Appendix B
Riparian Modeling

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RIPARIAN MODELING

1. Introduction

In forested watersheds throughout the Pacific Northwest, the protection of riparian areas is considered critical to the long-term health of aquatic ecosystems (FEMAT 1993; Cederholm 1994; Murphy 1995). The protection of riparian areas usually occurs by restricting management activities within an area adjacent to water bodies referred to as the riparian management zone or RMZ. Management within the RMZ usually involves the delineation of the RMZ (or several zones within the RMZ) and restrictions on management activities within the RMZ (or its zones). The four alternatives under consideration in the EIS represent different strategies for protecting riparian areas using different RMZ prescriptions and widths. In order to compare these alternatives quantitatively in the EIS, they were modeled based on: 1) information determined in sampled areas (referred to as the sample sections – see below) and 2) total stream miles by type, as measured over the entire State. In addition, a number of assumptions were made in order to identify average values for RMZ widths, harvest rates, and other parameters to be applied in specific situations. These assumptions were based on the knowledge obtained through studies of the sample areas and the collective expertise of Washington DNR foresters with experience in implementation of the pre-1999 and the current Washington Forest Practices Rules. This appendix describes the modeling approaches and the assumptions used for the quantitative comparisons.

The remainder of this appendix is divided into five sections. These include: 1) description of the sample areas; 2) water type modeling for comparing the alternatives; 3) RMZ modeling for comparing the alternatives; 4) applying the Large Woody Debris (LWD) Equivalent Buffer Area Index (EBAI) to each alternative; and 5) applying the Sediment EBAI to each alternative. Included in each analysis is an introduction, the rationale for the analysis, the assumptions made for the analysis, and the results of the analysis. For some of the analyses (e.g., the LWD EBAI) there are multiple steps with separate assumptions; these are described for each step.

2. Description of Sample Areas

Forestlands subject to the Washington State Forest Practices Rules cover 11.4 million acres (including all lands within existing HCPs). The alternatives were modeled and quantitatively compared in this EIS using a random sample of one square mile sections of the State, selected using a Geographic Information System (GIS)-based random sampling method.

The sample was stratified by ownership (private vs. State) and the side of the State (westside vs. eastside). The requirements were that the sections must contain some forestland, must contain either private or State ownership, and must not be entirely within an existing Habitat Conservation Plan (HCP) or Urban Growth Area (UGA) as of 1999.

Three categories of land within Washington State were randomly sampled: 1) Eastside State, 2) Eastside Private, and 3) Westside Private. The categories sampled were limited to these three because they represent the vast majority of lands in Washington State subject to Washington Forest Practices Rules. Westside State lands were not sampled and few private HCP lands were included because these lands are managed under existing HCPs, where protection measures aren't necessarily the same as the Washington Forest Practices Rules. Similarly, few UGA lands were included because these lands are not likely to remain subject to Washington Forest Practices Rules over the long term because of their high likelihood for conversion to non-forest uses.

A total of 186 sections was selected, including 92 sections containing private forestland on the westside, 65 sections containing private forestland on the eastside, and 29 sections containing State forestland on the eastside. Table B-1 itemizes the number of sections sampled and the acres of forestland in each sample section by region of the State.

The analyses that required spatial measurements were evaluated on these sample sections. GIS coverages used in the analyses included Washington DNR hydrography (streams by type), soils (including site class), vegetation (including seral stage), topography (from 10-meter digital elevation models), and others. The primary analyses conducted using these sample sections are described in Section 3 (Water Type Modeling).

Table B-2 lists the three sample categories and the forested area sampled within each category, as well as the distribution of these categories throughout Washington State. A total of about 91,787 acres of forestlands was sampled. Because the proportion of eastside State lands sampled (2.0%) was higher than the proportion of eastside private land area sampled (0.8%), it was necessary to weight the eastside data before combining the two. The weighting factor used was 0.8 / 2.0 = 0.36 (i.e., all eastside State totals were multiplied by this factor before combining the data with eastside private data for the purpose of estimating eastside averages).

Table B-1. Total Acreage and Number of Sample Sections Selected to Represent Washington State Forestlands Subject to Washington Forest Practices Rules by Region.

	Private Lands		*State Lands*	
Region	**# of Sections**	**Total Acres in Sample Sections**	**# of Sections**	**Total Acres in Sample Sections**
Westside				
North Puget Sound	13	6,546	-	-
South Puget Sound	9	5,257	-	-
West Puget Sound	15	7,170	-	-
Islands	0	0	-	-
Olympic Coast	8	2,723	-	-
Southwest	26	16,016	-	-
Lower Columbia	21	11,532	-	-
Subtotal	**92**	**49,246**	**-**	**-**
Eastside				
Middle Columbia	12	7,662	8	3,376
Upper Columbia – Below Grand Coulee	17	7,399	18	11,409
Upper Columbia – Above Grand Coulee	32	18,070	3	1,554
Snake River	3	1,535	-	-
Columbia Basin	1	319	-	-
Subtotal	**65**	**34,984**	**29**	**16,339**
Grand Total	**157**	**84,230**	**29**	**16,339**

Table B-2. Forested Area of Washington State and Sample Sections for each of the Three Categories Randomly Sampled (the percent of area represented in the sample sections is also given).

Categories Sampled	Total WA State Forested Area (ac)	Forested Portion of Sampled Area (ac)	Percent Sampled (%)
Eastside State	745,035	14,703	2.0
Eastside Private	2,619,736	21,090	0.8
Westside Private	6,289,303	43,719	0.7
Total	**8,750,250**	**91,787**	**1.0**

On the eastside, 2.0 percent of the total area of forested State lands was sampled and 0.8 percent of the private forested lands was sampled (Table B-2). Of the total forested State and private lands on the eastside, 22 percent are State lands and 78 percent are private.

3. Water Type Modeling

3.1 Introduction

Water typing is a systematic classification of streams and other water bodies in groups or classes according to specified criteria. These criteria include physical characteristics, processes, and beneficial uses. In Washington, different water types are used to protect beneficial uses (e.g., fish habitat and water quality). Washington Department of Natural Resources (DNR) and other State agencies currently use presence of fish and protection of downstream water quality to classify surface waters for management purposes. On State and private forestlands, the classification of surface waters dictates the management activity permitted adjacent to the water type.

The permanent water typing system is defined in the rules (see WAC 222-16-030) and is based on a GIS-based multi-parameter field-verified logistic regression model. Maps identifying waters under this system are not yet available. Therefore, forest practices in RMZs are regulated according to an interim water typing system (WAC 222-16-031). This system is based on a number of criteria identified in the current Washington Forest Practices Rules, including stream gradient, stream width, basin size, and other factors. These factors were used to represent No Action Alternative 1-Scenario 2 in this EIS, since it is assumed that the interim system would continue to be used. In order to quantitatively compare No Action Alternative 1-Scenario 2 with the other alternatives, modeling was used to represent No Action Alternative 1-Scenario 1 and Alternatives 2 and 3, which would each use the permanent water typing system defined in the rules (not the interim system), and Alternative 4, which would use a completely new system. This appendix describes the water typing under the alternatives and the modeling used to represent these alternatives.

3.2 Description of Water Typing Under the Alternatives

This section describes the water typing system that would be implemented under each of the alternatives.

3.2.1 <u>No Action Alternative 1-Scenario 2</u>

Under No Action Alternative 1-Scenario 2, water typing would be the same as the interim rules. The five water types in the interim system are defined as follows:

- Type 1: Major waterways of the State including rivers, lakes, and saltwater. This includes all waters inventoried as "shorelines of the State."
- Type 2: Waters, not classified as Type 1, which have high fish, wildlife, or human use. They generally are streams having a defined channel 20 feet or greater within the bankfull width and having a gradient of less than 4 percent.
- Type 3: Waters, not classified as Type 1 or Type 2, which have moderate to slight fish, wildlife, or human use. They generally have a defined channel of 2 feet or greater within the bankfull width in western Washington and 3 feet or greater in width in eastern Washington, with a gradient of 16 percent or less. Waters of this size, but having a gradient between 16 and 20 percent may also be classified as Type 3 if they have a contributing basin size of at least 50 acres in western Washington and at least 175 acres in eastern Washington.
- Type 4: Waters within the bankfull width of defined channels that are perennial non-fish habitat waters. Generally they are waters not classified as Type 1, Type 2, or Type 3, and which have a contributing basin size of: a) at least 13 acres in the western Washington coastal zone (Sitka Spruce zone of Franklin and Dyrness 1973); b) at least 52 acres in other locations in western Washington; and c) at least 300 acres in eastern Washington.
- Type 5: Waters not classified as Type 1, Type 2, Type 3, or Type 4. They are seasonal non-fish waters.

