low**. DNR has not identified probable significant adverse environmental impacts from either alternative for this indicator.

Indicator: Potential Road Failure

Table 3-32 shows the current percentage of the road network located on potentially unstable slopes on state trust lands in each of the 11 landscapes in the OESF. Five landscapes have potential high impacts, meaning more than 10 percent of the road network is located on potentially unstable slopes. Road failures can deliver coarse sediment to streams.

Table 3-32. Current Percentage of Road Network Located on Potentially Unstable Slopes, by Landscape

Landscape	Percentage of road network
Clallam	17% ■
Clearwater	23% ■
Copper Mine	13% ■
Dickodochtedar	3% ●
Goodman	3% ●
Kalaloch	8% ◆
Queets	3% ●
Reade Hill	16% ■
Sekiu	10% ◆
Sol Duc	7% ●
Willy Huel	20% ■

● Low impact ◆ Medium impact ■ High impact

Considering all landscapes together, the potential environmental impact of either alternative for this indicator is considered **high**. Should it occur, the environmental impact of a road failure could potentially be adverse. However, this impact rating is based solely on the percentage of the road network located on potentially unstable slopes, and is made without considering the condition of the road network, or current management practices (established programs, rules, procedures, or other practices) that may mitigate a potential high impact to a level of non-significance. Potential road failure will be mitigated to a non-significant level through repair and maintenance of roads identified in road maintenance and abandonment plans (refer to "Mitigation" in this section). Therefore, DNR has not identified probable significant environmental impacts under either alternative for this indicator.

Mitigation

Following, DNR describes current management practices (established programs, rules, procedures, or other practices) that are expected to mitigate potential high impacts to a level of non-significance. This mitigation applies to the indicator potential road failure.

Road Maintenance and Abandonment Plans

The forest practices rules require large forest landowners,[15] such as DNR, to prepare road maintenance and abandonment plans for all roads that have been used or constructed since 1974.[16] These plans specify the steps that will be taken to either abandon roads or bring roads that do not meet current standards into compliance. Consistent with the forest practices rules, DNR has developed road maintenance and abandonment plans for roads on state trust lands in each of the 11 landscapes in the OESF. To complete the work identified under these plans, DNR will use, as appropriate, the best management practices in DNR's current Forest Practices Board Manual[17] (DNR 2013) and the guidance provided in DNR's Forest Roads Guidebook (DNR 2011).

In road maintenance and abandonment plans, priority is given to roads or road systems in areas containing sensitive geology or soils with a history of landslides, and to roads with evidence of existing or potential instability that could affect public resources adversely (WAC 222-24). Registered geologists and engineers inspect potentially unstable roads. Mitigation may range from maintaining or improving drainage structures, such as relief culverts or ditches, to building retaining walls, to redesigning or abandoning the road.

Work under these plans is ongoing. Table 3-41 in "Water Quality," p. 3-132 shows the number of projects completed under road maintenance and abandonment plans for roads on state trust lands in each of the 11 landscapes in the OESF. Work associated with these plans must be completed by October 31, 2016 (refer to "Water Quality" for more information on road maintenance and abandonment plans).

EFFECTIVENESS OF ROAD MAINTENANCE AND ABANDONMENT PLANS

Implementing current forest practices rules for road maintenance correctly is expected to minimize runoff water and sediment delivery to typed waters (DNR 2013). A statewide study conducted on private forestlands in Washington found that road maintenance and abandonment appear to reduce the amount of road-related sediment that reaches streams (Martin 2009). This study found that implementing best management practices decreased the number of road miles hydrologically connected to streams, and that most roads studied had a low probability of delivering sediment to streams (Martin 2009). In addition, road maintenance and abandonment plan effectiveness monitoring conducted statewide by Dubé and others (2010) from 2006 through 2008 found that, as roads were brought up to modern standards, they showed decreased sediment delivery to streams.

Inspection, Maintenance, and Repair

After work identified under road maintenance and abandonment plans has been completed in 2016, DNR will continue to inspect, maintain, and repair roads and bridges as needed using the appropriate best management practices for road maintenance and repair identified in the current Forest Practices Board Manual and guidance provided in the Forest Roads Guidebook. Routine maintenance of road dips and surfaces and responding quickly to problems can reduce road-caused slumps and slides significantly and prevent the creation of berms that could channelize runoff (Environmental Protection Agency 2012).

DNR does not anticipate building new roads on potentially unstable slopes. However, if building such roads is unavoidable, DNR will obtain a forest practices Class IV permit and follow all current forest practice standards for the design and maintenance of new roads (WAC 222-24). These standards are designed to minimize the risk of road failure.

Topic: Soils 3

Summary of Potential Impacts

Table 3-33 provides an overview of the potential environmental impacts on soils when the criterion and all of the indicators are considered. For this analysis, only high impacts are considered potentially significant. DNR has not identified probable significant adverse impacts from either alternative for the indicators soil compaction, erosion, displacement, productivity, or landslide potential. Potential high impacts for the indicator potential road failure are expected to be mitigated to a level of non-significance through current management practices, which include the implementation of road maintenance and abandonment plans and inspecting, maintaining, and repairing roads. Therefore, DNR has not identified probable significant impacts for this indicator.

Table 3-33. Summary of Potential Impacts on Soils, by Alternative

Criterion	Indicators	No Action Alternative	Landscape Alternative
Soil conservation	Soil compaction	Medium ◊	Medium ◊
	Soil erosion	Low ●	Low ●
	Soil displacement	Medium ◊	Medium ◊
	Soil productivity	Low ●	Low ●
	Landslide potential	Low ●	Low ●
	Potential road failure	High ■	High ■

● **Low impact** ◊ **Medium impact** ■ **High impact**

Section Notes

1. The use of a 20 percent threshold followed recommendations from federal watershed monitoring programs (Reeves and others 2004, Gallo and others 2005). Reeves and others recommended using a minimum 25 percent ownership threshold in order for a given watershed to be included in the monitoring program. As described by Gallo and others (2005), this 25 percent threshold was selected to avoid sampling watersheds in which "the contribution of federal lands to the condition of the watershed was insignificant." A more stringent 20 percent threshold was used in this analysis.
2. Types of soils prone to compaction: basic igneous bedrock, clayey or fine-textured old alluvium, glacial drift, glacial till, non-carbonate sedimentary bedrock, silty alluvium, silty alluvium over sand and gravel, and volcanic ash over non-carbonate sedimentary bedrock.
3. Types of soils prone to erosion: basic igneous bedrock, glacial drift, glacial outwash, non-carbonate sedimentary bedrock, and volcanic ash over non-carbonated sedimentary bedrock
4. In rill or gully erosion, water runoff creates small channels in the soil. Because water tends to run through these channels, they can enlarge over time, leading to increased rates of soil erosion.
5. Types of soils prone to displacement: basic igneous bedrock, glacial drift, glacial outwash, non-carbonate sedimentary bedrock, and volcanic ash over non-carbonated sedimentary bedrock
6. After trees are cut down, they are moved to a landing (place where trees or logs are collected for transport) either with ground-based equipment or via a suspended cable. When cables are used, one or both ends of the log or tree may be suspended (full suspension).
7. The removal of competing vegetation from a site, prior to tree planting. Includes mechanical / physical removal and the use of herbicides.

8. A geologic unit is a combination of similar rock types, often grouped and portrayed on a geologic map.

9. The historic landslide rate is the average number of shallow-rapid landslides per year on a given site. The historic landslide rate is averaged using landslide data from no more than 70 years. Watershed administrative units differ in the number of years of data available for calculating the historic landslide rate.

10. Convergent slopes come together from different directions.

11. Areas identified as potentially unstable in the forest estate model are field-verified using both office and field techniques. A geologist performs an office review of relevant information including geologic and landslide hazard maps, slope stability computer models, topographic information, and previous slope stability studies on nearby areas and recommends, if appropriate, that a geologist perform a field review. As part of the pre-sales process for each timber sale, field staff (foresters and engineers) identify unstable slopes and typically remove those areas from the sale. If field staff are uncertain about indicators of instability, they request that a geologist visit the site. If additional unstable slopes are identified, field staff either remove them from the sale or request a geotechnical report to evaluate the risk of conducting an activity (such as timber harvesting or road building) in that area. The geotechnical report is required by forest practices for activities on unstable slopes and is referenced in the SEPA environmental checklist.

12. Seventy percent has been established as the average slope for landslide initiation in the OESF. Some areas may have higher or lower average slopes for landslide initiation depending on conditions.

13. Under the forest practices rules (WAC 222-24-52(3)), a road is considered abandoned if: (a) roads are out-sloped, water barred, or otherwise left in a condition suitable to control erosion and maintain water movement within wetlands and natural drainages; (b) ditches are left in a suitable condition to reduce erosion; (c) the road is blocked so that four-wheel highway vehicles cannot pass the point of closure at the time of abandonment; (d) water crossing structures and fills on all typed waters are removed, except where the department determines other measures would provide adequate protection to public resources; and (e) DNR has determined that the road is abandoned.

14. In the event that, during the statewide sustainable calculation, a change in the harvest level would require an increase in road density, DNR would first analyze the impacts of a higher road density through the sustainable harvest calculation process.

15. In Washington, large forest landowners are those who harvest an annual average of more than 2 million board feet of timber from their own forestland in the state.

16. Older roads that have not been used since 1974 are considered "orphaned."

17. Available at: http://www.dnr.wa.gov/BusinessPermits/Topics/ForestPracticesRules/Pages/fp_board_manual.aspx

Water Quality

Why Is Water Quality Important?

Water quality is important to the health of riparian areas. Riparian areas, which include streams, lakes, rivers, and wetlands, support native fish populations and other aquatic species as well as the birds and mammals that depend on these areas for all or part of their life cycles. High quality water is also essential for human life.

What Is the Criterion for Water Quality?

The criterion for water quality is **compliance with water quality standards**. Water quality in the OESF is governed by the federal Clean Water Act and the state Water Pollution Control Act (Chapter 90.48 RCW). The Clean Water Act requires states to set water quality standards consistent with federal standards. The Water Pollution Control Act requires the state to maintain the highest possible water quality standards to ensure the purity of all waters in the state.

Consistent with these requirements, Ecology developed and published "Water Quality Standards for Surface Waters of the State of Washington" (Chapter 173-201A WAC [Ecology 2006] as revised [Ecology 2011a]). In this chapter of the code, Ecology establishes water quality standards for surface waters of the state consistent with public health and enjoyment of waters and the protection of fish, shellfish, and wildlife (Ecology 2006).

What Are the Indicators for Water Quality?

The indicators used to assess the criterion (compliance with water quality standards) are **stream shade**, **road density**, **stream crossing density**, **proximity of roads to streams or other water bodies**, and **traffic impact scores**. DNR's indicators are based on Ecology's water quality standards. These standards identify watershed resource inventory areas as the basis for environmental analysis and administration (refer to Appendix C for a description of water resource inventory areas). All of water resource inventory area 20 (Soleduck/Hoh) and portions of water resource inventory areas 19 (Lyre/Hoko) and 21 (Queets/Quinault) are located within the OESF. For each water resource inventory area, Ecology assigns water quality indicators to water bodies based on their use designation.[1] Use designations include aquatic life, recreation, water supply, and miscellaneous. Indicators specific to aquatic life are stream temperature, dissolved oxygen, turbidity, total dissolved gas, and pH. The indicator specific to recreational uses is fecal coliform bacteria. Indicators applicable to all uses are toxic, radioactive, and deleterious materials and aesthetic values.

This analysis does not include total dissolved gas, pH, or fecal coliform bacteria. To learn why, refer to "Considered but Not Analyzed" at the end of this section. Refer to Appendix C for use designations of water bodies in the OESF.

Water Quality Monitoring Station 20B070 Hoh River Near Hoh Oxbow Campground (Ecology 2012a)

Although some water quality data has been collected, comprehensive in-stream data for stream temperature, dissolved oxygen, and turbidity is not available in a comprehensive or readily usable form for all streams in the OESF. For example, limited spot water quality sampling began in the OESF in the 1950s. However, the portion of the rivers and streams sampled is small compared to the miles of rivers and streams in the entire OESF water system (10,730 miles of stream in the OESF, 2,785 miles of which are located on state trust lands; refer to Table 3-1). Several tribes in the OESF, a local citizen groups, USFS, and NPS have collected water quality data, with some data being collected on state trust lands; however, such data is not comprehensive for state trust lands in the OESF. Ecology maintains only one long-term water quality monitoring station on state trust lands in the OESF (refer to photo).

Based on the collected data, approximately 10 stream miles on state trust lands in the OESF are listed on the 303(d) list[2] as not meeting water quality standards for stream temperature, dissolved oxygen, turbidity, or fecal coliform bacteria (refer to Appendix N). Ten miles is approximately 0.35 percent of the total stream miles on state trust lands in the OESF.

Because comprehensive in-stream data is not available, DNR relies on surrogates to assess current and future water quality conditions.

- DNR measures stream temperature and dissolved oxygen using the indicator stream shade because shade influences both water temperature and dissolved oxygen.
- DNR measures turbidity by analyzing the potential of the road network to deliver fine sediment to streams. Roads can increase the amount of fine sediment delivered to streams to levels above what would occur naturally. DNR analyzes potential using four road-related indicators: **road density**, **stream crossing density**, **proximity of roads to stream or other water bodies**, and **traffic impact scores**.

Stream shade is an overlapping indicator. In addition to this section, it is used to assess functioning riparian habitat in "Riparian," p. 3-51 and "Fish," p. 3-143. Overlapping indicators are expected due to the complexity and interrelatedness of the components of the forest ecosystem. In this section (Water Quality), DNR presents the results for this indicator and discusses how it relates to water quality; refer to "Riparian," p. 3-72 for the full analysis.

Fine sediment delivery is also analyzed in "Riparian," p. 3-52 and "Fish," p. 3-144 using spatial scales appropriate to those topics. For both of those analyses, DNR couples the potential for fine sediment delivery to streams (how likely it is to occur) with the sensitivity, or the expected stream channel response, to inputs of fine sediment to streams. Sensitivity is based on gradient (how steep the stream is) and confinement (how much a stream channel can move within its valley). For example, higher gradients and stream channel confinement combine to produce enough stream energy to route most introduced fine sediment downstream (Oregon Watershed Enhancement Board [OWEB] 1999). Such streams may be less sensitive to fine sediment delivery than streams that are less steep or confined. Refer to "Riparian" and "Fish" for more information.

In this section (Water Quality), DNR considers potential *only*; DNR does not consider sensitivity. As stated previously, DNR's indicators for water quality are based on Ecology's water quality standards. Those standards are primarily concerned with whether or not an impact is occurring (in this case, turbidity caused by delivery of fine sediment), regardless of the sensitivity of the stream channel to fine sediment input. For that reason, DNR considered only potential for this water quality analysis.

What Is Important About Stream Temperature, Dissolved Oxygen, and Turbidity?

Stream temperature helps determine which aquatic life forms can live in a stream. All aquatic life forms (fish, insects, zooplankton, phytoplankton, and other aquatic species) have a temperature range in which they can survive. If temperatures shift too far above or below this range, populations of aquatic life forms may decline or eventually disappear (Michaud 1991, Ecology 2012a).

Temperature influences water chemistry, such as the amount of dissolved oxygen available in water. For example, warm water holds less oxygen than cold water. Warm water may be at its maximum level of dissolved oxygen but still not contain enough oxygen for fish and other aquatic life to survive. Oxygen also is necessary for the decomposition of organic matter, such as leaves and needles that fall into the water (Michaud 1991, Ecology 2012b, Tank and others 2010).

Turbidity is a measurement of the amount of solids suspended in water (cloudiness). Solids that cause cloudiness in water may include soil particles (fine sediment) or algae. Turbidity can affect fish and their habitat negatively (refer to fine sediment delivery discussion in "Fish," p. 3-144). Turbidity also can reduce a water body's value for recreation, drinking water, and other uses.

Which Roads Does the Analysis Include?

Discussions follow of the roads DNR included in its analysis for each indicator.

- For the indicators **road density**, **stream crossing density**, and the **proximity of roads to streams or other water bodies**, DNR analyzed **all roads (paved and unpaved) on state trust lands** in each of the 11 landscapes (Appendix C) *except* for roads certified as abandoned.[3] Roads certified as abandoned are not included because

they have been stabilized and closed to traffic (refer to photo). Although there is no guarantee, DNR does not expect abandoned roads to contribute sediment to streams.

DNR did not include roads on non-state trust lands because of disparities in DNR's state trust lands transportation GIS database. This GIS database includes data for roads and streams on all ownerships in the OESF (DNR, USFS, NPS, private, tribal, and other). However, the information in this database for roads and streams on state trust lands is more complete than it is for non-state trust lands. For that reason, DNR believed that quantifying road density, stream crossing density, and proximity of roads to streams and other water bodies across all ownerships could lead to unreliable estimates. Therefore, DNR based its results for these indicators on roads and streams found on state trust lands only.

- For the indicator **traffic impact scores**, DNR analyzed traffic on **all roads (roads on state trust lands and non-state trust lands)** in the OESF because traffic associated with harvest activities may run on roads built and maintained by DNR or on roads built and maintained by other landowners.

CONSERVATIVE APPROACH

As described in the introduction to this chapter, DNR first assigns each indicator in this RDEIS a potential low, medium, or high impact. For road-related indictors, DNR bases this analysis on the current extent and location of the road network. DNR assumes that all roads that have not been certified as abandoned can contribute sediment to streams, even though some of these roads have been mitigated already or will be mitigated through current management practices to prevent the delivery of sediment from roads to streams (for example, by installing culverts to direct runoff away from streams). Mitigation through current management practices is not considered until the second step of DNR's analysis process, when DNR determines if a potential high impact is probable significant adverse. DNR feels this approach is conservative.

For all indicators, DNR analyzed roads classified as decommissioned as though they have the potential to deliver fine sediment, even though these roads have been stabilized to the same forest practices standards as abandoned roads. Abandonment is permanent; decommissioned roads may be re-opened during the analysis period (DNR 2011).

In addition, 24 percent of the roads on state trust lands are classified as having the surface type "other." For this analysis, DNR has taken the conservative approach of assuming roads classified as "other" are not paved, even though some may be paved. Road traffic generates sediment through surface erosion, which occurs only on unpaved roads. Refer to Appendix C for a description of road classifications and surface types.

Descriptions of the Indicators

Indicator: Stream Shade

Stream shade refers to the extent to which incoming sunlight is blocked on its way to the stream channel. Lack of shade allows sunlight to heat the water and is a common cause of elevated stream temperatures (Cafferata 1990) which in turn affect the level of dissolved oxygen in the stream.

Stream shade is measured by using a computer model that projects how sunlight decreases as it passes through riparian forests or is blocked by surrounding terrain. Each stream reach is assigned a target shade level[4] based on the amount of shade necessary to maintain stream temperatures within acceptable levels (adapted from WAC 222-30-040) and the maximum amount of shade available, given the orientation and width of the stream channel. To determine impacts, DNR compares the target shade level for each stream reach to the amount of shade that would be present after management activities take place. DNR assessed all streams that cross state trust lands within Type 3 watersheds that contain at least 20 percent state trust lands (a Type 3 watershed is a watershed that drains a Type 3 stream).[5] For more information on the methodology used to analyze shade, refer to "Riparian," p. 3-51 and Appendix G.

Indicator: Road Density

Road density is the number of miles of road in a defined area, expressed as miles of road per square mile. Road density is calculated by dividing the miles of road in a landscape (road miles) by the area of state trust lands in that landscape (square miles). The method and thresholds used for this indicator to determine a potential low, medium, or high impact follow those described in Potyondy and Geier (2011). For this indicator, DNR first assigns an impact level to each landscape, and then assigns an impact level to this indicator by considering all landscapes together.

Potential impacts from road density include increased delivery of fine sediment to streams due to a change in the timing, magnitude, duration, and spatial distribution of water runoff flows (Potyondy and Geier 2011). As road density increases, the potential impacts from roads may also increase (Potyondy and Geier 2011, Forman and Hersperger undated, Forman and Alexander 1998).

Indicator: Stream Crossing Density

Stream crossings are the points at which roads and streams intersect, commonly at bridges and culverts. Stream crossing density is the number of times a road crosses a stream per mile of stream. It is measured by dividing the number of stream crossings (how many times a road crosses a stream) by the miles of streams on state trust lands in a landscape. This calculation provides the number of stream crossings per mile of stream (Gallo and others 2005). For this indicator, DNR first assigns an impact level to each landscape, and then assigns an impact level to this indicator by considering all landscapes together. The methods and thresholds used to determine a potential low, medium, or high impact for each landscape follow those described in Gallo and others (2005).

Stream crossings have the potential to block fish passage, alter riparian vegetation, reduce large woody debris recruitment, increase stream temperature, change channel morphology, increase stream bank erosion, reduce bank stability, and increase sediment delivery to fish-bearing waters (Potyondy and Geier 2011). Researchers have found that stream crossings, especially during road construction, are the most frequent source of sediment to streams (Taylor and others 1999, Potyondy and Geier 2011).

Indicator: Proximity of Roads to Streams or Other Water Bodies

This indicator measures the percentage of the road network on state trust lands that is located within 300 feet of streams or other water bodies in each of the 11 landscapes in the OESF. This distance (300 feet) is based on the methods in Potyondy and Geier (2011).

Using GIS tools, DNR calculates the number of miles of road on state trust lands in each landscape that are within 300 feet of a stream or water body. DNR then divides that total by the total number of miles of road on state trust lands in that landscape to derive a percentage. For this analysis, DNR uses percentage instead of actual miles because landscapes differ in size and using a percentage gives an index of relative impacts.

DNR first assigns an impact level to each landscape, and then assigns an impact level to this indicator by considering all landscapes together. The methods and thresholds used to determine a potential low, medium, or high impact for each landscape follow those described in Potyondy and Geier (2011).

Indicator: Traffic Impact Scores

The role of traffic in increasing road sediment production is well-recognized (Luce and Black 2001, Reid and Dunne 1984), particularly on roads that are unpaved and have high volumes of vehicle traffic (Elliot and others 2009). Traffic impact scores are based on an analysis of road surface type, the proximity of roads to streams or other water bodies, and the projected traffic levels associated with the projected harvests on state trust lands as well as federal, tribal, and private lands in each landscape. DNR analyzes traffic on all roads (roads on state trust lands and non-state trust lands).

- Traffic on roads generates sediment through surface erosion, which occurs only on unpaved roads. Paved roads are not scored as having an impact.
- DNR assigns roads a weighted score based on how close the road is to the stream. Roads that are closer to the stream receive a higher score (higher impact) than those farther away. Roads more than 300 feet from a water body are not scored as having an impact. DNR based this distance on the methodology of Potyondy and Geier (2011).
- Projected traffic levels for other ownerships are based on a review of past timber harvest volume reports and assumptions about harvest intensity relative to DNR's projected management activities; these projected traffic levels are held constant, meaning they do not vary from one decade to the next.

DNR computes traffic scores for each landscape. Based on the criteria described in Gallo and others (2005), DNR categorizes traffic impact scores for each landscape as follows: 0 to 32, low impact; 33 to 67, medium impact; and 68 to 100, high impact. DNR then assigns an impact level to this indicator by considering all landscapes together. For information on the methodology used to calculate traffic scores, refer to "Riparian," p. 3-52 and Appendix C.

Criterion and Indicators: Summary

Table 3-34 summarizes the criteria and indicators and how they are measured. For all indicators except stream shade, DNR first assigns an impact level to each landscape, and then assigns an impact level to the indicator by considering all landscapes together.

Table 3-34. Criterion and Indicators for Water Quality and How They Are Measured

Criterion/Indicator	**How the indicator is measured**	**Potential environmental impacts**
Adherence to water quality standards/ Stream shade (surrogate for stream temperature and dissolved oxygen)	Ability of the riparian forest to provide shade to the stream. Assessment area: All streams on state trust lands within Type 3 watersheds that contain at least 20 percent state trust lands	**Low:** Most Type 3 watersheds in, or moving toward, a low impact condition. **Medium:** Most Type 3 watersheds in, or moving toward, a medium impact condition. **High:** Most Type 3 watersheds in, or moving toward, a high impact condition.
Adherence to water quality standards/ Road density (analyzes the potential for fine sediment delivery as a surrogate for turbidity)	Road miles per square mile, measured by dividing the miles of roads on state trust lands in a landscape (road miles) by the area of state trust lands in the landscape (square miles) (Potyondy and Geier 2011). Assessment area: All roads (paved or unpaved) on state trust lands	**Low:** Less than 1.0 road mile per square mile. **Medium:** 1.0 to 2.4 road miles per square mile. **High:** Over 2.4 road miles per square mile.

Table 3-34, Continued. Criterion and Indicators for Roads and How They Are Measured

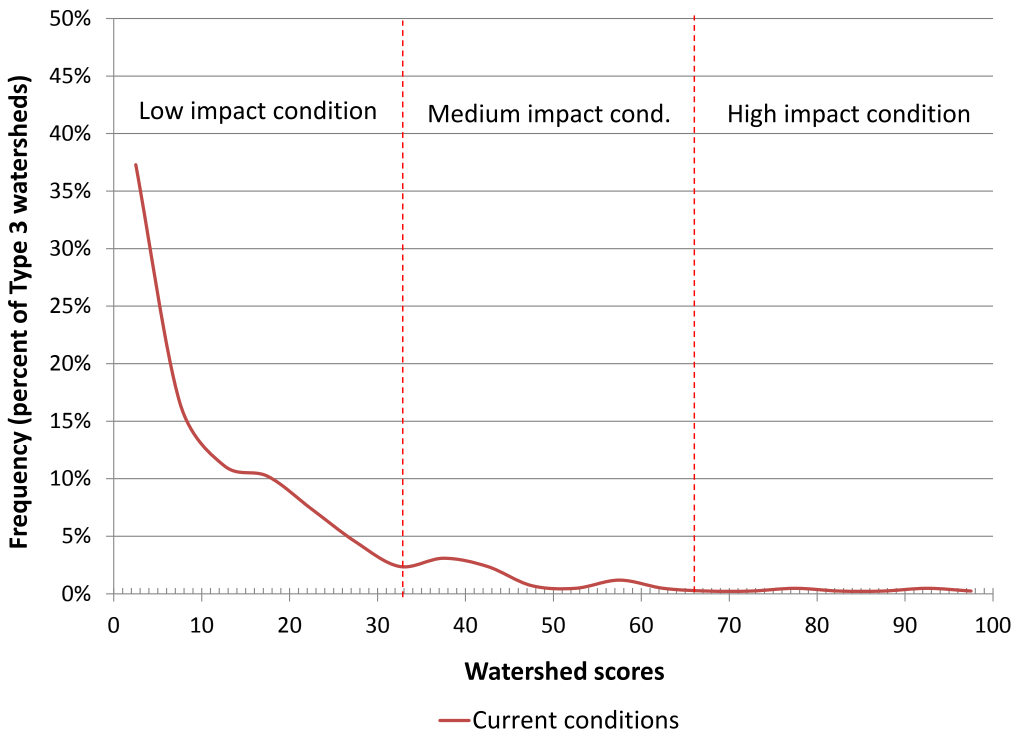
Criterion/Indicator	**How the indicator is measured**	**Potential environmental impacts**
Adherence to water quality standards/ Stream crossing density (analyzes the potential for fine sediment delivery as a surrogate for turbidity)	Stream crossings per mile of stream, measured by dividing the number of stream crossings by the miles of stream on state trust lands in a landscape (Gallo and others 2005). Assessment area: All roads (paved or unpaved) on state trust lands	**Low:** Less than 1.3 stream crossings per mile of stream. **Medium:** 1.3 to 2.6 stream crossings per mile of stream. **High:** Over 2.6 stream crossings per mile of stream.
Adherence to water quality standards/ Proximity of roads to streams or other water bodies (analyzes the potential for fine sediment delivery as a surrogate for turbidity)	Percentage of the road network on state trust lands in each landscape within 300 feet of a stream or other water body (Potyondy and Geier 2011). Assessment area: All roads (paved or unpaved) on state trust lands	**Low:** Less than 10 percent of the road network located within 300 feet of streams and water bodies. **Medium:** 10 to 25 percent of the road network located within 300 feet of streams and water bodies. **High:** Over 25 percent of the road network located within 300 feet of streams and water bodies.
Adherence to water quality standards/ Traffic impact score (analyzes the potential for fine sediment delivery as a surrogate for turbidity)	Traffic impact score, based on the proximity of roads to streams and water bodies, road surface type (paved or unpaved), and traffic levels. Assessment area: All roads on state trust lands and non-state trust lands	**Low:** Traffic impact score less than 33. **Medium:** Traffic impact score 33 to 67. **High:** Traffic impact score 68 to 100.

Current Conditions

Indicator: Stream Shade

Currently, 89 percent of Type 3 watersheds are in a low impact condition, 9 percent are in a medium impact condition, and 2 percent are in a high impact condition (Chart 3-17 from "Riparian" is presented here as Chart 3-46.) The current distribution of watershed scores for shade reflects that most stream reaches are at or above their shade targets.

Chart 3-46. Current Conditions, Stream Shade



Indicators: Road Density, Stream Crossing Density, and Proximity of Roads to Stream or Other Water Bodies

For this analysis, DNR assumes the extent of the road network in the OESF will remain essentially unchanged under both alternatives throughout the 100-year analysis period.[6] DNR does not expect a substantial reduction of the road network because roads are essential to working forests. Although DNR has abandoned some of its roads, very little additional road abandonment is identified in current plans. Nor does DNR expect a substantial expansion of its road network, although some new roads may be needed. It is too speculative to estimate their locations or number of miles; the exact locations and lengths of roads cannot be determined until a harvest is planned and a site assessment is performed. (For more information about the accomplishment of road maintenance and abandonment plans, refer to the summaries in Appendix C; for more information on the methodology used to calculate traffic scores, refer to Appendix C.) However, DNR compared the two alternatives by considering how far planned timber harvests are from current roads (refer to "Results").

Because the extent of the road network is held constant for this analysis, DNR bases its results for all indicators except traffic impact scores on the current condition of the road network. Current conditions and results by indicator are presented under "Results" and are not, in most instances, presented by alternative.

Traffic Impact Scores

As explained previously, traffic impact scores are based on road surface type, proximity of roads to streams or other water bodies, and the level of log-truck traffic that may result from future harvests in each landscape on all ownerships (state trust lands as well as federal, tribal, and private lands). Instead of current conditions, DNR reports traffic impact scores based on the first decade's worth of harvest activities under the No Action Alternative. Scores are provided for road networks in each of the 11 landscapes (Table 3-35). All landscapes are in the low or medium impact category, meaning their traffic impact scores are below 67. DNR does not expect significant changes in the level of road use during the 100-year analysis period. Therefore, significant changes in traffic impact scores are not expected.

Table 3-35. Traffic Impact Scores for the First Decade's Worth of Harvest Activities Under the No Action Alternative, by Landscape

Landscape	Impact score
Clallam	52 ◊
Clearwater	23 ●
Copper Mine	39 ◊
Dickodochtedar	53 ◊
Goodman	39 ◊
Kalaloch	38 ◊
Queets	32 ●
Reade Hill	33 ◊
Sekiu	65 ◊
Sol Duc	29 ●
Willy Huel	30 ●

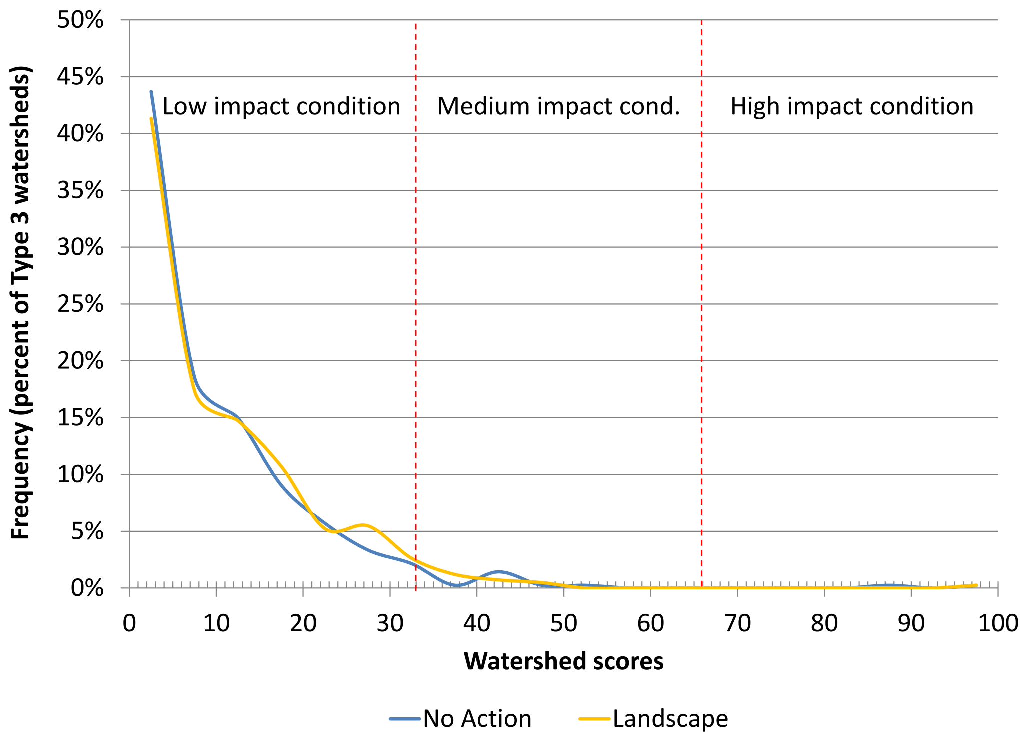
● Low impact ◊ Medium impact

Results

Indicator: Stream Shade

Under both alternatives, most watersheds are projected to remain in a low impact condition for the duration of the 100-year analysis period (Chart 3-31 from "Riparian" is presented as Chart 3-47).

Chart 3-47. Distribution of Watershed Scores for Stream Shade, Decade 9



The relative stability of shade levels in Type 3 watersheds may be due to a variety of factors. For example, physical factors that affect shade, such as the shape of the surrounding terrain, the orientation of the stream channel, and the width of the stream itself, will not change over time. In addition, 57 percent of the first 150 feet of the area of influence for shade is currently deferred from harvest. In these areas, changes in stream shade will be due solely to natural growth and disturbance. Forty-three percent of the first 150 feet of the area of influence is currently in the Competitive Exclusion stand development stage with crowded canopies and high shade levels. Changes will occur in these areas, but the shift will be slow.

In addition, variable retention harvest may reduce shade levels along Type 5 streams on stable ground because these streams do not receive interior-core buffers under either alternative. However, Type 5 streams tend to be found at higher elevations where temperatures are cooler, the terrain is more likely to provide shade, and the target shade level necessary to maintain cooler water temperatures is lower.

Because shade levels are expected to remain relatively stable over the 100-year analysis period, temperature and dissolved oxygen are expected to remain stable as well. The potential environmental impact of either alternative for this indicator is considered **low**. DNR has not identified probable significant adverse environmental impacts from either alternative for this indicator.

Indicator: Road Density

Table 3-36 shows the road density on state trust lands in each of the 11 landscapes in the OESF. Currently, road densities in all 11 landscapes exceed the 2.4 miles per square mile threshold for potential high impacts (refer to Table 3-34). Most roads in the OESF were built for timber harvesting. High road densities in the OESF are primarily due to topography; more miles of road are needed to navigate steep terrain than flat terrain. In part, high road densities are also a legacy of the 1962 Columbus Day storm, which caused extensive windthrow on the western Olympic Peninsula. A salvage logging operation after this storm required the building of an extensive road network. Impacts from road density may include increased delivery of fine sediment to streams. As mentioned previously, DNR does not expect road density to change through the 100-year analysis period.

Table 3-36. Current Road Density on State Trust Lands in the OESF, by Landscape

Landscape	Road density (road miles per square mile)
Clallam	4.3 ■
Clearwater	3.7 ■
Copper Mine	5.0 ■
Dickodochtedar	4.5 ■
Goodman	4.2 ■
Kalaloch	5.0 ■
Queets	5.0 ■
Reade Hill	3.7 ■
Sekiu	4.7 ■
Sol Duc	3.7 ■
Willy Huel	4.1 ■

■ **High impact**

As stated previously, it is too speculative to determine the precise number of miles of new roads necessary to complete planned harvest activities. However, using the forest estate model, it is possible to compare the two alternatives by determining the number of acres of harvest activities projected to occur in the first decade of the analysis period on state trust lands that are more than 800 feet from the nearest road. (DNR measured the distance from a central point in each harvest unit.) DNR predicts that harvests more than 800 feet from an existing road may require extending existing roads or building new roads. Table 3-37 presents the results.

Table 3-37. Projected Acres of Harvest Activities on State Trust Lands and More Than 800 Feet From an Existing Road in the First Decade of the Analysis Period, by Alternative

Landscape	Acres of harvest activities located more than 800 feet from an existing road	
	No Action Alternative	Landscape Alternative
Clallam	1,233	1,103
Clearwater	138	114
Coppermine	53	43
Dickodochtedar	328	351
Goodman	124	33
Kalaloch	118	76
Queets	80	71
Reade Hill	397	425
Sekiu	264	162
Sol Duc	2,033	2,610
Willy Huel	216	235
TOTAL	4,982	5,221

According to Table 3-37, during the first decade under both alternatives, the Clallam and Sol Duc landscapes have the highest projected number of acres of harvests on state trust lands that are more than 800 feet from an existing road. With the exception of the Goodman and Sekiu landscapes, the number of acres harvested over 800 feet from existing roads is similar for both alternatives.

Because potential impacts are rated high for all landscapes, the potential environmental impact of either alternative for this indicator is considered **high**. Roads can potentially deliver fine sediment to streams unless the roads have been certified as abandoned. Fine sediment delivery to streams is considered an adverse impact.

Text Box 3-6. Is the Impact Probable Significant Adverse?

DNR considers the full range of its current management practices to identify specific programs, rules, procedures, or other measures that are expected to mitigate a potential high impact to a level of non-significance. If an impact will be mitigated, it is not considered probable significant adverse.

However, this impact rating is based solely on the number of roads per square mile, and is made without considering the condition of the road network or current management practices (established programs, rules, procedures, or other practices) that are expected to mitigate a potential high impact to a level of non-significance. DNR expects potential fine sediment delivery from the road network to be mitigated to a non-significant level through current management practices (refer to Text Box 3-6), including the accomplishment of road maintenance and abandonment plans; inspecting, repairing, and maintaining roads; and suspending timber hauling during storms (refer to "Mitigation" later in this section for more information). Also, new roads will be constructed to current forest practices standards, which are designed to prevent or limit the delivery of fine sediment to streams (Martin 2009, Dubé and others

2010). Therefore, DNR has not identified probable significant environmental impacts from either alternative for this indicator.

Indicator: Stream Crossing Density

Table 3-38 shows the number of stream crossings per mile of stream for roads on state trust lands in each of the 11 landscapes in the OESF. Currently, stream crossing densities range from low (in seven landscapes) to medium (in four landscapes). None of the landscapes exceeds the high impact threshold of 2.6 stream crossings per mile (refer to Table 3-34). Since the road network is not expected to change significantly over the 100-year analysis period, stream crossing density is not expected to change significantly. DNR expects all landscapes to remain in the low or medium impact categories. Potential impacts from stream crossing density may include increased sediment delivery and stream bank erosion.