3.2.2 No Action Alternative 1-Scenario 1, Alternative 2, and Alternative 3

Under No Action Alternative 1-Scenario 1, Alternative 2, and Alternative 3, water typing would follow the current rules. In this system, four water types are recognized, which are defined as follows:

- Type S: All waters inventoried as "shorelines of the State."
- Type F: Waters not classified as Type S, which contain fish habitat. It also includes some waters diverted for domestic use, waters diverted for fish hatchery use, waters within certain campgrounds, and riverine ponds and off-channel habitats used by fish.
- Type N_P: Waters within the bankfull width of defined channels that are perennial non-fish habitat waters. Generally they are waters which have a contributing basin size of: a) at least 13 acres in the western Washington coastal zone (Sitka Spruce zone of Franklin and Dyrness 1973); b) at least 52 acres in other locations in western Washington; and c) at least 300 acres in eastern Washington.
- Type N_S: Waters within the bankfull width of defined channels that are not Type S, Type F, or Type N_P waters. They must be physically connected to one of these other water types by an above-ground channel system.

3.2.3 Alternative 4

- Under Alternative 4, a geomorphic-based system consisting of three water types is defined as follows:
- Waters with a gradient from 0 to 20 percent; these are channels considered to be important for fish.

- Waters with a gradient from 21 to 30 percent; these are channels considered to be important for coarse sediment storage and as a source of LWD.
- Waters with a gradient greater than 30 percent; these are channels considered to be important because they are prone to channelized landslides and as a source of LWD.

3.3 Modeling of the Alternative Water Typing Systems

To model the three alternative groupings the existing Washington DNR GIS hydrography coverage, consisting of surface water location and water type, was used along with a channel gradient classification (based on 10-m digital elevation models [DEMs]) and estimated basin size (estimated using 1:24,000 scale topographic maps).

3.3.1 Initial Approach

The following steps were taken using the sample sections described in Section 2:

- The 2004 Washington DNR hydrography layer was acquired for the sample sections within Washington State. Washington DNR hydrography layer classifies waters as Types 1, 2, 3, 4, 5, or 9.
- A GIS ArcInfo macro language (AML) script was used to assign gradients to the waters in the sample sections based on the 10-m DEMs. Gradient classes were mapped along each channel segment; these were broken down into four classes: 0 to 16 percent, 17 to 20 percent, 21 to 30 percent, and greater than 30 percent.
- In order to improve the quality of the gradient classification, an individual map of each section containing the above information along with water type was printed on a topographic map and reviewed by a biologist. Because the computer-generated gradient classification sometimes gave irregular values, the gradient classes were manually adjusted to the nearest regular value. In addition, contributing basin sizes were measured for those reaches where basin sizes were close to the appropriate threshhold described for each alternative.

3.3.2 No Action Alternative 1-Scenario 2 Approach

The waters identified in the State's GIS hydrography coverage have been classified according to the system in place prior to 1999. Therefore, the mapped water types do not reflect the interim water typing system and had to be converted to the interim system. The following rules were applied for modeling (note that the codename for water types under this alternative is Alt1Code):

Western Washington

If Type 1, Alt1Code = 1
If Type 2, Alt1Code = 2
If Type 3, Alt1Code = 3
If Type 4, 5, or 9 and Gradient = 0-16%, then Alt1Code = 3
If Type 4, 5, or 9 and Gradient = 16-20% and Basin > 50 acres, then Alt1Code = 3
If Type 4, 5, or 9 and Gradient = 16-20% and Basin < 50 acres, then Alt1Code = 4/5
If Type 4, 5, or 9 and Gradient > 20%, then Alt1Code = 4/5

Eastern Washington

If Type 1, Alt1-S2Code = 1
If Type 2, Alt1Code = 2

If Type 3, Alt1Code = 3
If Type 4, 5, or 9* and Gradient = 0-16%, then Alt1Code = 3
If Type 4, 5, or 9* and Gradient = 16-20% and Basin > 175 acres, then Alt1Code = 3
If Type 4, 5, or 9* and Gradient = 16-20% and Basin < 175 acres, then Alt1Code = 4/5
If Type 4, 5, or 9* and Gradient > 20%, then Alt1Code = 4/5

*In Eastern Washington, because many Type 9 waters lack defined stream channels a portion of them were eliminated. The portion eliminated varied with the vegetation zone (75% eliminated in Ponderosa Pine, 50% eliminated in Mixed Conifer, and 25% eliminated in High Elevation). The percentages assumed to lack defined channels were based on observations made by field foresters and reflect the lower precipitation levels and corresponding lower stream densities in the Ponderosa Pine zone and higher precipitation levels and corresponding higher stream densities in the High Elevation zone.

3.3.3 No Action Alternative 1-Scenario 1, Alternative 2, and Alternative 3 Approach

For No Action Alternative 1-Scenario 1 and Alternatives 2 and 3, the following rules were applied for modeling (note that the codename for water types under these alternatives is Alt2Code):

Western Washington – Fish habitat (S and F) vs. Non-fish habitat

If Type 1, then Alt2Code = S
If Type 2 or 3, then Alt2Code = F
If Type 4, 5, or 9 and Gradient = 0-16%, then Alt2Code = F
If Type 4, 5, or 9 and Gradient = 16-20% and Basin > 50 acres, then Alt2Code = F
If Type 4, 5, or 9 and Gradient = 16-20% and Basin < 50 acres, then Alt2Code = Non-fish (see below)
If Type 4, 5, or 9 and Gradient > 20%, then Alt2Code = Non-fish (see below)

Western Washington Non-fish habitat streams

If Basin > 13 acres in Sitka Spruce Zone, then Np
If Basin > 52 acres in other Western Washington areas, then Np
Otherwise Ns

Eastern Washington – Fish habitat (S and F) vs. Non-fish habitat

If Type 1, then Alt2Code = S
If Type 2 or 3, then Alt2Code = F
If Type 4, 5, or 9* and Gradient = 0-16%, then Alt2Code = F
If Type 4, 5, or 9* and Gradient = 16-20% and Basin > 175 acres, then Alt2Code = F
If Type 4, 5, or 9* and Gradient = 16-20% and Basin < 175 acres, then Alt2Code = Non-fish (see below)
If Type 4, 5, or 9* and Gradient > 20%, then Alt2Code = Non-fish (see below)

*In Eastern Washington, because many Type 9 waters lack defined stream channels, a portion of them was eliminated. The portion eliminated varied with the vegetation zone (75% eliminated in Ponderosa Pine, 50% eliminated in Mixed Conifer, and 25% eliminated in High Elevation). The percentages were based on observations made by field foresters and reflect the lower precipitation levels and corresponding lower stream densities in the Ponderosa Pine zone and higher precipitation levels and corresponding higher stream densities in the High Elevation zone.

Eastern Washington Non-fish habitat

If Basin > 300 acres, then N_p
If Basin < 300 acres, then N_s

3.3.4 Alternative 4 Approach

For Alternative 4, the following rules were applied for modeling (note that the codename for water types under this alternative is Alt4Code):

Western Washington

For all water types, if Gradient <20%, then Alt4Code = 1
For all water types, if Gradient = 20-30%, then Alt4Code = 2
For all water types, if Gradient >30%, then Alt4Code =3

Eastern Washington

For all* water types, if Gradient <20%, then Alt4Code = 1
For all* water types, if Gradient = 20-30%, then Alt4Code = 2
For all* water types, if Gradient >30%, then Alt4Code =3

*In Eastern Washington, because many Type 9waters lack defined channels a portion of them was eliminated. The portion eliminated varied with the vegetation zone (75% eliminated in Ponderosa Pine, 50% eliminated in Mixed Conifer, and 25% eliminated in High Elevation). The percentages assumed to lack defined channels were based on observations made by field foresters and reflect the lower precipitation levels and corresponding lower stream densities in the Ponderosa Pine zone and higher precipitation levels and corresponding higher stream densities in the High Elevation zone.

3.4 Results of Water Type Modeling

The distribution of forested stream miles in the sample sections according to mapped water types in Washington DNR Hydrography layer is shown in Table B-3. Tables B-4, B-5, and B-6 display the number of forested stream miles in the sample sections after conversion for No Action Alternative 1-Scenario 1, No Action Alternative 1-Scenario 2 and Alternatives 2 and 3, and Alternative 4, respectively.

Table B-3. Stream Miles by Mapped Water Type for Forested Lands in the Sample Sections.

	Mapped Water Types						
	Water Type						
	1	**2**	**3**	**4**	**5**	**9**	**Grand Total**
Westside-Private Lands	57.5	6.9	72.2	44.2	143.4	139.0	**463.2**
Eastside-Private Lands	19.4	8.3	15.4	35.9	94.7	115.8	**289.4**
Eastside-State Lands	1.6	0.9	13.0	12.9	28.8	52.6	**109.7**
Total Sample	**78.5**	**16.1**	**100.6**	**93.0**	**359.9**	**307.4**	**862.3**

Table B-4. Stream Miles by Modeled Water Type for Forested Lands in the Sample Sections under No Action Alternative 1-Scenario 2.

No Action Alternative 1-Scenario 2						
	Water Type					
	1	2	3	4	5	Grand Total
Westside-Private Lands	57.5	6.9	170.2	114.3	114.3	**463.2**
Eastside-Private Lands	19.4	8.3	89.3	86.2	86.3	**289.4**
Eastside-State Lands	1.6	0.9	41.3	33.0	33.0	**109.7**
Total Sample	**78.5**	**16.1**	**300.8**	**233.5**	**233.6**	**862.3**

Table B-5. Stream Miles by Modeled Water Type for Forested Lands in the Sample Sections under No Action Alternative 1-Scenario 1, Alternative 2, and Alternative 3.

No Action Alternative 1-Scenario 1, Alternative 2, and Alternative 3					
	Water Type				
	S	F	N_p	N_s	Grand Total
Westside-Private Lands	57.5	177.1	57.2	171.4	**463.2**
Eastside-Private Lands	19.4	97.6	43.1	129.3	**289.4**
Eastside-State Lands	1.6	42.2	16.5	49.4	**109.7**
Total Sample	**78.5**	**316.9**	**116.8**	**350.1**	**862.3**

Table B-6. Stream Miles by Modeled Water Type for Forested Lands in the Sample Sections under Alternative 4.

Alternative 4				
	Stream Gradient			
	0-20%	20-30%	>30%	Grand Total
Westside-Private Lands	268.7	69.0	125.5	**463.2**
Eastside-Private Lands	167.9	43.1	78.4	**289.4**
Eastside-State Lands	63.6	16.3	29.7	**109.7**
Total Sample	**500.2**	**128.4**	**233.6**	**862.3**

4. RMZ Area Modeling

4.1 Introduction

Chapter 2 of this EIS provides a detailed description of how the RMZs are delineated and protected under each alternative. This section describes how the RMZ zones for each alternative were modeled spatially across the landscape so that an estimate of the amount of area protected within each zone could be calculated. The spatial modeling was conducted using the sample sections described in Section 2, the water type modeling described in Section 3, and the Washington DNR GIS hydrography layer.

As outlined in Section 3, the alternative groups rely on different water typing systems. The RMZ rules for each alternative group vary by water type. In addition, depending on the alternative group, RMZ width depends on whether the stream is in western or eastern Washington, channel width, substrate type, and other factors. Modeling the effects of the different RMZ rules required making assumptions about average buffer widths applied in the field. The sections below describe each assumption, as well as the rationale for making it.

As a general caveat: we emphasize that in many cases these are generalized assumptions for modeling purposes only. We acknowledge that many site-specific factors could result in more or less protection under the different alternatives. However, since the goal of this analysis is to provide an objective, quantifiable and reproducible comparison of the alternatives across Washington State (as opposed to an exact prediction of the effects on each sample area), these assumptions are appropriate.

4.2 Task 1 – Defining Stream Widths

4.2.1 Rationale

Because total RMZ widths include the bankfull width as well as the RMZ width on each side of the stream, it was necessary to assign a representative bankfull width to each water type. In this way, the total area protected by RMZs (including the bankfull area) could be determined under each alternative.

4.2.2 Assumptions

The analysis presented in Washington Forest Practices Board (2001) was used to establish a "representative" (average) bankfull width by water type, stratified by east and westside. The following assumptions were made to determine bankfull widths associated with mapped water types in the Washington DNR hydrography layer:

- Ordinary high water mark (OHWM) (FPB 1998) is considered equal to bankfull width (Rosgen 1996).
- Type 1 bankfull width was based on the analysis presented in Washington Forest Practices Board (2001). It also utilized the TFW report 1988-90 Cumulative Report-data appendix (WDW 1991). This document collected channel width data across Washington State and calculated the average stream channel width by stream water type stratified by east and westside.
- Type 2 waters include all waters designated as Type 2 streams in the Washington DNR hydrography layer. The TFW report 1988-90 Cumulative Report-data appendix (WDW 1991) was used to define the average channel width of Type 2 waters stratified by eastside and westside of the State.
- Type 3 waters include all waters designated as Type 3 streams in the Washington DNR hydrography layer. The TFW report 1988-90 Cumulative Report-data appendix (WDW 1991) was used to define the average channel width of Type 3 waters stratified by eastside and westside of the State.
- Type 4 waters include all waters designated as Type 4 streams in the Washington DNR hydrography layer. It was assumed that bankfull width for all Types 4 streams was 5 feet or less. The TFW report 1988-90 Cumulative Report-data appendix (WDW 1991) did not calculate average bankfull widths for Type 4 waters. For modeling purposes it was decided to use the maximum width rather than the average since there was no data available to provide guidance on the average width of Type 4 waters.
- Type 5 waters include all waters designated as Type 5 streams in the Washington DNR hydrography layer. It was assumed that bankfull width for Type 5 streams was 2 feet or less. The TFW report 1988-90 Cumulative Report-data appendix (WDW 1991) did not calculate

average bankfull widths for Type 5 waters. For modeling purposes it was decided to use the maximum width rather than the average since there was no data available to provide guidance on the average width for Type 5 waters.

Table B-7 presents the average bankfull widths used for mapped water types. Table B-8 presents the average widths used for modeling RMZs under each alternative, based on the widths and relative proportion of mapped water types that make up the modeled water types.

Table B-7. Average Bankfull Widths by Water Type and Region Assumed for Mapped Water Types.

	Bankfull Width (feet)				
Region	**Type 1**	**Type 2**	**Type 3**	**Type 4**	**Type 5**
Westside	60	31	15	5	2
Eastside	50	25	12	5	2

Table B-8. Average Bankfull Widths by Stream Water Type and Region Used for Modeling RMZ Areas under Each Alternative.

Region	**Bankfull Width (feet)**				
Alternative 1-Scenario 2					
Water Type	**1**	**2**	**3**	**4**	**5**
Westside	60	31	8	4	4
Eastside	50	25	6	3	3
No Action Alternative 1-Scenario 1, Alternative 2, and Alternative 3					
Water Type		**S**	**F**	**Np**	**Ns**
Westside		60	10.5	5	2.5
Eastside		50	7.5	5	2
Alternative 4					
Water Type			**0 – 20% Gradient**	**20 – 30% Gradient**	**>30% Gradient**
Westside			60	9	4
Eastside			50	5	2

4.3 Task 2 – Modeling RMZ Areas Protected Under Each Alternative

There are many factors that influence RMZ widths under the alternatives that could not be readily modeled across the State using our generalized GIS-based analysis. The assumptions that are defined below for the westside and eastside RMZs were peer reviewed by Washington DNR foresters that regulate forest practices in the field. It is recognized that these are generalized assumptions for modeling purposes and that many site-specific factors may result in more or less protection than applied in this exercise. However, the following assumptions were made to quantify acres of RMZs under the alternatives.

4.3.1 Assumptions Tables

Tables B-9 through B-14 show the assumed average bankfull width, RMZ management, rationale, and other information, for each RMZ zone under each alternative and on each side of the State. The first column identifies the RMZ zone width based on the distance from the bankfull width.

The second column presents the management intensity within each RMZ zone. The fact that each alternative group uses a different water typing system, has different levels of RMZ management and different RMZ zone widths creates difficulties in making straightforward comparisons between modeled outcomes for RMZ areas. In order to compare RMZ acres, it was necessary to classify each RMZ zone into similar management intensity categories. Three categories were developed for comparisons: no-cut, light selective harvest (10-30 percent volume removal), and moderate-heavy selective harvest (70-90 percent volume removal). The management allowed in each RMZ zone under each alternative was assigned to one of these categories.

The third column represents the rationale for each of the assumptions and is based on field experience and knowledge of average conditions in the field. Much of this information was gained through conversations with Washington DNR foresters who regulate forest practices in the field. In addition, information was collected from the sample sections for the purpose of quantifying the assumptions. This information included: the relative abundance of site classes on State and private forestlands and the average CMZ width for major streams.

The fourth column presents the assumed area reduction due to RMZ width and is an adjustment factor to account for the fact that buffers on intersecting streams overlap. The column gives the approximate percentage of RMZ area associated with each RMZ that overlaps with other RMZs on larger streams. This percentage was estimated using GIS and was based on examining RMZ overlap patterns on the sample sections.

Table B-9. No Action Alternative 1-Scenario 2 – Assumptions for Modeling RMZs Western Washington.