Table 3-38. Current Stream Crossing Density on State Trust Lands in the OESF, by Landscape

Landscape	Stream crossings per mile of stream
Clallam	1.2 ●
Clearwater	0.9 ●
Copper Mine	1.0 ●
Dickodochtedar	1.3 ◇
Goodman	0.8 ●
Kalaloch	1.4 ◇
Queets	1.5 ◇
Reade Hill	0.8 ●
Sekiu	1.0 ●
Sol Duc	1.2 ●
Willy Huel	1.3 ◇

● Low impact ◇ Medium impact

Appendix C shows the number of stream crossings by stream type for roads on state trust lands in each of the 11 landscapes in the OESF. Most (65 percent) stream crossings are on Type 5 streams, 30 percent are on Type 3 and Type 4 streams, and the remaining 5 percent are on Type 1, Type 2, or Type 9 streams.

Because potential impacts are rated low for seven of the landscapes, the potential environmental impact of either alternative for this indicator is considered **low**. DNR has not identified probable significant adverse environmental impacts from either alternative for this indicator.

Indicator: Proximity of Roads to Streams or Other Water Bodies

Table 3-39 shows the current percentage of the road network that is located within 300 feet of a stream or other water body in each of the 11 landscapes. All of the landscapes in the OESF, except the Queets, currently exceed the 25 percent threshold (Potyondy and Geier 2011) for potential high impacts (refer to Table 3-34).

Table 3-39. Current Percentage of Road Network on State Trust Lands and Within 300 Feet of Streams or Other Water Bodies

Landscape	Percentage of road network
Clallam	48% ■
Clearwater	55% ■
Copper Mine	65% ■
Dickodochtedar	44% ■
Goodman	54% ■
Kalaloch	60% ■
Queets	22% ◆
Reade Hill	64% ■
Sekiu	47% ■
Sol Duc	36% ■
Willy Huel	51% ■

◆ Medium impact ■ High impact

Overall, 50 percent of the total road network on state trust lands (all landscapes) is located within 300 feet of a stream or a water body, in part because streams in the OESF are so numerous (refer to Table 3-1). Thirty-three percent of roads are located within 300 feet of a Type 5 stream (refer to Appendix C).

Because potential impacts are rated high in all landscapes except for the Queets, the potential environmental impact of either alternative for this indicator is considered **high**. Roads can potentially deliver fine sediment to streams unless the roads have been certified as abandoned. Fine sediment delivery to streams is considered an adverse impact.

However, this impact rating is based solely on the percentage of roads located within 300 feet of a stream or water body, and is made without considering the condition of the road network or current management practices (established programs, rules, procedures, or other practices) that are expected to mitigate a potential high impact to a level of non-significance. DNR expects potential fine sediment delivery from the road network to be mitigated to a non-significant level through current practices, including accomplishing road maintenance and abandonment plans; inspecting, repairing, and maintaining roads; and suspending timber hauling during storms (refer to "Mitigation" later in this section for more information). Also, new roads will be constructed to current forest practices standards, which are designed to prevent or limit the delivery of fine sediment to streams (Martin 2009, Dubé and others 2010). Therefore, DNR has not identified probable significant environmental impacts from either alternative for this indicator.

Indicator: Traffic Impact Scores

Table 3-40 shows the traffic impact scores for each landscape averaged over the 100-year analysis period for both alternatives. As the tables show, there is little difference between the alternatives.

Table 3-40. Traffic Impact Scores by Landscape and Alternative Averaged Over 100 Years

Landscape	No Action Alternative	Landscape Alternative
Clallam	51 ◇	51 ◇
Clearwater	24 ●	24 ●
Copper Mine	39 ◇	39 ◇
Dickodochtedar	54 ◇	54 ◇
Goodman	40 ◇	40 ◇
Kalaloch	38 ◇	39 ◇
Queets	32 ●	33 ◇
Reade Hill	32 ●	32 ●
Sekiu	65 ◇	65 ◇
Sol Duc	29 ●	29 ●
Willy Huel	30 ●	30 ●
OVERALL AVERAGE	40 ◇	40 ◇

● Low impact ◇ Medium impact

Because potential impacts are rated medium in seven landscapes under the No Action Alternative and 8 landscapes under the Landscape Alternative, the potential environmental impact of either alternative for this indicator is considered **medium**. DNR has not identified probable significant adverse environmental impacts from either alternative for this indicator.

Additional information in Appendix C includes the long-term traffic levels of roads in each landscape (by ownership). Appendix C also includes the current number of log truck trips per day from DNR harvest activities, and traffic impact scores for each landscape over the 100-year analysis period by decade.

Mitigation

Following, DNR describes current management practices (established programs, rules, procedures, or other practices) that are expected to mitigate potential high impacts to a level of non-significance. This mitigation applies to the following indicators: road density and proximity of roads to streams or other water bodies.

Road Maintenance and Abandonment Plans

The forest practices rules contain direction for road construction and maintenance (WAC 222-24) to protect water quality and riparian habitat. Road construction and maintenance must prevent or limit actual or potential delivery of sediment and surface water to any typed water where such delivery would prevent the achievement of fish habitat or water quality goals.

The forest practices rules require large forest landowners,[7] such as DNR, to prepare road maintenance and abandonment plans for all roads that have been used or constructed since 1974.[8] These plans specify the steps that will be taken to either abandon roads or bring roads that do not meet current standards into compliance. Consistent with the forest practices rules, DNR has developed road maintenance and abandonment plans for roads on state trust lands in each of the 11 landscapes in the OESF.

Road maintenance and abandonment plans are used to prioritize road improvement, abandonment, and maintenance projects. DNR first prioritizes projects for roads that potentially cause the greatest damage to public resources:

- Roads with fish passage barriers
- Roads that deliver sediment to streams
- Roads with evidence of existing or potential instability that could affect public resources adversely
- Roads or ditch lines that intercept ground water
- Roads or ditches that deliver surface water to streams

DNR then prioritizes projects by their potential benefit to public resources; for example, projects that affect:

- Waters containing listed threatened or endangered fish species
- Waters listed as 303(d) impaired for road-related reasons
- Areas containing sensitive geology or soils with a history of landslides
- Areas with ongoing restoration projects
- Road systems that have the highest potential use for future timber harvests

Road traffic generates sediment through surface erosion, and the key to controlling sediment is controlling erosion. Erosion control measures are necessary if exposed soils can deliver sediment to streams. DNR's objective for roads is to create a stable, dispersed, non-erosive drainage pattern associated with road surface runoff to minimize potential or actual sediment delivery to streams. Depending on what is appropriate for site-specific conditions, this objective can be accomplished in a variety of ways:

- Use ditches, culverts, and other structures to collect sediment-laden water runoff from the road and direct it to areas on the forest floor where it can be captured or safely dissipated away from the stream.
- Stabilize ditch walls by seeding them with grass or lining them with rocks.
- Construct catch basins to capture water runoff and allow sediment to settle out of the water.
- Place rock on the road surface before and after a stream crossing to help stabilize the road surface and prevent sediment delivery.
- Use temporary measures, such as placing straw bales, to capture sediment while repairs are being carried out.

Work under these plans is ongoing. Table 3-41 shows the number of projects completed under these plans by the end of 2012.

Table 3-41. Percentage of Projects Identified in Road Maintenance and Abandonment Plans and Completed by Year End 2012

Landscape	Number of projects completed by end of 2012	Total number of projects identified in plan	Percent completed
Clallam	187	252	74%
Clearwater	147	309	48%
Coppermine	150	302	50%
Dickodochtedar	423	789	54%
Goodman	239	361	66%
Kalaloch	184	227	81%
Queets	216	271	80%
Reade Hill	67	76	88%
Sekiu	89	360	25%
Sol Duc	104	107	97%
Willy Huel	246	272	90%

All work completed under these plans is performed using (as appropriate) the best management practices for road construction and maintenance described in the Forest Practices Board Manual (DNR 2013) and the guidance provided in DNR's Forest Roads Guidebook (DNR 2011). Most work involves culvert replacement, maintenance, or removal. DNR continually updates and prioritizes these plans to address newly identified environmental impacts of the existing road network.

Work associated with these plans must be completed by October 31, 2016. Summaries of DNR's accomplishments for roads in each of the 11 landscapes in the OESF and DNR's road maintenance priorities and standards are included in Appendix C.

EFFECTIVENESS OF ROAD MAINTENANCE AND ABANDONMENT PLANS

Implementing current forest practices rules for road maintenance correctly is expected to minimize runoff water and sediment delivery to typed waters (DNR 2013). A statewide study conducted on private forestlands in Washington found that road maintenance and abandonment appear to reduce the amount of road-related sediment that reaches streams (Martin 2009). This study found that implementing best management practices decreased the number of road miles hydrologically connected to streams, and that most roads studied had a low probability of delivering sediment to streams (Martin 2009). In addition, road maintenance and abandonment plan effectiveness monitoring conducted statewide by Dubé and others (2010) from 2006 through 2008 found that, as roads were brought up to modern standards, they showed decreased sediment delivery to streams.

Inspection, Maintenance, and Repair

After work identified under road maintenance and abandonment plans has been completed by 2016, DNR will continue to inspect, maintain, and repair roads and bridges as needed using the appropriate best management practices for road maintenance and repair identified in the current Forest Practices Board Manual and the guidance in the Forest Roads Guidebook. Routine maintenance of road dips and surfaces and responding quickly to problems can reduce road-caused slumps and slides significantly and prevent the creation of berms that could channelize runoff (Environmental Protection Agency 2012).

Suspension of Timber Hauling During Storm Events

In addition to road maintenance and abandonment plans, DNR also considers how operations can be adjusted to further prevent delivery of fine sediment to streams. For example, DNR suspends timber hauling on state trust lands in the OESF during storm events, when heavy rainfall can potentially increase surface water runoff and sediment delivery. The decision to suspend timber hauling on state trust lands is based on professional judgment. A weather event is considered a storm event when high levels of precipitation are forecast and there is a potential for drainage structures, such as culverts and ditches, to be overwhelmed, increasing the potential for sediment delivery to streams. If timber hauling is suspended, DNR monitors the road to determine if potential problems are developing that may lead to sediment delivery to streams and takes action as necessary.

Summary of Potential Impacts

Table 3-42 provides an overview of the potential environmental impacts on water quality when the criterion and all of the indicators are considered. For this analysis, only high impacts are considered potentially significant impacts. DNR has not identified probable significant adverse impacts from either alternative for the indicators stream shade, stream crossing density, or traffic use. For the indicators road density and proximity of roads to streams or other water bodies, potential high impacts will be mitigated to a level of non-significance through current management practices: the accomplishment of road maintenance and abandonment plans; the inspection, maintenance, and repair of roads; and the suspension of timber hauling during storm events. Therefore, DNR has not identified probable significant impacts for these indicators.

Table 3-42. Summary of Potential Impacts from Roads, by Alternative

Criteria	Indicator	No Action Alternative	Landscape Alternative
Adherence to water quality standards	Stream shade (surrogate for stream temperature and dissolved oxygen)	Medium ◆	Medium ◆
	Road density (surrogate for turbidity)	High ■	High ■
	Stream crossing density (surrogate for turbidity)	Low ●	Low ●
	Proximity of roads to streams or other water bodies (surrogate for turbidity)	High ■	High ■
	Traffic use (surrogate for turbidity)	Medium ◆	Medium ◆

● **Low impact** ◆ **Medium impact** ■ **High impact**

Indicators Considered but Not Analyzed

Total Dissolved Gas

Total dissolved gas refers to the amount of dissolved nitrogen and oxygen in a water body. Levels of total dissolved gas above the maximum set by Ecology (2006) can cause bubbles to form in the vascular[9] systems of fish, which can kill the fish by blocking the flow of blood through their capillary vessels (Carter 2008).

High levels of total dissolved gas can occur naturally below waterfalls, in pools at the end of river rapids, and in warm shallow water where high levels of photosynthesis occur in aquatic plants. High levels of total dissolved gas caused by human activities generally occur in pools below dam spillways during spill events, and in areas where heated water is released from industrial facilities, allowing increased plant growth and increased photosynthesis to occur (Weitkamp 2008, Carter 2008).

Because no dams or industrial facilities are located on state trust lands in the OESF, only natural occurrences of high levels of total dissolved gas are expected. These levels are beyond the control of DNR. This indicator therefore was considered but not analyzed.

Fecal Coliform Bacteria

Fecal coliform bacteria are microscopic organisms that live in the intestines of warm-blooded animals and in the waste material (feces) excreted from their intestinal tracts. Fecal coliform bacteria are not necessarily agents of disease, but may indicate the presence of disease-carrying organisms that live in the same environment as the fecal coliform bacteria (Ecology 2012b).

The presence of high numbers of fecal coliform bacteria in a water sample means that the water has received fecal matter from one or more sources. For surface water, the primary sources are wastewater treatment plant discharges, failing septic systems, and animal waste (Ecology 2012b).

There are no wastewater treatment plants or septic systems on state trust lands in the OESF, nor are there grazing allotments for domestic livestock. In the OESF, fecal coliform bacteria from animal waste would come from wildlife; this occurrence is natural and beyond the control of DNR. This indicator therefore was considered but not analyzed.

Stream pH

Stream pH is a measure of how acidic or alkaline the water is. The pH of water determines the amount of chemical materials, such as nutrients or heavy metals, which can be dissolved into the water and become biologically available to aquatic organisms. The pH of water is initially determined by the geology of the watershed and the original source of the water. In unpolluted waters such as streams, fluctuations of pH are caused naturally by seasonal and daily variations in the amount of photosynthesis occurring in the water. Waters polluted by municipal or industrial effluents (liquid waste or sewage) can experience large fluctuations in pH to levels unsuitable for aquatic organisms (Michaud 1991, Ecology 2012b). Since there are no sources of these types of effluents on state trust lands in the OESF, only naturally occurring fluctuations in pH are expected. This indicator therefore was considered but not analyzed.

Toxic, Radioactive, and Deleterious Materials

In managed forests, toxic or deleterious materials (materials that can cause harm or damage), such as pesticides, fertilizers, or oil or gasoline, can enter a water body during harvest activities. Radioactive materials are not expected to occur on the OESF.

DNR follows forest practices rules for forest chemicals such as fertilizer or herbicides. The rules are intended to eliminate the entry of forest chemicals to streams or other water bodies and to minimize the entry of forest chemicals to other sensitive areas, including channel migration zones, wetland management zones, and the interior core buffers of Type 1 through Type 5 streams.

In addition, DNR's riparian conservation strategy prevents the accidental release of deleterious materials to streams by limiting harvest activities in riparian buffers for Type 1 through Type 4 streams, as described in DNR's 1997 Habitat Conservation Plan. Because harvest activities are limited within these buffers, the potential for toxic or deleterious materials to be introduced into streams is reduced.

When management activities such as road construction or culvert replacement require in-water work, DNR follows the best management practices specified in the application for a Hydraulic Permit Approval from the Washington Department of Fish and Wildlife (WDFW). These practices are designed to avoid the release of toxic or deleterious materials. Obtaining Hydraulic Permit Approval requires compliance with the Hydraulic

Code (220-110 WAC). While the potential for accidental spills always exists, over the last 20 years, DNR has not experienced any release of toxic materials (gas, oil, or herbicides) into waters of the state (Rosanbalm 2012, pers. comm.) on state trust lands in the OESF. Therefore, this indicator was considered but not analyzed.

Section Notes

1. Except for the Lyre/Hoko Water Resource Inventory Area. Use designations have not been set for the Lyre/Hoko; however, protection of all waters for all use designations is required for surface waters not specifically identified for a particular use (Ecology 2006).
2. Section 303(d) of the Clean Water Act requires preparation of a list of waters in the state that do not meet water quality standards; the list is prepared every 2 years.
3. Under the forest practices rules (WAC 222-24-52(3)), a road is considered abandoned if: (a) roads are out-sloped, water barred, or otherwise left in a condition suitable to control erosion and maintain water movement within wetlands and natural drainages; (b) ditches are left in a suitable condition to reduce erosion; (c) the road is blocked so that four-wheel highway vehicles cannot pass the point of closure at the time of abandonment; (d) water crossing structures and fills on all typed waters are removed, except where the department determines other measures would provide adequate protection to public resources; and (e) DNR has determined that the road is abandoned.
4. Each stream reach is assigned a target shade level based on fish habitat (WAC 222-30-040) and the maximum amount of shade available given the orientation and width of the stream channel. The target shade level is intended solely for the purpose of conducting this environmental impact analysis, and does not connote or imply DNR policy direction. Refer to "Riparian," p. 3-51 for more information.
5. This ownership threshold is used to identify areas where DNR manages enough of the watershed that its management practices could influence watershed conditions. The use of such a threshold followed recommendations from federal watershed monitoring programs (Reeves and others 2004, Gallo and others 2005).
6. In the event that, during the statewide sustainable calculation, a change in the harvest level would require an increase in road density, DNR would first analyze the impacts of a higher road density through the sustainable harvest calculation process.
7. In Washington, large forest landowners are those who harvest an annual average of more than 2 million board feet of timber from their own forestland in the state.
8. Older roads that have not been used since 1974 are considered "orphaned."
9. The system of vessels and tissue that carry fluids such as blood or lymph through the body of an animal.

Fish


Photo courtesy WDFW

Why Are Fish Important?

Fish have ecological, economic, and cultural significance in Washington. Fish species such as Pacific salmon and trout are good indicators of a functioning aquatic ecosystem because they require cool, clean water as well as complex channel structures and substrates and low levels of fine sediment (Bjorn and Reiser 1991). Pacific salmon transport marine nutrients from saltwater to freshwater (Cederholm and others 1999) and, because of their abundance, play an important role as both predator and prey in riparian food webs (Gende and others 2002). Salmon are important to the economy of Washington and play an integral role in tribal culture (DNR 1997).

What Is the Status of Fish in the OESF?

Although the waters of the western Olympic Peninsula contain several federally listed and state sensitive populations of fish (refer to Appendix P), overall, this area maintains a greater proportion of robust fish populations than many other locations on the Pacific coast (Huntington and others 1996). Salmon and steelhead trout (including wild populations and those augmented by fish hatcheries) support thriving tribal and sport freshwater fisheries managed jointly by WDFW and western Washington tribes.

Nine native species of resident or anadromous[1] salmonids inhabit the rivers and stream of the OESF: sockeye salmon (*Oncorhynchus nerka*), pink salmon (*O. gorbuscha*), chum salmon (*O. keta*), Chinook salmon (*O. tshawytscha*), coho salmon (*O. kisutch*), steelhead trout (*O. mykiss*), cutthroat trout (*O. clarkii*), bull trout (*Salvelinus confluentus*), and mountain whitefish (*Prosopium williamsoni*). Seventeen species of non-game fish, including lampreys, minnows, suckers, and sculpins, are also found in the OESF. For a summary highlighting the species of special concern in the OESF, refer to Appendix P.

What Is the Criterion for Fish?

The criterion for fish is **functioning riparian habitat**. For this analysis, functioning riparian habitat is defined as habitat capable of supporting viable populations of salmonid species as well as other non-listed and candidate species that depend on healthy in-stream and riparian environments.

What Are the Indicators for Fish?

The indicators used to assess the criterion (functioning riparian habitat) are **large woody debris recruitment**, **peak flow**, **stream shade**, and **fine sediment delivery**. These indicators were selected based on DNR's expertise, existing scientific information, and current data. They reflect the primary habitat requirements shared by the life-history stages of all freshwater salmonids, which include structural diversity provided by submerged large woody debris, moderate stream flows, cool, well-oxygenated water, and low suspended sediment load (Cederholm 1994 as cited in DNR 1997).

Currently, DNR does not have, in a comprehensive or readily usable form, in-stream data on fish presence and the utilization and quality of habitat such as the amount and distribution of large woody debris, the availability and composition of spawning gravel, discharge, stream temperature, and sedimentation (settling and accumulation of sediment on the stream bed) for all streams in the OESF. Therefore, DNR used surrogates to assess current and future conditions for each indicator. For example, as a surrogate for the number and size of logs in each stream reach,[2] DNR assesses the characteristics of the riparian forest and its potential to provide large woody debris to the stream channel. DNR uses the potential of the riparian forest to provide stream shade as a surrogate for stream temperature, the potential delivery of fine sediment from the road network as a surrogate for sedimentation or turbidity (water cloudiness), and the hydrologic maturity of forests within each watershed as a surrogate for peak flow (hydrologic maturity will be discussed later in this section). These indicators will be described in detail later in this section.

Overlapping Indicators

All of the indicators used in this section overlap to some degree, meaning that they are also used to assess other topics in this RDEIS. Overlapping indicators are expected due to the complexity and interrelatedness of the components of the forest ecosystem. For example, large woody debris, peak flow, fine sediment delivery, and stream shade are also used to assess the criterion riparian function in "Riparian," p. 3-45, and stream shade is also used to assess the criterion compliance with water quality standards in "Water Quality," p. 3-115.

How Are the Indicators Analyzed?

In this section of the RDEIS, DNR uses the four indicators of riparian function (large woody debris recruitment, peak flow, stream shade, and fine sediment delivery) to analyze six types of fish habitat. In the following section, DNR explains its methodology for identifying and analyzing each habitat type. In a subsequent section DNR discusses each indicator in detail.

Identify Essential Habitat

For this analysis, DNR identifies stream reaches on state trust lands that are "essential habitat" for five species of salmonids: Chinook, coho, and Lake Ozette sockeye salmon and steelhead and bull trout. For this analysis, essential habitat is considered highly suitable for the species and life history stage in question. **The term "essential habitat" is**

used solely for the purpose of conducting this environmental impact analysis, and does not connote or imply DNR policy direction.

DNR identifies essential habitat in one of two ways:

- For Chinook and coho salmon and steelhead trout, DNR identifies essential habitat using published, peer-reviewed intrinsic potential models (refer to the next section for descriptions of these models).
- For Lake Ozette sockeye salmon and bull trout, which are listed as threatened under the Endangered Species Act, DNR identifies essential habitat using NOAA Fisheries critical habitat designations. For these species, published, peer-reviewed intrinsic potential models are not available. Maps showing the essential habitat for each species are found in Appendix P.

DNR recognizes that there are other salmonid species in the OESF (refer to Appendix P, Table P-2). DNR selected Chinook and coho salmon and steelhead trout because peer-reviewed intrinsic potential models are available for these species, and selected Lake Ozette sockeye salmon and bull trout because they are listed as threatened species and critical habitat has been designated for them.

WHAT IS AN INTRINSIC POTENTIAL MODEL?

Intrinsic potential models are computer models that provide a means to estimate, at a large scale, those portions of an area with streams that provide high-quality habitat for fish. Intrinsic potential modeling is based on the assumption that the relative value of aquatic habitat to a given fish species is strongly influenced by persistent, geomorphic characteristics not easily modified by human activities; these characteristics include channel gradient (how steep the stream is), width, and confinement (how much a channel can move within its valley). Identifying streams reaches with a high intrinsic potential enables land managers to prioritize habitat restoration, maintenance, and conservation efforts (Burnett and others 2007 as cited in Bennet and Wecker 2013).

In the absence of comprehensive, detailed, and empirical (observation-based) information on habitat suitability, intrinsic potential models offer a means of making useful comparisons based on available data (Bennet and Wecker 2013). Intrinsic potential models are particularly useful for the OESF because, as mentioned previously, in-stream data on fish presence, the utilization of habitat by fish, and the quality of fish habitat is not available in a comprehensive or readily usable form for all streams in the OESF.

Some intrinsic potential models are tailored to specific life history stages, such as spawning or rearing;[3] other models are specific to certain seasons, such as summer versus winter runs. For this analysis, DNR identified essential habitat reaches using four separate intrinsic potential models: 1) Chinook salmon spawning; 2) coho salmon summer rearing; 3) coho salmon winter rearing; and 4) steelhead trout rearing. Each model was developed by the University of Washington / Olympic Natural Resource Center in partnership with the Wild Salmon Center (Bennet and Wecker 2013).

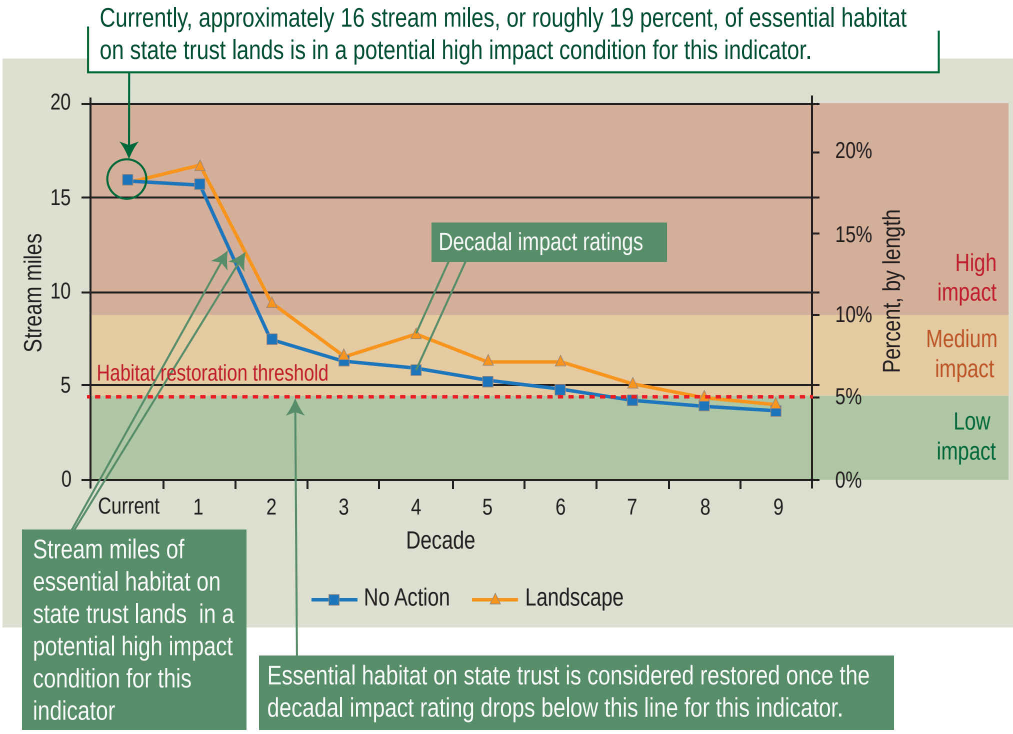
Tally the Amount of Essential Habitat in a Potential High Impact Condition and Assign Decadal Impact Ratings

Once essential habitat is identified, DNR tallies the amount (in stream miles) of essential habitat on state trust lands projected to be in a potential high impact condition for each indicator in each decade of the 100-year analysis period. A potential high impact condition indicates that riparian function is impaired for that indicator. This tally is completed for each type of fish habitat: Chinook salmon spawning, coho salmon summer rearing, coho salmon winter rearing, steelhead trout rearing, bull trout, and Lake Ozette sockeye salmon.

To complete this step, DNR uses forest estate model outputs to determine the type and location of future harvest activities and the forest conditions that are projected to result from those activities. As in "Riparian," DNR bases its analysis on an "area of influence," the area in which each indicator is expected to have an influence on the stream channel. The area of influence is different for each indicator and is based on DNR's review of current scientific literature (refer to "Riparian," p. 3-46 for more information). All indicators except stream shade are analyzed using two factors: the potential of the surrounding area of influence to provide riparian function, and the sensitivity, or expected stream channel response, to that function. For example, some stream reaches are more sensitive than others to large woody debris recruitment, meaning that large woody debris is critical to maintaining the shape of the stream channel, providing habitat features such as pools, trapping sediment, or protecting stream banks. Sensitivity is based on gradient and confinement. Refer to "Riparian," p. 3-47 for more information on sensitivity and potential. A full explanation of how sensitivity and potential are determined can be found in Appendix G.

Results are graphed to show trends across time (refer to Figure 3-18). Each decade is assigned a decadal impact rating according to the following criteria: if less than 5 percent of essential habitat is in a potential high impact condition, the decadal impact is low; if between 5 and 10 percent, the decadal impact is medium; if more than 10 percent, the decadal impact is high. For this impact analysis, DNR considers 5 percent the "habitat restoration threshold," meaning that if less than 5 percent of habitat is in a potential high impact condition, habitat is considered restored. These thresholds are based on DNR's professional judgment. **The "habitat restoration threshold" is intended solely for the purpose of conducting this environmental impact analysis, and does not connote or imply DNR policy direction.**

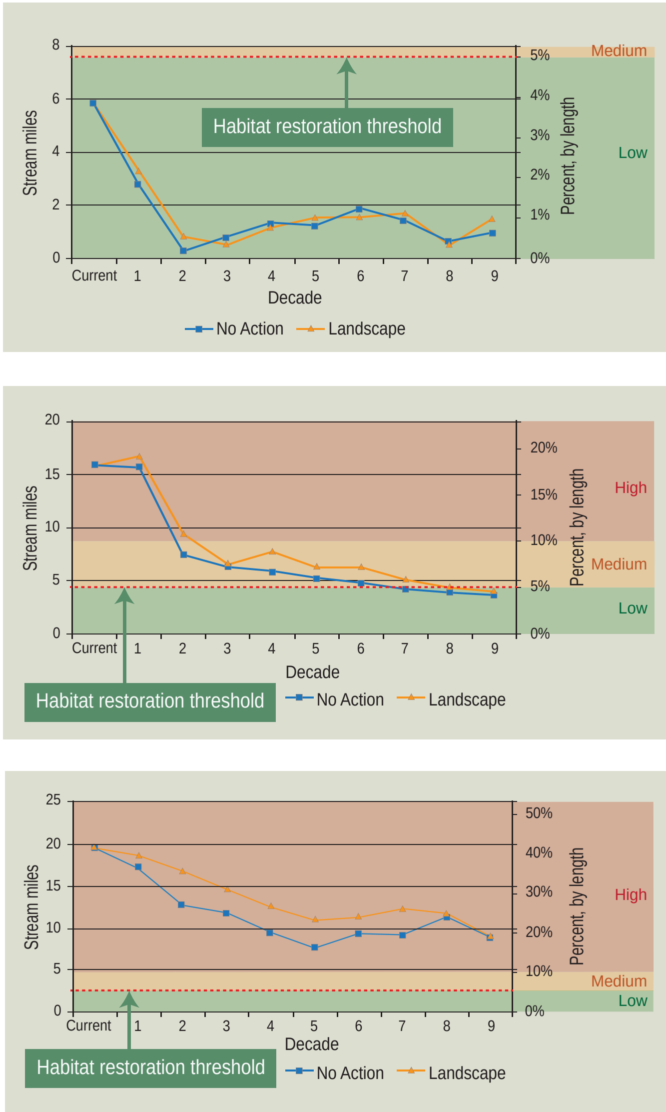
Figure 3-18. Example, Decadal Impact Ratings (for illustrative purposes only)



Determine Final Impact Ratings

To make a final, qualitative assessment of impacts for each indicator, DNR considers the proportion of essential habitat in a potential high impact condition across all decades of the 100-year analysis period. Impact levels are assigned according to the criteria in Figure 3-19. DNR provides results for each indicator, for each type of fish habitat, for each alternative.

Figure 3-19. Examples, Final Impact Ratings (for illustrative purposes only)



Low Impact
Habitat is projected to be restored and maintained.

For most or all of the analysis period, the decadal impact rating is low (less than 5 percent of essential habitat is in a potential high impact condition). Put another way, most or all of the decadal impact ratings fall below the habitat restoration threshold.

Medium Impact
Habitat is either not projected to be restored or maintained, or the rate of recovery is slow.

For most of the analysis period, the decadal impact rating is medium (between 5 and 10 percent of essential habitat is in a potential high impact condition).

High Impact
Habitat is either not projected to be restored or maintained, or the rate of recovery is slow.

For most of the analysis period, the decadal impact rating is high (more than 10 percent of essential habitat is in a potential high impact condition).

Descriptions of the Indicators

Indicator: Large Woody Debris Recruitment

Large woody debris recruitment refers to logs, pieces of logs, root wads, and large chunks of wood that fall into stream channels. Large woody debris causes the stream channel to move back and forth across the floodplain, which creates backwaters (areas with little or no current) along the stream edge, increases variations in stream depth (Maser and others 1988 as cited in DNR 1997), and slows the flow of water during periods of high stream flows, which decreases streambed scour and bank erosion.

Large woody debris in streams creates essential elements of fish habitat, such as pools, riffles,[4] side channels, and undercut banks (Swanston 1991, Maser and others 1988 as cited in DNR 1997), and also provides cover for fish to hide from predators and competitors (Bjornn and Reiser 1991 as cited in DNR 1997). Water and sediment can become partially dammed above a large log or group of logs, which can create an area of calm water in an otherwise steep, fast-flowing stream. Gravel of various sizes, essential to salmon spawning, can be deposited in these relatively calm areas (Bisson and others 1987 as cited in DNR 1997). Logs or groups of logs in the stream can hold fine and coarse sediments that otherwise would impact downstream salmon spawning areas (DNR 1997). Logs or groups of logs can also help increase stream productivity[5] by trapping leaf and needle litter, salmon carcasses, or other sources of nutrients that otherwise would be flushed downstream (DNR 1997). In some steeper streams, most of the suitable spawning sites are located upstream of large woody debris (Opperman and others 2006).

For this indicator, DNR assesses the potential of the area of influence to provide large woody debris to the stream reach, and the expected channel response, or sensitivity of the stream channel, to large woody debris input. The area of influence for large woody debris recruitment is the 100-year floodplain[6] plus an additional 150 feet (approximately one tree height).

Riparian forests in a potential low impact condition are the most capable of providing large woody debris to the stream channel. Stream reaches in riparian forests that are not capable of providing large woody debris (potential high impact condition) may lack important fish habitat components that are provided or influenced by the presence of large woody debris.

Indicator: Peak Flow

Peak flow is a period of high stream flow or maximum discharge, usually associated with storm events. Peak flows can cause changes in the shape and function of the stream channel, which can cause long-term damage to riparian ecosystems and loss of salmon habitat. Peak flows can destabilize and transport large woody debris, fill pools with sediment, and destroy the nests (referred to as redds) where salmon lay their eggs. Peak flows can transform complex stream channels containing large woody debris, pools, riffles, and side channels into simple, more uniform channels with limited value as salmon habitat (DNR 1997).

The area of influence for this indicator is the Type 3 watershed (a Type 3 watershed is a watershed that drains a Type 3 stream[7]). For this indicator, DNR assessess the potential for peak flow by measuring the proportion of hydrologically immature forests in a watershed. Hydrologically immature forests are young (less than 25 years old) and sparse (relative density less than 25). These forests contribute more to peak flow because they lack a dense canopy and therefore have greater snow accumulations and subsequent rapid melting (DNR 2004). Excessive peak flows are more likely during storm events in watersheds with a high proportion of hydrologically immature forests. DNR combines potential for peak flow with the sensitivity of stream reaches to peak flow.

Indicator: Stream Shade

Stream shade refers to the extent to which incoming sunlight is blocked on its way to the stream channel. Stream shade is one of the primary factors influencing stream temperature (Brown 1969). Water temperature affects salmon's rate of growth and development.

Salmon are cold-water fish, and their preferred temperature range is between 50 and 57 degrees Fahrenheit (Bjornn and Reiser 1991 as cited in DNR 1997). Bull trout favor even colder water; in Washington, most bull trout spawn in water between 41 and 42.8 degrees Fahrenheit (Brown 1994 as cited in DNR 1997). High water temperatures also can reduce dissolved oxygen levels in the water (DNR 1997), which can stress populations of fish and the aquatic insects that support them. For example, salmon eggs require a high concentration of dissolved oxygen in order to incubate successfully.

Factors that affect shading include stream size and orientation, local topography, tree species, tree height, stand density, and elevation (DNR 2004). For example, streams at higher elevations require less shade to maintain cool water temperatures (Sullivan and others 1990) than streams at lower elevations. In addition, at higher elevations terrain is steeper, stream channels tend to be narrower and more confined, and the topography itself is more likely to provide shade (refer to Figure 3-10 in "Riparian"). At lower elevations, streams tend to occupy flatter terrain and are less likely to be shaded by topography. In addition, wide, low-elevation streams are generally more open to the sky and naturally shade-limited.

Stream shade is measured by using a computer model that projects how sunlight decreases as it passes through riparian forests or is blocked by surrounding terrain. The model for this indicator measures the potential amount of shade at the midpoint of each stream reach at hourly intervals on the hottest day of the year (July 31).[8] For this RDEIS analysis, each stream reach is assigned a target shade level[9] based on the amount of shade necessary to maintain stream temperatures within acceptable levels (adapted from WAC 222-30-040) and the maximum amount of shade available, given the orientation and width of the stream channel.

The area of influence is the area through which sunlight passes on its way to the stream. To determine impacts, DNR compares the target shade level for each stream reach to the amount of shade that would be present after management activities have taken place. For a detailed explanation of how shade is measured, refer to Appendix G.

Indicator: Fine Sediment Delivery

Fine sediment refers to small soil particles, such as sand, silt, or clay, generally less than approximately 1/16th of an inch in diameter. Increased levels of fine sediment in streams can have detrimental effects on both water quality and aquatic habitat. Fine sediment can fill in pools and reduce overall habitat complexity. As particles of silt, clay, and other organic materials settle to the streambed, they can suffocate newly hatched fish larvae (Cederholm and Reid 1987) and fill in spaces between rocks which could have been used by aquatic organisms as habitat (Cederholm and Reid 1987, Cederholm and Salo 1979). Fine sediment can clog or damage sensitive gill structures, decrease a fish's resistance to disease, prevent proper egg and larval development, and potentially interfere with feeding.

Fine sediment that settles on streambeds or stays suspended in the water column can reduce salmon survival (Hicks and others 1991). For example, fine sediment deposited in areas where salmon spawn can decrease the survival of eggs and young hatchlings by reducing the availability of oxygen. Muddy, sediment-filled water causes stress to juvenile salmon during the summer (Cederholm and Reid 1987). Increased levels of fine sediment can also reduce populations of small aquatic insects, an important food source for salmon (Cederholm and Reid 1987).

Fine sediment is derived primarily from the erosion of road surfaces over time. The role of traffic in increasing road sediment production is well recognized (Luce and Black 2001, Reid and Dunne 1984), particularly on roads that are unpaved and have high volumes of vehicle traffic (Elliot and others 2009).

DNR uses traffic impact scores to assess the potential of the road network to deliver fine sediment to streams The scores are based on road surface type, proximity of roads to streams and other water bodies, and projected traffic levels. For traffic levels, DNR considers the number of times per day a log truck will drive over each segment of road to transport harvested timber to market. DNR includes log truck traffic associated with projected harvests on all ownerships (state trust lands as well as federal, tribal, and private lands). Projected traffic levels for other ownerships are based on reports of past timber harvest volume and assumptions about harvest intensity relative to DNR's projected management activities; these projected traffic levels are held constant, meaning they do not vary from one decade to the next. Recreational and other uses are not included in the analysis because information about the levels of traffic in the OESF for these uses is not available. Traffic levels are determined based on the methods of Dubé and others (2004) (refer to Appendix C for additional information). The potential for fine sediment delivery (traffic impact score) is coupled with the expected channel response, or sensitivity of the stream channel, to fine sediment input.

For this analysis, DNR assumes the extent of the road network in the OESF will remain essentially unchanged under both alternatives throughout the 100-year analysis period.[10] DNR does not expect substantial reduction of the road network because roads are essential to working forests. Although DNR has abandoned some of its roads (refer to road maintenance and abandonment plan accomplishment summaries in Appendix C), very little additional road abandonment is identified in current plans. Also, DNR does not expect a substantial expansion of its road network, although some new roads may be needed. However, it is too speculative to estimate the number of miles of road that will be needed in the future. The exact locations and lengths of roads cannot be determined until a harvest is planned and a site assessment is performed. For more information on the methodology used to calculate traffic scores, refer to Appendix C.

The area of influence for fine sediment delivery is all roads (on state trust lands and non-state trust lands) that are located within 300 feet of essential habitat on state trust lands in each Type 3 watershed. DNR based this distance on the methodology of Potyondy and Geier (2011). DNR analyzes traffic on all roads (roads on state trust lands and non-state trust lands) in the OESF because traffic associated with harvest activities may run on roads built and maintained by DNR or by other landowners. Refer to "Riparian," p. 3-52 for more information on the OESF road network and how traffic impact scores are calculated.

CONSERVATIVE APPROACH

As described in the introduction to this chapter (p. 3-14), DNR first assigns each indicator a potential low, medium, or high impact. For fine sediment delivery, in this step DNR assumes that all roads that have not been certified as abandoned[11] can contribute sediment to streams, even though some of these roads have been mitigated already or will be mitigated through current management practices to prevent the delivery of sediment from roads to stream channels. For example, mitigation can include installing culverts to direct runoff away from streams. Mitigation is not considered until the second step of DNR's analysis process, when DNR determines if a potential high impact is probable significant adverse. DNR feels this approach is conservative. Refer to the introduction to this chapter for more information on DNR's analysis methodology.

For all indicators, DNR analyzed roads classified as decommissioned as though they have the potential to deliver fine sediment, even though they have been stabilized to the same forest practices standards as abandoned roads. Abandonment is permanent; decommissioned roads may be re-opened during the analysis period (DNR 2011).

In addition, 24 percent of the roads on state trust lands are classified as having the surface type "other." For this analysis, DNR has taken a conservative approach of assuming roads classified as "other" are not paved, even though some may be paved. Road traffic generates sediment through surface erosion, which occurs only on unpaved roads. Refer to Appendix C for a description of road classifications and surface types.

SEPARATE FINE SEDIMENT ANALYSES

In this RDEIS, fine sediment delivery is also analyzed in "Riparian" and "Water Quality." Each analysis of fine sediment delivery is performed at a spatial scale appropriate to the topic and therefore the analyses will have different results.

In both "Riparian" and "Fish," DNR analyzes fine sediment delivery potential using traffic impact scores, as described in the preceding section. Both sections couple potential and sensitivity.

In "Water Quality" (p. 3-115), DNR considers potential only; DNR does not consider sensitivity. Fine sediment delivery potential in "Water Quality" is analyzed with four separate road-related indicators: traffic impact scores, road density, stream crossing density, and proximity of roads to streams and other water bodies. These indicators are based on Ecology's water quality standards. The water quality standards are primarily concerned with whether or not an impact is occurring, regardless of the sensitivity of the stream channel. For that reason, DNR considered potential only for its analysis in "Water Quality."

Summary of Criterion and Indicators

Table 3-43 summarizes the criterion and indicators and how they are measured.

Table 3-43. Criterion and Indicators for Fish and How They Are Measured

Criterion/Indicator	How the indicator is measured	Potential environmental impacts
Functioning riparian habitat/ Large woody debris recruitment	Characteristics of the riparian forest, such as the relative density and the size and species of trees, and the distance of trees from the floodplain **Area of influence**: 100-year floodplain plus an additional 150 feet (McDade and others 1990, FEMAT 1993) **Assessment area**: All stream reaches on state trust lands considered essential habitat for the species in question, using either intrinsic potential models or critical habitat designations	**Low impact**: Habitat is projected to be restored and maintained. For most of the analysis period, the decadal impact rating is low. **Medium impact**: Habitat is not projected to be restored or maintained, or the rate of recovery is slow. For most of the analysis period, the decadal impact rating is medium. **High impact**: Habitat is not projected to be restored or maintained, or the rate of recovery is slow. For most of the analysis period, the decadal impact rating is high.
Functioning riparian habitat/ Peak flow	Hydrologic maturity of the Type 3 watershed. **Area of influence**: Type 3 watershed **Assessment area**: All stream reaches on state trust lands considered essential habitat for the species in question, using either intrinsic potential models or critical habitat designations	
Functioning riparian habitat/ Stream shade	Topography, stream orientation, and characteristics of the riparian forest, including canopy closure and tree height **Area of influence**: Area through which sunlight passes on its way to the stream; shade measured at hourly intervals on the hottest day of the year (July 31) **Assessment area**: All stream reaches on state trust lands considered essential habitat for the species in question, using either intrinsic potential models or critical habitat designations	

Table 3-43, Continued. Criterion and Indicators for Fish and How They Are Measured

Criterion/Indicator	How the indicator is measured	Potential environmental impacts
Functioning riparian habitat/ Fine sediment delivery	Characteristics of the road network, such as proximity to streams and water bodies, surface type (paved or unpaved), and traffic levels, measured using traffic impact scores **Area of influence**: All roads on state trust lands and non-state trust lands that are located within 300 feet (Potyondy and Geier 2011) of stream reaches on state trust lands that are considered essential habitat for the species in question **Assessment area**: All stream reaches on state trust lands considered essential habitat for the species in question, using either intrinsic potential models or critical habitat designations	**Low impact**: Habitat is projected to be restored and maintained. For most of the analysis period, the decadal impact rating is low. **Medium impact**: Habitat is not projected to be restored or maintained, or the rate of recovery is slow. For most of the analysis period, the decadal impact rating is medium. **High impact**: Habitat is not projected to be restored or maintained, or the rate of recovery is slow. For most of the analysis period, the decadal impact rating is high.

Current Conditions and Results

In the following section, DNR describes current conditions and results for each of the six habitat types. For each habitat type, DNR first describes the habitat and then presents current conditions and results for each of the four indicators. A graphic at the beginning of each habitat type is included to help readers navigate this section. Following current conditions and results, DNR provides a brief discussion of the results.

Chinook Salmon Spawning Habitat

Chinook salmon tend to spawn in the mainstem of streams, where the water flow is high, but have been known to spawn in habitats ranging from small tributaries 7 to 10 feet wide and an inch or less deep, to large rivers 10 feet deep. Because of their large size, Chinook salmon can spawn in faster-flowing water and use coarser substrates (such as gravel) than other salmon species. While Chinook salmon may migrate

Section Signpost

Habitat type	*Indicator*
Chinook salmon spawning	LWD PF Shade Fine sed
Coho salmon summer rearing	LWD PF Shade Fine sed
Coho salmon winter rearing	LWD PF Shade Fine sed
Steelhead trout rearing	LWD PF Shade Fine sed
Bull trout	LWD PF Shade Fine sed
Lake Ozette sockeye salmon	LWD PF Shade Fine sed

LWD: large woody debris recruitment PF: peak flow
Shade: stream shade Fine Sed: fine sediment delivery

through steeper stream reaches, it is generally accepted that they spawn (and rear) primarily in stream reaches with a slope of less than 4 or 5 percent (Lunet and others 1997 as cited in Pacific Fisheries Management Council [PFMC] 1999). In general, within a given stream, Chinook salmon tend to be in the lower reaches, coho salmon in reaches at intermediate elevations and distances upriver, and steelhead trout still farther up (Quinn 2005).

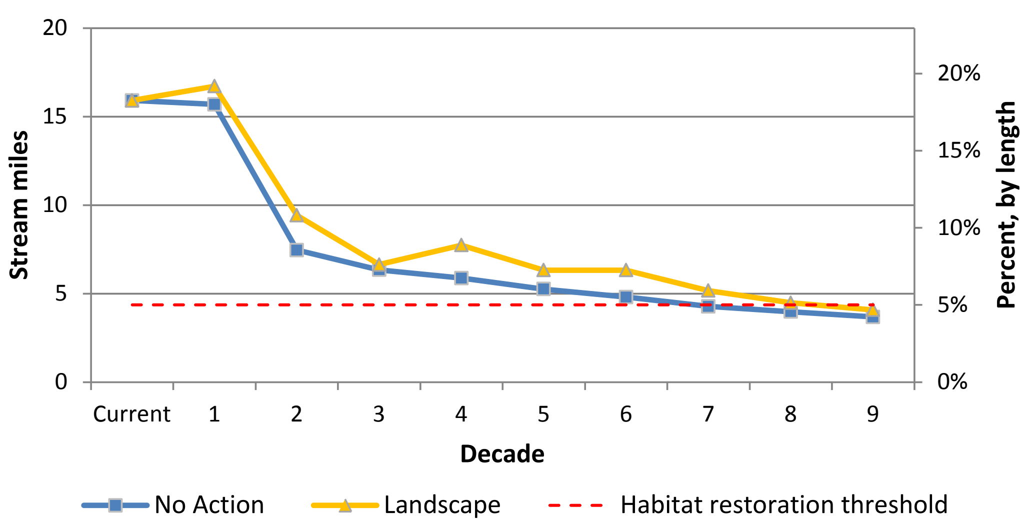
Using an intrinsic potential model, DNR identified 87.2 miles of streams on state trust lands within the OESF as essential spawning habitat for Chinook salmon (Map P-1, Appendix P).

LARGE WOODY DEBRIS RECRUITMENT | Chinook Salmon Spawning Habitat

- **Current conditions**: Of the 87.2 miles of essential habitat on state trust lands, 15.9 miles (18.3 percent) are in a potential high impact condition for large woody debris recruitment (Chart 3-48).
- **Results**: Rapid improvement in early decades followed by gradual improvement under either alternative; the amount of essential habitat in a potential high impact condition is projected to decrease (Chart 3-48).

Chart 3-48. Impacts to Large Woody Debris Recruitment Along Essential Chinook Salmon Spawning Habitat on State Trust Lands

Reported as the amount (stream miles) and proportion (percent, by length) of essential habitat with potential high impacts



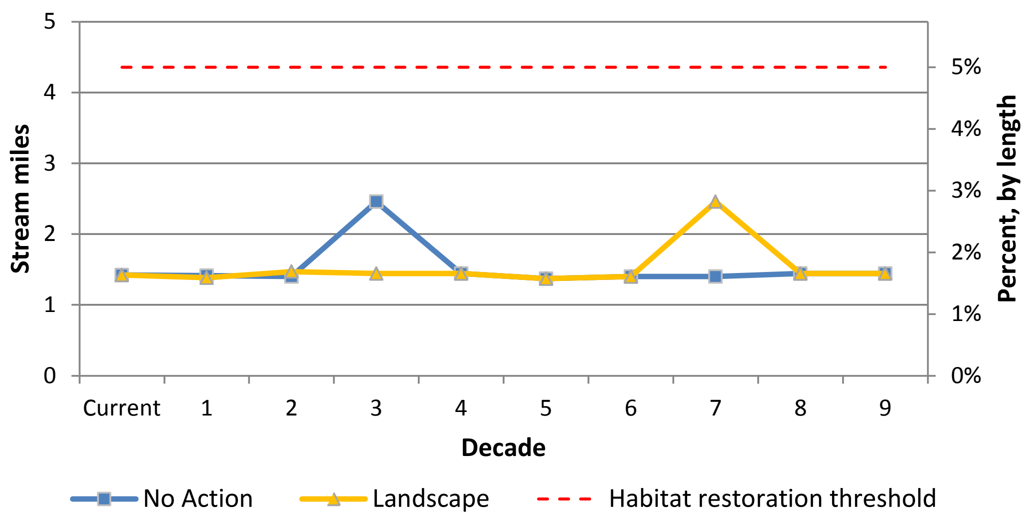
- **Impact rating**: The potential environmental impact is considered **medium** under either alternative. Habitat restoration occurs but the rate of recovery is slow (Decade 7 under the No Action Alternative, Decade 9 under the Landscape Alternative). DNR has not identified probable significant adverse impacts from either alternative for large woody debris recruitment for Chinook salmon spawning habitat.

PEAK FLOW | Chinook Salmon Spawning Habitat

- **Current conditions**: Of the 87.2 miles of essential habitat on state trust lands, 1.4 miles (1.6 percent) are in a potential high impact condition for peak flow (Chart 3-49).
- **Results**: Generally stable under either alternative; a relatively small amount (approximately 2 to 3 percent) of essential habitat is projected to be in a potential high impact condition in any decade, with the exception of Decade 3 (No Action Alternative) and Decade 7 (Landscape Alternative) (Chart 3-49).

Chart 3-49. Impacts From Peak Flow Along Essential Chinook Salmon Spawning Habitat on State Trust Lands

Reported as the amount (stream miles) and proportion (percent, by length) of essential habitat with potential high impacts



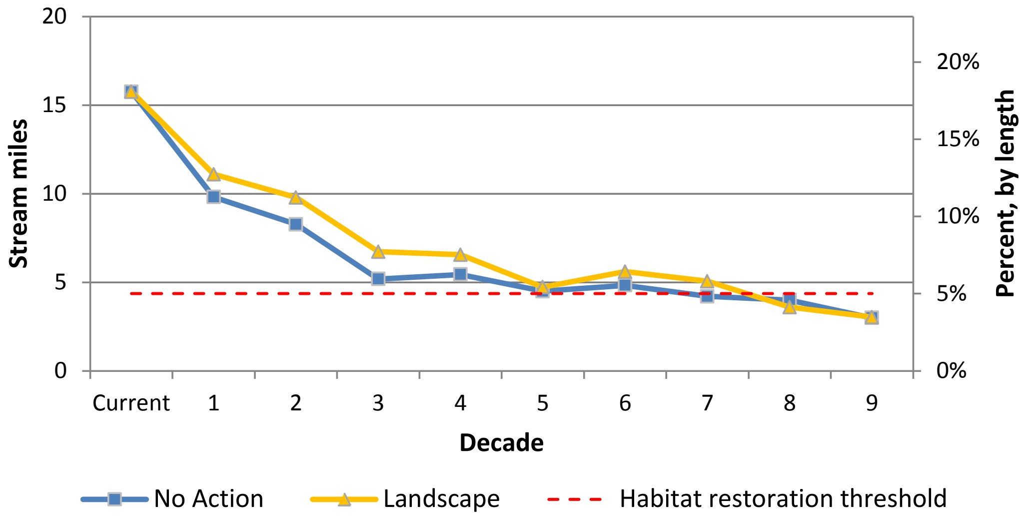
- **Impact rating**: The potential environmental impact is considered **low** under either alternative. Habitat is restored and maintained. DNR has not identified probable significant adverse impacts from either alternative for peak flow for Chinook salmon spawning habitat.

STREAM SHADE | Chinook Salmon Spawning Habitat

- **Current conditions**: Of the 87.2 miles of essential habitat on state trust lands, 15.8 miles (18.1 percent) are in a potential high impact condition for stream shade (Chart 3-50).
- **Results**: Gradual improvement under either alternative; the amount of essential habitat in a potential high impact condition is projected to decrease (Chart 3-50).

Chart 3-50. Impacts to Stream Shade Along Essential Chinook Salmon Spawning Habitat on State Trust Lands

Reported as the amount (stream miles) and proportion (percent, by length) of essential habitat with potential high impacts



- **Impact rating**: The potential environmental impact under either alternative is considered **medium**. Habitat restoration occurs but the rate of recovery is projected to be slow (Decade 5 under the No Action Alternative, Decade 8 under the Landscape Alternative). DNR has not identified probable significant adverse impacts from either alternative for stream shade for Chinook salmon spawning habitat.

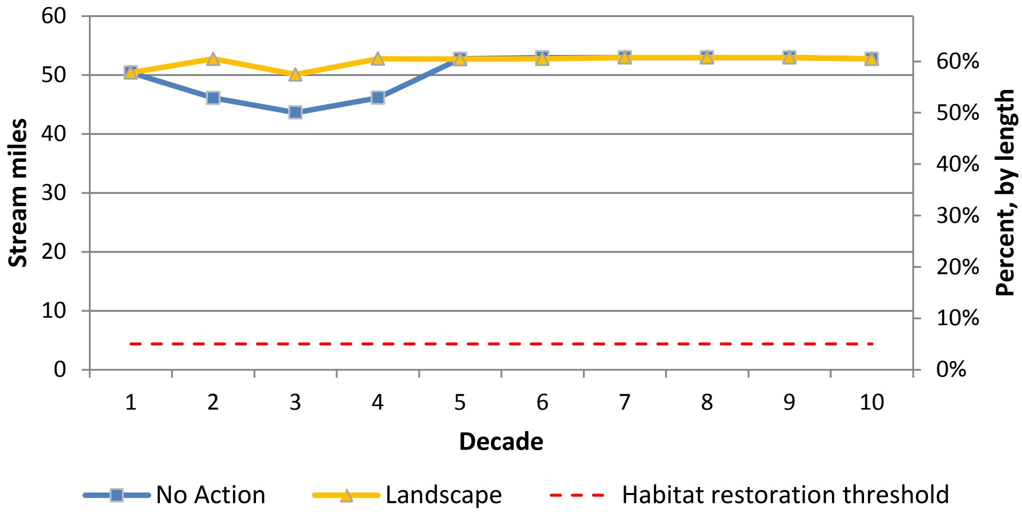
FINE SEDIMENT DELIVERY | Chinook Salmon Spawning Habitat

- **Decade 1 conditions**:[12] Of the 87.2 miles of essential habitat on state trust lands, 50.4 miles (57.8 percent) are in a potential high impact condition for fine sediment delivery (Chart 3-51).

- **Results:** Generally stable under either alternative; approximately 60 percent of essential habitat is projected to be in a potential high impact condition in most decades, with minor fluctuations in early decades (Chart 3-51).

Chart 3-51. Impacts From Fine Sediment Delivery Along Essential Chinook Salmon Spawning Habitat on State Trust Lands

Reported as the amount (stream miles) and proportion (percent, by length) of essential habitat with potential high impacts



- **Impact rating**: The potential environmental impact under either alternative is considered **high**. Habitat is not restored or maintained. Impacts for fine sediment delivery for Chinook salmon spawning habitat are adverse but not probable or significant due to mitigation through current management practices. Mitigation is expected to reduce impacts to a level of non-significance (refer to "Mitigation" later in this section).

Coho Salmon Summer Rearing Habitat

Section Signpost

Habitat type	*Indicator*
Chinook salmon spawning	LWD PF Shade Fine sed
Coho salmon summer rearing	LWD PF Shade Fine sed
Coho salmon winter rearing	LWD PF Shade Fine sed
Steelhead trout rearing	LWD PF Shade Fine sed
Bull trout	LWD PF Shade Fine sed
Lake Ozette sockeye salmon	LWD PF Shade Fine sed

LWD: large woody debris recruitment PF: peak flow
Shade: stream shade Fine Sed: fine sediment delivery

Coho salmon are often the most numerous salmonid in streams where they occur and are generally found in stream reaches with higher gradients than Chinook salmon (Quinn 2005). Unlike other Pacific salmon species, for which the majority of production comes from large spawning populations in a few river basins, coho salmon production results from spawners using numerous small streams (Sandercock 1991 as cited in PFMC 1999).

Coho salmon are highly migratory at each stage of their lives and are dependent on high-quality spawning, rearing, and migration habitat. Soon after emergence in spring, fry (recently hatched fish) move from spawning areas to rearing areas. The vast majority of juvenile coho salmon spend one year in freshwater before migrating to the sea (PFMC 1999).

During summer rearing, the highest juvenile coho salmon densities tend to occur in areas with abundant prey and structural habitat elements (such as large woody debris and associated pools). Preferred habitats include a mixture of different types of pools, glides[13], and riffles with large woody debris, undercut banks, and overhanging vegetation (Foerster and Ricker 1953, Chapman 1965, Reeves and others 1989, Bjornn and Reiser 1991, as cited in PFMC 1999). Juvenile coho salmon use higher gradient, colder water, upper reaches in summer; winter freshets[14] move juveniles to downstream, lower gradient reaches where they occupy off-channel habitat such as oxbows and beaver ponds until undergoing smoltification (adaptation from fresh to saltwater) (Bennet and Wecker 2013). Coho salmon smolt[15] production is most often limited by the availability of summer and winter freshwater rearing habitats (Williams and others 1975, Reeves and others 1989, Nickelson and others 1992, as cited in PFMC 1999).

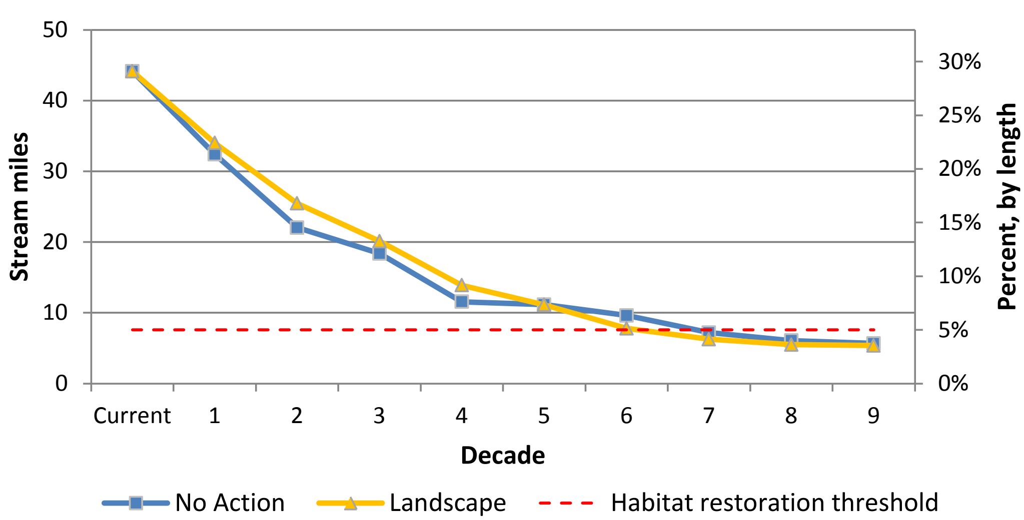
Using an intrinsic potential model, DNR identified 151.7 miles of streams on state trust lands within the OESF as essential summer rearing habitat for coho salmon (Map P-2, Appendix P).

LARGE WOODY DEBRIS RECRUITMENT | Coho Salmon Summer Rearing Habitat

- **Current conditions**: Of the 151.7 miles of essential habitat on state trust lands, 44.1 miles (29.1 percent) are in a potential high impact condition for large woody debris recruitment (Chart 3-52).
- **Results**: Gradual improvement under either alternative; the amount of essential habitat in a potential high impact condition is projected to decrease (Chart 3-52).

Chart 3-52. Impacts to Large Woody Debris Recruitment Along Essential Coho Salmon Summer Rearing Habitat on State Trust Lands

Reported as the amount (stream miles) and proportion (percent, by length) of essential habitat with potential high impacts



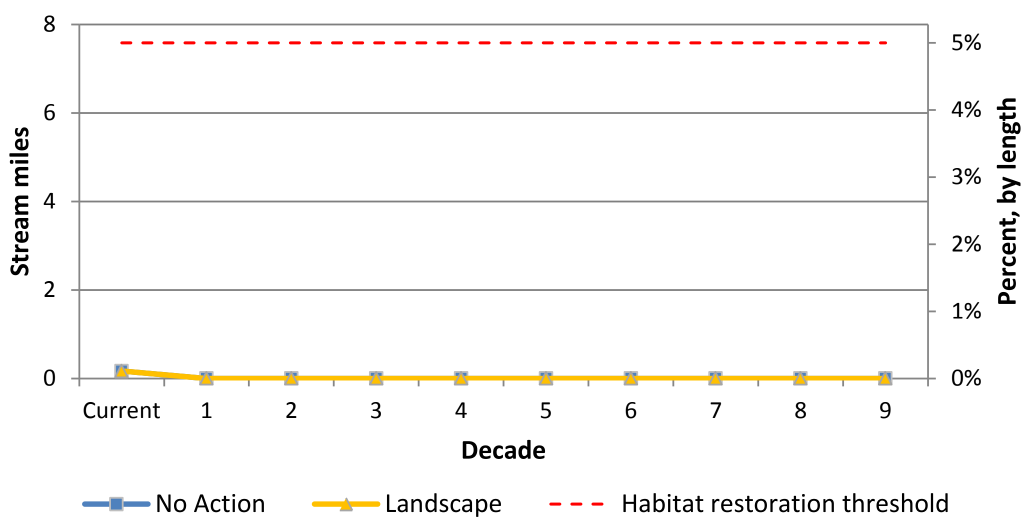
- **Impact rating**: The potential environmental impact under either alternative is considered **medium**. Habitat restoration occurs but the rate of recovery is slow (Decade 7 under either alternative). DNR has not identified probable significant adverse impacts from either alternative for large woody debris recruitment for coho salmon summer rearing habitat.

PEAK FLOW | Coho Salmon Summer Rearing Habitat

- **Current conditions**: Of the 151.7 miles of essential habitat on state trust lands, 0.02 mile (less than one tenth of one percent) are in a potential high impact condition for peak flow (Chart 3-53).
- **Results**: Generally stable under either alternative; after Decade 1, no essential habitat is projected to be in a potential high impact condition (Chart 3-53).

Chart 3-53. Impacts From Peak Flow Along Essential Coho Salmon Summer Rearing Habitat on State Trust Lands

Reported as the amount (stream miles) and proportion (percent, by length) of essential habitat with potential high impacts



- **Impact rating**: The potential environmental impact under either alternative is considered **low**. Habitat is restored and maintained. DNR has not identified probable significant adverse impacts from either alternative for peak flow for coho salmon summer rearing habitat.

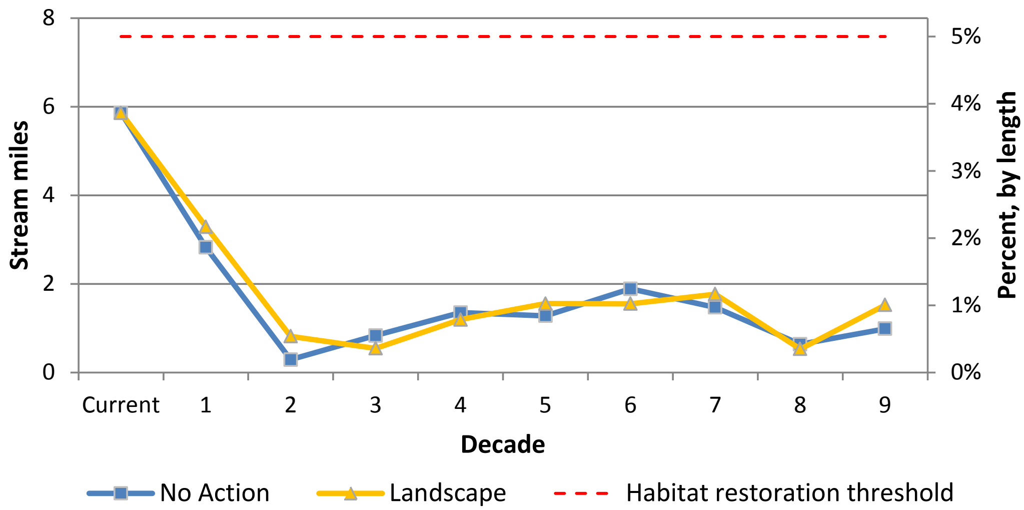
STREAM SHADE | Coho Salmon Summer Rearing Habitat

- **Current conditions**: Of the 151.7 miles of essential habitat on state trust lands, 5.6 miles (3.9 percent) are in a potential high impact condition for stream shade (Chart 3-54).

- **Results**: Under either alternative, a rapid improvement in conditions in the first two decades followed by variable conditions in subsequent decades (Chart 3-54); after the first decade, approximately one percent or less of essential habitat is projected to be in a potential high impact condition.

Chart 3-54. Impacts to Stream Shade Along Essential Coho Salmon Summer Rearing Habitat on State Trust Lands

Reported as the amount (stream miles) and proportion (percent, by length) of essential habitat with potential high impacts



- **Impact rating**: The potential environmental impact of either alternative for this indicator is considered **low**. Habitat is restored and is maintained. DNR has not identified probable significant adverse impacts from either alternative for stream shade for coho salmon summer rearing habitat.

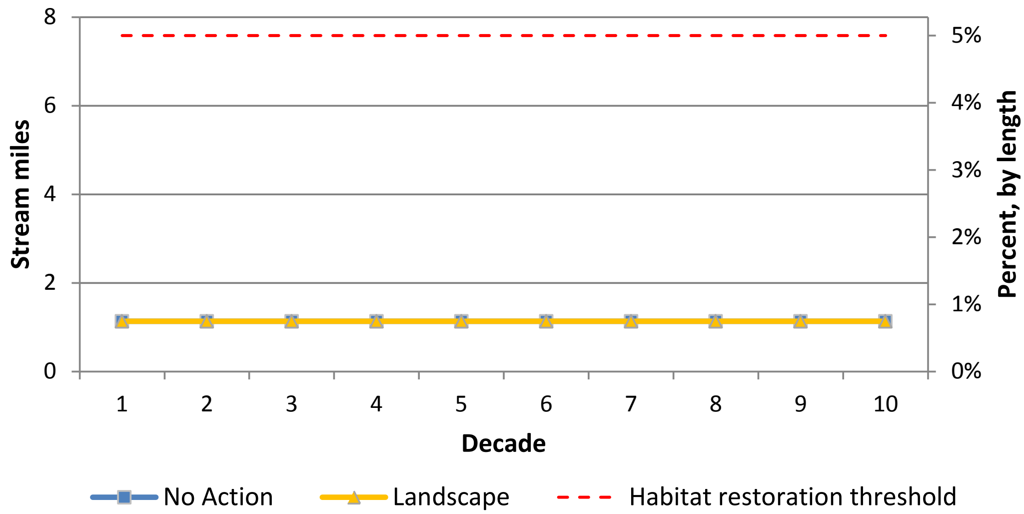
FINE SEDIMENT DELIVERY | Coho Salmon Summer Rearing Habitat

- **Decade 1 conditions**: Of the 151.7 miles of essential habitat on state trust lands, 1.1 miles (0.8 percent) are in a potential high impact condition for fine sediment delivery (Chart 3-55).

- **Results**: Generally stable under either alternative; in all decades, less than 1 percent of essential habitat is projected to be in a potential high impact condition (Chart 3-55).

Chart 3-55. Impacts From Fine Sediment Delivery Along Essential Coho Salmon Summer Rearing Habitat on State Trust Lands

Reported as the amount (stream miles) and proportion (percent, by length) of essential habitat with potential high impacts



- **Impact rating**: The potential environmental impact of either alternative for this indicator is considered **low.** Habitat is restored and maintained. DNR has not identified probable significant adverse impacts from either alternative for fine sediment delivery for coho salmon summer rearing habitat.

Coho Salmon Winter Rearing Habitat

Section Signpost

Habitat type	*Indicator*
Chinook salmon spawning	LWD PF Shade Fine sed
Coho salmon summer rearing	LWD PF Shade Fine sed
Coho salmon winter rearing	LWD PF Shade Fine sed
Steelhead trout rearing	LWD PF Shade Fine sed
Bull trout	LWD PF Shade Fine sed
Lake Ozette sockeye salmon	LWD PF Shade Fine sed

LWD: large woody debris recruitment PF: peak flow
Shade: stream shade Fine Sed: fine sediment delivery

In the fall, juvenile coho salmon migrate from summer to winter rearing areas. Winter freshets also move juveniles into downstream, lower-gradient reaches. During the winter, juvenile coho salmon gather in freshwater habitats that provide cover with relatively stable depth, velocity, and water quality. In general, juvenile coho prefer a narrower range of habitats in winter than summer, favoring large mainstem pools, backwaters, beaver ponds, off-channel ponds, sloughs, and secondary channel pools with abundant large woody debris, undercut banks, and debris along riffle margins (Skeesick 1970, Nickelson and others 1992 as cited in PFMC 1999).

Coastal streams, wetlands, lakes, sloughs, estuaries, and tributaries to large rivers can all provide coho rearing habitat. The most productive habitat exists in smaller streams having low-gradient alluvial channels with abundant pools formed by large woody debris (Foerster and Ricker 1953, Chapman 1965 as cited in PFMC 1999). Beaver ponds and large slackwater areas can provide some of the best rearing areas for juvenile coho (Bustard and Narver 1975, Nickelson and others 1992, as cited in PFMC 1999).

Inadequate winter rearing habitat is considered the primary factor limiting coho production in many coastal streams (Cederholm and Scarlett 1981, Swales and others 1988, Nickelson and others 1992 as cited in PFMC 1999). The key features of winter habitat for juvenile salmonids are substrate, cover, and lower water velocity. These features are affected by natural and land use processes. Winter mortality factors include hazardous conditions (such as scour and high water velocities) during winter peak flow events, stranding of fish during floods or by ice damming, stress from low temperature, and starvation (Hartman and others 1984 as cited in PFMC 1999).

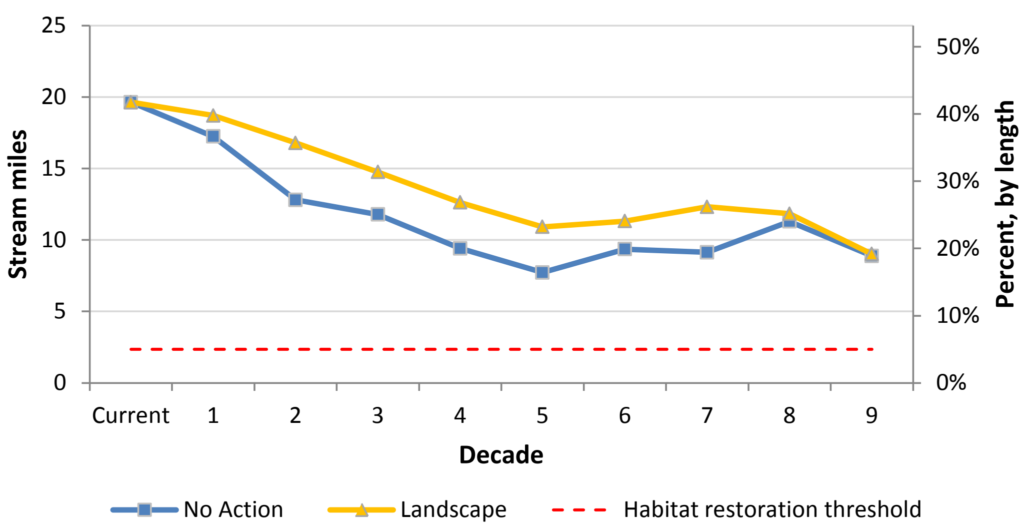
Using an intrinsic potential model, DNR identified 47.0 miles of streams on state trust lands within the OESF as essential winter rearing habitat for coho salmon (Map P-3, Appendix P).

LARGE WOODY DEBRIS RECRUITMENT | Coho Salmon Winter Rearing Habitat

- **Current conditions**: Of the 47.0 miles of essential habitat on state trust lands, 19.6 miles (41.7 percent) are in a potential high impact condition for large woody debris recruitment (Chart 3-56).
- **Results**: Gradual improvement under either alternative; the amount of essential habitat in a potential high impact condition is projected to decrease but remain above 10 percent (Chart 3-56).

Chart 3-56. Impacts to Large Woody Debris Recruitment Along Essential Coho Salmon Winter Rearing Habitat on State Trust Lands

Reported as the amount (stream miles) and proportion (percent, by length) of essential habitat with potential high impacts



- **Impact rating**: The potential environmental impact of either alternative for this indicator is considered **high**. Habitat is not restored or maintained. Probable significant adverse impacts have been identified under both alternatives for large woody debris recruitment for coho salmon winter rearing habitat. Refer to "Mitigation" in this section.

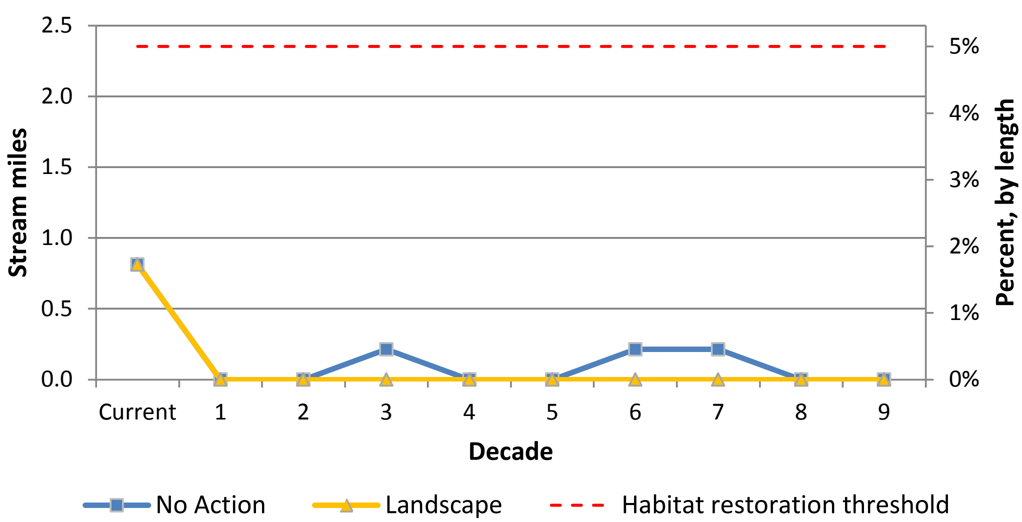
PEAK FLOW | Coho Salmon Winter Rearing Habitat

- **Current conditions**: Of the 47.0 miles of essential habitat on state trust lands, 0.8 mile (1.7 percent) is in a potential high impact condition for peak flow (Chart 3-57).

- **Results**: Generally stable under either alternative, with between zero and less than one percent of essential habitat projected to be in a potential high impact condition (Chart 3-57).

Chart 3-57. Impacts From Peak Flow Along Essential Coho Salmon Winter Rearing Habitat on State Trust Lands

Reported as the amount (stream miles) and proportion (percent, by length) of essential habitat with potential high impacts



- **Impact rating**: The potential environmental impact of either alternative for this indicator is considered **low**. Habitat is restored and maintained. DNR has not identified probable significant adverse impacts from either alternative for peak flow for coho salmon winter rearing habitat.

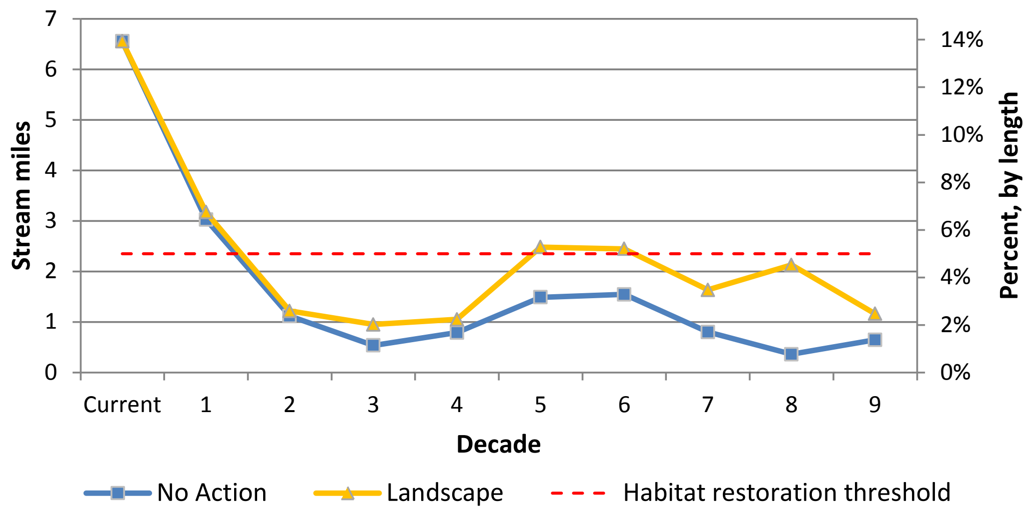
STREAM SHADE | Coho Salmon Winter Rearing Habitat

- **Current conditions**: Of the 47.0 miles of essential habitat on state trust lands, 6.6 miles (13.9 percent) are in a potential high impact condition for stream shade (Chart 3-58).