Bankfull Width and Distance from Stream	RMZ Management	Rationale	Area Reduction due to RMZ Overlap
Type 1 Waters			
Bankfull Width = 60 ft.	No-harvest	Average width of Type 1 waters in this alternative is based on the average width of mapped Type 1 waters, which is based on Washington Department of Wildlife (1991) and Washington Forest Practices Board (2001) – see Section 4.2. Type 1 waters in this alternative consist only of mapped Type 1 waters (see Section 3.3.2).	None
0-75 ft.	No-harvest	This portion is assumed to be No-harvest because of the shade rule, the relative ease of harvesting the outer portion of RMZ relative to the portion near the stream bank, and bank stability considerations.	None
75-200 ft.	Light Selection	The remainder of the 200-ft. Shoreline Management Zone is assumed to be light selection harvest because maximum of 30% volume can be removed in one entry.	None
Type 2 Waters			
Bankfull Width = 31 ft.	No-harvest	Average width of Type 2 waters in this alternative is based on the average width of mapped Type 2 waters, which is based on Washington Department of Wildlife (1991) and Washington Forest Practices Board (2001) – see Section 4.2. Type 2 waters in this alternative consist only of mapped Type 2 waters (see Section 3.3.2).	None
0-50 ft.	No-harvest	This portion is assumed to be No-harvest because of the shade rule, the relative ease of harvesting the outer portion of RMZ relative to the portion near the stream bank, and bank stability considerations.	2% Reduction
50-70 ft.	Light Selection	Total RMZ width is 25-75 ft. for streams <75 ft. wide and 25-100 ft. for streams >75 ft. wide. Based on the fact that the majority of Type 2 waters are <75 ft. wide, the shade rule, and field experience, 70 ft. was estimated to be the average total width. Light selection was assumed for management because of the shade rule and the fact that most Type 2 waters are low elevation streams that require high levels of shade under the shade rule.	5% Reduction

Table B-9. No Action Alternative 1-Scenario 2 – Assumptions for Modeling RMZs Western Washington (continued).

Bankfull Width and Distance from Stream	RMZ Management	Rationale	Area Reduction due to RMZ Overlap
Type 3 Waters			
Bankfull Width = 8 ft.	No-harvest	Average width of Type 3 waters in this alternative is based on mapped channel widths and their relative proportions in Type 3 waters. Mapped channel widths are based on Washington Department of Wildlife (1991) & Washington Forest Practices Board (2001) – see Section 4.2. Type 3 waters in this alternative include all mapped Type 3 waters, as well as some mapped Types 4, 5, and 9 waters (see Section 3.3.2).	None
0-25 ft.	No-harvest	This portion is assumed to be No-harvest because of the shade rule, the relative ease of harvesting the outer portion of RMZ relative to the portion near the stream bank, and bank stability considerations.	5% Reduction
25-40 ft.	Light Selection	Total RMZ width is 25 ft. for waters <5 ft. wide and 25-50 ft. for waters >5 ft. wide. The majority of Type 3 waters are >5 ft. wide, so 40 ft. was estimated to be the average maximum width. Light selection was assumed for management because of the shade rule and the fact that most Type 3 waters are relatively low in elevation that require high levels of shade under the shade rule.	5% Reduction
Type 4 & 5 Waters			
Bankfull Width = 4 ft.	No-harvest	Average width of Type 4 and 5 streams waters in this alternative is based on mapped stream channel widths from Washington Department of Wildlife (1991) and Washington Forest Practices Board (2001) – see Section 4.2. Type 4 and 5 streams waters in this alternative include only mapped Type 4, 5, and 9 streams waters (see Section 3.3.2).	None
No RMZ			

Table B-10. No Action Alternative 1-Scenario 2 – Assumptions for Modeling RMZs Eastern Washington.

Bankfull Width and Distance from Stream	RMZ Management	Rationale	Area Reduction due to RMZ Overlap
Type 1 Waters			
Bankfull Width = 50 ft.	No-harvest	Average width of Type 1 streams in this alternative is based on the average width of mapped Type 1 streams, which is based on Washington Department of Wildlife (1991) and Washington Forest Practices Board (2001) – see Section 4.2. Type 1 streams in this alternative consist only of mapped Type 1 streams (see Section 3.3.2).	None
0-50 ft.	No-harvest	This portion is assumed to be No-harvest because of the shade rule, the relative ease of harvesting the outer portion of RMZ relative to the portion near the stream bank, and bank stability considerations.	None
50-200 ft.	Light Selection	The remainder of the 200-ft. Shoreline Management Zone is assumed to be light selection harvest because maximum of 30% volume can be removed in one entry, within a 10-year period.	None
Type 2 Waters			
Bankfull Width = 25 ft.	No-harvest	Average width of Type 2 streams in this alternative is based on the average width of mapped Type 2 streams, which is based on Washington Department of Wildlife (1991) and Washington Forest Practices Board (2001) – see Section 4.2. Type 2 streams in this alternative consist only of mapped Type 2 streams (see Section 3.3.2).	None
0-25 ft.	No-harvest	This portion is assumed to be No-harvest because of the shade rule, the relative ease of harvesting the outer portion of RMZ relative to the portion near the stream bank, and bank stability considerations.	2% Reduction
25-50 ft.	Light Selection	Total RMZ width is 30-50 ft. for streams in partial cut units and 30-300 ft. for streams in clearcut units. The majority of units are partial cut (assumed to be 60%), so 50 ft. was estimated to be the average width. Moderate to heavy selection was assumed for management.	5% Reduction

Table B-10. No Action Alternative 1-Scenario 2 – Assumptions for Modeling RMZs Eastern Washington (continued).

Bankfull Width and Distance from Stream	RMZ Management	Rationale	Area Reduction due to RMZ Overlap
Type 3 Waters			
Bankfull Width = 6 ft.	No-harvest	Average width of Type 3 streams in this alternative is based on mapped stream widths and their relative proportions in Type 3 streams. Mapped stream widths are based on Washington Department of Wildlife (1991) & Washington Forest Practices Board (2001) – see Section 4.2. Type 3 streams in this alternative include all mapped Type 3 streams, as well as some mapped Type 4, 5, and 9 streams (see Section 3.3.2).	None
0-20 ft.	No-harvest	This portion is assumed to be No-harvest because of the shade rule, the relative ease of harvesting the outer portion of RMZ relative to the portion near the stream bank, and bank stability considerations.	5% Reduction
20-40 ft.	Light Selection	Total RMZ width is 30-50 ft. for streams in partial cut units and 30-300 ft. for streams in clearcut units. The majority of units are partial cut (assumed to be 60%), so 50 ft. was estimated to be the average width. Moderate to heavy selection was assumed for management.	5% Reduction
Type 4 & 5 Waters			
Bankfull Width = 3 ft.	No-harvest	Average width of Type 4 and 5 streams in this alternative is based on mapped stream widths from Washington Department of Wildlife (1991) and Washington Forest Practices Board (2001) – see Section 4.2. Type 4 and 5 streams in this alternative include only mapped Type 4, 5, and 9 streams (see Section 3.3.2).	None
No RMZ			

Table B-11. Alternative 2, Alternative 3, and No Action Alternative 1-Scenario 1 – Assumptions for Modeling RMZs Western Washington.

Bankfull Width and Distance from Stream	RMZ Management	Rationale	Area Reduction due to RMZ Overlap
Type S Waters			
Bankfull Width = 60 ft.	No-harvest	Average width of Type S streams is based on the average width of mapped Type 1 streams, which are based on Washington Department of Wildlife (1991) and Washington Forest Practices Board (2001) – see Section 4.2. Type S streams consist only of mapped Type 1 streams (see Section 3.3.3).	None
0-30 ft.	No-harvest	Estimated average CMZ width over all Type S streams.	None
30-80 ft.	No-harvest	Core zone is 50-ft. wide in western Washington.	None
80-145 ft.	Light Selection	Inner zone is 43-64 ft. wide for streams <10 ft. wide on Site Class II and III areas. Inner zone is 55-78 ft. wide for streams >10 ft. wide on Site Class II and III areas. Site Class II and III areas represent the majority of site classes. Light selection is assumed because inner zone stand requirements are designed to maintain a fully-stocked conditions representative of a mature (i.e., 140 years of age) forest.	None
145-200 ft.	Light Selection	The remainder of the 200-ft. Shoreline Management Zone is assumed to be light selection harvest because maximum of 30% volume can be removed in one entry, within a 10-year period.	None
Type F Waters			
Bankfull Width = 10.5 ft.	No-harvest	Average width of Type F streams is based on mapped stream widths and their relative proportions in Type F streams. Mapped stream widths are based on Washington Department of Wildlife (1991) and Washington Forest Practices Board (2001) – see Section 4.2. Type F streams include all mapped Type 2 and 3 streams and some mapped Type 4, 5, and 9 streams (see Section 3.3.3).	None
0-10 ft.	No-harvest	Estimated average CMZ width over all Type F streams.	2% Reduction
10-60 ft.	No-harvest	Core zone is 50-ft. wide in western Washington.	5% Reduction

Table B-11. Alternative 2, Alternative 3, and No Action Alternative 1-Scenario 1 – Assumptions for Modeling RMZs Western Washington (continued).

Bankfull Width and Distance from Stream	RMZ Management	Rationale	Area Reduction due to RMZ Overlap
60-120 ft.	Light Selection	Inner zone is 43-64 ft. wide for streams <10 ft. wide on Site Class II and III areas. Inner zone is 55-78 ft. wide for streams >10 ft. wide on Site Class II and III areas. Site Class II and III areas represent the majority of site classes. Light selection is assumed because inner zone stand requirements are designed to maintain a fully-stocked conditions representative of a mature (i.e., 140 years of age) forest.	10% Reduction
120-165 ft.	Mod-Heavy Selection	Average total RMZ width is 140 ft. for Site Class III and 170 ft. for Site Class II. Because these site classes are the most prevalent, the average total RMZ width (155 ft., not including the CMZ) is an average of these two widths.	10% Reduction
Type Np Waters			
Bankfull Width = 5 ft.	No-harvest	Average width of Type Np streams is based on mapped stream widths and their relative proportions in Type Np streams. Mapped stream widths are based on Washington Department of Wildlife (1991) and Washington Forest Practices Board (2001) – see Section 4.2. Type Np streams include some mapped Type 4, 5, and 9 streams (see Section 3.3.3).	None
0-50 ft. (along 70% of stream length)	No-harvest	Assumes 50-ft. no-harvest buffer along 70% of stream length because minimum is 50% and many are much higher due to unstable slopes and sensitive sites.	10% Reduction
Type Ns Waters			
Bankfull Width = 2.5 ft.	No-harvest	Average width of Type Ns streams is based on mapped stream widths and their relative proportions in Type Ns streams. Mapped stream widths are based on Washington Department of Wildlife (1991) and Washington Forest Practices Board (2001) – see Section 4.2. Type Ns streams include some mapped Type 4, 5, and 9 streams (see Section 3.3.3).	None
No RMZ that limits harvest			

Table B-12. Alternative 2, Alternative 3, and No Action Alternative 1-Scenario 1 – Assumptions for Modeling RMZs Eastern Washington.

Bankfull Width and Distance from Stream	RMZ Management	Rationale	Area Reduction due to RMZ Overlap
Type S Waters			
Bankfull Width = 50 ft.	No-harvest	Average width of Type S streams is based on the average width of mapped Type 1 streams, which are based on Washington Department of Wildlife (1991) and Washington Forest Practices Board (2001) – see Section 4.2. Type S streams consist only of mapped Type 1 streams (see Section 3.3.3).	None
0-5 ft.	No-harvest	Estimated average CMZ width over all Type S streams.	None
5-35 ft.	No-harvest	Core zone is 30-ft. wide in eastern Washington.	None
35-95 ft.	Light Selection	Inner zone is 45 ft. wide for streams <15 ft. wide and 70 ft. wide for streams >15 ft.	None
95-200 ft.	Light Selection	The remainder of the 200-ft. Shoreline Management Zone is assumed to be light selection harvest because maximum of 30% volume can be removed in one entry.	None
Type F Waters			
Bankfull Width = 7.5 ft.	No-harvest	Average width of Type F streams is based on mapped stream widths and their relative proportions in Type F streams. Mapped stream widths are based on Washington Department of Wildlife (1991) and Washington Forest Practices Board (2001) – see Section 4.2. Type F streams include all mapped Type 2 and 3 streams and some mapped Type 4, 5, and 9 streams (see Section 3.3.3).	None
0-2 ft.	No-harvest	Estimated average CMZ width over all Type F streams.	None
2-32 ft.	No-harvest	Core zone is 30-ft. wide in eastern Washington.	5% Reduction
32-87 ft.	Light Selection	Inner zone is 45 ft. wide for streams <15 ft. wide and 70 ft. wide for streams >15 ft.	10% Reduction

Table B-12. Alternative 2, Alternative 3, and No Action Alternative 1-Scenario 1 – Assumptions for Modeling RMZs Eastern Washington (continued).

Bankfull Width and Distance from Stream	RMZ Management	Rationale	Area Reduction due to RMZ Overlap
87-102 ft.	Mod-Heavy Selection	Average total RMZ width is 90-110 ft. for streams <15 ft. wide on Site Class II and III areas and 100-110 ft. for streams >15 ft. wide on Site Class II and III areas. Because these site classes are the most prevalent, the average total RMZ width (100 ft., not including the CMZ) is an average of these widths.	10% Reduction
Type Np Waters			
Bankfull Width = 5 ft.	No-harvest	Average width of Type Np streams is based on mapped stream widths and their relative proportions in Type Np streams. Mapped stream widths are based on Washington Department of Wildlife (1991) and Washington Forest Practices Board (2001) – see Section 4.2. Type Np streams include some mapped Type 4, 5, and 9 streams (see Section 3.3.3).	None
0-50 ft. (along 70% of streams in clearcut units)	No-harvest	Assumes 50-ft. no-harvest buffer along 70% of stream length in clearcut units because minimum is 50% and many are much higher due to unstable slopes and sensitive sites. Clearcut units are assumed to make up 40% of all units on the eastside.	10% Reduction
0-50 ft. (along full length of streams in partial cut units)	Light Selection	Assumes 50-ft. light selection cut buffer along 100% of stream length in partial cut units. Partial cut units are assumed to make up 60% of all units on the eastside.	10% Reduction
Type Ns Waters			
Bankfull Width = 2 ft.	No-harvest	Average width of Type Ns streams is based on mapped stream widths and their relative proportions in Type Ns streams. Mapped stream widths are based on Washington Department of Wildlife (1991) and Washington Forest Practices Board (2001) – see Section 4.2. Type Ns streams include some mapped Type 4, 5, and 9 streams (see Section 3.3.3).	None
No RMZ that limits harvest			

Table B-13. Alternative 4 – Assumptions for Modeling RMZs Western Washington.

Bankfull Width and Distance from Stream	RMZ Management	Rationale	Area Reduction due to RMZ Overlap
0-20% Gradient Streams (existing Type 1 streams)			
Bankfull Width = 60 ft.	No-harvest	Average width of streams in this category is the average width of mapped Type 1 streams, which are based on Washington Department of Wildlife (1991) and Washington Forest Practices Board (2001) – see Section 4.2. This category consists only of mapped Type 1 streams (see Section 3.3.4).	None
0-35 ft.	No-harvest	Estimated average CMZ and BHZ width over all Type 1 streams.	None
35-235 ft.	No-harvest	No-harvest zone is 200 ft. wide.	None
0-20% Gradient Streams (streams other than Type 1)			
Bankfull Width = 9 ft.	No-harvest	Average width of streams in this category is based on mapped stream widths and their relative proportions in this category. Mapped stream widths are based on Washington Department of Wildlife (1991) and Washington Forest Practices Board (2001) – see Section 4.2. This category consists of mapped Type 2, 3, 4, 5, and 9 streams (see Section 3.3.4).	None
0-12 ft.	No-harvest	Estimated average CMZ and BHZ width over all streams in this category.	None
12-212 ft.	No-harvest	No-harvest zone is 200 ft. wide.	10% Reduction

Table B-13. Alternative 4 – Assumptions for Modeling RMZs Western Washington (continued).

Bankfull Width and Distance from Stream	RMZ Management	Rationale	Area Reduction due to RMZ Overlap
20-30% Gradient Streams			
Bankfull Width = 4 ft.	No-harvest	Average width of streams in this category is based on mapped stream widths and their relative proportions in this category. Mapped stream widths are based on Washington Department of Wildlife (1991) and Washington Forest Practices Board (2001) – see Section 4.2. This category consists of mapped Type 4, 5, and 9 streams (see Section 3.3.4).	None
0-10 ft.	No-harvest	Estimated average Channel Disturbance Zone width over all streams in this category.	None
10-110 ft.	No-harvest	No-harvest zone is 100 ft.	20% Reduction
>30% Gradient Streams			
Bankfull Width = 2.5 ft.	No-harvest	Average width of streams in this category is based on mapped stream widths and their relative proportions in this category. Mapped stream widths are based on Washington Department of Wildlife (1991) and Washington Forest Practices Board (2001) – see Section 4.2. This category consists of mapped Type 4, 5, and 9 streams (see Section 3.3.4).	None
0-10 ft.	No-harvest	Estimated average Channel Disturbance Zone width over all streams in this category.	None
10-80 ft.	No-harvest	No-harvest zone is 70 ft.	30% Reduction

Table B-14. Alternative 4 – Assumptions for Modeling RMZs Eastern Washington.