- **Results**: Rapid improvement in the first two decades under either alternative; variable conditions in subsequent decades with small to moderate amounts of habitat projected to be in a potential high impact condition (approximately 3 percent under the No Action and approximately 5 percent under the Landscape Alternative) (Chart 3-58).

Chart 3-58. Impacts to Stream Shade Along Essential Coho Salmon Winter Rearing Habitat on State Trust Lands

Reported as the amount (stream miles) and proportion (percent, by length) of essential habitat with potential high impacts



- **Impact rating**: The potential environmental impact of either alternative for this indicator is considered **low**. Most habitat is restored by the second decade. DNR has not identified probable significant adverse impacts from either alternative for stream shade for coho salmon winter rearing habitat.

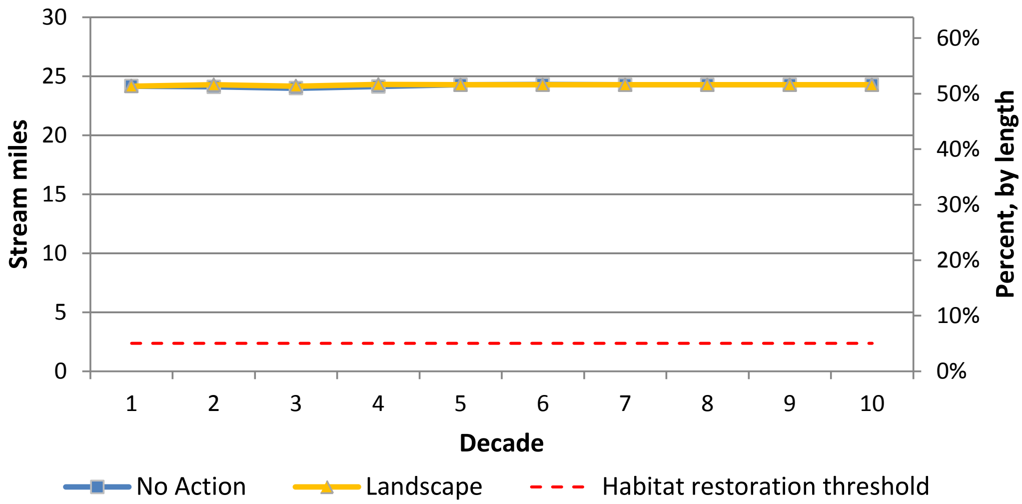
FINE SEDIMENT DELIVERY | Coho Salmon Winter Rearing Habitat

- **Decade 1 conditions**: Of the 47.0 miles of essential habitat on state trust lands, 24.2 miles (51.2 percent) are in a potential high impact condition for fine sediment delivery (Chart 3-59).

- **Results**: Generally stable; approximately 50 percent of essential habitat is projected to be in a potential high impact condition in any decade (Chart 3-59).

Chart 3-59. Impacts From Fine Sediment Delivery Along Essential Coho Salmon Winter Rearing Habitat on State Trust Lands

Reported as the amount (stream miles) and proportion (percent, by length) of essential habitat with potential high impacts



- **Impact rating**: The potential environmental impact of either alternative for this indicator is considered **high**. Habitat is not restored or maintained. Impacts for fine sediment delivery for coho salmon winter rearing habitat are adverse but not probable or significant due to mitigation through current management practices. Mitigation is expected to reduce impacts to a level of non-significance (refer to "Mitigation" later in this section).

Steelhead Trout Rearing Habitat

Section Signpost

Habitat type	*Indicator*
Chinook salmon spawning	LWD PF Shade Fine sed
Coho salmon summer rearing	LWD PF Shade Fine sed
Coho salmon winter rearing	LWD PF Shade Fine sed
Steelhead trout rearing	LWD PF Shade Fine sed
Bull trout	LWD PF Shade Fine sed
Lake Ozette sockeye salmon	LWD PF Shade Fine sed

LWD: large woody debris recruitment PF: peak flow
Shade: stream shade Fine Sed: fine sediment delivery

Steelhead trout have one of the most complex life history patterns of any Pacific salmonid species (Shapovalov and Taft 1954). In Washington, there are two major types of runs: winter and summer. Winter steelhead trout adults enter rivers in a mature reproductive state in December and generally spawn from February to May. Summer steelhead trout enter rivers in an immature state in May through October and, after maturing for several months, spawn in February through May. Coastal streams generally support more winter than summer steelhead trout populations (Smith and Wenger 2001).

Steelhead trout fry emerge from the gravel in summer and generally rear for two or three years in freshwater, occasionally one or four years depending on the productivity of the stream. Juvenile steelhead trout are found in clear, low velocity, low gradient streams;

sloughs; and off-channel habitat. Because of their long rearing and residence times, steelhead trout rely heavily on freshwater habitat and are present in streams year round.

Streamside vegetation and submerged cover in the form of rocks, logs, and aquatic vegetation are extremely important to steelhead trout during rearing (Narver 1976, Reiser and Bjornn 1979 as cited in Pauley and others 1986). Cover plays an important role in the selection of habitat by young steelhead trout. Densities of young steelhead trout are highest in areas containing in-stream cover, as it provides food, stabilizes temperature, and protects young fish from predators (Johnson 1985 as cited in Pauley and others 1986).

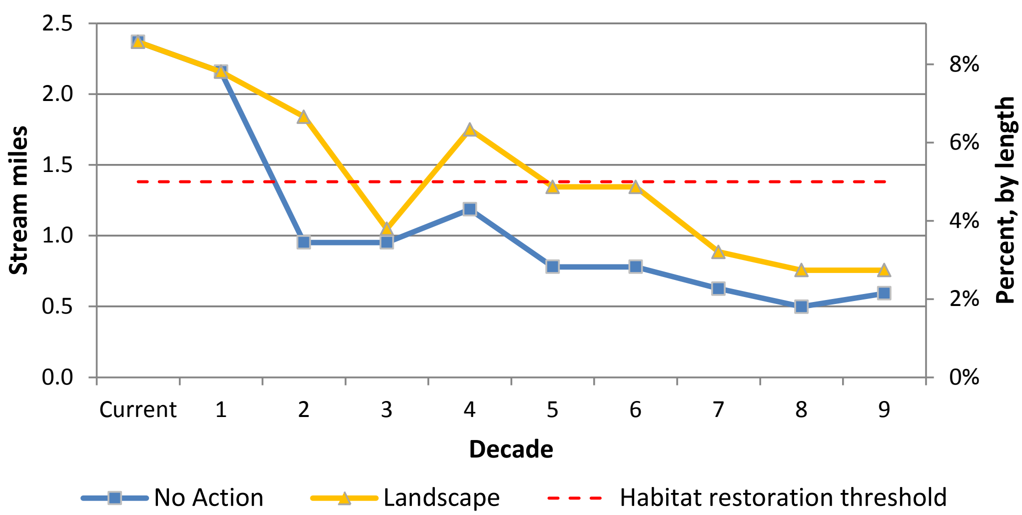
Using an intrinsic potential model, DNR identified 27.6 miles of streams on state trust lands within the OESF as essential rearing habitat for steelhead (Map P-4, Appendix P).

LARGE WOODY DEBRIS RECRUITMENT | Steelhead Trout Rearing Habitat

- **Current conditions**: Of the 27.6 miles of essential habitat on state trust lands, 2.4 miles (8.6 percent) are in a potential high impact condition for large woody debris recruitment (Chart 3-60).
- **Results**: Gradual improvement under either alternative; the amount of essential habitat in a potential high impact condition is projected to decrease (Chart 3-60). Improvement is more rapid under the No Action Alternative. Results are more variable under the Landscape Alternative.

Chart 3-60. Impacts to Large Woody Debris Recruitment Along Essential Steelhead Trout Rearing Habitat on State Trust Lands

Reported as the amount (stream miles) and proportion (percent, by length) of essential habitat with potential high impacts



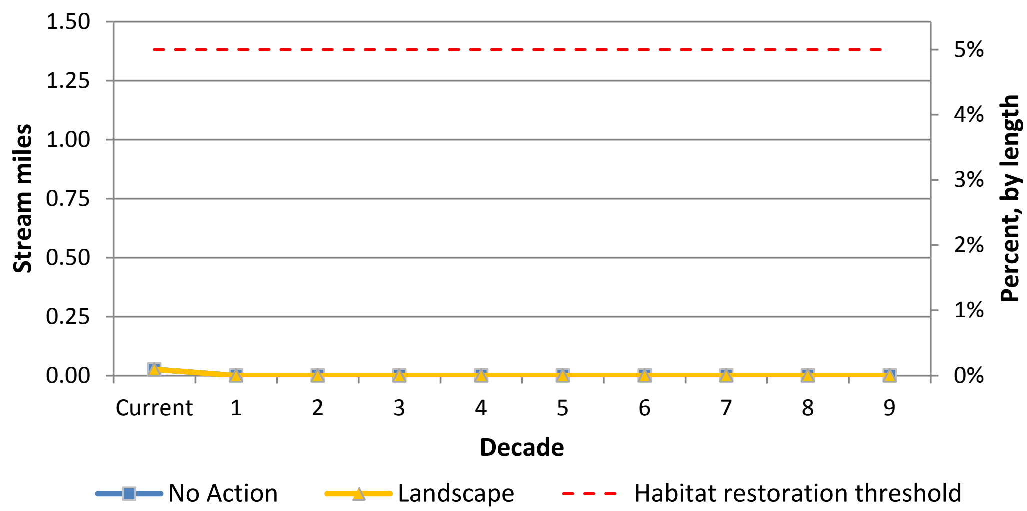
- **Impact rating**: The potential environmental impact of either alternative for this indicator is considered **low**. Under the No Action Alternative, habitat is restored by Decade 2. Under the Landscape Alternative, habitat is restored by Decade 3 and, with the exception of Decade 4, remains restored for the remainder of the analysis period. DNR has not identified probable significant adverse impacts from either alternative for large woody debris recruitment for steelhead trout rearing habitat.

PEAK FLOW | Steelhead Trout Rearing Habitat

- **Current conditions**: Of the 27.6 miles of essential habitat on state trust lands, approximately 140 feet (less than one tenth of one percent) are in a potential high impact condition for peak flow (Chart 3-61).
- **Results**: Generally stable under either alternative, with no essential habitat projected to be in a potential high impact condition after Decade 1 (Chart 3-61).

Chart 3-61. Impacts From Peak Flow Along Essential Steelhead Trout Rearing Habitat on State Trust Lands

Reported as the amount (stream miles) and proportion (percent, by length) of essential habitat with potential high impacts



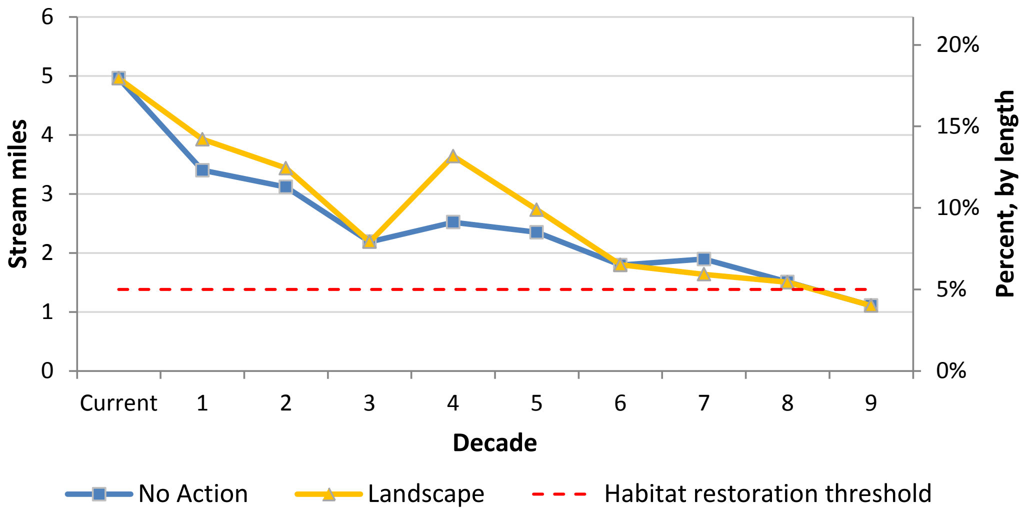
- **Impact rating**: The potential environmental impact of either alternative for this indicator is considered **low**. Habitat is restored and maintained. DNR has not identified probable significant adverse impacts from either alternative for peak flow for steelhead trout rearing habitat.

STREAM SHADE | Steelhead Trout Rearing Habitat

- **Current conditions**: Of the 27.6 miles of essential habitat on state trust lands, 5.0 miles (17.9 percent) are in a potential high impact condition for stream shade (Chart 3-62).
- **Results**: Gradual improvement under either alternative; the amount of essential habitat in a potential high impact condition is projected to decrease (Chart 3-62).

Chart 3-62. Impacts to Stream Shade Along Essential Steelhead Trout Rearing Habitat on State Trust Lands

Reported as the amount (stream miles) and proportion (percent, by length) of essential habitat with potential high impacts



- **Impact rating**: The potential environmental impact of either alternative for this indicator is considered **medium**. Habitat restoration occurs but the rate of recovery is slow (Decade 9 under either alternative). DNR has not identified probable significant adverse impacts from either alternative for stream shade for steelhead trout rearing habitat.

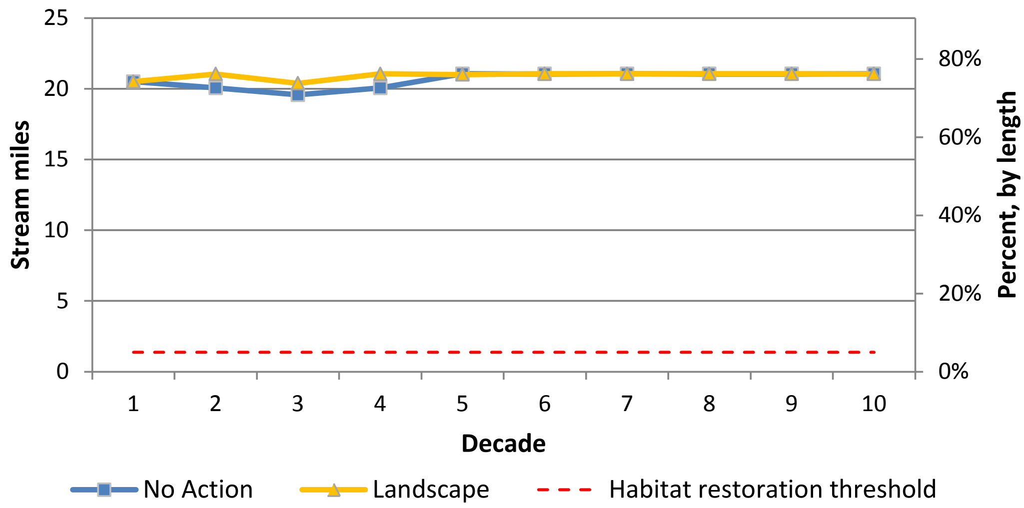
STREAM SHADE | Steelhead Trout Rearing Habitat

- **Decade 1 conditions**: Of the 27.6 miles of essential habitat on state trust lands, 20.5 miles (74.2 percent) are in a potential high impact condition for this indicator (Chart 3-63).

- **Results**: Generally stable under either alternative, with approximately 75 percent of essential habitat in a potential high impact condition in all decades (Chart 3-63).

Chart 3-63. Impacts From Fine Sediment Delivery Along Essential Steelhead Trout Rearing Habitat on State Trust Lands

Reported as the amount (stream miles) and proportion (percent, by length) of essential habitat with potential high impacts



- **Impact rating**: The potential environmental impact of either alternative for this indicator is considered **high**. Habitat is not restored or maintained. Impacts for fine sediment delivery for steelhead trout rearing habitat are adverse but not probable or significant due to mitigation through current management practices. Mitigation is expected to reduce impacts to a level of non-significance (refer to "Mitigation" later in this section).

Bull Trout Habitat

Section Signpost

Habitat type	*Indicator*
Chinook salmon spawning	LWD PF Shade Fine sed
Coho salmon summer rearing	LWD PF Shade Fine sed
Coho salmon winter rearing	LWD PF Shade Fine sed
Steelhead trout rearing	LWD PF Shade Fine sed
Bull trout	LWD PF Shade Fine sed
Lake Ozette sockeye salmon	LWD PF Shade Fine sed

LWD: large woody debris recruitment PF: peak flow
Shade: stream shade Fine Sed: fine sediment delivery

Bull trout have more specific habitat requirements than most other salmonid species. Although bull trout are found primarily in cold streams, occasionally these fish are found in larger, warmer river systems and may use certain streams and rivers in the fall and winter when water temperatures have dropped seasonally. Because bull trout inhabit side channels and the margins of streams, they are highly sensitive to flow patterns and channel structure. They need complex forms of cover such as large woody debris, undercut banks, boulders, and pools to protect them from predators and to provide prey.

Unlike most anadromous salmonids, bull trout survive to spawn year after year and may live 12 years or more, spawning annually or bi-annually in headwater areas. Since many populations of bull trout migrate from their natal tributary streams to larger water bodies such as rivers, lakes and saltwater, bull trout require two-way passage for repeat spawning as well as foraging. Repeat spawners are extremely important to the long-term persistence of bull trout populations; they typically have greater fecundity (potential reproductive capacity), and these survivors have multiple opportunities to contribute to the gene pool (NOAA Fisheries 2007).

The Olympic Peninsula is essential for maintaining bull trout distribution within coastal regions of Washington. Watersheds on the Olympic Peninsula drain to marine waters and major glaciers still cover the Olympic Mountains, providing sources of cold water to glacially fed rivers. The area is essential for maintaining the distribution of the amphidromous[16] life history form, which is rare across the geographic range of the species.

Bull trout are listed as threatened under the Endangered Species Act. A 2005 USFWS review described the status of bull trout stocks in 121 "core areas," two of which are within the OESF along the Hoh and Queets rivers. A core area represents the closest approximation of a biologically functioning unit for bull trout, and is a combination of critical habitat (habitat with all necessary components for spawning, rearing, foraging, migrating and overwintering) and a core population. By definition, each bull trout core area is considered to be a functioning, stand-alone population unit (USFWS 2006). Populations in the Hoh River and Queets River core areas were ranked "at risk" and "potential risk," respectively, which indicate a medium-high and medium-low level of risk to their recovery (USFWS 2005).

The Hoh and Queets rivers and their tributaries are considered essential to bull trout conservation. The Hoh River system maintains the northernmost population of amphidromous bull trout along the Pacific coast of the Olympic Peninsula and may represent the stronghold for the three Washington coast populations of bull trout, as well as serving as a key climate change refugium[17] for the species because of the extensive glacially influenced habitat. The Queets River system represents part of the core distribution of amphidromous bull trout along the Washington coast and is vital for population redundancy. Extensive portions of the headwater habitat within both river systems are located in Olympic National Park, a protected area (USFWS 2009).

Habitat is often dynamic. Species may move from one area to another over time, and habitat designated at one point in time may not include all areas that are later deemed necessary for the recovery of the species. On January 14, 2010, USFWS proposed to revise its 2005 designation of critical habitat for the bull trout (75 FR 2270). Under the Endangered Species Act, critical habitat identifies geographic areas that contain features essential for the conservation of a listed species. Critical habitat designations provide extra regulatory protection to areas that may require special management considerations, and habitats are then prioritized for recovery actions. Generally, the conservation role of critical habitat is to support viable core area populations (USFWS 2010). The proposed revision is the result of extensive review of the earlier bull trout critical habitat proposals and 2005 designation, public comments, and new information.

Currently designated bull trout critical habitat and the proposed 2010 revisions are shown in Map P-5, Appendix P. Approximately 47.6 miles of streams on state trust lands within the OESF were identified as critical habitat for bull trout (Map P-5, Appendix P).

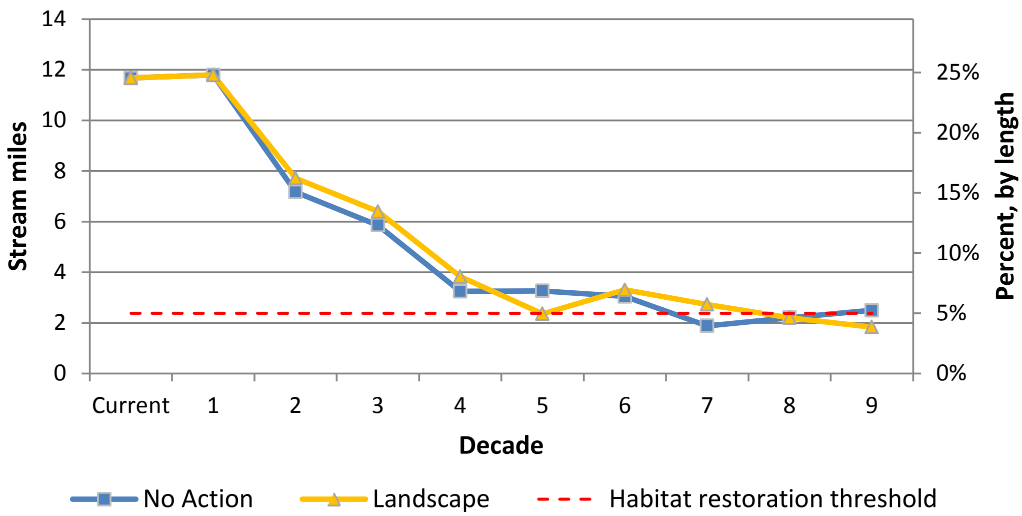
LARGE WOODY DEBRIS RECRUITMENT | Bull Trout Habitat

- **Current conditions**: Of the 47.6 miles of essential habitat on state trust lands, 11.7 miles (24.5 percent) are in a potential high impact condition for large woody debris recruitment (Chart 3-64).

- **Results**: Gradual improvement under either alternative; the amount of essential habitat in a potential high impact condition is projected to decrease (Chart 3-64).

Chart 3-64. Impacts to Large Woody Debris Recruitment Along Essential Bull Trout Habitat on State Trust Lands

Reported as the amount (stream miles) and proportion (percent, by length) of essential habitat with potential high impacts



- **Impact rating**: The potential environmental impact of either alternative for this indicator is considered **medium**. Habitat restoration occurs but the rate of recovery is slow. For the No Action Alternative, habitat is restored in Decade 7 but returns to a non-restored condition in Decade 10. Habitat is restored in Decade 9 under the Landscape Alternative. DNR has not identified probable significant adverse impacts from either alternative for large woody debris recruitment for bull trout habitat.

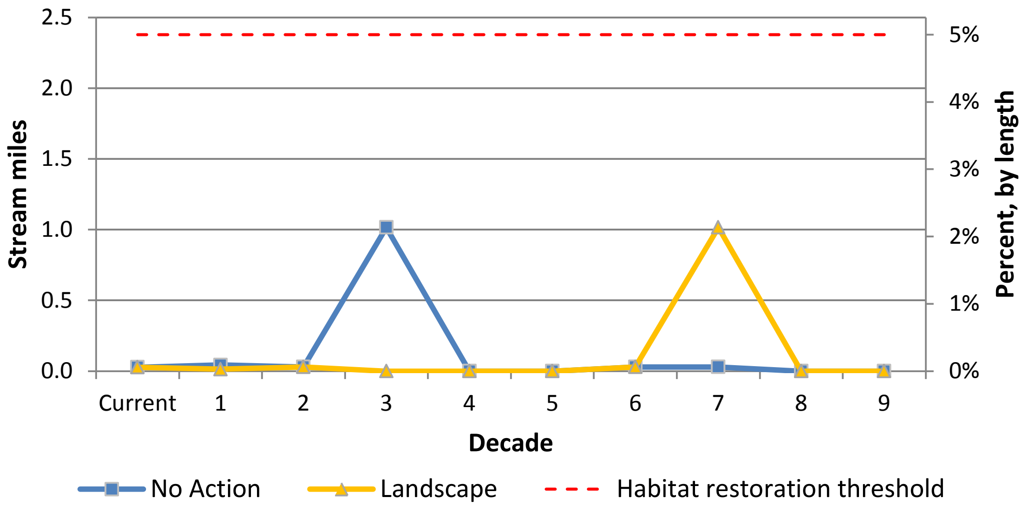
PEAK FLOW | Bull Trout Habitat

- **Current conditions**: Of the 47.6 miles of essential habitat on state trust lands, approximately 140 feet (less than one tenth of one percent) are in a potential high impact condition for peak flow (Chart 3-65).

- **Results and rating**: Generally stable under either alternative, with less than one percent of essential habitat projected to be in a potential high impact condition, except for Decade 3 (No Action Alternative) and Decade 7 (Landscape Alternative) (Chart 3-65).

Chart 3-65. Impacts From Peak Flow Along Essential Bull Trout Habitat on State Trust Lands

Reported as the amount (stream miles) and proportion (percent, by length) of essential habitat with potential high impacts



- **Impact rating**: The potential environmental impact of either alternative for this indicator is considered **low**. Habitat is restored and maintained. DNR has not identified probable significant adverse impacts from either alternative for peak flow for bull trout habitat.

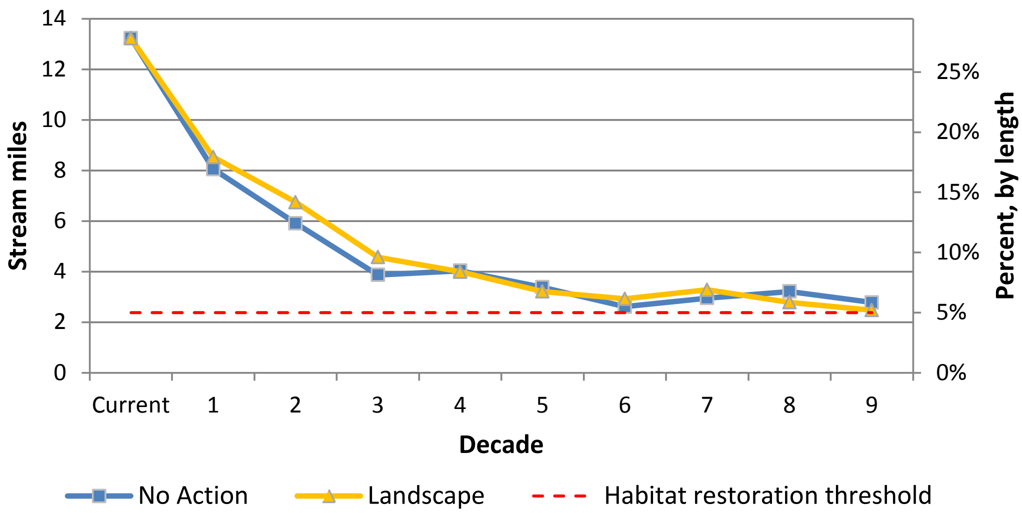
STREAM SHADE | Bull Trout Habitat

- **Current conditions**: Of the 47.6 miles of essential habitat on state trust lands, 13.2 miles (27.8 percent) are in a potential high impact condition for stream shade (Chart 3-66).

- **Results and rating**: Gradual improvement under either alternative; the amount of essential habitat in a potential high impact condition is projected to decrease to between 5 and 10 percent (Chart 3-66).

Chart 3-66. Impacts to Stream Shade Along Essential Bull Trout Habitat on State Trust Lands

Reported as the amount (stream miles) and proportion (percent, by length) of essential habitat with potential high impacts



- **Impact rating**: The potential environmental impact of either alternative for this indicator is considered **medium**. The rate of recovery is slow, and essential habitat is not restored or maintained under either alternative. DNR has not identified probable significant adverse impacts from either alternative for stream shade for bull trout habitat.

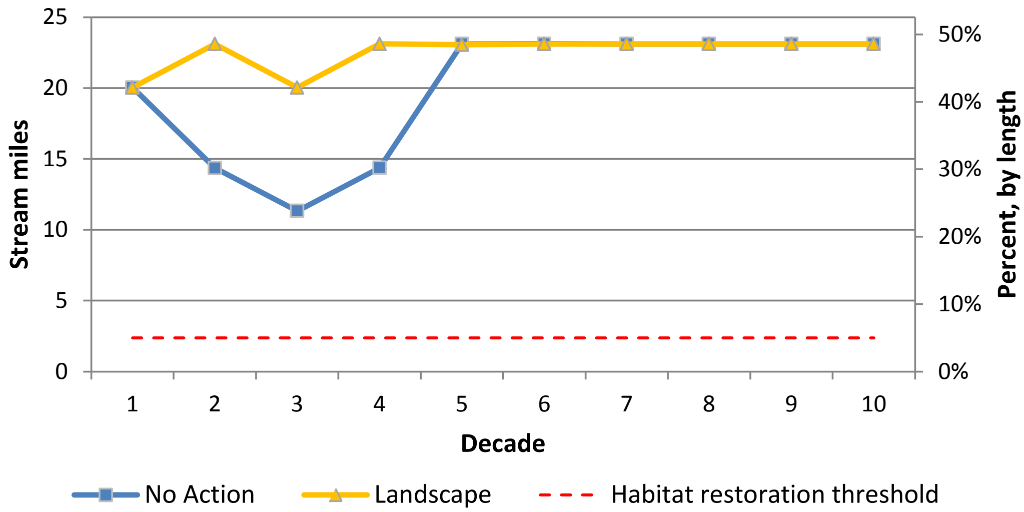
FINE SEDIMENT DELIVERY | Bull Trout Habitat

- **Current conditions**: Of the 47.6 miles of essential habitat on state trust lands, 20.0 miles (42.1 percent) are in a potential high impact condition for fine sediment delivery (Chart 3-67).

- **Results**: Fluctuations in early decades followed by stable but higher impact conditions in later decades (Chart 3-67); more than 10 percent of essential habitat is projected to be in a potential high impact condition at all times.

Chart 3-67. Impacts From Fine Sediment Delivery Along Essential Bull Trout Habitat on State Trust Lands

Reported as the amount (stream miles) and proportion (percent, by length) of essential habitat with potential high impacts



- **Impact rating**: The potential environmental impact of either alternative for this indicator is considered **high**. Essential habitat is not restored or maintained. Impacts for fine sediment delivery for bull trout habitat are adverse but not probable or significant due to mitigation through current management practices. Mitigation is expected to reduce impacts to a level of non-significance (refer to "Mitigation" later in this section).

Lake Ozette Sockeye Salmon Habitat

Section Signpost

Habitat type	*Indicator*
Chinook salmon spawning	LWD PF Shade Fine sed
Coho salmon summer rearing	LWD PF Shade Fine sed
Coho salmon winter rearing	LWD PF Shade Fine sed
Steelhead trout rearing	LWD PF Shade Fine sed
Bull trout	LWD PF Shade Fine sed
Lake Ozette sockeye salmon	LWD PF Shade Fine sed

LWD: large woody debris recruitment PF: peak flow
Shade: stream shade Fine Sed: fine sediment delivery

The vast majority of sockeye salmon populations spawn in or near lakes. Spawning can take place in lake tributaries, lake outlets, rivers between lakes, and on lake shorelines or beaches where suitable upwelling or intra-gravel flow is present. Sockeye fry spawned in lake tributaries typically exhibit a behavior of rapid downstream migration to the nursery lake after hatching, whereas lake- or beach-spawned sockeye rapidly migrate to open lake waters after hatching. Lake-rearing juveniles typically spend 1 to 3 years in their nursery lake before emigrating to the marine environment (Gustafson and others 1997 as cited in NOAA Fisheries 2009).

Lake Ozette sockeye were listed as a threatened species under the Endangered Species Act in 1999 (64 FR 14528). The listing was primarily attributed to concerns over abundance and the effects of small population genetic and demographic variability.

There are five known subpopulations or aggregations of Lake Ozette sockeye, defined in terms of where they spawn—on beaches around the lake or in tributaries. Beach spawning subpopulations include Olsen's Beach and Allen's Beach, while tributary spawning subpopulations include Umbrella Creek, Big River, and Crooked Creek. The non-anadromous, resident sockeye are called kokanee, and they are genetically different enough from anadromous Lake Ozette sockeye to be considered a separate evolutionarily significant unit.

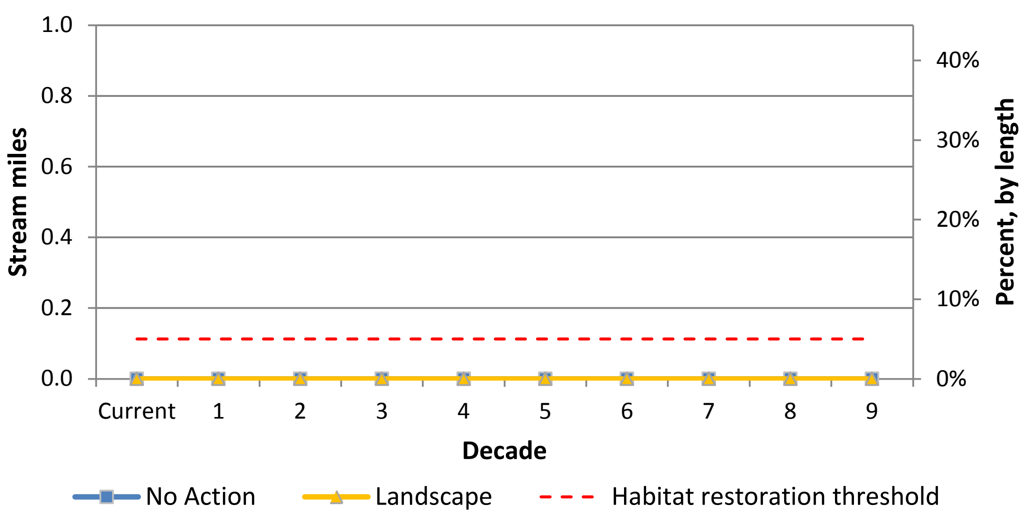
Lake Ozette, its perimeter shore, and most of the Ozette River, which forms the outlet of the lake to its estuary and the Pacific Ocean, are included in Olympic National Park. DNR manages a portion of the Lake Ozette watershed, and 2.2 miles of stream designated as critical habitat are located on state trust lands along portions of the Big River and the North Fork and South Fork of Crooked Creek (Map P-6, Appendix P).

LARGE WOODY DEBRIS RECRUITMENT | Lake Ozette Sockeye Salmon Habitat

- **Current conditions**: Of the 2.2 miles of essential habitat on state trust lands, none is in a potential high impact condition for large woody debris recruitment (Chart 3-68).
- **Results**: Stable under either alternative; no essential habitat is projected to be in a potential high impact condition in any decade under either alternative (Chart 3-68).

Chart 3-68. Impacts to Large Woody Debris Recruitment Along Essential Lake Ozette Sockeye Salmon Habitat on State Trust Lands

Reported as the amount (stream miles) and proportion (percent, by length) of essential habitat with potential high impacts



- **Impact rating**: The potential environmental impact of either alternative for this indicator is considered **low**. Habitat is restored and maintained. DNR has not identified probable significant adverse impacts from either alternative for large woody debris recruitment for Lake Ozette sockeye salmon.

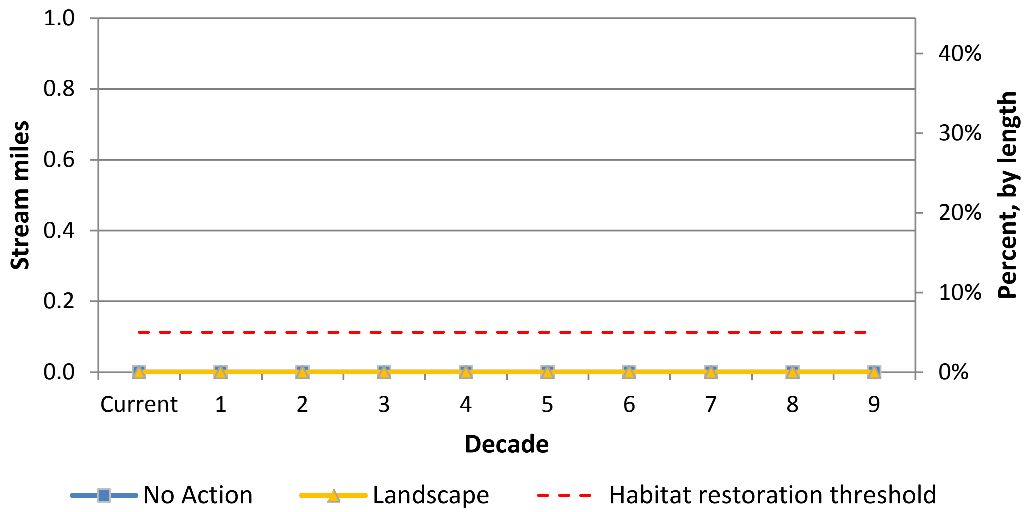
PEAK FLOW | Lake Ozette Sockeye Salmon Habitat

- **Current conditions**: Of the 2.2 miles of essential habitat on state trust lands, none is in a potential high impact condition for peak flow (Chart 3-69).

- **Results**: Stable under either alternative; no essential habitat is projected to be in a potential high impact condition in any decade under either alternative (Chart 3-69).

Chart 3-69. Impacts From Peak Flow Along Essential Lake Ozette Sockeye Salmon Habitat on State Trust Lands

Reported as the amount (stream miles) and proportion (percent, by length) of essential habitat with potential high impacts



- **Impact rating**: The potential environmental impact of either alternative for this indicator is considered low. Habitat is restored and maintained. DNR has not identified probable significant adverse impacts from either alternative for peak flow for Lake Ozette sockeye salmon.

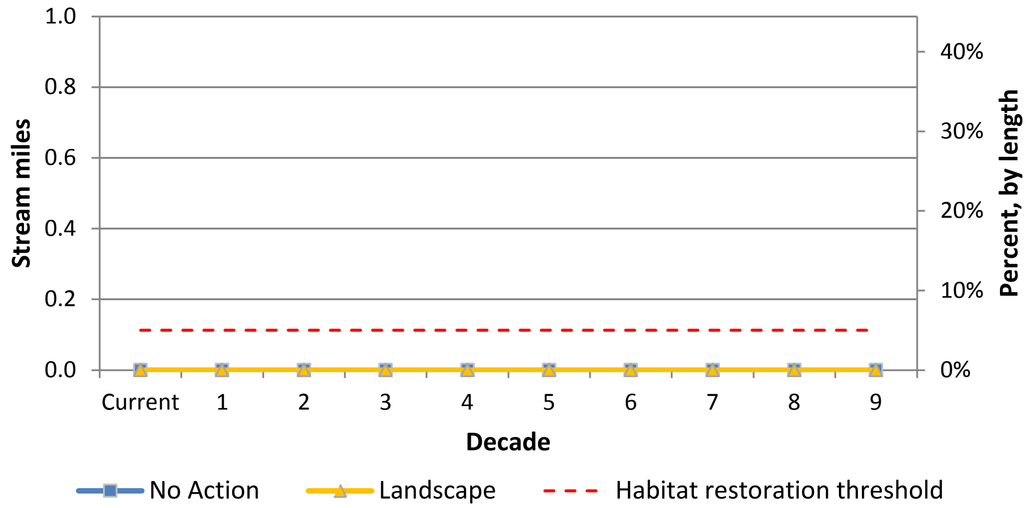
STREAM SHADE | Lake Ozette Sockeye Salmon Habitat

- **Current conditions**: Of the 2.2 miles of essential habitat on state trust lands, none is in a potential high impact condition for stream shade (Chart 3-70).

- **Results**: Stable under either alternative; no essential habitat is projected to be in a potential high impact condition in any decade under either alternative (Chart 3-70).