Bankfull Width and Distance from Stream	RMZ Management	Rationale	Area Reduction due to RMZ Overlap
0-20% Gradient Streams (existing Type 1 streams)			
Bankfull Width = 50 ft.	No-harvest	Average width of streams in this category is the average width of mapped Type 1 streams, which are based on Washington Department of Wildlife (1991) and Washington Forest Practices Board (2001) – see Section 4.2. This category consists only of mapped Type 1 streams (see Section 3.3.4).	None
0-6 ft.	No-harvest	Estimated average CMZ and BHZ width over all Type 1 streams.	None
6-206 ft.	No-harvest	No-harvest zone is 200 ft. wide.	None
0-20% Gradient Streams (others)			
Bankfull Width = 5 ft.	No-harvest	Average width of streams in this category is based on mapped stream widths and their relative proportions in this category. Mapped stream widths are based on Washington Department of Wildlife (1991) and Washington Forest Practices Board (2001) – see Section 4.2. This category consists of mapped Type 2, 3, 4, 5, and 9 streams (see Section 3.3.4).	None
0-3 ft.	No-harvest	Estimated average CMZ and BHZ width over all streams in this category.	None
3-203 ft.	No-harvest	No-harvest zone is 200 ft. wide.	5% Reduction

Table B-14. Alternative 4 – Assumptions for Modeling RMZs Eastern Washington (continued).

Bankfull Width and Distance from Stream	RMZ Management	Rationale	Area Reduction due to RMZ Overlap
20-30% Gradient Streams			
Bankfull Width = 4 ft.	No-harvest	Average width of streams in this category is based on mapped stream widths and their relative proportions in this category. Mapped stream widths are based on Washington Department of Wildlife (1991) and Washington Forest Practices Board (2001) – see Section 4.2. This category consists of mapped Type 4, 5, and 9 streams (see Section 3.3.4).	None
0-10 ft.	No-harvest	Estimated average Channel Disturbance Zone width over all streams in this category.	None
10-110 ft.	No-harvest	No-harvest zone is 100 ft.	20% Reduction
>30% Gradient Streams			
Bankfull Width = 2 ft.	No-harvest	Average width of streams in this category is based on mapped stream widths and their relative proportions in this category. Mapped stream widths are based on Washington Department of Wildlife (1991) and Washington Forest Practices Board (2001) – see Section 4.2. This category consists of mapped Type 4, 5, and 9 streams (see Section 3.3.4).	None
0-10 ft.	No-harvest	Estimated average Channel Disturbance Zone width over all streams in this category.	None
10-80 ft.	No-harvest	No-harvest zone is 70 ft.	30% Reduction

4.3.2 Process for Developing RMZ Area (acres) Estimates for the Alternatives

Eestimating RMZ acreages under each alternative included several steps:

1) The water type models described in Section 3.3 were applied to the existing mapped waters in the Washington DNR hydrography coverage in the sample sections. The percentage of existing mapped Type 1, 2, 3, 4, 5, and 9 waters that correspond to each new water type under each alternative was then quantified.
2) Total stream miles on all covered lands were quantified using GIS and Washington DNR hydrography coverage by mapped water type.
3) The proportion of the existing mapped water types that make up the alternative water types were then multiplied by the total stream miles and summed for each of the alternative groups. This produced an estimate of the number of stream miles for each alternative water type.
4) Finally, the average values defined in the assumptions tables (Tables B-9 through B-14) were applied to the estimated total stream miles for each alternative, water type, and side of the State. These values were summed to develop an estimate of total RMZ areas (acres) under each alternative.

The result of this process was the production of total RMZ area estimates (in acres) by RMZ management category, and by alternative, as presented in Tables B-15 and B-16 and shown graphically in Figures B-1 and B-2.

Table B-15. Estimated RMZ acres on Private (including City and County) Forestlands in Western Washington.[1/]

Treatment Type	No Action Alternative 1-Scenario 2	No Action Alternative 1-Scenario 1 Alternative 2 Alternative 3	Alternative 4
No Harvest	263,000	502,000	2,603,000
Light Selective Harvest	196,000	499,000	0
Moderate-Heavy Selective Harvest	84,000	233,000	0
Stream Area[2/]	88,000	88,000	93,000
Total	**631,000**	**1,322,000**	**2,695,000**

1/ Total area in western Washington private forestlands is approximately 6,289,000 acres.
2/ Stream area varies slightly among alternatives due to modeling.

Table B-16. Estimated RMZ acres on Private (including City and County) Forestlands in Eastern Washington. [1/]

Treatment Type	No Action Alternative 1-Scenario 2	No Action Alternative 1-Scenario 1 Alternative 2 Alternative 3	Alternative 4
No Harvest	74,000	107,000	854,000
Light Selective Harvest	43,000	205,000	0
Moderate-Heavy Selective Harvest	60,000	42,000	0
Stream Area[2/]	19,000	20,000	17,000
Total	**196,000**	**374,000**	**871,000**

1/ Total area in eastern Washington private and state forestlands is approximately 3,365,00.
2/ Stream area varies slightly among alternatives due to modeling.

Figure B-1. Estimated RMZ Areas (acres) on Western Washington Private (including City and County) Lands (total area in western Washington private forestlands is approximately 6,289,000 acres).