Chart 3-70. Impacts to Stream Shade Along Essential Lake Ozette Sockeye Salmon Habitat on State Trust Lands

Reported as the amount (stream miles) and proportion (percent, by length) of essential habitat with potential high impacts



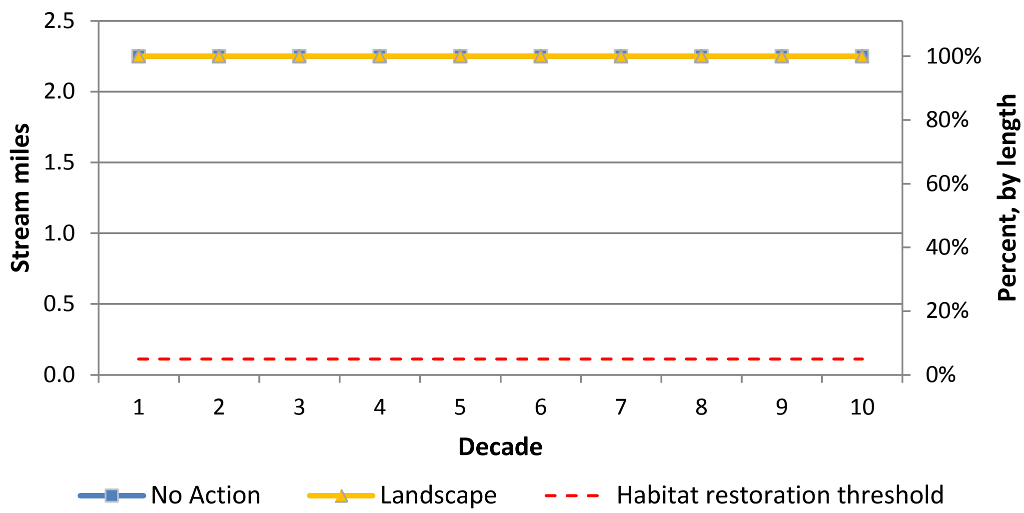
- **Impact rating**: The potential environmental impact of either alternative for this indicator is considered **low.** Habitat is restored and maintained. DNR has not identified probable significant adverse impacts from either alternative for stream shade for Lake Ozette Sockeye Salmon.

FINE SEDIMENT DELIVERY | Lake Ozette Sockeye Salmon Habitat

- **Current conditions**: Of the 2.2 miles of essential habitat on state trust lands, 100 percent is in a potential high impact condition for fine sediment delivery (Chart 3-71).
- **Results**: Stable under either alternative; all essential habitat is projected to be in a potential high impact condition in all decades under either alternative (Chart 3-71).

Chart 3-71. Impacts From Fine Sediment Delivery Along Essential Lake Ozette Sockeye Salmon Habitat on State Trust Lands

Reported as the amount (stream miles) and proportion (percent, by length) of essential habitat with potential high impacts



- **Impact rating**: The potential environmental impact of either alternative for this indicator is considered high. Habitat is not restored or maintained. Impacts for fine sediment delivery for Lake Ozette sockeye salmon are adverse but not probable or significant due to mitigation through current management practices. Mitigation is expected to reduce impacts to a level of non-significance (refer to "Mitigation" later in this section).

Discussion of Results

LARGE WOODY DEBRIS RECRUITMENT

The current condition of large woody debris recruitment along all streams on state lands in the OESF is primarily the result of timber harvests that occurred prior to the implementation of the 1997 *Habitat Conservation Plan*. Between 1970 and 1990, approximately half of the forests from which large woody debris is recruited to stream channels was clearcut (today, DNR uses variable retention harvest; refer to Text Box 3-1). While regrowth has occurred, 53 percent of these areas are currently in the Competitive Exclusion stand development stage (refer to Text Box 3-2, p. 3-26).

During the Competitive Exclusion stage, stand density typically reaches its maximum. Competition for limited resources, such as light, nutrients, and growing space, is high. Many trees in the stand may decline in growth and eventually die as competition intensifies (Franklin and others 2007). While some stand-level parameters such as basal area[18] or standing volume increase at their maximum rate during the Competitive Exclusion stage because of the sheer number of trees, individual tree growth is generally depressed.

As a result, stands in the Competitive Exclusion stage often lack the large trees, snags, multiple canopy layers, and significant large woody debris found in more structurally complex forests (Bigley and Deisenhofer 2006). The woody debris these forests provide currently consists of small diameter pieces, which decay faster, are less stable in the stream channel, and are less likely to influence in-stream habitat.

In general, large woody debris recruitment potential is projected to improve across most stream reaches on state trust lands in the OESF (refer to "Riparian," p. 3-67), resulting in a reduction in the amount of essential habitat in a high impact condition. However, the change is projected to be slow, primarily because over half of the areas currently in the Competitive Exclusion stage are also deferred from harvest. An analysis of the results of DNR's forest estate model has shown that, in the absence of management, stands in the Competitive Exclusion stage may remain in this stage for 50 years or more. For these reasons, most habitat types are rated with low or medium impacts for large woody debris recruitment.

Harvest activities in areas not deferred from harvest may have either a positive or negative effect on large woody debris recruitment. Thinning harvests can be an effective means of reducing competition for resources. Trees respond to thinning with accelerated growth, which can lead to higher quality large woody debris. By contrast, variable retention harvest results in a reduction of trees available for in large woody debris recruitment until the forest regrows.

While DNR's analysis shows that large woody debris recruitment potential is improving along coho winter rearing habitat (Chart 3-56), the rate of improvement is slow, and the amount of essential habitat in a potential high impact condition remains above 10 percent. Therefore, impacts are high under either alternative. As a result of past harvest activities, much of the area from which large woody debris is recruited to coho winter rearing habitat has a low to moderate potential for providing quality, functioning pieces to the in-stream environment. At the same time, the physical characteristics of the habitat preferred by coho salmon for winter rearing coincides with the gradient and confinement classes most responsive to changes in large woody debris input. Sensitivity is moderate to high; on average, coho winter rearing habitat is rated the most sensitive of all the habitat types to large woody debris input. A low to moderate potential coupled with a moderate to high sensitivity results in a high impact rating for many essential reaches of this habitat type.

PEAK FLOW

In most watersheds, hydrologic maturity is sufficient to prevent or minimize an adverse increase in the magnitude of peak flow along essential habitat reaches. On average, across state trust lands in the OESF, hydrologically immature forests comprise less than 25 percent of each Type 3 watershed in each decade of the 100-year analysis period. For these reasons, all habitat types are rated with low or medium impacts for peak flow.

STREAM SHADE

As explained previously, the amount of shade provided to the stream is a combination of physical characteristics such as the shape of the surrounding terrain and the characteristics of the riparian forest such as tree height and canopy density.

The impacts of harvest activities on shade, including both the magnitude and duration of those impacts, depend on the type and intensity of harvest. For example, variable retention harvests remove the majority of trees in a forest; the result is a reduction in stream shade until the forest regrows. DNR's proposed thinning harvests are not expected to greatly impact shade levels because DNR does not thin below a relative density of 35 (refer to "Forest Conditions and Management," p. 3-29 for a description of relative density). Chan and others (2004) only found substantial reductions in shade when harvest reduced relative density below 30. For less intensive thinnings, they found light levels to be similar to those in unthinned forests.

Potential impacts to shade are projected to be low or medium for all habitat types. Shade levels are expected to increase as riparian forests age and increase in height and canopy density.

FINE SEDIMENT DELIVERY

Based on gradient and confinement, much of the essential habitat for many of the species analyzed is rated as highly sensitive to fine sediment delivery (refer to Appendix G). In these locations, fine sediment is readily stored; increased fine sediment results in widespread pool filling and loss of overall bed form complexity. The combination of high sensitivity to, and moderate potential for, fine sediment delivery results in a high impact rating for all habitat types except coho salmon summer rearing. For one species, Lake Ozette sockeye, water quality is hypothesized as a limiting factor. Specifically, it is possible that high water temperatures and high sediment concentrations in the tributaries either weaken or kill enough sockeye salmon and their eggs to make a difference in their rate of reproduction (NOAA Fisheries 2009).

The potential low impact rating for coho summer rearing habitat (Chart 3-52) stems from its gradient. In the somewhat steeper streams which comprise this type of habitat, fine sediment is only temporarily stored. In these streams, most fine sediment is transported through with little impact. Accordingly, these streams are assigned a low sensitivity rating to fine sediment delivery. The projected potential for fine sediment delivery in the watersheds in question, when coupled with a low sensitivity rating, is insufficient to warrant a higher impact rating.

Mitigation

Mitigation Through Current Management Practices

In this section, DNR describes current management practices (established programs, rules, procedures, or other practices) that are expected to mitigate potential high impacts to a level of non-significance. This mitigation applies to fine sediment delivery for all habitat types except coho salmon summer rearing.

ROAD MAINTENANCE AND ABANDONMENT PLANS

The forest practices rules contain direction for road construction and maintenance (WAC 222-24) to protect water quality and riparian habitat. Road construction and maintenance must prevent or limit actual or potential delivery of sediment and surface water to any typed water where such delivery would prevent the achievement of fish habitat or water quality goals.

The forest practices rules require large forest landowners,[19] such as DNR, to prepare road maintenance and abandonment plans for all roads that have been used or constructed since 1974.[20] These plans specify the steps that will be taken to either abandon roads or bring roads that do not meet current standards into compliance. Consistent with the forest practices rules, DNR has developed road maintenance and abandonment plans for roads on state trust lands in each of the 11 landscapes in the OESF.

Work under these plans is ongoing. Table 3-41 in "Water Quality," p. 3-132 shows the number of projects completed under road maintenance and abandonment plans for roads on state trust lands in each of the 11 landscapes in the OESF. Work associated with these plans must be completed by October 31, 2016. A summary of DNR's accomplishments for roads in each of the 11 landscapes in the OESF and DNR's road maintenance priorities and standards are included in Appendix C.

All work completed under these plans is performed using (as appropriate) the best management practices for road construction and maintenance described in the Forest Practices Board Manual (DNR 2013) and the guidance provided in DNR's Forest Roads Guidebook (DNR 2011). Most work involves culvert replacement, maintenance, or removal. DNR continually updates and prioritizes these plans to address newly identified environmental impacts from the existing road network.

Refer to "Water Quality," p. 3-131 for more information on road maintenance and abandonment. Information on road maintenance and abandonment for small private forest landowners and federal agencies can be found in Chapter 4 (p. 4-7).

Effectiveness of Road Maintenance and Abandonment Plans

Correct implementation of current forest practices rules for road maintenance is expected to minimize runoff water and sediment delivery to typed waters (DNR 2013). A statewide study conducted on private forestlands in Washington found that road maintenance and abandonment appears to reduce the amount of road-related sediment that reaches streams (Martin 2009). This study found that implementing best management practices decreased the number of road miles hydrologically connected to streams, and that the majority of roads studied had a low probability of delivering sediment to streams (Martin 2009). In addition, the monitoring of the effectiveness of road maintenance and abandonment plans conducted statewide by Dubé and others (2010) from 2006 through 2008 found that as roads were brought up to modern standards, they showed decreased sediment delivery to streams.

INSPECTION, MAINTENANCE, AND REPAIR

After work identified under road maintenance and abandonment plans has been completed in 2016, DNR will continue to inspect, maintain, and repair roads and bridges as needed using the appropriate best management practices for road maintenance and repair identified in the current Forest Practices Board Manual and guidance provided in the Forest Roads Guidebook. Routine maintenance of road dips and surfaces and quick response to problems can significantly reduce road-caused slumps and slides and prevent the creation of berms that could channelize runoff (Environmental Protection Agency 2012).

SUSPENSION OF TIMBER HAULING DURING STORM EVENTS

In addition to road maintenance and abandonment plans, DNR also considers how operations can be adjusted to further prevent delivery of fine sediment to streams. For example, DNR suspends timber hauling on state trust lands in the OESF during storm events, when heavy rainfall can potentially increase surface water runoff and sediment delivery. The decision to suspend timber hauling on state trust lands is based on professional judgment. A weather event is considered a storm event when high levels of precipitation are forecast and there is a potential for drainage structures, such as culverts and ditches, to be overwhelmed, increasing the potential for sediment delivery to streams. If timber hauling is suspended, DNR monitors the road to determine if potential problems are developing that may lead to sediment delivery to streams and takes action as necessary.

Possible Mitigation

Following, DNR describes possible mitigation for the indicator large woody debris recruitment for coho salmon winter rearing habitat. This possible mitigation may be implemented along stream reaches of essential coho salmon winter rearing habitat where DNR has identified potential high impacts for large woody debris recruitment. Possible mitigation may reduce potential high impacts for large woody debris recruitment in this habitat type to a lower level. As described in the introduction to this chapter, possible mitigation is something DNR may or may not implement. Although DNR may adopt possible mitigation in the future, DNR is not committed to implementing it at this time.

- Thin riparian forests that are currently in the Competitive Exclusion stand development stage to accelerate tree growth, thereby decreasing the time until large woody debris is available to the stream.
- In riparian forests dominated by deciduous trees (typically red alder), use silviculture to convert the stand to conifer dominance. The restoration goal would be to encourage the development of a forest containing large-diameter conifers. Red alder-dominated riparian forests are likely the result of past forestry practices. If left untreated, many red alder-dominated stands may be replaced by salmonberry (a type of shrub) rather than conifers (Hibbs and Giodano 1996 as cited in Bigley and Deisenhofer 2006).
- Perform riparian area enhancement activities, such as felling a limited number of trees from the riparian forest into the stream channel to augment in-stream large woody debris. Such efforts could be funded and implemented jointly with external parties.

Summary of Potential Impacts

Tables 3-44 provides an overview of the potential environmental impacts of either alternative on fish habitat. Results are presented by type of habitat, indicator, and alternative. DNR identified probable significant adverse impacts from either alternative for only one indicator and habitat type: large woody debris recruitment along coho salmon winter rearing habitat. Possible mitigation is proposed for this indicator. Potential high impacts from fine sediment delivery along all habitat types except coho salmon summer rearing under either alternative are expected to be mitigated to a level of non-significance through current management practices, which include road maintenance and abandonment plans; road inspection, maintenance, and repair; and suspension of timber hauling during storms.

Table 3-44. Summary of Potential Impacts on Fish Habitat

Criteria	Indicators	No Action Alternative	Landscape Alternative
Chinook salmon spawning			
Functioning riparian habitat	Large woody debris recruitment	Medium ◇	Medium ◇
	Peak flow	Low ●	Low ●
	Stream shade	Medium ◇	Medium ◇
	Fine sediment delivery	High ■	High ■
Coho salmon summer rearing			
Functioning riparian habitat	Large woody debris recruitment	Medium ◇	Medium ◇
	Peak flow	Low ●	Low ●
	Stream shade	Low ●	Low ●
	Fine sediment delivery	Low ●	Low ●
Coho salmon winter rearing			
Functioning riparian habitat	Large woody debris recruitment	High ■	High ■
	Peak flow	Low ●	Low ●
	Stream shade	Low ●	Low ●
	Fine sediment delivery	High ■	High ■
Steelhead trout rearing			
Functioning riparian habitat	Large woody debris recruitment	Low ●	Low ●
	Peak flow	Low ●	Low ●
	Stream shade	Medium ◇	Medium ◇
	Fine sediment delivery	High ■	High ■
Bull trout			
Functioning riparian habitat	Large woody debris recruitment	Medium ◇	Medium ◇
	Peak flow	Low ●	Low ●
	Stream shade	Medium ◇	Medium ◇
	Fine sediment delivery	High ■	High ■
Lake Ozette sockeye salmon			
Functioning riparian habitat	Large woody debris recruitment	Low ●	Low ●
	Peak flow	Low ●	Low ●
	Stream shade	Low ●	Low ●
	Fine sediment delivery	High ■	High ■

● **Low impact** ◇ **Medium impact** ■ **High impact**

Section Notes

1. Resident fish spend their entire lives in freshwater. Anadromous fish spend part of their life at sea and return to freshwater to reproduce.
2. A stream reach is a section of stream with consistent channel and floodplain characteristics, such as gradient (how steep the stream is) or confinement (how much a channel can move within its valley).
3. Spawning is fish reproduction. Rearing is the growth and maturation of juvenile fish.
4. A riffle is a short, relatively shallow and coarse-bedded length of stream over which the stream flows at higher velocity and higher turbulence.
5. Stream productivity refers to the level of biomass that is produced or generated in the stream. Biomass can be generated by organisms (such as plants, algae, and some bacteria) that fix carbon through photosynthesis. These organisms are called autotrophs, and a measure of their abundance is known as primary productivity. Biomass can also be generated by organisms that consume other organisms. These organisms are called heterotrophs, and a measure of their abundance is known as secondary productivity. Stream productivity, as a general term, refers to the sum of both primary and secondary productivity.
6. Streams are dynamic. Many studies to date that make recommendations for the recruitment of large woody debris have not considered how stream channels migrate over time (Murphy and Koski 1989, Robison and Beschta 1990, McDade and others 1990, WFPB 1994 as cited in DNR 1997). To account for lateral stream migration across the floodplain, recruitment to the floodplain was considered equivalent to the recruitment to the stream channel. Large woody debris in the floodplain provides riparian function during flood events (DNR 1997), and in time, may eventually become in-stream large woody debris as streams migrate. Therefore, the area of influence includes the floodplain itself plus an additional 150 feet. For this analysis, the width of the 100-year floodplain was defined by stream type, measured outward horizontally from the center of the stream channel along both sides of the stream: 150 feet along each side of Type 1 streams (300 feet total), 30 feet along each side of Type 2 streams (60 feet total), 15 feet along each side of Type 3 streams (30 feet total), 3.75 feet along each side of Type 4 streams (7.5 feet total), and 0 feet for Type 5 and 9 streams. DNR analyzed the additional 150 feet (one tree height) beyond the edge of the 100-year floodplain because this area is expected to provide the majority of large woody debris, based on FEMAT (1993) and McDade and others (1990). For a detailed description of how the area of influence for large woody debris as calculated, refer to Appendix G.
7. DNR uses a numerical system (one through five) to categorize streams based on physical characteristics such as stream width, steepness, and whether or not fish are present. Type 1 streams are the largest; Type 5 streams are the smallest. Type 9 streams are "unclassified" and refer to streams that are currently mapped, but lack sufficient data to determine the correct water type. Only Type 1, 2 and 3 streams are considered fish-bearing. DNR and the Federal Services have agreed that the Washington Forest Practices Board Emergency Rules (stream typing), November 1996 (WAC 222-16-031 [water typing interim]) meet the intent of DNR's 1997 *Habitat Conservation Plan*. A comparison of DNR's water typing system is provided in the rules (WAC 222-16-031).
8. Based on a review of approximately 30 years of daily average temperature records for the Clearwater, Quinault, and Forks weather stations archived by the NOAA Western Regional Climate Center, July 31st is the hottest day of the year and therefore the one in which thermal loading to the stream is expected to be at a maximum.
9. The target shade level is intended solely for the purpose of conducting this environmental impact analysis, and does not connote or imply DNR policy direction.
10. In the event that, during the statewide sustainable calculation, a change in the harvest level is made that would require an increase in road density, DNR would first analyze the impacts of a higher road density through the sustainable harvest calculation process.
11. Under the forest practices rules (WAC 222-24-52(3)), a road is considered abandoned if (a) roads are out-sloped, water barred, or otherwise left in a condition suitable to control erosion and maintain water movement within wetlands and natural drainages; (b) ditches are left in a suitable condition to reduce erosion; (c) the road is blocked so that four wheel highway vehicles cannot pass the point of closure at the time of abandonment; (d) water crossing structures and fills on all typed waters are removed, except where DNR determines other measures would provide adequate protection to public resources; and (e) DNR has determined that the road is abandoned.

12. Instead of current conditions, DNR reports results that are based on the first decade's worth of harvest activities.
13. A glide is a section of calm water.
14. A freshet is a period of higher stream flow due to heavy rain or melting snow. This term should not be confused with the terms flood or peak flow.
15. A smolt is a young fish that has just adapted to saltwater.
16. Amphidromous salmon move between fresh and saltwater during their life cycle, but not to breed.
17. A refugium is an area in which organisms can survive through a period of unfavorable conditions.
18. In forestry, the term basal area describes the sum of the cross-sectional area of all trees in a stand, measured at breast height. It is generally expressed as square feet per acre.
19. In Washington, large forest landowners are those who harvest an annual average of more than 2 million board feet of timber from their own forestland in the state.
20. Older roads that have not been used since 1974 are considered "orphaned."


Sockeye Salmon
Photo Courtesy WSDFW

Wildlife

What Is Wildlife Habitat, and Why Is It Important?

Wildlife habitat is defined as the combination of resources (food, water, cover) and environment (climate, soils, vegetation structure) that attracts and supports a species, population, or group of species (Johnson and O'Neil 2001). Wildlife habitat, regardless of its location—uplands, riparian areas, or wetlands—serves a variety of important functions for both terrestrial and aquatic species. For example, wildlife habitat provides areas for foraging (finding food), roosting, breeding, nesting, and refuge (hiding from predators or other dangers).

Which Wildlife Species Does This Analysis Include?

In this section of the RDEIS, DNR considers how either alternative will impact the ability of state trust lands in the OESF *as a whole* to support wildlife. For that reason, the analysis in this section focuses on the habitat needs of a broad range of wildlife species rather than the needs of specific species, and emphasizes potential environmental impacts at the largest spatial scale (all state trust lands in the OESF) instead of smaller scales such as landscapes or watershed administrative units. Results at the landscape scale can be found in Appendix K.

The potential environmental impacts of the alternatives on northern spotted owls are analyzed in a separate section of this RDEIS (p. 3-203) because they are listed as threatened under the Endangered Species Act. Also, DNR is updating its current management strategy and associated procedure for northern spotted owls as part of this proposed action. (For the management strategy, refer to Appendix A. For the procedure, refer to Appendix F.)

In this RDEIS, DNR did not include a separate section for the potential environmental impacts of the alternatives on marbled murrelets. Although marbled murrelets are also listed as threatened under the Endangered Species Act, DNR is currently developing a long-term marbled murrelet conservation strategy in a separate planning process. Instead, DNR includes marbled murrelets in the following analysis of wildlife habitat.

What Is the Criterion for Wildlife Habitat?

The criterion for assessing wildlife habitat is **conservation of biodiversity**. The Washington Biodiversity Council defines biodiversity as "the full range of life in all its forms" including the habitats in which life occurs, the ways that species and habitat interact with each other, and the ecosystem processes necessary for those interactions.

Biodiversity is an environmental end point (goal) that is difficult to measure directly. Instead, biodiversity is measured by surrogate indicators including habitat structure (such as forest structure), landscape patterns (such as patch size), species abundance, species populations, genetic processes, or ecosystem processes (Franklin 1988, Noss 1990). Given that structural features provide critical habitat components for forest-dwelling wildlife species, it follows that the presence or absence of these species may be positively correlated with the presence or absence of such structural features (McCleary and Mowat 2002). For this analysis, DNR measures biodiversity by habitat structure and landscape patterns because they represent the physical places and structures that provide habitat for wildlife species, and because they can be quantified and modeled through time.

What Are the Indicators for Wildlife Habitat?

The indicators used to measure the criterion are **stand development stages supporting wildlife guilds** and **interior older forest**. These indicators were selected based on DNR's expertise, existing scientific information, and current data. The following sections provide information on each indicator.

Stand development stages are analyzed in "Forest Conditions and Management," p. 3-40. In this chapter, DNR discusses stand development stages in context with wildlife.

Descriptions of the Indicators

Indicator: Stand Development Stages Supporting Wildlife Guilds

As forest stands grow from planted seedlings after a harvest or regenerate on their own after natural disturbances, they move in and out of stand development stages (refer to Text Box 3-2 on page 3-26 in "Forest Conditions and Management"). Stand development stages are based on stand structure, not age. Stand structure is a combination of measurable attributes such as tree height and diameter, stand density, canopy layers, understory vegetation, down wood, and snags.

Each stand development stage has specific structures, such as large trees, down wood, or snags, which can benefit certain wildlife guilds (a wildlife guild is a group of species that has similar habitat requirements for foraging, breeding, or shelter). For example, the understory found in the Understory Development and Structurally Complex stages can benefit understory-gleaning insectivores (insect-eating birds). Species with general habitat requirements can belong to several guilds, and since they use a wide variety of forest structures, can benefit from all stand development stages (refer to Table 3-45).

Table 3-45. Wildlife Guilds Benefitting From All Stand Development Stages

Benefitting wildlife guilds	Representative species
Foliage-gleaning insectivores (feed on insects)	Warbling vireo, golden-crowned kinglet, yellow-rumped warbler, western tanager
Large mammal predators	Cougar and black bear
Small mammal predators	Bobcat, long-tailed weasel, and spotted skunk

In general, the early stand development stages, such as Ecosystem Initiation, and later stages, such as Structurally Complex, can support the greatest diversity and abundance of wildlife species (Johnson and O'Neil 2001, Carey 2003). This indicator considers whether the proportion of state trust lands in each of the 11 landscapes in the OESF in early and late stand development stages is projected to increase, stay the same, or decrease over the 100-year analysis period. This analysis is conducted using the outputs of the forest estate model.

Following, DNR provides descriptions of each stand development stage and examples of representative species of wildlife that benefit from the structures found in those stages. The tables in the following section are adapted from Brown (1985) and Johnson and O'Neil (2001).

ECOSYSTEM INITIATION

The establishment of a new forest ecosystem begins with rapidly growing young trees and shrubs. Many wildlife species use this stand development stage more for foraging than for breeding. Brown (1985) identified 70 species in western Washington and Oregon that used this stage (grass/forb stage in Brown 1985) as their primary foraging habitat, compared to 26 species that used this stage as their primary breeding habitat. Table 3-46 lists the wildlife guilds that may benefit from the Ecosystem Initiation stand development stage.

Table 3-46. Wildlife Guilds That May Benefit From the Ecosystem Initiation Stand Development Stage

Benefitting guilds	Representative species
Perching/hawking birds	Red-tailed hawk, great horned owl, olive-sided flycatcher, cedar waxwing
Herbivorous (plant-eating) mammals	Columbia black-tailed deer, Roosevelt elk, snowshoe hare, mountain beaver, creeping vole
Foliage-gleaning insectivores	Golden-crowned kinglet, warbling vireo, black-throated gray warbler (these species also benefit from Understory Development and later stand development stages)

Ecosystem Initiation stands adjacent to mature forests have high contrast edges (refer to photo, right). Ecosystem Initiation stands with high contrast edges may have increased wildlife use (Hunter 1990, Patton 1992, Johnson and O'Neil 2001) because they provide foraging habitat (in the Ecosystem Initiation stand) next to cover and perching habitat (in the adjacent stand). For example, hawks and several species of owls (Johnsgard 1988, 1990) are known to use high contrast edges for hunting. High contrast edges provide escape and cover for deer, elk (Kirchhoff and others 1983, Yahner 1988), and other species that forage within these relatively open areas. Table 3-47 provides examples of wildlife guilds that may benefit from Ecosystem Initiation stands with high contrast edges.

Table 3-47. Wildlife Guilds That May Benefit From Ecosystem Initiation Stands With High Contrast Edges

Benefitting guilds	Representative species
Aerial salliers (perch in foliage and catch flying insects)	Western tanager, olive-sided flycatcher
Forage on high contrast edge	Blue grouse, Cooper's hawk, northern pygmy-owl, northern saw-whet owl, western screech-owl, ruby-crowned kinglet, Vaux's swift, big brown bat, silver-haired bat, hoary bat, California myotis, Keen's myotis, little brown myotis, American marten, short-tailed weasel, mountain lion, Columbia black-tailed deer, bobcat
High contrast edge species	Great horned owl, American robin, spotted towhee, dark-eyed junco, brown-headed cowbird, common raven, Steller's jay, vagrant shrew, mountain beaver
Edge species	Western screech owl, great horned owl, Columbia black-tailed deer, Roosevelt elk, big brown bat, silver-haired bat, hoary bat, California myotis, Keen's myotis, little brown myotis
Herbivorous mammals	Columbia black-tailed deer, Roosevelt elk, snowshoe hare, mountain beaver, creeping vole

Table 3-48 lists an example of a wildlife guild that may benefit from Ecosystem Initiation stands when other, older stands are also available in the area.

Table 3-48. Wildlife Guild That May Benefit From the Ecosystem Initiation Stand Development Stage When Other, Older Stands Are Available in Area

Benefitting guild	Representative species
Herbivorous mammals	Columbia black-tailed deer, Roosevelt elk, snowshoe hare, mountain beaver, creeping vole

COMPETITIVE EXCLUSION

In this stage, trees are often close together and compete closely for light, water, nutrients, and space (refer to photo, right). No wildlife species in Western Washington are found exclusively in the Competitive Exclusion stand development stage (Carey and Johnson 1995) because of its low structural diversity and low or absent shrub cover (Johnson and O'Neil 2001). However, some species use these stands as cover for hiding, escape, breeding, and protection from weather.


Competitive Exclusion Stand Development Stage

UNDERSTORY DEVELOPMENT

Forest stands in this stage begin to have gaps in the canopy. These gaps allow some sunlight to reach the forest floor, which allows an understory of trees, ferns, and shrubs to develop. Fewer and larger trees have larger crowns that produce more seeds.


Understory Development Stand Development Stage

Wildlife species associated with arboreal seed-eating and needle/bud-eating wildlife guilds use this stage (Johnson and O'Neil 2001). Table 3-49 lists examples of wildlife guilds that may benefit from the Understory Development stand development stage. Other common species such as black bear, coyote, ruffed grouse, Townsend's solitaire, and hermit thrush also use this stage (Johnson and O'Neil 2001).

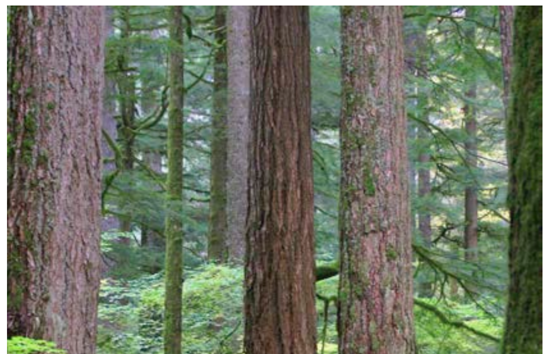
Table 3-49. Wildlife Guilds That May Benefit From the Understory Development Stand Development Stage

Benefitting guilds	Representative species
Arboreal (live in trees) seed-eaters	Pine siskin, Douglas squirrel, Townsend's chipmunk
Arboreal needle/bud-eating	Blue grouse, Douglas squirrel
Arboreal omnivores (feed on plants and animals)	Raccoon, forest deer mouse
Bark probers/gleaners	Hairy woodpecker, red breasted nuthatch, brown creeper

Table 3-49, Continued. Wildlife Guilds That May Benefit From the Understory Development Stand Development Stage

Benefitting guilds	Representative species
Understory birds	Dark-eyed junco, fox sparrow, Swainson's thrush, orange-crowned warbler, ruby-crowned kinglet, Wilson's warbler, winter wren
Understory-gleaning insectivores	Winter wren, song sparrow

BIOMASS ACCUMULATION


Biomass Accumulation Stand Development Stage

For this RDEIS analysis, DNR considers Biomass Accumulation roughly equivalent to the maturation stand development stage defined by Franklin and others (2002). Forest stands in the Biomass Accumulation stage contain numerous large, overstory trees that continue to rapidly add woody biomass (grow larger in diameter). Forests in this stage occupy the site fully, and competition between trees is moderate. This stage lacks the large snag and/or down woody debris and understory diversity that characterize later stages.

Johnson and O'Neil (2001) listed 11 wildlife species closely associated with this stand development stage, although many require the presence of remnant snags for breeding. Trees in the Biomass Accumulation stage are sufficiently mature to produce large cone crops and food for seed-eating wildlife such as the red crossbill, Douglas' squirrel, and Townsend's chipmunk (Adkisson 1996, Chapman and Feldhammer 1982) and are large enough to support primary and secondary cavity nesters (primary nesters excavate cavities; secondary nesters use cavities excavated by other wildlife). Larger crowns and crown growth in this stage may support needle-eating wildlife (Cade and Hoffman 1990). Wildlife species that feed or breed in large trees (generally greater than 24 inches in diameter) may also benefit from this stage. For example, marbled murrelets, a seabird that forages in the ocean and nests in the forest, may benefit from trees (generally, greater than 30 inches in diameter) that have branches large enough to produce platforms on which they can nest (Huff and others 2006). (Refer to "Structurally Complex" in the following section for more information.)

Table 3-50 lists examples of wildlife guilds that may benefit from the Biomass Accumulation stand development stage.

Table 3-50. Wildlife Guilds That May Benefit From the Biomass Accumulation Stand Development Stage

Benefitting guilds	Representative species
Feed and/or breed in large trees (generally greater than 24 inches diameter)	Chestnut-backed chickadee, brown creeper, red crossbill, pileated woodpecker, northern flying squirrel, marbled murrelet
Primary cavity nesters	Hairy woodpecker
Secondary cavity nesters	Chestnut-backed chickadee, saw-whet owl
Arboreal seed-eaters	Pine siskin, Douglas squirrel, Townsend's chipmunk
Arboreal needle/bud-eating	Blue grouse, Douglas squirrel
Arboreal omnivores	Raccoon, forest deer mouse
Bark probers/gleaners	Hairy woodpecker, red-breasted nuthatch, brown creeper
Understory birds	Dark-eyed junco, fox sparrow, Swainson's thrush, orange-crowned warbler, ruby-crowned kinglet, Wilson's warbler, winter wren
Understory-gleaning insectivores	Winter wren, song sparrow

STRUCTURALLY COMPLEX

Key elements of the Structurally Complex stand development stage include large live trees, dead trees (snags), down woody debris of various sizes and conditions (DNR 2004), multiple vertical canopy layers (for example hemlock, vine maple), in-stand structural diversity (patches of larger trees and small openings), and a diverse understory of tree and shrub species of varying sizes and shapes.


Structurally Complex Stand Development Stage

Numerous studies have shown that many species depend on Structurally Complex stands for some or all of their life history requirements (Zobrist and Hinckley 2005). The structural features and complexity of these forest stands may benefit rare and endangered wildlife species such as northern spotted owls, northern goshawks, and marbled murrelets. For example, marbled murrelet populations in Washington, Oregon, and California nest on large tree limbs covered with a thick layer of moss or duff, mistletoe brooms, or other deformities that create a sufficiently wide and flat space on which to lay eggs (Hamer and Nelson 1995). Nesting sites are limited to forests with large-limbed trees (typically old-growth and mature coniferous forests) that are within commutable (flying) distance of the sea (Hamer 1995). The primary marbled murrelet nesting range for Washington encompasses suitable habitat within 40 miles of the coast (Madsen and others 1999), which includes state trust lands in the OESF.

The wildlife guilds associated with this stand development stage include large snag-dependents (species that depend on large snags for nesting, foraging, and other essential activities), large down wood- dependents, ground insectivores, and late successionalist specialists (species that depend on structurally complex forest). Many of these wildlife species depend on forest structures (such as large trees, snags, and down wood) that are found in this stand development stage to a greater extent than in other stages. Table 3-51 lists examples of wildlife guilds that benefit from the Structurally Complex stand development stage.

Table 3-51. Wildlife Guilds Benefitting From Structurally Complex Stand Development Stage

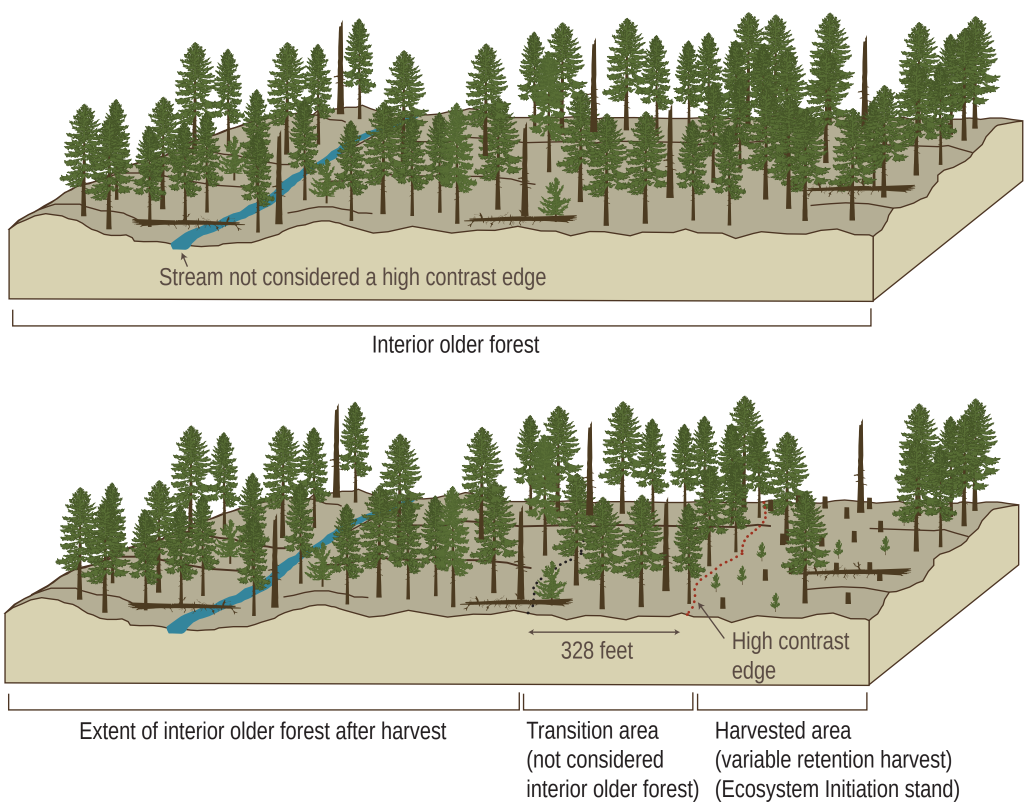
Benefitting guilds	Representative species
Arboreal insectivores (nesting)	Tree swallow, violet green swallow, Vaux's swift
Arboreal seed-eaters	Pine siskin, Douglas squirrel, Townsend's chipmunk
Arboreal needle/bud-eating	Blue grouse, Douglas squirrel
Arboreal omnivores	Raccoon, forest deer mouse
Bark probers/gleaners	Hairy woodpecker, red-breasted nuthatch, brown creeper
Understory birds	Dark-eyed junco, fox sparrow, Swainson's thrush, orange-crowned warbler, ruby-crowned kinglet, Wilson's warbler, winter wren
Understory-gleaning insectivores	Winter wren, song sparrow
Large snag-dependent	Pileated woodpecker, northern saw-whet owl, western screech owl, northern spotted owl, black bear, fisher, bats
Herbivorous and fungivorous (fungus-eating) forest floor small mammals (truffles and fungi, seeds, berries, insects)	Trowbridge's shrew, shrew-mole, red backed vole
Ground insectivores	Western toad, northwestern salamander, Pacific tree frog, shrews, moles, black bear
Large down wood-dependent	Ensatina, northwestern salamander, black bear, fisher
Late successional specialists	Northern goshawk, northern spotted owl, marbled murrelet, northern flying squirrel
Feed and/or breed in large trees (generally greater than 24 inches diameter)	Chestnut-backed chickadee, brown creeper, red crossbill, pileated woodpecker, northern flying squirrel, marbled murrelet
Primary cavity nesters	Hairy woodpecker
Secondary cavity nesters	Chestnut-backed chickadee, saw-whet owl

Indicator: Interior Older Forest

Interior older forest refers to stands that are in the Biomass Accumulation or Structurally Complex stand development stage. For this analysis, stands in these stages must be located at least 328 feet (100 meters) from high contrast edges to be considered interior older forest. Examples of high contrast edges include an Ecosystem Initiation stand, paved road, large water body, or openings in the forest created by natural disturbance (for example, windthrow, fire, or landslides) or human activities (for example, rock pits). DNR does not consider the 328-foot area between the high contrast edge and the remainder of the stand to be interior older forest (refer to Figure 3-20) because this area is subject to edge effects and therefore not part of the interior. However, this 328-foot area provides support for wildlife commensurate with its stand development stage; refer to "Stand Development Stages Supporting Wildlife Guilds" for more information.

Along high contrast edges, more sunlight may reach the forest floor, trees may be more vulnerable to windthrow, and the air and soil may become warmer and drier. Some wildlife species may move away from the edge due to these conditions, while other species may find the conditions along the edge advantageous. Other species may be affected adversely because the high contrast edge can give predators easier access into the stand. For example, predation has been the most significant cause of nest failure in marbled murrelets, with corvids[1] being the primary predator (Nelson and Hamer 1995, Raphael and others 2002).

Figure 3-20. Extent of Interior Older Forest Before and After a Variable Retention Harvest

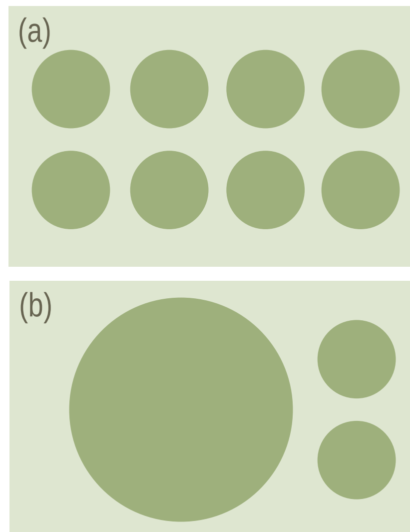


Interior older forest can support a wide range of wildlife species and may provide a refuge for species that are preyed upon by other species, such as great horned owls or crows generally associated with edges and openings. Interior older forest is also able to provide, for long periods and without the influence of edge effects, the specific forest structures (snags, large trees, and down wood) on which many threatened and rare species depend. These threatened or rare species, such as northern spotted owls, are often vulnerable to predation or starvation because they have poor dispersal ability (ability to move from one patch to another). Some species, such as marbled murrelets, may be vulnerable because they have very specific breeding requirements.

Using the outputs of the forest estate model, DNR measures this indicator with three metrics:

- **Acres of interior older forest**: DNR considers whether the total number of acres of interior older forest on state trust lands in the OESF is projected to increase, stay the same, or decrease over the 100-year analysis period.
- **Average edge-to-area ratio of interior older forest patches**: For patches of interior older forest on state trust lands in the OESF, DNR considers whether the average edge-to-area ratio is projected to increase or decrease over the 100-year analysis period (refer to Figure 3-21).
- **Average size of interior older forest patches**: DNR considers whether the average size of interior older forest patches on state trust lands in the OESF is projected to increase, stay the same, or decrease over the 100-year analysis period.

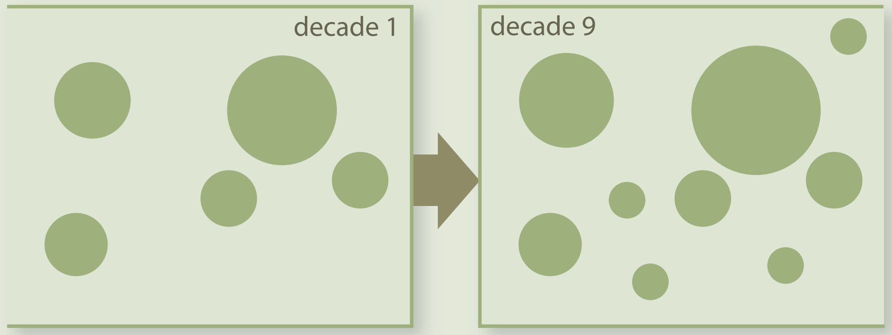
Figure 3-21. Edge-to-Area Ratio



The edge-to-area ratio is a relative metric that compares the length of the edge to the area of either a shape or collection of shapes. In the example above, both collections of shapes have approximately the same area, but the edge-to-area ratio of (a) is higher than (b) because (a) has more edges in relation to area.

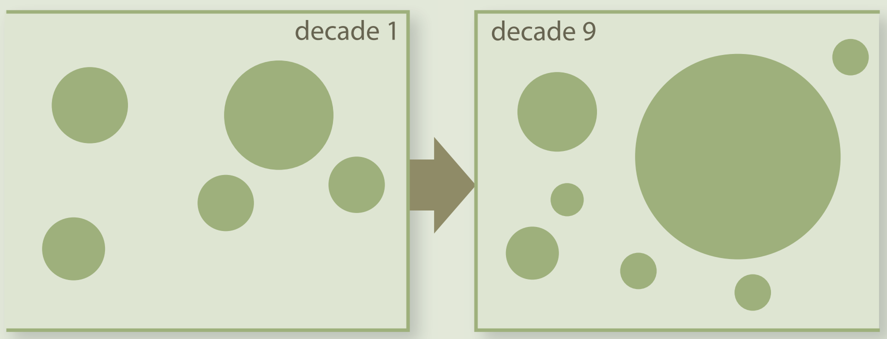
To understand how interior older forest is configured across the landscape, these three metrics must be considered together. For example, assuming the amount of interior older forest increases, an increase in the edge-to-area and a decrease in the average patch size may indicate that interior older forest is developing in many small patches (refer to Figure 3-22). However, it is also possible that interior older forest is developing in both large and small patches (refer to Figure 3-23).

Figure 3-22. Example 1, Increased Number of Acres of Interior Older Forest, Decreased Average Patch Size, and Increased Edge-to-Area Ratio



Even though existing patches remain the same size or grow slightly larger, new, smaller patches develop. These new patches decrease the average patch size and increase the edge-to-area ratio.

Figure 3-23. Example 2, Increased Number of Acres of Interior Older Forest, Decreased Average Patch Size, and Increased Edge-to-Area Ratio



While one patch has grown larger, the development of new, smaller patches increases the edge-to-area ratio and decreases the average patch size.

For each of the three metrics, DNR excludes from analysis any interior older forest patches that are less than 100 acres in size because these smaller patches are less likely to meet the needs of some species of wildlife, such as fishers, which are believed to need large, contiguous tracts of forest (Powell and Zielinski 1994). DNR feels this is a conservative approach because this analysis considers the habitat needs of all wildlife species, and because the size and isolation of patches does not affect all wildlife species equally (Carey 2007). In other words, this analysis considers only larger patches even though some wildlife species, such as deer mice, do not require larger patches.

Criterion and Indicators: Summary

Table 3-52 summarizes the criterion and indicators used in this analysis.

Table 3-52. Criterion and Indicators for Wildlife and How They Are Measured

Criterion/Indicator	How the indicator is measured	Potential environmental impacts
Conservation of biodiversity/ Stand development stages supporting wildlife guilds	The proportion of state trust lands in the OESF in each stand development stage.	**Low**: Proportion of stands in the Structurally Complex stand development stage increases, and Ecosystem Initiation and Biomass Accumulation stages are present. **Medium**: Proportion of stands in the Structurally Complex stand development stage remains the same, and Ecosystem Initiation and Biomass Accumulation stages are present. **High**: Proportion of stands in the Structurally Complex stand development stages decreases, and Ecosystem Initiation and Biomass Accumulation stages are absent.
Conservation of biodiversity/ Interior older forest	Measured with three metrics: **Number of acres**: The total number of acres of interior older forest on state trust lands in the OESF. **Average edge-to-area ratio**: The amount of edges compared to area of all patches of interior older forest on state trust lands in the OESF. **Average patch size**: The average size of interior older forest patches on state trust lands in the OESF.	**Low**: Number of acres of interior older forest increases, edge-to-area ratio decreases, and average patch size increases. **Medium**: Number of acres of interior older forest increases, edge-to-area ratio increases, and average patch size decreases. **High**: Number of acres of interior older forest decreases, edge-to-area ratio increases, and average patch size decreases.

Current Conditions and Results

Indicator: Stand Development Stages Supporting Wildlife Guilds

As mentioned previously, each stand development stage has specific forest structures that benefit different guilds of wildlife. A change in the proportion of stand development stages can affect the wildlife that depend on these structures.

- **Current conditions**: The current distribution of stand development stages is presented in Chart 3-5 in "Forest Conditions and Management," p. 3-34. Currently, 54 percent of state trust lands in the OESF are in the Competitive Exclusion stage, 29 percent are in the Understory Development stage, 11 percent are in the Structurally Complex stage, 4 percent are in the Ecosystem Initiation stage, and 2 percent are in the Biomass Accumulation stage.

- **Results**: Chart 3-10 and Chart 3-11 from "Forest Conditions and Management," p. 3-40 are presented here as Chart 3-72 and Chart 3-73 to show how the proportion of stand development stages is projected to change over the 100-year analysis period. The trends for both alternatives are very similar. Refer to Appendix E for charts showing the stand development stages for the 11 landscapes.

Chart 3-72. Projected Stand Development Stages on State Trust Lands in the OESF, No Action Alternative

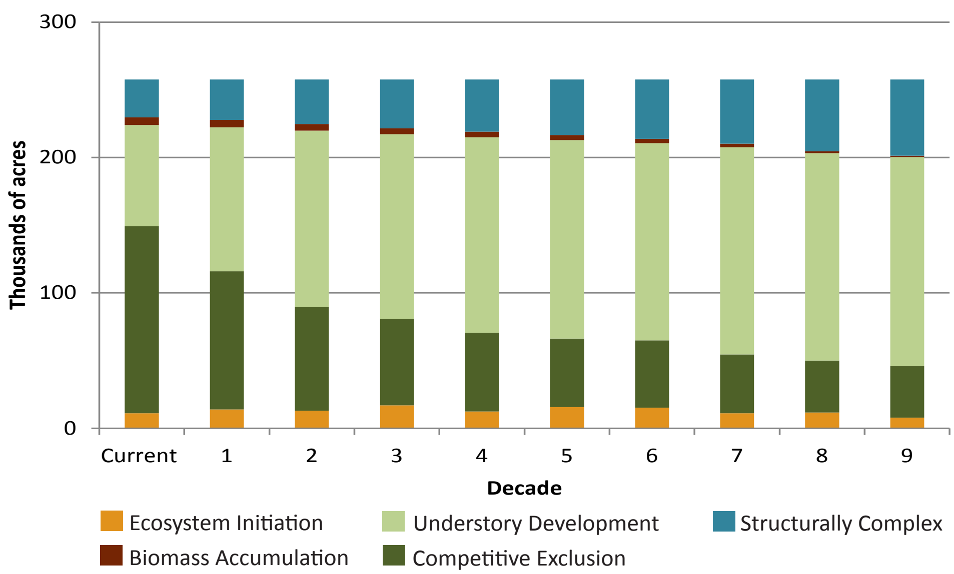
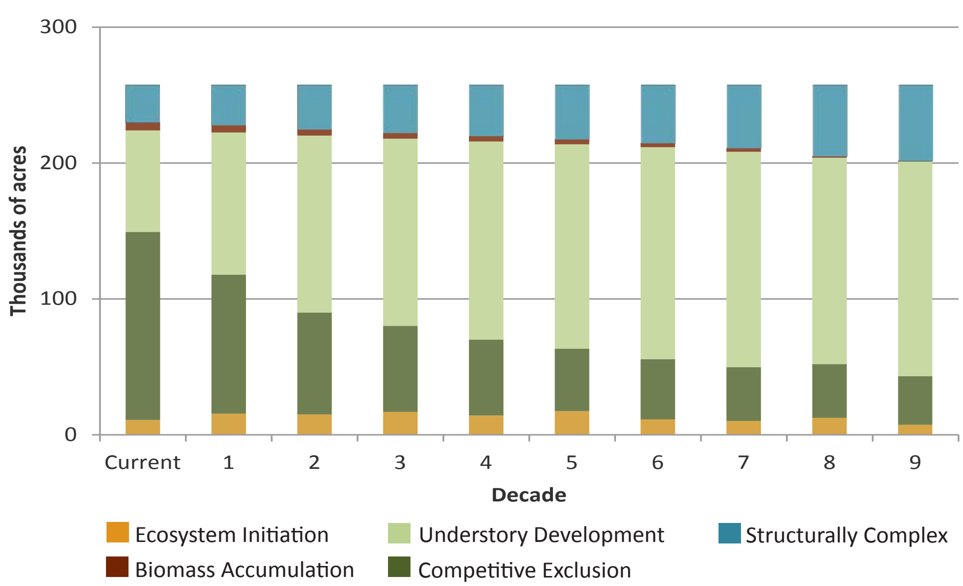


Chart 3-73. Projected Stand Development Stages on State Trust Lands in the OESF, Landscape Alternative



The Structurally Complex stand development stage is projected to increase steadily and almost double over the 100-year analysis period under both alternatives. Numerous studies have shown that many species require Structurally Complex stands for some or all of their life history requirements (Zobrist and Hinckley 2005). An increase in this stand development stage could benefit numerous species of wildlife (refer to Table 3-51). For example, this stand development stage may benefit marbled murrelets, which are associated with the forest structures found within this stage (Hamer 1995, Hamer and Nelson 1995).

The Ecosystem Initiation stand development stage is projected to remain nearly constant throughout the 100-year analysis period under both alternatives, remaining near its current level of approximately 4 percent.

Many wildlife species use the Ecosystem Initiation stand development stage, although more for foraging than for breeding. Deer and elk populations have been declining in the Northwest coastal region since the 1990s because of declining foraging habitat (Spencer 2002). The presence of the Ecosystem Initiation stand development stage on state trust lands in the OESF could provide habitat for these species.

The Biomass Accumulation stand development stage is the least represented on state trust lands in the OESF and is projected to decrease under both alternatives through the 100-year analysis period, most likely because stands in this stage are becoming more complex and moving into the Structurally Complex stage, or are being harvested and planted with new trees.

The Biomass Accumulation stage supports primary and secondary cavity nesters and species that feed or breed in large trees. Some species, such as marbled murrelets, need large trees (30 inches in diameter and larger) for nesting because large trees have a higher likelihood of developing nesting platforms (Huff and others 2006). Although the proportion of this stage is projected to decline over the 100-year analysis period, it remains present and continues to provide support for these species.

Because the proportion of state trust lands in the Structurally Complex stand development stage is projected to increase and both Biomass Accumulation and Ecosystem Initiation stages are present throughout the 100-year analysis period, the potential environmental impact of either alternative for this indicator is considered **low**. DNR has not identified probable significant adverse environmental impacts from either alternative for this indicator.

Indicator: Interior Older Forest

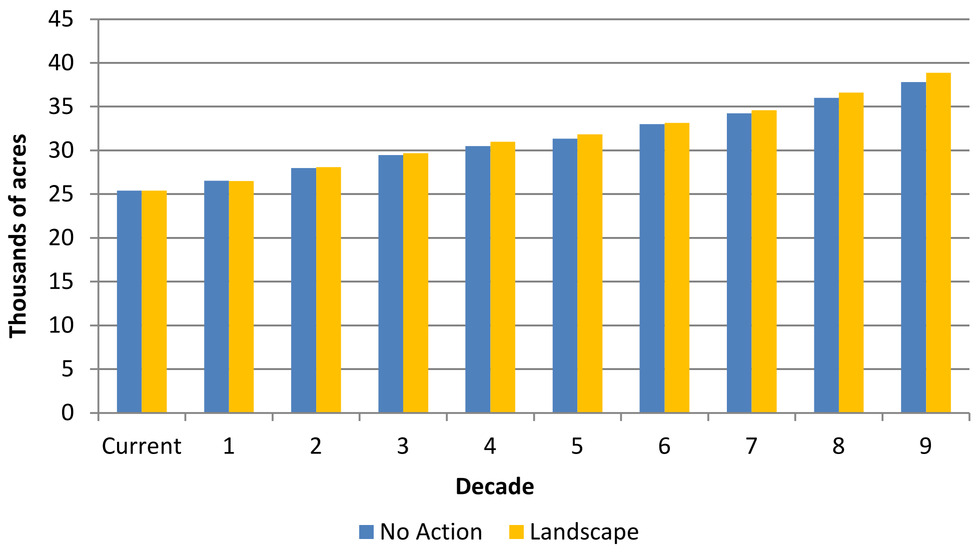
As mentioned previously, interior older forest refers to stands that are in Biomass Accumulation or Structurally Complex stand development stages and are at least 328 feet away from high contrast edges. Interior older forest is assessed with three metrics. These metrics must be considered together to understand how the configuration of interior older forest across the landscape changes over time. A summary of the three metrics is provided at the end of this section.

NUMBER OF ACRES OF INTERIOR OLDER FOREST

This metric considers the total number of acres of interior older forest that are projected to develop over the 100-year analysis period.

- **Current conditions**: The projected number of acres of interior older forest is approximately 26,000 acres, as shown in Chart 3-74.
- **Results**: Chart 3-74 shows that the number of acres of interior older forest is projected to increase over the 100-year analysis period to approximately 38,000 acres under both alternatives (trends by landscape are included in Appendix K). The increase in the number of acres of interior older forest is primarily due to an increase in the Structurally Complex stand development stage, since the number of acres in the Biomass Accumulation stage decreases over the 100-year analysis period (refer to "Stand Development Stages Supporting Wildlife Guilds" earlier in this section).

Chart 3-74. Projected Number of Acres of Interior Older Forest on State Trust Lands in the OESF

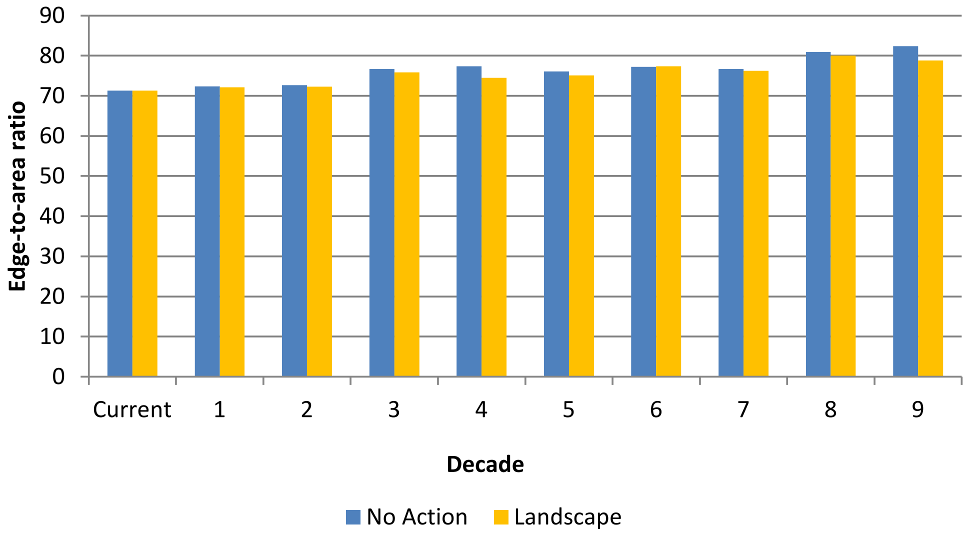


AVERAGE EDGE-TO-AREA RATIO

Edge-to-area ratio compares the amount of edge to the area of interior older forest patches (refer to Figure 3-21).

- **Current condition**: The current average edge-to-area ratio of interior older forest patches is shown in Chart 3-75.
- **Results**: Chart 3-75 shows a trend of increased average edge-to-area ratio over the 100-year analysis period under both alternatives. The No Action Alternative has slightly higher ratios in the middle and late decades.

Chart 3-75. Projected Average Edge-to-Area Ratio of Interior Older Forest on State Trust Lands in the OESF

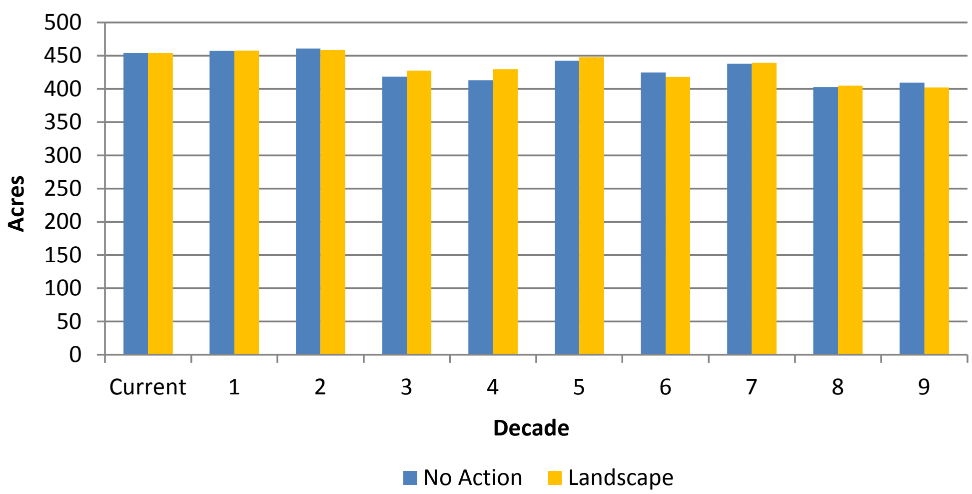


AVERAGE SIZE OF PATCHES OF INTERIOR OLDER FOREST

DNR considers whether the average size of interior older forest patches on state trust lands in the OESF is projected to increase, stay the same, or decrease over the 100-year analysis period.

- **Current conditions**: The average size of patches of interior older forest is approximately 450 acres, as shown in Chart 3-76.
- **Results**: Chart 3-76 shows that the average size of patches of interior older forest is projected to decrease under both alternatives, from the current average of 450 acres to 410 acres (No Action Alternative) or 400 acres (Landscape Alternative).

Chart 3-76. Projected Average Acre Size of Patches of Interior Older Forest on State Trust Lands in the OESF



For a better understanding of both this metric and the edge-to-area ratio, DNR considered how acres of interior older forest are distributed between different categories of patch sizes. Chart 3-77 shows that the total number of acres of interior older forest in the small patch category—100 to 250 acres—is projected to increase over the 100-year analysis period. The total number of acres in the large patch category—over 1,000 acres—also is projected to increase, from approximately 10,000 acres to over 17,000 acres. Only small changes are projected in all other categories. Trends are similar for both alternatives.

Chart 3-77. Projected Number of Interior Older Forest Acres on State Trust Lands in the OESF, Separated by Patch Size

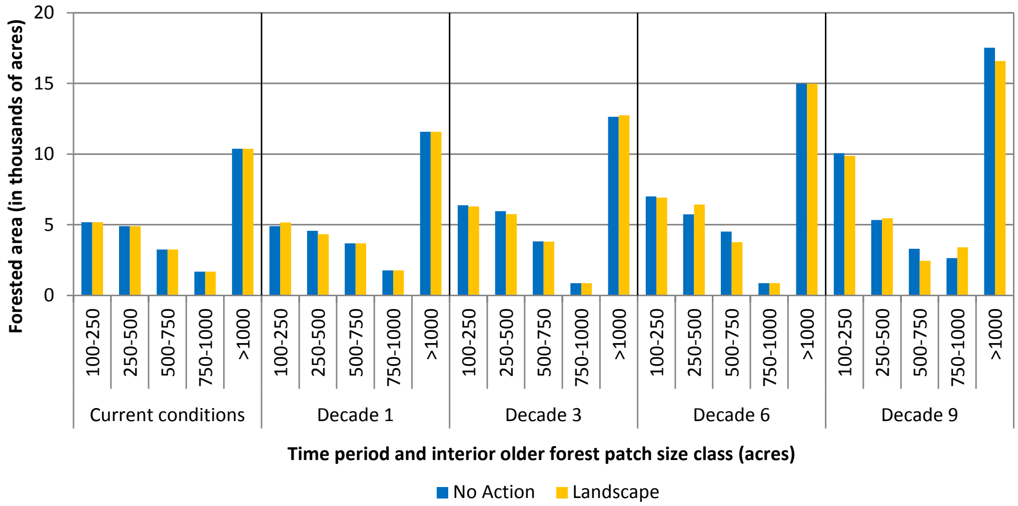
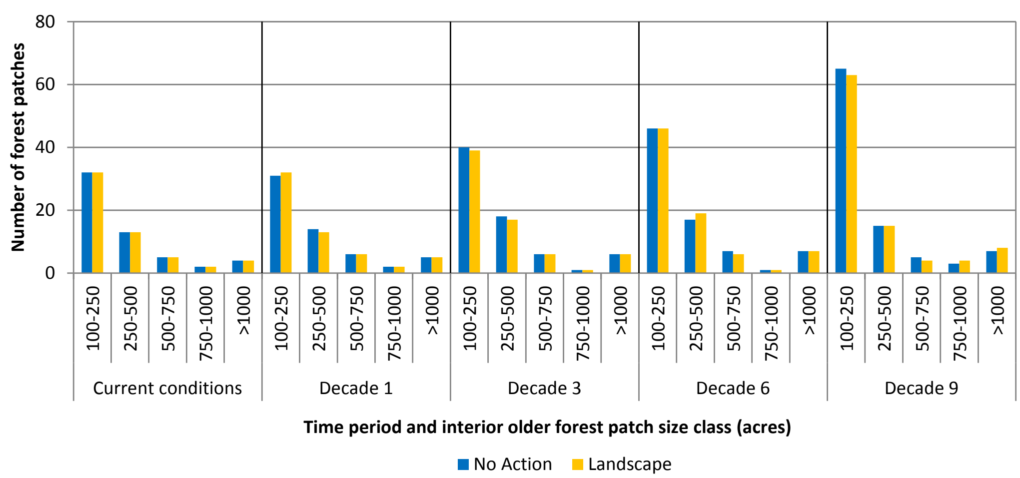


Chart 3-78 shows that the number of patches in the small patch category—100 to 250 acres—is projected to increase from approximately 31 to 62. The number of patches in the large patch category—over 1,000 acres—also is projected to increase, from approximately 4 to 8. Only small changes are projected in all other categories. Trends are similar for both alternatives. Refer to "Interior Older Forest Summary" in the following section for a discussion of these results.

Chart 3-78. Projected Number of Interior Older Forest Patches on State Trust Lands in Different Patch Size Classes



INTERIOR OLDER FOREST SUMMARY

Over the 100-year analysis period on state trust lands in the OESF:

- The number of acres of interior older forest is projected to increase (Chart 3-74),
- The average edge-to-area ratio is projected to increase (Chart 3-75), and
- The average patch size is projected to decrease (Chart 3-76).

As stated previously, these results can lead to different conclusions (Figure 3-22 and Figure 3-23). To clarify these trends, DNR also considered how interior older forest is distributed between different patch size categories (Chart 3-77 and Chart 3-78). Under either alternative, the analysis suggests that across state trust lands,

- Interior older forest most likely will develop in numerous small patches,
- A few larger patches of interior older forest may develop, most likely from mid-size patches growing larger, and
- Existing large patches of interior older forest are likely to expand in size.

Places where interior older forest is projected to increase include riparian areas and areas currently deferred as Old Forest Habitat for northern spotted owls. The development of structural complexity in riparian areas was predicted in the 1997 *Habitat Conservation Plan*. Patches in riparian areas may tend to be smaller and long and narrow in shape, which would increase the edge-to-area ratio and decrease average patch size.

Interior older forest may have more value to some species of wildlife when located in large patches. Large patches are especially important for rare or threatened species that are sensitive to disturbance, have specific breeding requirements, have poor dispersal ability, or require specific forest structures such as snags and deformed trees well away from high contrast edges (Noss 1983). For example, the nesting success of marbled murrelets may be lower near high-contrast edges due to predation (Malt and Land 2009, Raphael and others 2002): high contrast edges may increase the chances of marbled murrelet eggs or chicks being found and killed by predators (Malt and Lank 2009, Nelson and Hamer 1995).

Landscapes dominated by small interior older forest patches may support fewer specialized species unable to use small, isolated forest patches, and more common generalist species such as small and large mammal predators (Noss 1983, Carey 2007). Small interior older forest patches may have more value to wildlife when patches are located closer together and surrounded by forest stands that do not produce high contrast edge effects (Forman and Godron 1986, Noss 1983). McShane and others (2004) summarized numerous studies on a specialist species, the marbled murrelet, and its habitat use at the landscape scale:

> Studies using audio-visual detection data to characterize murrelet nesting habitat at a landscape scale have often found murrelet use to be associated with (1) the presence of mature and old-growth forests, (2) larger core areas of old-growth, (3) low amounts of edge…(4) lower fragmentation levels, and (5) proximity to the marine environment. In some cases, murrelet use was associated with lower elevations, more

complex landscape patterns, and stands that were less isolated from other similar stands (p. 6-2 to 6-3).

The potential environmental impact of either alternative for this indicator is considered **medium**. Most of the interior older forest patches that develop are smaller and potentially isolated, but because the overall amount of interior older forest is projected to increase and some large patches are projected to develop, the impact is considered medium. DNR has not identified probable significant adverse impacts from either alternative for this indicator.

Summary of Potential Impacts

Table 3-53 provides an overview of the potential environmental impacts on wildlife when the criterion and all of the indicators are considered. For this analysis, only high impacts are considered potentially significant impacts. DNR has not identified probable significant adverse environmental impacts from either alternative for any indicator used for this topic.

Table 3-53. Potential Environmental Impacts on Wildlife by Indicator and Alternative

Criteria	Indicators	No Action Alternative	Landscape Alternative
Conservation of biodiversity	Stand development stages supporting wildlife guilds	Low ●	Low ●
	Interior older forest	Medium ◇	Medium ◇

● Low impact ◇ Medium impact

Considered but Not Analyzed

Forest Stand-Level Impacts

DNR did not evaluate the impacts of harvest on individual forest stands because it is too fine a scale for an analysis of wildlife guilds and species. Individual timber harvests may alter a specific site and affect the wildlife guilds using that site, but the same general forest type and structure (stand development stage) and associated wildlife guilds are found in other areas on state trust lands. As explained in Chapter 2, the potential environmental impacts of individual timber sales are analyzed through SEPA at the time the sale is proposed.

Table 3-54 lists some of the general disturbances and benefits to wildlife that may occur at the forest stand level following either variable retention harvest or thinning (refer to Text Box 3-1 for a description and photos of harvest methods).

Table 3-54. Potential Disturbance and Benefit to Wildlife at the Forest Stand Scale, by Harvest Method

Harvest Type/ Duration	Potential disturbance	Potential benefits
Variable retention harvest/ Short-term	May eliminate habitat for species currently using the forest stand being harvested (Hayes and others 2003, Wallendorf and others 2007). Noise from harvest activities may cause wildlife (including deer, elk, and bear) to leave the immediate area temporarily. Physical disturbance from yarding (moving trees from where they are felled to where they are collected for transport) may reduce shrub layers and affect habitat for ground-associated species. Harvest may result in possible direct mortality (unintentionally cutting down a nest tree). Potential removal of snags for worker safety can reduce habitat for cavity nesting birds.	Immediately opens stand and promotes shrub growth, providing foraging habitat for species that use the Ecosystem Initiation stand development stage. May produce habitat for species that are rare or absent in other stand development stages. Leave trees (trees that are not harvested) provide perches for olive-sided flycatchers, red-tailed hawks, and great horned owls. Wildlife reserve trees[a] can provide habitat for cavity-nesting birds such as woodpeckers. The high contrast edge (edge where forested and non-forested areas meet) created by harvest supports species such as western screech owls and accipiter hawks. Retained snags and large woody debris support cavity-nesting birds, small mammals, and amphibians.
Variable retention harvest/ Long-term	May reduce or eliminate habitat for wildlife species, such as hermit warblers and northern flying squirrels, that require mature overstory trees.	Legacy trees[b] and leave patches (patches of unharvested trees) may eventually support species, such as brown creepers, pileated woodpeckers, and many species of bats, that require large trees and snags.

Table 3-54, Continued. Potential Disturbance and Benefit to Wildlife at the Forest Stand Scale, by Harvest Method

Harvest Type/ Duration	**Potential disturbance**	**Potential benefits**
Variable density thinning/ Short-term	Noise and management activity may cause wildlife to leave the area temporarily. Physical disturbance can reduce shrubs and associated habitat for birds. Potential removal of snags for worker safety may reduce habitat for cavity-nesting birds. Could potentially result in direct mortality (unintentionally cutting down a nest tree). Thinning may suppress northern flying squirrel populations, possibly for several decades (Wilson 2010).	Opens stand to provide flying space for birds such as sharp-shinned and Cooper's hawks. Creates openings used by many types of wildlife that forage within Ecosystem Initiation stands. Dead and down wood created and retained within legacy patches (areas left from a previous harvest) provide hiding or nesting cover for amphibians, small mammals, and insects.
Variable density thinning/ Long-term	Tree removal may reduce habitat for species, such as blue grouse, that require denser stands.	Encourages development of large trees that are necessary components of structurally diverse stands, which support breeding habitat for woodpeckers, bats, and other species. Can potentially lead to development of greater structural complexity, which can lead to an increase in wildlife diversity and abundance.

[a] A tree that is suitable for wildlife and is not harvested; a type of leave tree.

[b] A tree, usually mature or old-growth, that is retained on a site after harvesting or natural disturbance to provide a biological legacy (Society of American Foresters).

Roads

Because of its isolation from major population centers, the OESF has limited road use. Most road traffic is associated with forest management activities. Approximately 94 percent of the roads on state trust lands in the OESF are unpaved and approximately 89 percent of roads have low use (refer to Appendix C). For the following reasons, roads were considered but not analyzed for wildlife impacts:

- Although vehicles on roads have the potential to kill wildlife, the infrequent loss of individual members of a species has a minimal effect on wildlife populations (Forman and Alexander 1998).
- Road density can affect some far-ranging species such as grizzly bears and wolves. However, the OESF does not contain populations of species known to be affected by road density.

Section Note

1. Corvids are a large family of birds that includes species of jays, crows, and ravens.

Northern Spotted Owls


Photo courtesy USFWS

What Is the Status of Northern Spotted Owls?

The northern spotted owl (*Strix occidentalis caurina*; refer to Text Box 3-7 on p. 3-204), a subspecies of spotted owl,[1] was listed as threatened under the Endangered Species Act in 1990.[2] In 2004, USFWS conducted a five-year review[3] of the status of the northern spotted owl and concluded that the subspecies should remain listed as threatened.

Northern spotted owl populations in Washington are declining at a rate between 5.9 and 7 percent per year (Anthony and others 2006; Forsman and others 2011). According to Courtney and others 2004, Gutierrez and others 2006, Olson and others 2004, and Gremel 2008, major threats to owl populations in Washington are competition with barred owls (*Strix varia varia*) and loss of habitat from past harvest activities and natural disturbance (refer to Appendix I for more information).

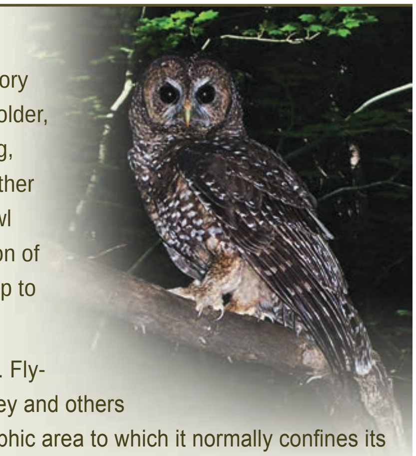
Northern spotted owls on the Olympic Peninsula are considered a distinct sub-population that is geographically isolated by a lack of suitable habitat connecting them to other sub-populations (DNR 1997).[4] Holthausen and others (1995) found that the Olympic sub-population of northern spotted owls is likely to be maintained, but factors such as competition with barred owls could change the sub-population's stability. Currently, owl numbers are declining on the Olympic Peninsula by 4.3 percent per year (Lint 2005, Forsman and others 2011).

In June 2011, USFWS released the R*ecovery Plan for the Northern Spotted Owl*. The plan recommends the development of spatially explicit computer models to evaluate northern spotted owl habitat and territories. To evaluate habitat for this RDEIS analysis, DNR developed stand-level models and a territory model; refer to "Descriptions of the Indicators" later in this section for more information. Additional information about the models can be found in Appendix I.

In 1997, DNR developed the *Habitat Conservation Plan*, a long-term management plan to maintain and improve habitat for threatened and endangered as well as unlisted native species on state trust lands within the range of the northern spotted owl. Authorized under the federal Endangered Species Act, this plan includes conservation goals and mitigation strategies for the northern spotted owl.

Northern spotted owl conservation objectives are described in the 1997 *Habitat Conservation Plan* (p. IV. 86). DNR's objective is to restore and maintain northern spotted owl habitat capable of supporting the species on state trust lands in each of the 11 land-

Text Box 3-7. Northern Spotted Owl Biology



Northern spotted owls are medium size owls with dark brown feathers and white spots on the head and breast. Non-migratory and highly territorial, northern spotted owls generally rely on older, structurally complex forests for nesting, roosting, and foraging, though they will move through less complex forest to reach other habitat patches or new territories (a territory is an area the owl occupies and defends). The Olympic Peninsula sub-population of northern spotted owls lives in low and mid-elevation forests up to approximately 3,000 feet above sea level.

Their predominant prey species is the northern flying squirrel. Flying squirrel abundance on the Olympic Peninsula is low (Carey and others 1995) and as a result, spotted owl home ranges (the geographic area to which it normally confines its activity) on the Olympic Peninsula are some of the largest that have been reported (Holthausen and others 1995). Forsman and others (2007) reported that the median size of annual home ranges of owl pairs on the Olympic Peninsula is 12,434 acres. For a more complete description of northern spotted owl biology, refer to Appendix I. Information may also be found in the 1997 *Habitat Conservation Plan* (p. III.1 through III.22).

scapes[5] in the OESF by developing and implementing a forest land plan that does not appreciably reduce the chances for the survival and recovery of the northern spotted owl sub-population on the Olympic Peninsula. DNR's contribution to federal recovery objectives for the northern spotted owl is to provide habitat on state trust lands in the OESF that makes a significant contribution to demographic support, maintenance of species distribution, and facilitation of dispersal on state trust lands in the OESF.[6]

What Is the Criterion for Northern Spotted Owls?

The criterion is the **amount of habitat capable of providing support for the recovery of the Olympic Peninsula sub-population of northern spotted owls on adjacent federal lands**. Most northern spotted owl recovery on the Olympic Peninsula is anticipated to occur on federal lands adjacent to the OESF (Olympic National Park, Olympic National Forest) that are managed by the federal government for this purpose. This criterion is in accordance with the guidance of the *Recovery Plan for the Northern Spotted Owl* (USFWS 2011).

What Are the Indicators for Northern Spotted Owls?

The indicators used to assess the criterion are the **number of acres of modeled northern spotted owl habitat**, the **number of acres supporting northern spotted owl life history requirements**[7] **(movement, nesting, roosting, and foraging)**, and the **number of modeled potential northern spotted owl territories**. These indicators were selected based on DNR's expertise, existing scientific information, and current data. The following section presents information about the significance of each indicator.

Descriptions of the Indicators

Indicator: Number of Acres of Modeled Northern Spotted Owl Habitat

The two categories of northern spotted owl habitat types used in this RDEIS are Old Forest and Young Forest habitats (refer to Text Box 3-8 and Appendix I). These habitat types are based on the habitat definitions in the 1997 *Habitat Conservation Plan*.[8]

Text Box 3-8. Northern Spotted Owl Habitat Types

Old Forest Habitat

Old Forest Habitat is a grouping of northern spotted owl habitat types[a] that supports owl nesting, roosting, foraging, and dispersal (movement).

Old Forest Habitat has multiple species of trees, more than one canopy layer, and enough canopy closure to protect owls from predators and buffer temperatures. The dominant trees are large (over 20 or 30 inches in diameter) and have deformities that can provide nesting sites. There is an abundance of large snags and down wood.