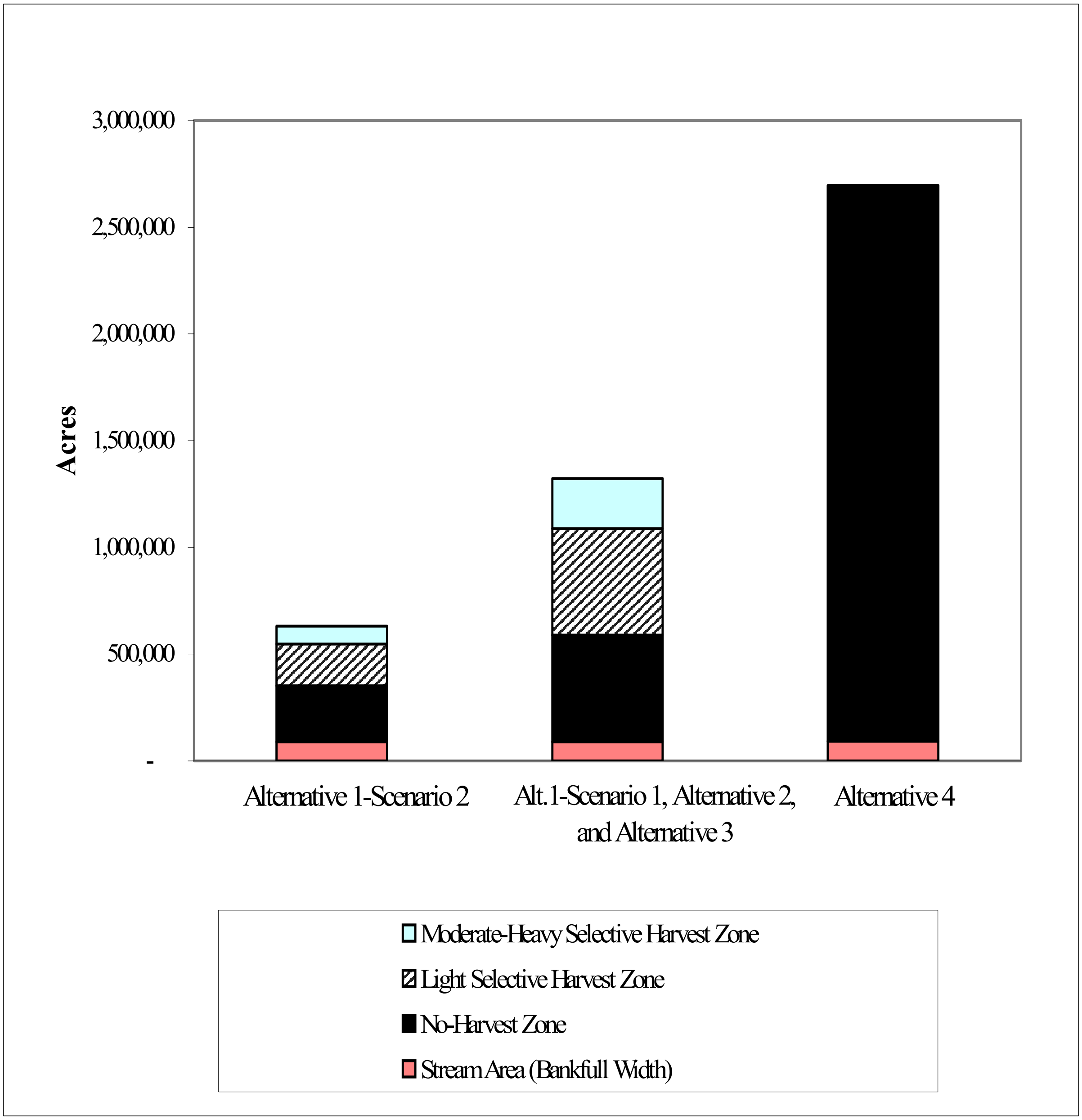
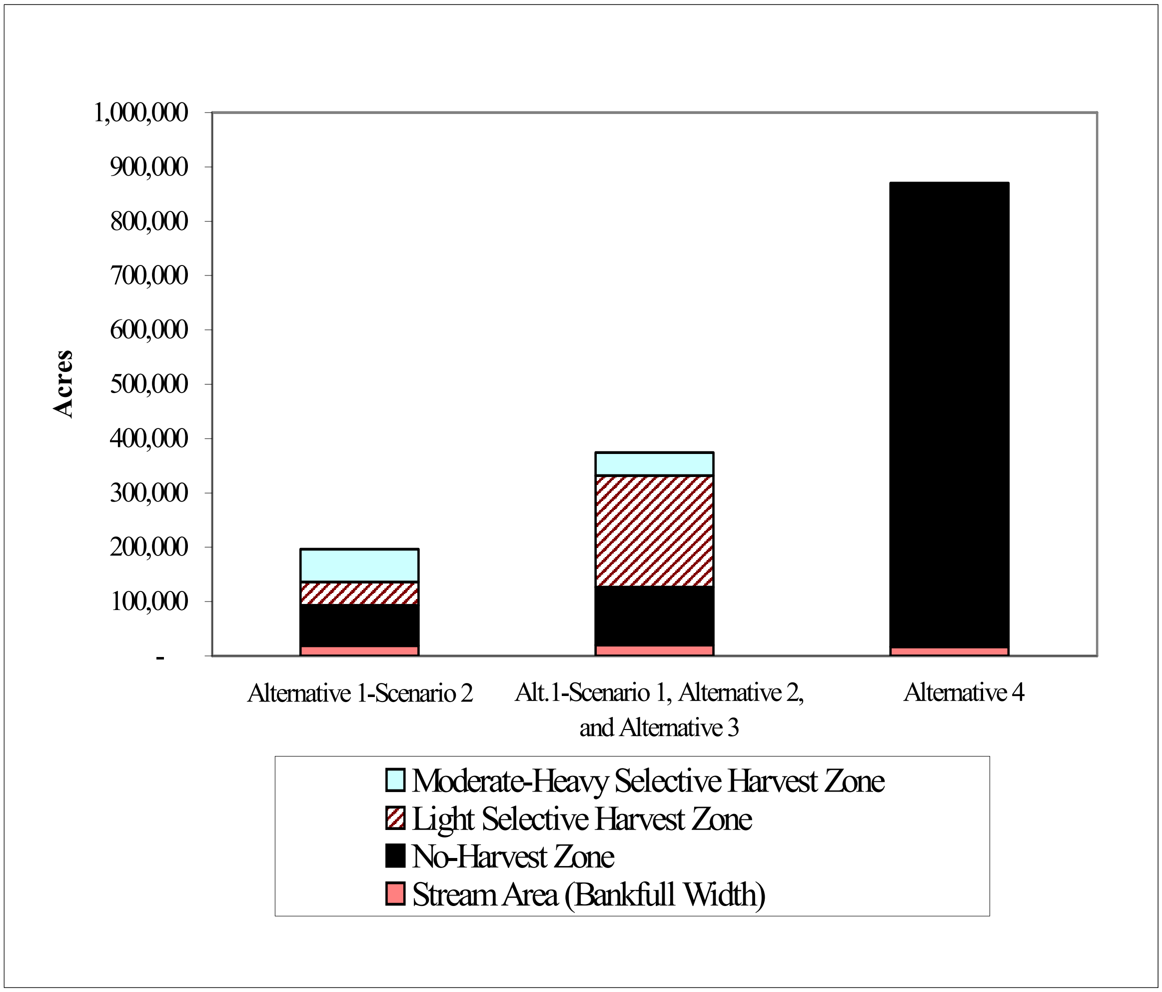


Figure B-2. Estimated RMZ Areas (acres) on Eastern Washington Private (including City and County) and State Lands (total area in eastern Washington private and State forestlands is approximately 3,365,000 acres).



5. Equivalent Buffer Area Index (EBAI) Methodology for LWD

The equivalent buffer area index (EBAI) was developed by the authors of this EIS as a tool for comparing alternatives in terms of the level of ecological function conserved by various management practices. The EBAI concept is used here to evaluate the contribution of large woody debris (LWD) from proposed or existing riparian buffers.

It was useful to develop the LWD EBAI because studies in the literature typically, but not exclusively, evaluate buffer widths based on "no harvest," or preservation of mature forest with no disturbance. New management strategies include riparian areas that are divided into zones allowing different levels of timber harvest and thus, are not directly comparable to the buffers in the literature. Similarly, existing riparian buffers in a given watershed may be a mixture of widths and activities, as a result of multiple jurisdictions, or Washington Forest Practices Rules that have changed over time.

The EBAI methodology takes into account management activities within the buffer zone. It combines the impacts of activities within riparian management zones (RMZ) to compare potential LWD recruitment by alternative.

The EBAI for LWD recruitment potential is a quantitative measure that compares the potential of a riparian area to provide woody debris to streams originating from tree mortality, windthrow, and bank undercutting (which are mainly a of slope distance from the stream channel in relationship to tree height). The EBAI value was determined for each alternative based upon the mature conifer curve of LWD recruitment potential by McDade et al. (1990) that relates cumulative percent of LWD recruitment with distance from the stream bank in terms of tree height. This model was used to calculate the percent of LWD recruitment potential that is provided by each RMZ zone identified in Tables 3-8 and described in Section 4. The LWD recruitment potential for each RMZ zone was reduced by the degree of harvest within each zone. The EBAI values for each zone were summed for each water type to establish a Recruitment Potential Index (RPI) for each water type under each alternative. These RPIs were multiplied by the number of stream miles to develop an overall index for a region for all water types or a group of water types (e.g.,all fish-bearing waters).

LWD EBAIs were developed in this way for all waters, all fish-bearing waters, all non-fish perennial waters, and all non-fish seasonal waters for each alternative. They were developed for both western and eastern Washington. In order to quantify this relationship using a range of assumptions for full protection of LWD recruitment potential, we developed indexes assuming both 100-year and 250-year old trees are required for full protection.

As an example, consider a Type F stream in western Washington under Alternative 2. From Table B-11, the assumptions for the RMZ of this stream are that there is a CMZ that is 10 feet wide, followed by a 50-foot core zone, followed by a 60-foot inner zone in which a light selection harvest is assumed (30% volume removal), followed by a 45-foot outer zone in which a moderate-heavy selection harvest is assumed (70% volume removal). This gives a total RMZ width of 155 feet plus a 10-foot CMZ. The total RMZ width of 155 feet is based on an average of Site Class II and III areas [(140+170)/2], which represent the most common site classes on the covered lands. Next, it is necessary to go to the McDade (1990) mature conifer curve, which has been standardized for 155 feet, which is the buffer distance that assumes full protection for the 100-year SPTH. This curve reads the cumulative percentage of LWD contribution in relation to the distance from the stream. In our example, we need the percent of the total LWD contributed by the different RMZ zones (e.g., 0-10 ft., 10-60 ft., 60-120 ft., and 120-165 ft.). The values are 17% for the 0-10-foot zone, 62% for the 10-60-foot zone, 18% for the 60-120-foot zone, and 3% for the 120-165-foot zone. The last step is to multiply the contribution percentage by the tree retention percentage for each RMZ zone and sum them up. So

$$0.17 \times 1.0 + 0.62 \times 1.0 + 0.18 \times .7 + 0.03 \times 0.3 = 0.925$$

Therefore, the RMZ under Alternative 2 for Type F streams in western Washington would provide for an estimated 92.5% of full LWD recruitment potential, given the assumption that full recruitment potential is achieved at a buffer width equal to the 100-year SPTH.

The LWD EBAI values estimated based on the 100-year and the 250-year SPTH are presented in Tables B-17 and B-18. These tables include the estimated values for fish-bearing, non-fish perennial, and non-fish seasonal streams.