[a]Old Forest Habitat is an aggregation of Type A, Type B, high-quality nesting (1997 *Habitat Conservation Plan* p. IV.11), and mapped Old Forest Habitat. These habitat types are described in Appendix I.

Young Forest Habitat

Young Forest Habitat is a grouping of northern spotted owl habitat types[b] which supports dispersal (movement) and provides some opportunities for roosting and foraging.

The canopy is closed enough to protect owls from predators and the forest is not too dense for owls to fly though. Trees are at least 85 feet tall and at least 30 percent of them are conifers (such as Douglas fir). A few larger snags are present and the forest floor has some down wood.

[b]Young Forest Habitat is an aggregation of sub-mature habitat (1997 *Habitat Conservation Plan* p. IV.11) and young forest marginal habitat (Procedure 14-004-120, modified from WAC 222-16-085). These habitat types are described in Appendix I.

The amounts of Old Forest Habitat and Young Forest Habitat on state trust lands in each of the 11 landscapes in the OESF provide different levels of support for northern spotted owls. For this analysis, in each landscape, DNR considers:

- The number of acres of modeled Old Forest Habitat, and
- The number of acres of modeled Young Forest Habitat and better (acres of Young Forest Habitat and Old Forest Habitat added together). DNR combines these two habitat types (Young Forest and Old Forest) to understand the full range of modeled northern spotted owl habitat in each landscape.

DNR refers to habitat as "modeled" to emphasize that the current conditions and results of this analysis are based on the outputs of DNR's forest estate model.

DNR first assigns each landscape a potential low, medium, or high impact rating based on whether the amount of modeled Old Forest Habitat and Young Forest Habitat and better on state trust lands is projected to increase, stay the same, or decrease by the end of the 100-year analysis period. DNR then considers all landscapes together to assign a potential low, medium, or high impact rating to this indicator.

Indicator: Number of Acres Supporting Northern Spotted Owl Life History Requirements

The four life history requirements of northern spotted owls are movement, roosting, foraging, and nesting (United States Department of Agriculture [USDA] and United States Department of Interior [USDOI] 1994). The stand conditions necessary for each of these life history requirements are as follows:

- **Movement**: Sufficient canopy cover for protection from predators and adequate flying space, including canopy lift (tree limbs off the ground) and tree densities low enough not to impede flight.
- **Roosting**: Adequate tree height, multiple tree and shrub layers for owls to move up and down in the canopy, a canopy deep enough to provide a thermal buffer (insulation) against temperature extremes, and sufficient canopy cover for protection from predators.
- **Foraging**: Adequate prey, which depends on the number of snags and amount of down wood, and a heterogeneous (varied) forest with multiple canopy layers that provide hunting perches to make catching prey easier.
- **Nesting**: Adequate number of trees from larger diameter classes, either large standing trees or snags, although on the Olympic Peninsula, large live trees are used for nesting approximately three times as often as snags (Forsman and Giese 1997).

DNR developed four northern spotted owl stand-level models to assess the ability of state trust lands in the OESF to support these four life history requirements. These models, which evaluate output data from the forest estate model, are specific to the Olympic Peninsula and incorporate stand-level habitat conditions such as snags and down wood.

Forest stands are given a habitat score for each life history requirement based on specific forest attributes (for example, down wood or snags). Scores range from 0 to 100, 100 being best. The minimum habitat score for supporting a life history requirement is assumed to be 50. For this indicator, DNR determines the number of forested acres on state trust lands in the OESF projected to have a habitat score of 50 and above for each life history requirement (refer to Appendix I for a detailed description of stand-level models).

Indicator: Number of Modeled, Potential Northern Spotted Owl Territories

For this indicator, DNR evaluates how many modeled, potential northern spotted owl territories the OESF could support over time under each alternative (a territory is an area that an owl occupies and defends). DNR evaluates state trust lands in the OESF as well as within a 10-mile distance, mostly to the east, encompassing adjacent federal lands.

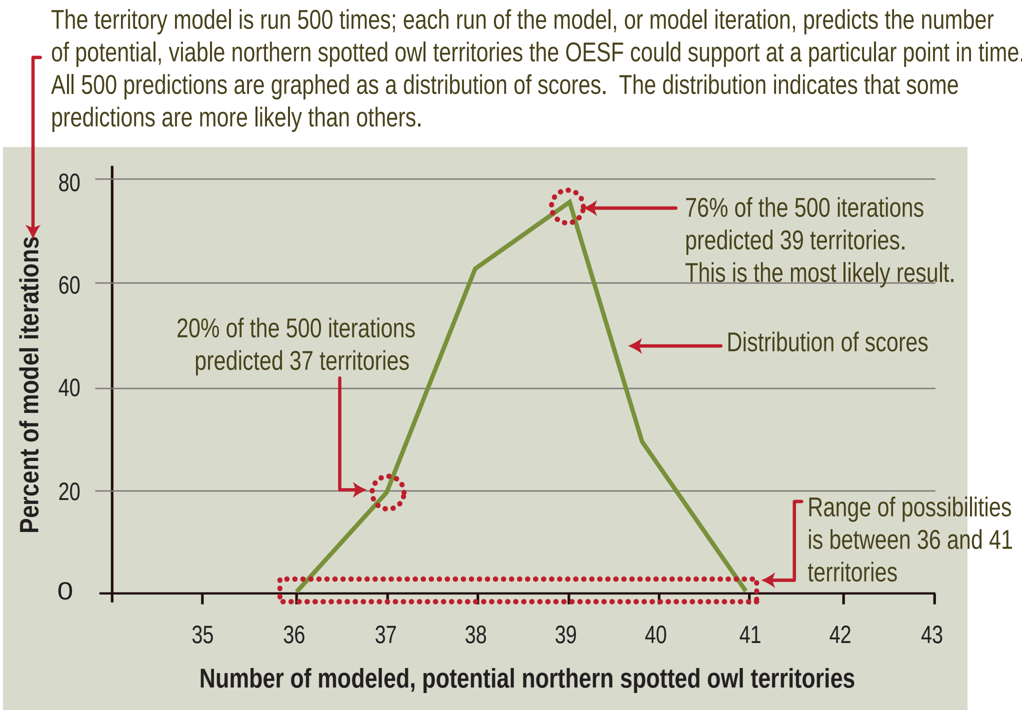
DNR developed a territory model that uses habitat scores to identify areas in the OESF with the potential to support a northern spotted owl territory. DNR's territory model provides an objective, repeatable analysis of the landscape's capability to support northern spotted owls. The model is based on one developed by Sutherland and others (2007) for the former British Columbia Ministry of Forests and Range (now known as the Ministry of Forests, Lands and Natural Resource Operations). The model is informed by literature on northern spotted owl ecology specific to the Olympic Peninsula and by DNR's professional experience.

These territories are hypothetical; they are not actual territories. Northern spotted owls may or may not be found in these areas now or in the future.

In order to incorporate the uncertainty surrounding how owls use the landscape, DNR runs the territory model 500 times per alternative.[9] Each model run, or iteration, predicts the number of potential northern spotted owl territories that the OESF could potentially support at a particular point in time, such as currently (Decade 0) or at the end of the analysis period (Decade 9). All 500 model predictions are then graphed as a distribution of scores (refer to Figure 3-24 on p. 208). The distribution shows that some predictions are more likely than others (refer to Appendix I for a detailed description of the territory model).

The data used in the model for non-state trust lands in the OESF and the lands within the 10-mile buffer remains unchanged throughout the 100-year analysis period. In other words, the model does not account for the continued growth or reduction of habitat on non-state trust lands over time. Therefore, the projected increase in the number of modeled, potential territories in the OESF in this analysis is due to the increased capability of state trust lands to support northern spotted owls. It is expected, however, that there will be a substantial amount of habitat development on federal lands (USDA 1994 and USDOI 1997) over the 100-year analysis period.

Figure 3-24. Example of a Distribution of Scores



Criterion and Indicators: Summary

Table 3-55 summarizes the criteria and indicators used in this analysis and how they are measured.

Table 3-55. Criterion and Indicators for Northern Spotted Owls and How They Are Measured

Criterion/Indicator	How indicator is measured	Potential environmental impacts
Amount of habitat capable of providing support for the recovery of the Olympic Peninsula sub-population of northern spotted owls on adjacent federal lands/ Number of acres of modeled northern spotted owl habitat	The number of acres of Old Forest Habitat and Young Forest Habitat and better on state trust lands in the OESF.	**Low**: The number of acres of Old Forest Habitat and Young Forest Habitat and better increases. **Medium**: The number of acres of Old Forest Habitat and Young Forest Habitat and better stays the same. **High**: The number of acres of Old Forest Habitat and Young Forest Habitat and better decreases.

Table 3-55, Continued. Criterion and Indicators for Northern Spotted Owls and How They Are Measured

Criterion/Indicator	How indicator is measured	Potential environmental impacts
Amount of habitat capable of providing support for the recovery of the Olympic Peninsula sub-population of northern spotted owls on adjacent federal lands/ Number of acres supporting northern spotted owl life history requirements	The number of acres with a habitat score of at least 50 (on a scale of 0 to 100) for each northern spotted owl life history requirement (nesting, roosting, foraging, and movement) on state trust lands in the OESF.	**Low**: The number of acres with habitat scores of 50 or above increases. **Medium**: The number of acres with habitat scores of 50 or above remains the same. **High**: The number of acres with habitat scores of 50 or above decreases.
Amount of habitat capable of providing support for the recovery of the Olympic Peninsula sub-population of northern spotted owls on adjacent federal lands/ Number of modeled potential northern spotted owl territories	The number of modeled potential northern spotted owl territories the entire OESF could support over time, reported by decade using a territory model.	**Low**: The number of territories increases. **Medium**: The number of territories stays the same. **High**: The number of territories decreases.

Current Conditions

Indicator: Number of Acres of Modeled Northern Spotted Owl Habitat

Table 3-56 on p. 3-210 shows the estimated number of acres of modeled Old Forest Habitat and Young Forest Habitat and better[10] on state trust lands in each of the 11 landscapes in the OESF. Current conditions within each landscape are a summation of numerous factors including past harvest activities, natural forest development, and natural disturbances (for example, wind, wildfire, or landslides). These factors influence the amount of modeled northern spotted owl habitat that is currently available in each landscape. While some landscapes have very little (Sekiu and Clallam with 1 percent and 2 percent, respectively), others have over, or close to, a quarter of their acres in Old Forest Habitat (Clearwater with 26 percent and Queets with 25 percent).

Table 3-56. Estimated Acres (and Percent) of Current Modeled Northern Spotted Habitat on State Trust Lands in the OESF, by Landscape

Landscape (acres)	Forest estate model estimate		
	Old Forest Habitat acres (percent)	Young Forest Habitat acres (percent)	Total northern spotted owl habitat (Young Forest Habitat and better) acres (percent)
Clallam (17,276)	314 (2%)	5,662 (33%)	5,976 (35%)
Clearwater (55,203)	14,101 (26%)	3,105 (6%)	17,206 (31%)
Copper Mine (19,246)	3,107 (16%)	708 (4%)	3,815 (20%)
Dickodochtedar (28,047)	2,570 (9%)	5,059 (18%)	7,629 (27%)
Goodman (23,799)	4,822 (20%)	2,392 (10%)	7,214 (30%)
Kalaloch (18,122)	2,472 (14%)	1,956 (11%)	4,428 (24%)
Queets (20,807)	5,179 (25%)	1,579 (8%)	6,758 (33%)
Reade Hill (8,479)	1,933 (23%)	2,038 (24%)	3,971 (47%)
Sekiu (10,014)	75 (1%)	1,424 (14%)	1,499 (15%)
Sol Duc (19,146)	643 (3%)	4,682 (24%)	5,325 (28%)
Willy Huel (37,428)	7,520 (20%)	993 (3%)	8,513 (23%)

Indicator: Number of Acres Supporting Northern Spotted Owl Life History Requirements

Table 3-57 presents the number of acres of state trust lands that currently have a habitat score of 50 or above for each of the life history requirements for northern spotted owls. Acres may support more than one life history requirement. For example, acres which support movement may also support roosting or foraging.

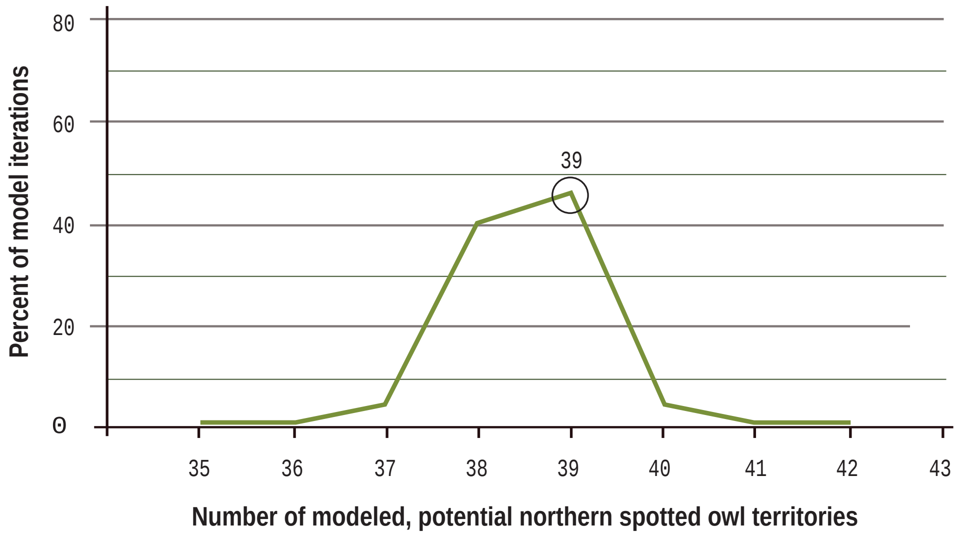
Table 3-57. Current Number of Acres of State Trust Lands with Habitat Scores of 50 and Above

Life history model	Acres with habitat scores of 50 and above
Roosting	70,538
Foraging	63,203
Movement	160,891
Nesting	47,016

Indicator: Number of Modeled, Potential Northern Spotted Owl Territories

The northern spotted owl territory model predicts that currently, the OESF can support between 36 and 41 potential territories. The most likely prediction is 39 (refer to Chart 3-79).

Chart 3-79. Current Conditions for Modeled, Potential Northern Spotted Owl Territories in the OESF



Results

Indicator: Number of Acres of Modeled Northern Spotted Owl Habitat

By the end of the 100-year analysis period, the estimated number of acres of modeled Old Forest Habitat and Young Forest Habitat and better on state trust lands in the OESF is projected to increase in each of the 11 landscapes, as indicated by Table 3-58 and Table 3-59 (refer to Appendix I for the number of acres of Old Forest Habitat and Young Forest Habitat and better by decade and landscape).

Table 3-58. Projected Acres (and Percent) of Modeled Old Forest Habitat on State Trust Lands in the OESF at End of Analysis Period, by Landscape

Landscape (acres)	Current conditions: Old Forest Habitat acres (percent)	Results: Old Forest Habitat acres (percent) No Action Alternative in Decade 9	Results: Old Forest Habitat acres (percent) Landscape Alternative in Decade 9
Clallam (17,276)	314 (2%)	3,492 (20%) ●	3,485 (20%) ●
Clearwater (55,203)	14,101 (26%)	18,587 (34%) ●	18,546 (34%) ●
Copper Mine (19,246)	3,107 (16%)	4,363 (23%) ●	3,991 (21%) ●
Dickodochtedar (28,047)	2,570 (9%)	6,274 (22%) ●	6,213 (22%) ●
Goodman (23,799)	4,822 (20%)	8,936 (37%) ●	8,667 (36%) ●
Kalaloch (18,122)	2,472 (14%)	4,845 (27%) ●	4,796 (26%) ●
Queets (20,807)	5,179 (25%)	6,557 (31%) ●	6,534 (31%) ●
Reade Hill (8,479)	1,933 (23%)	4,268 (50%) ●	4,154 (49%) ●
Sekiu (10,014)	75 (1%)	2,095 (21%) ●	2,099 (21%) ●
Sol Duc (19,146)	643 (3%)	4,715 (25%) ●	4,613 (24%) ●
Willy Huel (37,428)	7,520 (20%)	10,597 (28%) ●	13,105 (35%) ●

● Low impact

Table 3-59. Projected Acres (and Percent) of Modeled Young Forest Habitat and Better on State Trust Lands in the OESF at End of Analysis Period, by Landscape [Amount of Old Forest Habitat in Brackets and Italics]

Landscape (acres)	Current conditions: Young Forest Habitat and better acres (percent)	Results: Young Forest Habitat and better acres (percent) No Action Alternative in Decade 9	Results: Young Forest Habitat and better acres (percent) Landscape Alternative in Decade 9
Clallam (17,276)	5,976 (35%) [314]	7,475 (43%) [3,492] ●	7,464 (43%) [3,485] ●
Clearwater (55,203)	17,206 (31%) [14,101]	30,780 (56%) [18,587] ●	28,522 (52%) [18,546] ●

Table 3-59, Continued. Projected Acres (and Percent) of Modeled Young Forest Habitat and Better on State Trust Lands in the OESF at End of Analysis Period, by Landscape [Amount of Old Forest Habitat in Brackets and Italics]

Landscape (acres)	Current conditions	Results	
	Young Forest Habitat and better acres (percent)	Young Forest Habitat and better acres (percent) No Action Alternative in Decade 9	Young Forest Habitat and better acres (percent) Landscape Alternative in Decade 9
Copper Mine (19,246)	3,815 (20%) [3,107]	8,353 (43%) [4,363] ●	7,848 (41%) [3,991] ●
Dickodochtedar (28,047)	7,629 (27%) [2,570]	13,602 (48%) [6,274] ●	12,179 (43%) [6,213] ●
Goodman (23,799)	7,214 (30%) [4,822]	12,923 (54%) [8,936] ●	12,682 (53%) [8,667] ●
Kalaloch (18,122)	4,428 (24%) [2,472]	9,091 (50%) [4,845] ●	8,345 (46%) [4,796] ●
Queets (20,807)	6,758 (33%) [5,179]	10,822 (52%) [6,557] ●	10,015 (48%) [6,534] ●
Reade Hill (8,479)	3,971 (47%) [1,933]	5,701 (67%) [4,268] ●	5,410 (64%) [4,154] ●
Sekiu (10,014)	1,499 (15%) [75]	4,284 (43%) [2,095] ●	4,509 (45%) [2,099] ●
Sol Duc (19,146)	5,325 (28%) [643]	9,011 (47%) [4,715] ●	8,255 (43%) [4,613] ●
Willy Huel (37,428)	8,513 (23%) [7,520]	15,213 (41%) [10,597] ●	15,905 (42%) [13,105] ●

When considering all state trust lands together, the projected trend over time is an increase in both modeled Old Forest Habitat and Young Forest Habitat on state trust lands, as indicated by Chart 3-80 and Chart 3-81.

Chart 3-80. Projected Trend of Modeled Northern Spotted Owl Habitat on State Trust Lands in the OESF, No Action Alternative

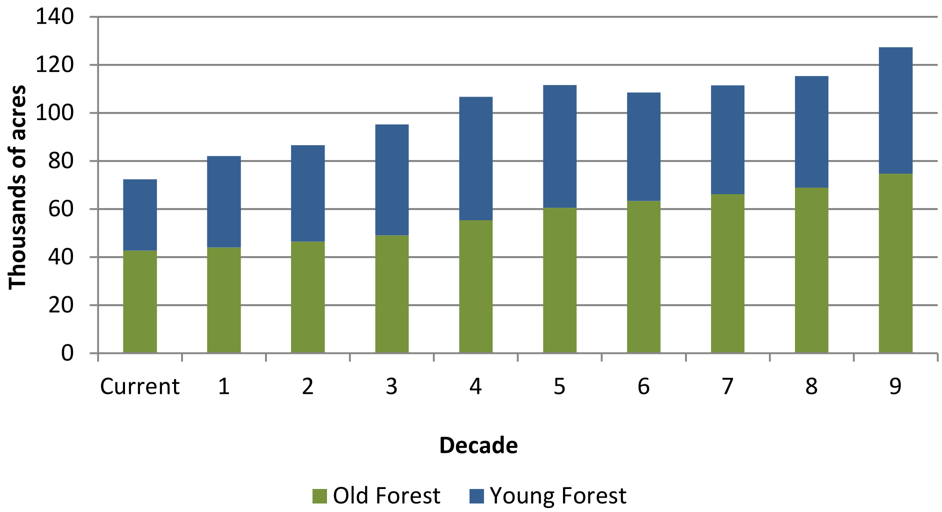
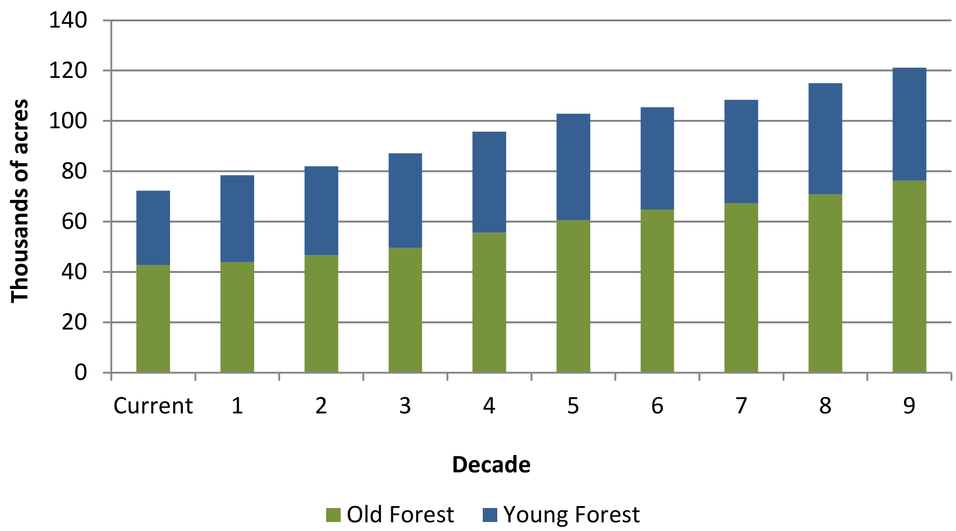


Chart 3-81. Projected Trend of Modeled Northern Spotted Owl Habitat on State Trust Lands in the OESF, Landscape Alternative

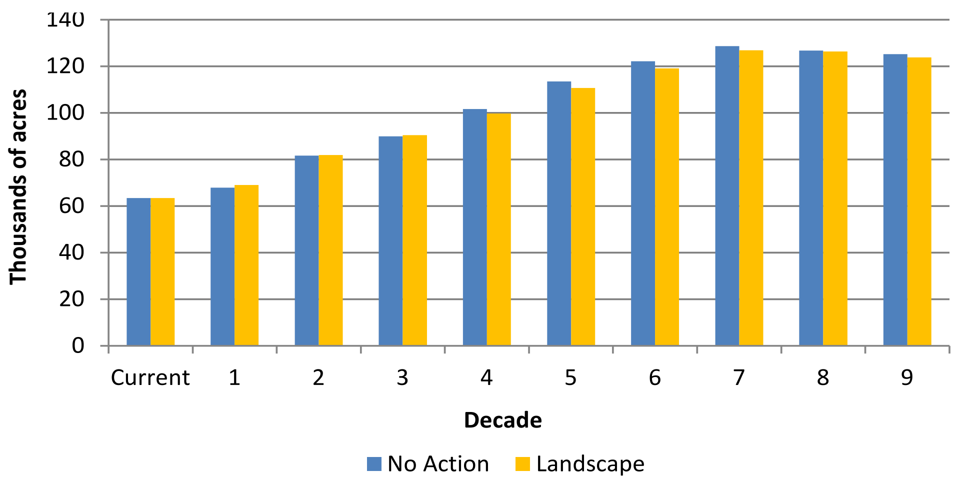


The potential environmental impact of either alternative for this indicator is considered **low**. The number of acres of modeled Old Forest Habitat and Young Forest Habitat and better in each landscape is projected to increase by the end of the analysis period. Considering all landscapes together, the trend over time is an increase in modeled Old Forest Habitat and Young Forest Habitat. DNR has not identified probable significant adverse environmental impacts from either alternative for this indicator.

Indicator: Number of Acres Supporting Northern Spotted Owl Life History Requirements

Habitat scores for northern spotted owl life history requirements are a way to represent the general trend of habitat development on state trust lands in the OESF. For this analysis, habitat scores of 50 and above (on a scale of 0 to 100) indicate that habitat provides moderate to full support for owl life history requirements. Chart 3-82 shows that the number of acres with habitat scores of 50 or above is projected to increase over the 100-year analysis period for both alternatives. In fact, the number of acres with these scores is projected to approximately double by Decade 6. Similarly, the number of acres with habitat scores of 75 to 100 also increases (refer to Appendix I for these results).

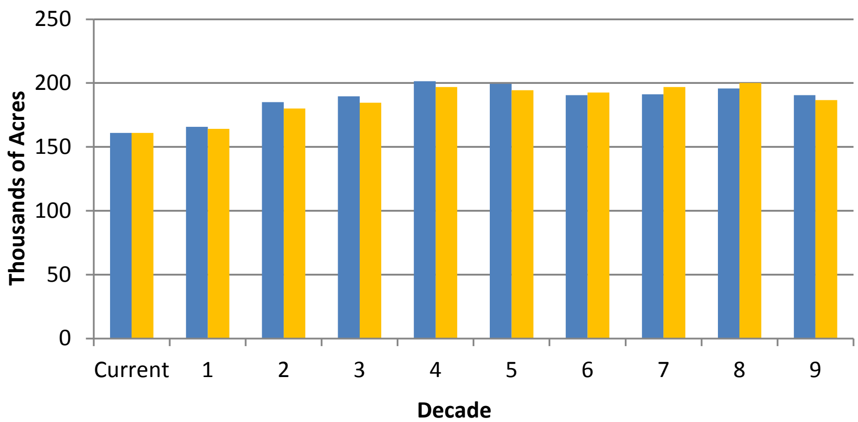
Chart 3-82. Projected Acres of State Trust Lands in the OESF with Habitat Scores of 50 or Above



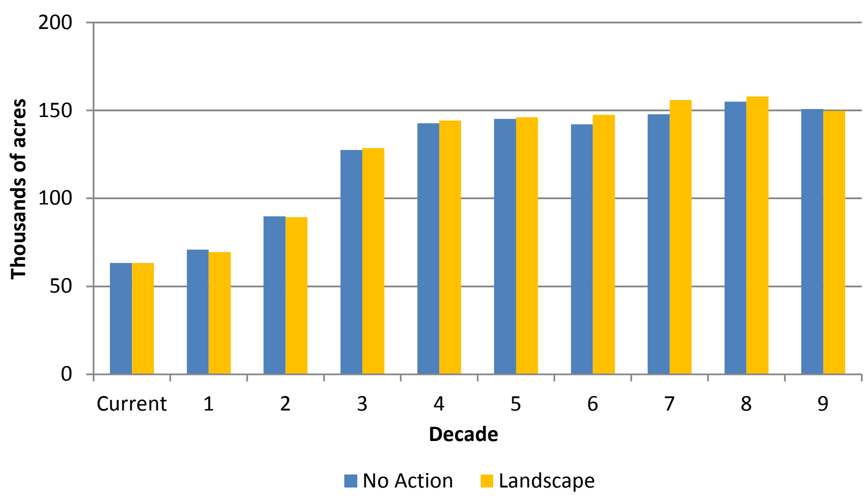
For each individual life history requirement, the differences between the alternatives are negligible. Both alternatives show that the projected number of acres with habitat scores of 50 or above for all four life history requirements increases over 100 years (Chart 3-83 A through D). The number of acres projected for foraging (B) increase the most, followed by roosting (C), then nesting (D), with the number of acres for movement (A) increasing the least. The slow increase in the number of acres for nesting may be due to the time it takes forests to develop elements of structural complexity such as large snags and down wood. The small increase in the number of acres for movement suggests that state trust lands in the OESF already have forest conditions that allow movement.

Chart 3-83. Number of Projected Acres With Habitat Scores of 50 or Above for A) Movement, B) Foraging, C) Roosting, and D) Nesting

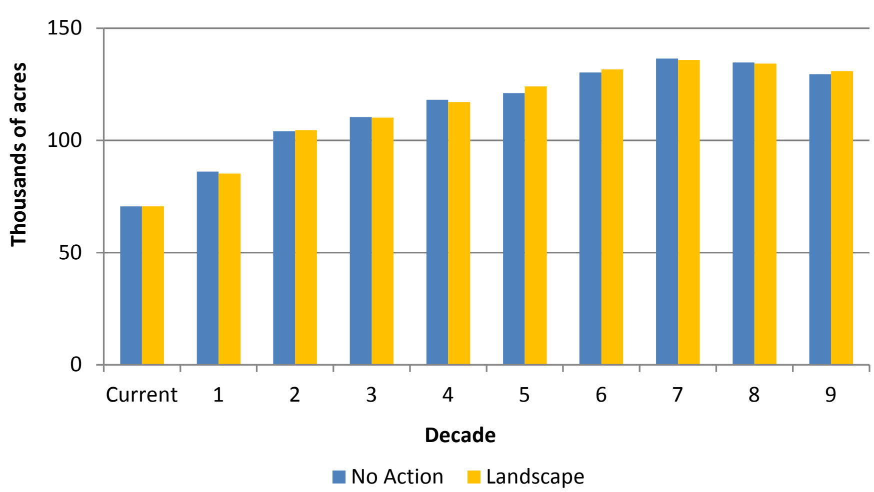
A) Movement



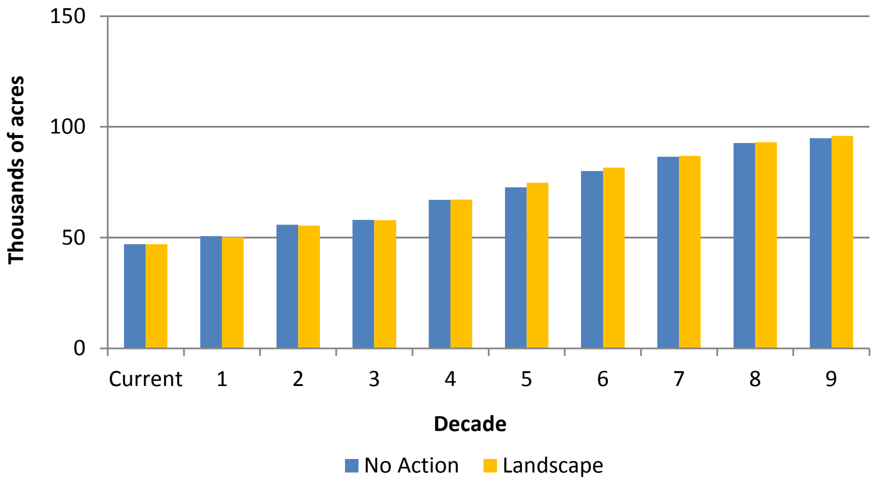
B) Foraging



C) Roosting



D) Nesting



The total increase in the projected number of acres with habitat scores of 50 and above for all life history requirements suggests that the ability of state trust lands in the OESF to provide habitat for northern spotted owls improves over time under both alternatives. These improvements should help support the recovery of the Olympic Peninsula sub-population of northern spotted owls on adjacent federal lands. The potential environmental impact of either alternative for this indicator is considered **low**. DNR has not identified probable significant adverse environmental impacts from either alternative for this indicator.

Indicator: Number of Modeled, Potential Northern Spotted Owl Territories

The number of modeled, potential northern spotted owl territories is similar for both alternatives. By Decade 6, the most likely number of territories increases from 39 (current condition) to 46 for the No Action Alternative and to 47 for the Landscape Alternative (refer to Chart 3-84). By Decade 9, the No Action Alternative has one more potential territory than the Landscape Alternative (refer to Chart 3-85).

Chart 3-84. Number of Modeled, Potential Northern Spotted Owl Territories in the OESF, Decade 6

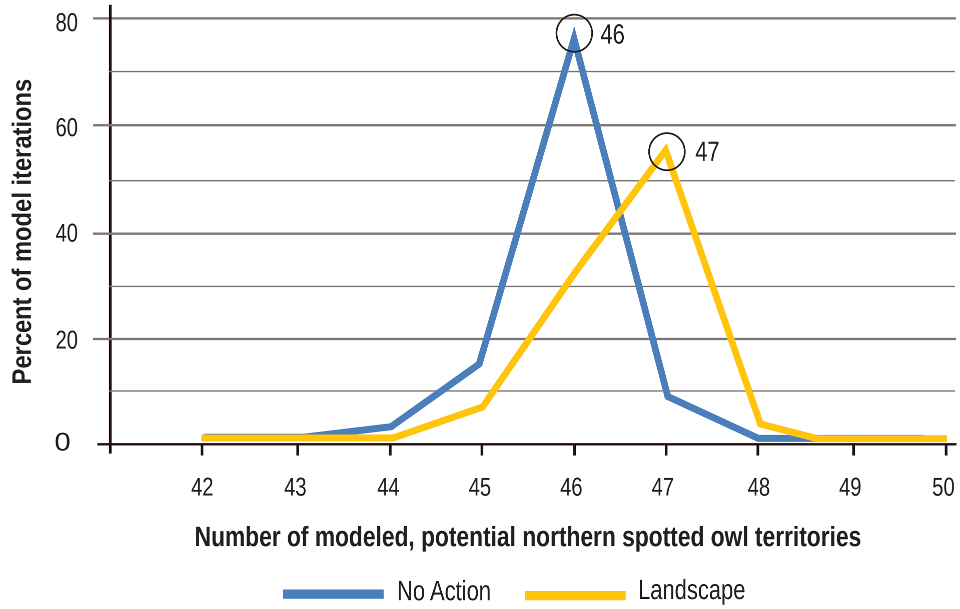
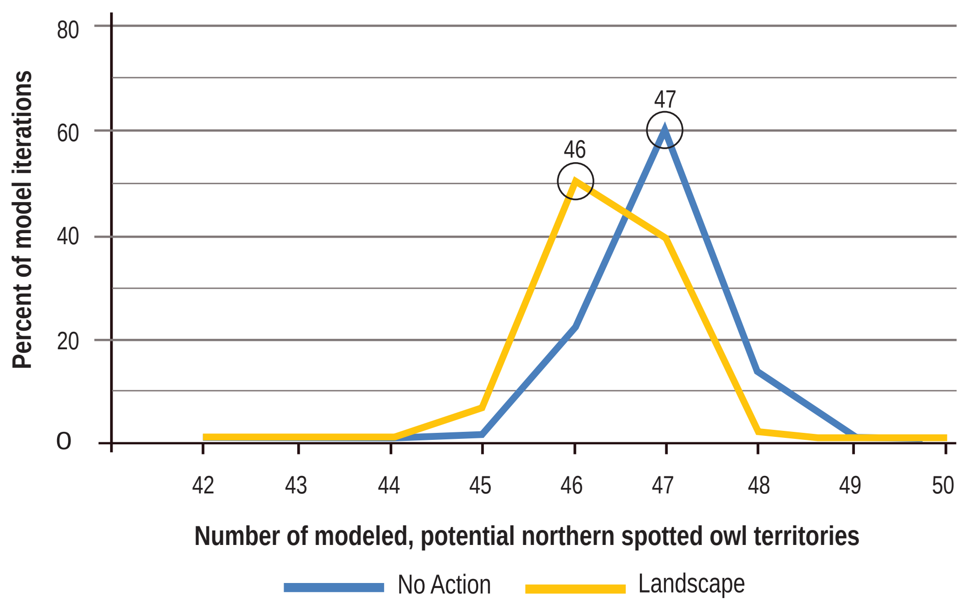


Chart 3-85. Number of Modeled, Potential Northern Spotted Owl Territories in the OESF, Decade 9



As previously stated, the habitat input data used in the model for non-state trust lands in the OESF remained unchanged throughout the 100-year analysis period. Therefore, the increase in the number of modeled, potential territories in the OESF in this analysis is attributable to the improved capability of state trust lands to support northern spotted owls.

Because the number of modeled, potential northern spotted owl territories is projected to increase, the potential environmental impact of either alternative for this indicator is considered **low**. DNR has not identified probable significant adverse environmental impacts from either alternative for this indicator.

Summary of Potential Impacts

All of the indicators used in this analysis project an increase in the amount of northern spotted owl habitat over the 100-year analysis period. Table 3-60 provides an overview of the potential environmental impacts on northern spotted owls when the criterion and all of the indicators are considered. For this analysis, only high impacts are considered potentially significant impacts. DNR has not identified probable significant adverse environmental impacts from either alternative for any indicator used for this topic area.

Table 3-60. Summary of Potential Impacts on Northern Spotted Owl Habitat, by Alternative

Criteria	Indicators	No Action Alternative	Landscape Alternative
Amount of habitat capable of providing support for the recovery of the Olympic Peninsula sub-population of northern spotted owls	Number of acres of modeled northern spotted owl habitat	Low ●	Low ●
	Number of acres supporting northern spotted owl life history requirements	Low ●	Low ●
	Number of viable northern spotted owl territories	Low ●	Low ●

● **Low impact**

What Are the Potential Short-Term Impacts on Northern Spotted Owls?

As a way to assess the short-term impacts of the two alternatives on northern spotted owls, DNR assesses the amount of harvest that is projected to occur in the first decade of the analysis period in owl circles, which are simplified representations of an owl's home range (the home range of a northern spotted owl is the geographic area to which it normally confines its activity). Field studies determined that the median home range of northern spotted owls on the Olympic Peninsula can be represented by a circle with a 2.7-mile radius centered at a nest or detection point. Status 1 owl circles are designated when a male and a female owl are found close together, a female is on the nest, or one or both adults are found with young (WAC 222-16-010). Since 2001, no northern spotted owls have been surveyed or detected within previously occupied owl circles on state trust lands in the OESF. These circles, however, represent the last known occupied habitat and may represent the habitat most likely to be re-occupied.

As part of implementing the 1997 *Habitat Conservation Plan*, DNR shifted from managing habitat in owl circles to managing habitat on a landscape scale. DNR and USFWS analyzed the impacts of harvest on northern spotted owl circles as part of the 1996 *Final EIS for the Habitat Conservation Plan* and the USFWS biological opinion (USDOI 1997) completed for DNR's 1997 *Habitat Conservation Plan*. Both of these documents anticipate that management activities will result in incidental take of territorial northern spotted owls (DNR 1996, p. 4-55 through 4-57). The USFWS incidental take permit (USDOI 1997) anticipated that in each decade, between 3,330 and 16,300 acres of habitat in owl circles on state trust lands in the OESF would be harvested.

Under both alternatives, per current modeling assumptions, the number of acres of harvest modeled to occur in owl circles in the first decade (refer to Table 3-61) is within the expected management levels analyzed in the 1996 Final EIS and the USFWS 1997 biological opinion. Variable density thinning is assumed to keep forest stands within Young Forest Habitat conditions (refer to Text Box 3-1 for a description of harvest methods).

Table 3-61. Acres of Projected Harvest Activities on State Trust Lands in All Status 1 Owl Circles in the OESF (2011–2021, Forest Estate Model)

	No Action Alternative			Landscape Alternative		
Harvest type	Non-habitat acres	Young Forest Habitat acres	Old Forest Habitat acres	Non-habitat acres	Young Forest Habitat acres	Old Forest Habitat acres
Variable retention harvest	7,684	0	0	8,119	0	0
Variable density thinning	823	3,417	0	666	2,200	0
Total per habitat type	8,507	3,417	0	8,785	2,200	0
Total of all activities in combined habitat types			11,924			10,985

Considered but Not Analyzed

Barred Owls

Barred owls are native to eastern North America and have expanded their range to the west (USFWS 2012). Barred owls were first detected in the Olympic Peninsula in 1985 (Sharpe 1989) and the number of sightings has steadily increased (Forsman and others 2011). The range of the barred owl now completely overlaps with the range of the northern spotted owl (USFWS 2012).


Barred Owl

Anthony and others (2006) found evidence suggesting that barred owls affect northern spotted owl survival on the Olympic Peninsula negatively. Weins (2012) found that competition for territory space between high densities of barred owls and spotted owls can constrain the availability of critical resources required for successful recruitment and reproduction of northern spotted owls.

Barred owls are recognized as an "extremely pressing and complex" threat requiring specific and immediate actions (USFWS 2011b). The USFWS is currently determining if the removal of barred owls would increase northern spotted owl site occupancy and improve population trends. Results from these experiments may be used to inform future decisions by the USFWS on potential long-term management strategies for barred owls (USFWS 2012). However, although studies are being conducted, the degree to which competition with barred owls will affect northern spotted owl recovery is not fully understood (Gutiérrez and others 2006). Because of this lack of understanding, evaluating the potential impacts of the two management alternatives on competition between barred and northern spotted owls is not feasible.

Roads

Wasser and others (1997) found that male northern spotted owls living within a quarter-mile of a logging road had elevated levels of corticosterone (a stress hormone). Females showed no increase in these levels related to road proximity. Hayward and other (2011) found a strong association of decreased reproductive success of northern spotted owls and nearby roads with loud traffic. Weigl (2007) reported that wide, exposed roads act as a barrier to movement for northern flying squirrels, the owl's primary prey species.

Road use in the OESF is limited because of its isolation from major population centers; most road traffic is associated with forest management activities. DNR does not believe that road traffic within the OESF poses an adverse impact to northern spotted owls. Also, further research is needed to identify the impacts of roads on northern flying squirrel populations. Therefore, the potential impacts of existing roads on northern spotted owls were not analyzed for this RDEIS.

Over the 100-year analysis period, DNR may build small sections of new road through Young Forest Habitat to provide access to planned timber harvests. Such roads will be built when DNR determines that building a longer section of road to avoid habitat could result in a higher environmental impact, such as multiple stream crossings. Because road building is a site-specific action that is evaluated separately through SEPA when it is proposed, it was not analyzed for this RDEIS.

Section Notes

1. The other two subspecies are Strix occidentalis occidentalis (California spotted owl) and Strix occidentalis lucida (Mexican spotted owl).
2. Under the Endangered Species Act, an endangered species is one that is in danger of extinction throughout all or a significant portion of its range; a threatened species is one that is likely to become endangered within the foreseeable future.
3. A five-year review is an Endangered Species Act-mandated process that is conducted to ensure that the listing classification of a species as either threatened or endangered is still accurate. It is a verification process with a definitive outcome: the review either does or does not indicate that a change in classification may be warranted. The five-year review looks back at least five years in reviewing data and information, and it is a requirement under the Endangered Species Act that a status assessment be conducted at least every 5 years for federally listed species.

4. Isolated populations are vulnerable to genetic, environmental, and demographic changes (USFWS 1992).

5. A landscape is an administrative designation; refer to the introduction to Chapter 3 for more information.

6. Demographic support refers to the contribution of individual territorial spotted owls or clusters of spotted owl sites to the stability and viability of the entire population (Hanson and others 1993). Maintenance of species distribution refers to supporting the continued presence of the northern spotted owl populations in as much of its historic range as possible (Thomas and others 1990; USFWS 1992). Dispersal refers to the movement of juvenile, sub-adult, and adult animals (northern spotted owls) from one sub-population to another. For juvenile northern spotted owls, dispersal is the process of leaving the natal (birth) territory to establish a new territory (Forsman and others 2002; Miller and others 1997; Thomas and others 1990).

7. Life history requirements are the environmental conditions necessary for completing life cycles.

8. Recent studies of spotted owl habitat relationships corroborate the earlier understanding of the habitat requirements of the species used in the 1997 *Habitat Conservation Plan* definitions (Courtney and others 2004). Indicators used in this evaluation are based on the 1997 *Habitat Conservation Plan* and the northern spotted owl procedure (Northern Spotted Owl Management Westside, Appendix E).These habitat definitions were built into model outputs representing the growth and yield of forest stands under different silvicultural treatments. The future projections of habitat were simulated using DNR's forest estate model (Appendix C). The habitat definitions are reported in this analysis as aggregations of Young Forest Habitat (Young Forest Marginal, Sub-Mature) and Old Forest Habitat (Type A, Type B, and additional forests identified through aerial photo-interpretation).

9. This technique is known as a Monte-Carlo simulation. In a Monte-Carlo simulation, one repeatedly runs a simulation and randomly varies one or more parameters.

10. The estimated acres of northern spotted habitat in Table 3-56 are different from acreages reported in other DNR documents because these estimates were generated from the forest estate model using different methodologies. As an example, for these estimates, DNR projected changes to all habitat attributes, including snags and down wood, that have occurred since forest inventory data was gathered. Refer to Appendix D for more information on the forest estate model and the attributes used to model northern spotted owl habitat. In addition, when the 1997 *Habitat Conservation Plan* was written, DNR used the best available data, which was stand age. Since stand age only describes the age of the stand, not its structure, DNR made assumptions that stands of a certain age would provide northern spotted owl habitat. This methodology was found to overestimate the amount of habitat present. Currently, DNR uses stand structure (such as snags, tree diameter, and tree height, based on forest inventory data) to estimate the amount of habitat present. This methodology lowered DNR's overall estimate of the amount of habitat present in the OESF.

Climate Change

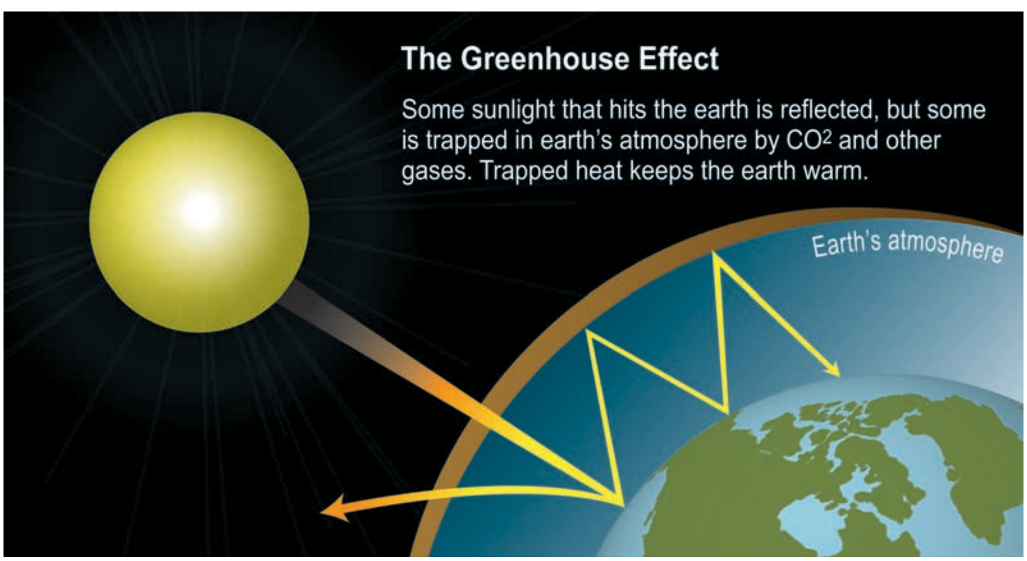
What Is Climate Change?

Climate change is a change in average temperature and weather patterns that occurs on a regional or global scale over decades to centuries. Climate change is closely linked to a global rise in temperature, often referred to as global warming (Ecology 2011b).

The earth is naturally warmed by the greenhouse effect. Greenhouse gases, such as carbon dioxide, methane, and nitrous oxide, trap heat from the sun and warm the atmosphere much like a greenhouse (refer to Figure 3-25). However, when the volume of greenhouse gases in the atmosphere increases—because of natural or human causes—to a certain point, global temperatures begin to rise (Ecology 2011b).

Current science suggests a link between global warming and human activity over the last century. Two possible causes are the burning of fossil fuels and deforestation (Karl and others 2006, Intergovernmental Panel on Climate Change 2007a, Ecology 2011b). Burning fossil fuels (coal, oil, and gas) releases greenhouse gases, particularly carbon dioxide, to the atmosphere. Deforestation reduces the number of trees available to remove carbon dioxide from the atmosphere, contributing to a net rise in greenhouse gases. Deforestation is often a result of changing land use patterns.

Figure 3-25. Greenhouse Effect



Adapted from Ecology, http://www.ecy.wa.gov/climatechange/whatis.htm

When discussing climate change, it is important to distinguish between climate change, climate variability, and weather. **Climate change** is a long-term trend, measured over decades or centuries. **Climate variability** is measured on a shorter scale, such as year-to-year or decade-to-decade. **Weather** is experienced daily and seasonally (Littell and others 2009).

In the Pacific Northwest, climate variability is strongly affected by the Pacific Ocean—in particular, by two large-scale patterns caused by changes in ocean temperature: the El Niño/Southern Oscillation and the Pacific Decadal Oscillation. For a discussion of these two oscillations, refer to Appendix O.

Why Is Climate Change a Concern?


Photo courtesy Federal Emergency Management Agency

Climate change, which results in long-term shifts in weather and temperature, can affect human populations and natural systems in various ways, some catastrophic. Examples may include increases in the number and severity of storms, extreme high temperatures, prolonged periods of drought, severe flooding, and a rise in sea level. Climate change is not expected to affect all areas of the earth in the same way. For example, some areas may experience drought while others will experience increased rainfall (Huber and Gulledge 2011, Intergovernmental Panel on Climate Change 2007b).

In Washington, the anticipated impacts of climate change may include warmer temperatures, reduced snow pack, increased frequency of extreme weather events, and a rise in sea level (Ecology 2011, USFWS 2011a). Appendix O contains detailed discussions of these impacts.

Climate change may have impacts on the OESF; however, it is not possible to predict and measure exactly what those impacts are likely to be. Instead, this analysis considers the extent to which forest stands on state trust lands in the OESF may help sequester carbon.

What Is the Criterion for Climate Change?

The criterion is **carbon sequestration (storage)**. Carbon that is sequestered does not enter the atmosphere as a greenhouse gas (carbon dioxide) or contribute to global warming.

What Are the Indicators for Climate Change?

The indicators used to assess the criterion are the **amount of carbon sequestered in forest stands** and the **difference between the amount of carbon sequestered and emitted (released)**. These indicators were selected based on DNR's expertise, existing scientific information, and current data. Following, DNR provides information about each indicator.

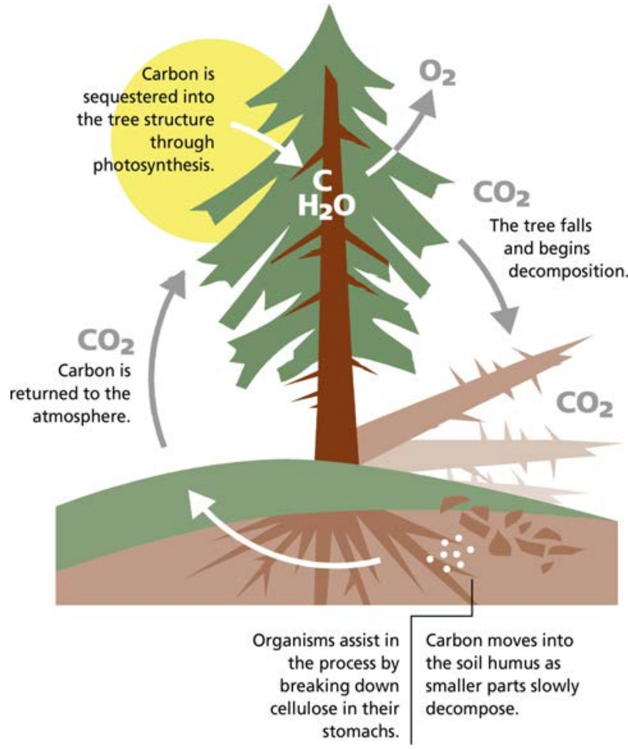
Descriptions of the Indicators

Indicator: Amount of Carbon Sequestered in Forest Stands

For this indicator, DNR considered whether the total amount of carbon sequestered in forest stands on state trust lands in the OESF is projected to increase or decrease over the 100-year analysis period.

Carbon is sequestered in forest stands through the process of photosynthesis. Trees (and other plants) absorb carbon dioxide from the atmosphere and, at the cellular level, combine it with water to form sugar (glucose) and oxygen (Figure 3-26). The tree uses some of this sugar as energy for growth, converts the remainder to starch, and stores it as wood, bark, needles/leaves, and roots (Carter 1996).Through this process, forest stands can absorb large quantities of carbon dioxide and sequester carbon for potentially long periods of time (McPherson and Simpson 1999). Carbon is released over time through decomposition or wildfire, and the cycle begins again.

Figure 3-26. Carbon Sequestration and Movement Through the Decomposition Cycle



Forests sequester carbon primarily in live trees (Smith and others 2006). In general, most of the carbon sequestered in a live tree is in the trunk (up to 51 percent), while branches and stems sequester 30 percent, and the below-ground root biomass holds 18 to 24 percent. Two to five percent of sequestered carbon is in the leaves or needles (McPherson and Simpson 1999).

The amount of carbon sequestered in a forest stand depends on factors such as tree growth, mortality, species composition, age distribution, structure class, time between harvests, and forest health (Ryan and others 2010). Newly planted forests accumulate carbon rapidly for several decades; sequestration declines as trees mature and growth slows. Once a tree dies, it becomes either a standing dead tree or down woody debris on the forest floor.[1] It can take several decades or longer for large trees to decay. Smaller pieces of wood decompose faster than larger pieces and therefore return carbon to the atmosphere faster than larger ones. Old forests generally store considerable amounts of carbon in standing dead trees or down woody debris (DNR 2004).

Carbon sequestration also differs by forest type. Forests in the Pacific Northwest have a high potential for carbon storage because trees grow quickly, live for a long time, decompose slowly, and have a relatively low wildfire frequency (Ryan and others 2010).

Different components of a forest stand, such as live trees or standing dead trees, store different amounts of carbon. To make it easier to analyze and compare the amounts of carbon sequestered over time, these components are separated into pools (categories). Table 3-62 lists the pools used in this analysis.

Table 3-62. Forest Stand Carbon Pools

Forest stand carbon pool	Description
Live trees	Live trees with a diameter at breast height of at least 1 inch; includes tree trunk, coarse roots, branches, and foliage.
Standing dead trees	Standing dead tree with a diameter at breast height of at least 1 inch; includes tree trunk, coarse roots, and branches.
Understory vegetation	Live vegetation; includes shrubs, bushes, and tree trunk, roots, branches, and foliage of seedlings (trees less than 1-inch diameter at breast height).
Down dead wood	Logging residue and other down woody debris; includes woody material larger than 3 inches in diameter, stumps, and the coarse roots of stumps.
Forest floor	Organic material on forest floor; includes fine woody debris up to 3 inches in diameter, tree litter, humus, and fine roots in the organic layer of the forest floor above the mineral soil.
Soil organic carbon	Below-ground carbon without coarse roots but including fine roots and all other organic carbon not included in other pools, to a depth of 3 feet.

Source: Smith and others 2006

Of these pools, live trees and understory vegetation actively sequester carbon. Standing dead trees, down dead wood, and forest floor organic material all sequester carbon that is released over a long period of time through decomposition. All pools may release carbon in a short period through wildfires. Carbon is released from soils through decomposition and respiration by microbial organisms, but in general, soil organic carbon remains fairly constant (Tyrell and others 2009).

Indicator: Difference Between Amount of Carbon Sequestered and Emitted

For this indicator, DNR considers whether, in the OESF, the total amount of carbon sequestered in forest stands on state trust lands, and in wood harvested from state trust lands, is projected to be greater than, or less than, the amount of carbon emitted from the burning or decay of wood harvested from state trust lands over the 100-year analysis period (refer to Figure 3-27 on p. 3-227). If the amount of carbon emitted is greater than the amount sequestered, then carbon dioxide is being added to the atmosphere.

Figure 3-27. How This Indicator Is Measured

Amount of carbon sequestered in forest stands on state trust lands in the OESF	plus	Amount of carbon sequestered in wood harvested from state trust lands in the OESF	equals	Total amount of carbon sequestered	Total amount of carbon sequestered	is greater than or less than	Total amount of carbon emitted from wood harvested from state trust lands in the OESF

CARBON SEQUESTERED IN HARVESTED WOOD

When trees are harvested, some of the carbon they contain remains on site (for example, as slash or stumps) and some is removed as cut timber. Wood that is removed from the site is made into a variety of wood-based products, such as paper or lumber for homes and furniture.

Wood-based products sequester carbon for varying lengths of time. For example, paper may sequester carbon for only a short time if it is discarded after use or burned. However, paper can last for a longer time if it is stored in books or magazines, or if it gets recycled. Items made from wood, such as houses or furniture, also can sequester carbon for a long time (Smith and others 2006). Products made from wood are eventually discarded and placed in a landfill, where they are covered and decay slowly due to a lack of oxygen in landfills (Ryan and others 2010).

To make it easier to analyze and compare the amounts of carbon sequestered over time, harvested wood is separated into carbon pools. Table 3-63 lists the carbon pools used in this analysis.

Table 3-63. Harvested Wood Carbon Pools (Sequestered Carbon)

Harvested wood carbon pool	Description
Products in use	Wood that has not been discarded or otherwise destroyed, such as houses and other buildings, furniture, wooden containers, paper products, and lumber.
Landfills	Wood that has been discarded and placed in landfills. Carbon is stored long term, because of the slow rate of decay.

Source: Smith and others 2006

CARBON EMITTED FROM HARVESTED WOOD

Carbon is emitted from harvested wood through burning or decay. If burned, the energy released may be captured to warm a home or generate electricity. To make it easier to analyze and compare the amounts of carbon emitted over time, carbon emitted from harvested wood is separated into carbon pools. Table 3-64 lists the carbon pools used in this analysis.

Table 3-64. Harvested Wood Carbon Pools (Emitted Carbon)

Harvested wood carbon pool	Description
Emitted with energy capture	Wood products are burned and the energy is captured or used. For example, wood is burned in a fireplace, and the energy (heat) is captured in the home for a period of time (Ryan and others 2010). Or, wood is burned to generate electricity, which is referred to as biomass energy. Biomass energy is used primarily by the forest products industry to run sawmills.
Emitted without energy capture	Wood products are burned intentionally or accidentally and no effort is made to capture or use the energy, such as a house fire or burning trash. Or, wood products decay naturally. Wood products that are exposed to weather and microbial fungi will eventually decompose, with rates of decomposition varying by type of wood product, size, and site conditions.

Source: Smith and others 2006

How Are Carbon Sequestration and Emission Measured?

Text Box 3-9. Tonnes of Carbon

One tonne = 1,000 kilograms
= 2,205 pounds

For this analysis, DNR follows the methodology described in Methods for Calculating Forest Ecosystem and Harvested Carbon with Standard Estimates for Forest Types of the United States (Smith and others 2006). This method estimates the amount of carbon sequestered in forest stands and the amount of carbon sequestered and emitted from harvested wood over time. Estimates of carbon sequestered in forest stands are provided for common forest types within each of the 10 regions of the United States. DNR uses the "Pacific Northwest, West" region and the Douglas fir forest type. The unit of measure used in this analysis is tonnes of carbon (also known as metric tons of carbon) (refer to Text Box 3-9 for tonne to kilogram and pound equivalent). Harvest levels are determined using the harvest schedule provided by the forest estate model.

Criterion and Indicators: Summary

The criterion and indicators used in this analysis, how they are measured, and the range of potential environmental impacts are summarized in Table 3-65. The rating "medium" was not defined or used in this analysis.

Table 3-65. Criterion and Indicators for Climate Change and How They are Measured

Criterion/ Indicator	**How the indicator is measured**	**Potential environmental impacts**
Carbon sequestration/ Amount of carbon sequestered in forest stands	Whether the amount of carbon sequestered in forest stands on state trust lands increases or decreases over the 100-year analysis period.	**Low**: The amount of carbon sequestered in forest stand carbon pools increases over time. **High**: The amount of carbon sequestered in forest stand carbon pools decreases over time.
Carbon sequestration/ Difference between amount of carbon sequestered and emitted	Whether the total amount of carbon sequestered in forest stands on state trust lands and in wood harvested from state trust lands is greater than, or less than, the total amount of carbon emitted from wood harvested from state trust lands.	**Low**: The amount of carbon sequestered is greater than the amount of carbon emitted at the end of the analysis period. **High**: The amount of carbon sequestered is less than the amount of carbon emitted at the end of the analysis period.

Current Conditions

Instead of current conditions, DNR reports results for the end of the first decade of the analysis period under the No Action Alternative. DNR uses the methods described in Smith and others (2006).

Indicator: Amount of Carbon Sequestered in Forest Stands

Table 3-66 shows the amount (and percentage) of carbon projected to be sequestered in each of the forest stand carbon pools on state trust lands in the OESF at the end of the first decade of the analysis period under the No Action Alternative. These totals reflect both harvest and natural forest growth.

Table 3-66. Amount of Carbon Projected to be Sequestered in Forest Stands on State Trust Lands in the OESF by End of First Decade of Analysis Period, in Tonnes

Forest stand carbon pool	Tonnes of carbon sequestered in each carbon pool type	Percentage of total carbon sequestered in forest stands
Live trees	14,088,938	44%
Standing dead trees	1,390,453	4%
Understory vegetation	329,374	1%
Down dead wood	3,292,155	10%
Forest floor	2,488,323	7%
Soil organic carbon	11,358,178	34%
TOTAL	32,947,422	100%

Currently, most carbon is sequestered in live trees, followed by soil. The least amount is sequestered in understory vegetation. As described in Table 3-13 of "Forest Conditions and Management," 54 percent of the OESF is currently in the Competitive Exclusion stand development stage, and 29 percent is in the Understory Development stand development stage. These stand development stages explain why large amounts of carbon are stored in trees and very little is stored in understory vegetation. Forest stands in the Competitive Exclusion stage have little to no understory vegetation and stands in the Understory Development stage are just starting to develop an understory.

Indicator: Difference Between Amount of Carbon Sequestered and Emitted

As explained previously, when wood is harvested from state trust lands, some of that carbon will be sequestered in wood-based products (in use or in landfills) and some will be emitted, for example through burning (refer to Figure 3-28).

Figure 3-28. Harvested Carbon

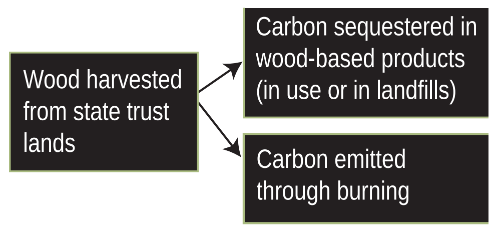


Table 3-67 shows the amount of carbon projected to be sequestered in wood harvested from state trust lands in the OESF at the end of the first decade of the analysis period. Most carbon is sequestered in lumber or other items made from wood. No carbon is sequestered in a landfill, because the method used by Smith and others (2006) assumes there is no harvest previous to the first decade, and thus no wood-based products in landfills.

Table 3-67. Amount of Carbon Projected to be Sequestered in Wood Harvested from State Trust Lands at End of First Decade of Analysis Period, in Tonnes

Harvested wood carbon pool	Tonnes carbon sequestered	Percent of total carbon harvested sequestered in each carbon pool
Carbon in use	402,175	66%
Carbon in landfill	0	0%
TOTAL	402,175	66%

Table 3-68 shows the amount of carbon projected to be emitted from wood harvested from state trust lands in the OESF by the end of the first decade of the analysis period. Carbon is emitted through burning, with or without energy capture.

Table 3-68. Amount of Carbon Projected to be Emitted from Wood Harvested from State Trust Lands by End of First Decade of Analysis Period, in Tonnes

Harvested wood carbon pool	Tonnes carbon emitted	Percent of total carbon harvested emitted from each carbon pool
Carbon emitted with energy capture	121,424	20%
Carbon emitted without energy capture	85,688	14%
Total	207,112	34%

COMPARING CARBON SEQUESTERED AND EMITTED

The total amount of carbon projected to be sequestered by the end of the first decade of the analysis period is as follows:

32,947,422	Tonnes of carbon sequestered in forest stands on state trust lands in the OESF (Table 3-66)
+ 402,175	Tonnes of carbon sequestered in wood harvested from state trust lands in the OESF (Table 3-67)
33,349,597	Total tonnes of carbon sequestered

The total amount of carbon emitted is 207,112 tonnes (Table 3-68).

Results

Indicator: Amount of Carbon Sequestered in Forest Stands

Chart 3-86 and Table 3-69 show the amount of carbon projected to be sequestered in forest stands on state trust lands in the OESF in each decade of the 100-year analysis period under either alternative. These totals reflect both harvest and natural forest growth and include the first decade of the analysis period. There is little difference between the alternatives in the amount of carbon sequestered.

Chart 3-86. Amount of Carbon Projected to be Sequestered in Forest Stands on State Trust Lands in the OESF at the End of the 100-Year Analysis Period Under Each Alternative

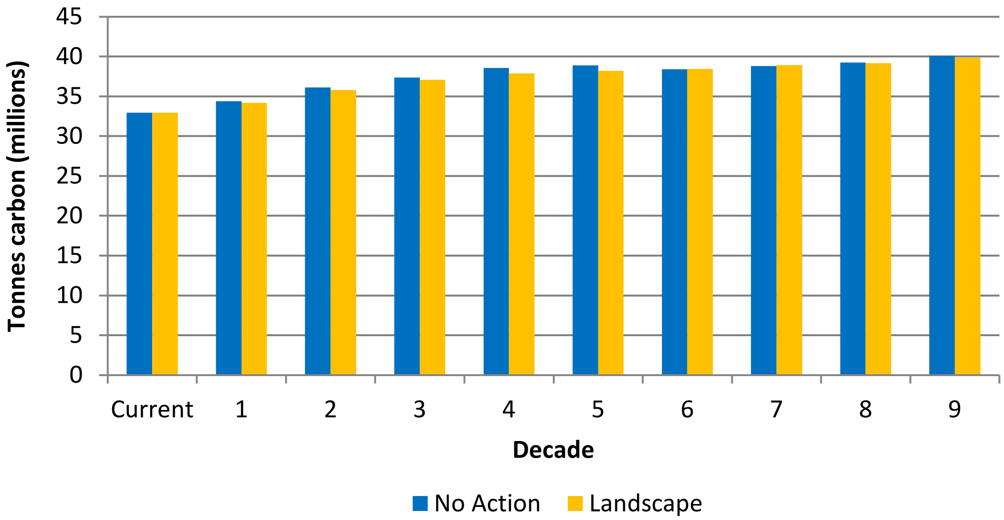


Table 3-69. Amount of Carbon Projected to be Sequestered in Forest Stand Carbon Pools on State Trust Lands in the OESF at End of the 100-Year Analysis Period Under Each Alternative, in Tonnes

Forest stand carbon pool	No Action Alternative		Landscape Alternative	
	Tonnes of carbon sequestered in each carbon pool type	Percent of carbon sequestered in each carbon pool type	Tonnes of carbon sequestered in each carbon pool type	Percent of carbon sequestered in each carbon pool type
Live trees	20,017,403	50%	19,759,925	50%
Standing dead trees	1,935,513	5%	1,911,427	5%
Understory vegetation	303,658	<1%	305,906	<1%
Down dead wood	3,516,881	9%	3,531,457	9%
Forest floor	2,778,709	7%	2,783,471	7%
Soil organic carbon	11,527,292	29%	11,536,072	29%
Total	40,079,456	100%	39,828,258	100%

Table 3-70 compares the Landscape Alternative to the No Action Alternative. Approximately 251,000 tonnes less carbon is projected to be stored in forest stand carbon pools under the Landscape Alternative, as compared to the No Action Alternative.

Table 3-70. Comparison of Landscape Alternative to No Action Alternative: Amount of Carbon Sequestered

Forest stand carbon pool	Comparison of Landscape Alternative to No Action Alternative
Live trees	257,478 tonnes less
Standing dead trees	24,086 tonnes less
Understory vegetation	2,248 tonnes more
Down dead wood	14,576 tonnes more
Forest floor	4,762 tonnes more
Soil organic carbon	8,780 tonnes more
TOTAL	251,199 tonnes less

Table 3-71 shows the projected increase or decrease in tonnes of carbon sequestered in forest stand carbon pools under each alternative. To determine these amounts, DNR subtracted the amount of carbon sequestered by the end of the first decade (Table 3-66) from the amount sequestered by the end of the 100-year analysis period (Table 69).

Table 3-71. Projected Increase or Decrease in Carbon Sequestered in Forest Stand Carbon Pools at End of 100-Year Analysis Period, in Tonnes

Arrows indicate increase or decrease

Forest stand carbon pool	No Action Alternative	Landscape Alternative
	Increase or decrease in tonnes of sequestered carbon	Increase or decrease in tonnes of sequestered carbon
Live trees	↑ 5,928,465	↑ 5,670,987
Standing dead trees	↑ 545,060	↑ 520,974
Understory vegetation	↓ 25,716	↓ 23,468
Down dead wood	↑ 224,726	↑ 239,302
Forest floor	↑ 290,386	↑ 295,148
Soil organic carbon	↑ 169,114	↑ 177,894
TOTAL	↑ 7,132,035	↑ 6,880,837

Under both alternatives, the amount of carbon sequestered in forest stands on state trust lands in the OESF is projected to increase for all forest stand carbon pool types except understory vegetation, which decreases. Most of this increase is in live tree growth (refer to Table 3-71).

Forest stands accumulate carbon as they move through stand development stages and studies have found that the greatest rate of carbon uptake occurs during the Competitive Exclusion stage (Tyrell and others 2009). The amount of carbon in standing dead trees, down dead wood, and forest floor organic matter also increases as trees die, primarily due to competition for sunlight in dense stands and from needles falling to the ground. Appendix O includes charts showing carbon sequestered in forest stand carbon pools for each alternative by decade.

For this indicator, the potential environmental impact of either alternative is considered **low**. The total amount of carbon sequestered in forest stands on state trust lands in the OESF increases under either alternative. DNR has not identified probable significant adverse environmental impacts from either alternative for this indicator.

Indicator: Difference Between Amount of Carbon Sequestered and Emitted

Table 3-72 shows the amount of carbon harvested from state trust lands in the OESF that is sequestered in wood-based products at the end of the 100-year analysis period. Of that carbon, 21 percent may be in use, meaning it is sequestered in wood-based products such as houses or furniture. This amount includes the wood in use from all previous decades and the wood harvested in the last decade. The remaining 16 percent may be in landfills, where wood-based products decompose slowly.

Table 3-72. Amount of Carbon Projected to be Sequestered in Wood Harvested from State Trust Lands in the OESF at End of 100-Year Analysis Period Under Each Alternative, in Tonnes

	No Action Alternative		Landscape Alternative	
Harvested carbon pool	Tonnes carbon sequestered	Percent of total carbon harvested sequestered in each carbon pool	Tonnes carbon sequestered	Percent of total carbon harvested sequestered in each carbon pool
Carbon in use	1,540,350	21%	1,597,452	21%
Carbon in landfill	1,163,764	16%	1,203,390	16%
TOTAL	2,704,114	37%	2,800,842	37%

Table 3-73 shows the amount of carbon harvested from state trust lands in the OESF that is emitted, with or without energy capture, by the end of the 100-year analysis period.

Table 3-73. Amount of Carbon Projected to be Emitted from Wood Harvested From State Trust Lands in the OESF by End of Analysis Period, in Tonnes

	No Action Alternative		Landscape Alternative	
Harvested carbon pool	Tonnes carbon sequestered	Percent of total carbon harvested sequestered in each carbon pool	Tonnes carbon sequestered	Percent of total carbon harvested sequestered in each carbon pool
Carbon emitted with energy capture	2,436,436	34%	2,520,233	34%
Carbon emitted without energy capture	2,073,366	29%	2,146,143	29%
TOTAL	4,509,802	63%	4,666,376	63%

COMPARING CARBON SEQUESTERED AND EMITTED

No Action Alternative

The total amount of carbon sequestered under the No Action Alternative is as follows:

40,079,456	Tonnes of carbon sequestered in forest stands on state trust lands in the OESF under the No Action Alternative (Table 3-69)
+ 2,704,114	Tonnes of carbon sequestered in wood harvested from state trust lands in the OESF (Table 3-72)
42,783,570	Total tonnes of carbon sequestered

The total amount of carbon emitted is 4,509,802 tonnes (Table 3-73). That amount is far below the total amount of carbon sequestered (42,783,571 tonnes).

Landscape Alternative

The total amount of carbon sequestered under the Landscape Alternative is as follows:

39,828,258	Tonnes of carbon sequestered in forest stands on state trust lands in the OESF under the Landscape Alternative (Table 3-69)
+ 2,800,842	Tonnes of carbon sequestered in wood harvested from state trust lands in the OESF under the Landscape Alternative (Table 3-72)
42,629,100	Total tonnes of carbon sequestered

The total amount of carbon emitted is 4,666,376 tonnes (Table 3-73). That amount is far below the total amount of carbon sequestered (42,629,100 tonnes).

For this indicator, the potential environmental impact of either alternative is considered **low**. The amount of carbon emitted is far below the amount of carbon sequestered under either alternative. DNR has not identified probable significant adverse environmental impacts from either alternative for this indicator.

The analysis does not calculate carbon emitted in the process of harvesting the wood or in the exhaust from logging equipment and vehicles transporting the harvested trees. A study conducted in Montana (Healey and others 2009) evaluated carbon emissions from vehicles transporting harvested trees as a percentage of the carbon emitted from the transported wood. Over the course of the study (1998 to 2004), the percentage rose from 0.5 to 1.7 percent. The increase was attributed to mill closures resulting in longer hauling routes; however, the overall percentage was low.

Similarly, it is expected that the OESF stores sufficient carbon to not only offset emissions from the wood harvested from state trust lands and the equipment used to harvest the wood, but also to store enough additional carbon to act as a biological carbon sink.

Summary of Potential Impacts

Table 3-74 provides an overview of the potential environmental impacts of the alternatives when the criterion and all of the indicators are considered. The two management alternatives perform in a similar manner. For this analysis, only high impacts are considered potentially significant impacts. DNR has not identified probable significant adverse environmental impacts from either alternative for any indicator used for this topic.

Table 3-74. Summary of Potential Impacts by Alternative

Criteria	Indicators	No Action Alternative	Landscape Alternative
Carbon sequestration	Amount of carbon sequestered in forest stands	Low ●	Low ●
	Difference between amount of carbon sequestered and emitted	Low ●	Low ●

● **Low impact**

Considered but Not Analyzed

Vulnerability of Tree Species to Climate Change

A study conducted by Aubry and others (2011) assessed potential impacts of predicted changes in climate on 15 overstory tree species in the Pacific Northwest. These tree species were selected because they are common to Western Washington and because changes in their distribution or health could change forest structure and habitat at a broad scale. The study analyzed each tree species to determine its vulnerability, based on a variety of characteristics, to the impacts of climate change. An overall climate change vulnerability score was calculated for each tree species, using a scale from zero to 100, with a higher score indicating higher climate change vulnerability. Table 3-75 lists the selected trees and their vulnerability scores.

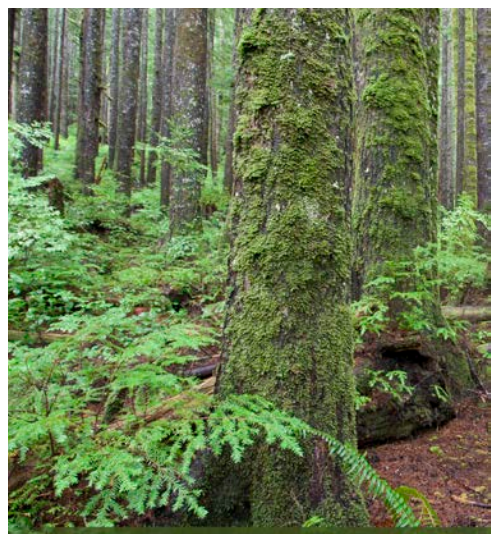

Western Hemlock

Table 3-75. Overall Climate Change Vulnerability Scores for 15 Common Overstory Trees in Western Washington

Tree species	Overall vulnerability score
Pacific Silver Fir *(Abies amabilis)*	81
Subalpine Fir *(Abies concolor)*	71
Engelmann Spruce *(Picea engelmannii)*	66
Noble Fir *(Abies procera)*	61
Grand Fir *(Abies grandis)*	54
Mountain Hemlock *(Tsuga mertensiana)*	51
Alaska Yellow Cedar *(Callitropsis nootkatensis)*	51
Western White Pine *(Pinus monticola)*	38
Douglas Fir *(Pseudotsuga menziesii)*	31
Bigleaf Maple *(Acer macrophyllum)*	29
Black Cottonwood *(Populus trichocarpa)*	28
Sitka Spruce *(Picea sitchensis)*	26
Western Red Cedar *(Thuja plicata)*	26
Western Hemlock *(Tsuga heterophylla)*	22
Red Alder *(Alnus rubra)*	20

Source: Aubry and others 2011

State trust lands in the OESF have three major vegetation zones (refer to Map 3-1, p. 3-2): Sitka spruce (33 percent of the land base), western hemlock (43 percent of the land base), and silver fir (24 percent of the land base). Based on the assessment conducted by Aubrey and others (2011), Sitka spruce and western hemlock have a relatively low vulnerability to the impacts of climate change, while silver fir has a relatively higher vulnerability; therefore, the impacts of climate change may be greater in the silver fir zone.

A recent study by van Mantgem and others (2009) suggests that regional warming (reported as 0.5 to 0.7 degrees Fahrenheit per decade from the 1970s to 2006) may be the dominant contributor to increases in tree mortality rates. In the Pacific Northwest, the tree mortality rate is one of the highest in the nation and on a trajectory to double in the next 17 years (van Mantgem and others 2009), although there may be an increase in tree growth and establishment at higher elevations (Halofsky and others 2011).

The extent to which climate change will affect Pacific Northwest forests and the plant, fish, and wildlife species associated with them is an emerging science. Predicting the effects of climate change on tree species in the OESF is too speculative and, because the impacts would be similar under either alternative, the information is not essential for choosing an alternative. Therefore, this RDEIS does not include such an analysis.

Impacts Associated with Increased Number and Severity of Storms

Halofsky and others (2011) predicted that increased precipitation and storm intensity in conjunction with higher snow lines and loss of snow cover are expected to increase the rate and volume of water delivered to streams. This, in turn, could cause an increase in landslides and debris flows and the amount of sediment and wood delivered to streams.

Increased precipitation and storm intensity are also anticipated to increase winter and spring flow volume in streams, which would lead to increased floodplain inundation, channel migration, and channel erosion and scour (Halofsky and others 2011). In the OESF, these types of impacts could result in degradation of habitat for fish and other aquatic species, as well as damage to roads, culverts, and other infrastructure.

Climate change is an emerging science. Predicting the effects of increased precipitation and storm intensity due to climate change is too speculative and, because the impacts would be similar under either alternative, the information is not essential for choosing an alternative. Therefore, this RDEIS does not include such an analysis.

Section Note

1. This chapter uses terminology from the Smith and others (2006) methodology. The chapter uses "standing dead tree" instead of "snag," and "down dead wood" or "down woody debris" instead of "down wood."