Table B-17. Equivalent Buffer Area Index (EBAI) Values for LWD, Estimated for all Streams, Fish-bearing Streams, Non-fish Perennial Streams, and Non-fish Seasonal Streams, Assuming a 100-year Site Potential Tree Height.

Alternative	All Streams	Fish-bearing Streams	Non-fish Perennial Streams	Non-fish Seasonal Streams
Western Washington				
No Action Alternative 1-Scenario 2	0.30	0.60	0.0	0.0
No Action Alternative 1-Scenario 1, Alternative 2, Alternative 3	0.52	0.93	0.51	0.0
Alternative 4	0.97	1.00	0.98	0.92
Eastern Washington				
No Action Alternative 1-Scenario 2	0.57	0.67	0.18	0.18
No Action Alternative 1-Scenario 1, Alternative 2, Alternative 3	0.77	0.91	0.43	0.18
Alternative 4	1.00	1.00	1.00	0.99

Table B-18. Equivalent Buffer Area Index (EBAI) Values for LWD, Estimated for all Streams, Fish-bearing Streams, Non-fish Perennial Streams, and Non-fish Seasonal Streams, Assuming a 250-year Site Potential Tree Height.

Alternative	All Streams	Fish-bearing Streams	Non-fish Perennial Streams	Non-fish Seasonal Streams
Western Washington				
No Action Alternative 1-Scenario 2	0.19	0.37	0.0	0.0
No Action Alternative 1-Scenario 1, Alternative 2, Alternative 3	0.50	0.90	0.44	0.0
Alternative 4	0.96	1.00	0.96	0.86
Eastern Washington				
No Action Alternative 1-Scenario 2	0.46	0.53	0.18	0.18
No Action Alternative 1-Scenario 1, Alternative 2, Alternative 3	0.69	0.82	0.38	0.18
Alternative 4	0.99	1.00	0.97	0.93

6. Equivalent Buffer Area Index (EBAI) Methodology for Sediment

Most of the riparian function research conducted to date has assessed riparian buffer effectiveness where there is no management activity within the buffer zone; in other words, only no-harvest buffers have been examined. Notably, Spence et al. (1996) recommend that activities that disturb downed wood and ground cover within the riparian zone should be avoided. It can be assumed that activities within the riparian zone that disturb or compact soils, destroy organic litter, and remove large downed wood can reduce the effectiveness of the riparian buffer as a sediment filter by some unknown amount. Because sediment filtration is influenced mostly by ground cover, a buffer with management activity may recover its sediment filtration capacity when ground cover becomes reestablished. The recovery period would involve many different site-specific variables, such as soil moisture, available light, logging equipment used, and yarding practices. It is very difficult to assess recovery periods on such a large and diverse landscape such as the one considered in this EIS. Therefore, while it can be assumed the sediment filtration would be regained after some recovery period, for the purpose of this analysis, and for ease of comparison of the alternatives, a “snapshot” of the buffer is assumed, taken immediately after harvest, to assess the effects. Because slope gradients within riparian zones are highly variable, the effect of slope gradient on sediment filtration is not considered here. This approach is consistent because the same approach is used for each alternative. Note that because prescribed burns are not common in Washington State, the effects of prescribed burns on sediment filtration are not a significant consideration and are not considered here.

To assess the effectiveness of buffer widths and management practices on sediment filtration, a numerical ranking system was developed based on previous studies of timber harvest and landscape effects. An Equivalent Buffer Area Index (EBAI) for sediment was devised as a crude assessment of risk to streams in relation to management activities. It is similar in concept to the equivalent road area (ERA) analysis of McGurk and Fong (1995) and the non-point source risk assessment of Lull et al. (1995). However, while those studies developed a method to assess sediment contribution from management activities, the EBAI is a relative measure of the protection of streams from fine sediment derived from hillslope erosion and road surface erosion.

It was practical to develop the EBAI because studies in the literature typically evaluate buffer widths based on "no harvest," or retention of mature forest with no disturbance. Management strategies include riparian areas that are divided into zones with different levels of timber harvest and thus are not directly comparable to the buffers in the literature.

The EBAI takes into account management within the buffer zones. It combines the impacts of activities within riparian management zones (RMZ) to compare the effectiveness of the RMZ at filtering sediment. In addition, because the buffer requirements for sediment filtration and LWD recruitment may be more restrictive than RMZ requirements for protection of other riparian functions (e.g. stream temperature, and detrital inputs (Johnson and Ryba 1992, Spence et. al. 1996), the EBAI can also be used to compare relative protection for those parameters as well.

The capacity of a vegetated buffer to filter sediment has been shown in numerous studies (e.g., Wilson 1967; Ermann, et al. 1977; Lynch et al. 1977). This effect is a result of the vegetation intercepting overland flow, slowing it down, and allowing fine sediment to settle out. This effect is limited to flow coming from hillslope erosion; channelized flow through existing drainages remains unaffected, since there is not sufficient vegetation in most channels to filter out fine sediment. Potential sources of fine sediment in overland flow include erosion from hillslope logging activities, and road surface erosion that comes from drainage relief culverts (road surface erosion from ditches is not included here because it directly enters streams at road crossings).

As in the ERA, this method uses coefficients assigned to various timber harvest practices based partly on the literature and partly on professional judgement. This reflects the relative ranking of these silvicultural practices presented in McGurk and Fong (1995).

The highest coefficient used is 1.0, representing no harvest, which is the highest amount of protection to the stream from sediment inputs. Any activity within the RMZ that removes trees or disturbs the soil reduces the coefficient. The lowest coefficient possible is zero, which is associated with building a road in the riparian zone. Table B-19 shows the coefficients used for each type of harvest practice. These coefficients were modified and simplified from the coefficients presented in Washington Forest Practices Board (2001).

Table B-19. EBAI (sediment input) Coefficients Associated with Various Management Activities within RMZs.

No Harvest	1.0
Light Selection Harvest (10-30% removal)	0.8
Mod-Hvy. Selection Harvest (70-90% removal)	0.7
Clearcut (100% removal)	0.6
Road (bare soil)	0.0

The width of riparian buffers is important for comparison purposes. Recommended buffer widths for sediment filtration vary widely, from 30 feet (Rashin et al. 1999) to over 300 feet (Spence et al. 1995; Wilson 1967: O'Laughlin and Belt 1994). To calculate the EBAI, the minimum buffer width that is 100% effective at sediment filtration must first be selected. Because of the range in buffer widths for effective sediment filtration, two widths were used in this analysis, and thus two different EBAIs were developed. Thirty feet was chosen to represent the lower end of the buffer widths recommended in the literature as required for effective sediment filtration, while 200 feet was chosen based on Spence et al. (1996) to represent the upper end.

The EBAI is calculated by multiplying the management coefficient by the proportion of the buffer width over which it is applied. Where multiple activities occur in the RMZ, the products of the coefficient and width proportions for each activity are summed.

Ultimately, the index incorporates effects to all waters, regardless of type, into a single number for each. This is done by multiplying the sum of the coefficients by the stream miles in each water type. The results for each water type are then totaled. The results are expressed in terms of percent effectiveness so that disturbance levels can be compared among all alternatives.

For example, if the 200-foot no-cut buffer is assumed to be required for 100 percent effectiveness, and a stream has a 75-foot no-cut buffer and the area outside of the buffer is clearcut, the Sediment EBAI would be (75 x 1.0 + 125 x 0.6) / 200. Thus, the Sediment EBAI would be 0.75.

The sediment EBAI values, estimated assuming 100 percent protection is provided by a 30-foot and 200-foot no-harvest buffer width, are presented in Tables B-20 and B-21. These tables include the estimated values for fish-bearing, non-fish perennial, and non-fish seasonal streams.

Table B-20. Equivalent Buffer Area Index (EBAI) Values for Sediment, Estimated for all Streams, Fish-bearing Streams, Non-fish Perennial Streams, and Non-fish Seasonal Streams, Assuming 100 Percent Protection is Provided by a 30-foot No-harvest Buffer.

Alternative	All Streams	Fish-bearing Streams	Non-fish Perennial Streams	Non-fish Seasonal Streams
Western Washington				
No Action Alternative 1-Scenario 2	0.78	0.96	0.60	0.60
No Action Alternative 1-Scenario 1, Alternative 2, Alternative 3	0.91	1.00	0.92	0.80
Alternative 4	1.00	1.00	1.00	1.00
Eastern Washington				
No Action Alternative 1-Scenario 2	0.86	0.91	0.66	0.66
No Action Alternative 1-Scenario 1, Alternative 2, Alternative 3	0.96	1.00	0.86	0.80
Alternative 4	1.00	1.00	1.00	1.00

Table B-21. Equivalent Buffer Area Index (EBAI) Values for Sediment, Estimated for all Streams, Fish-bearing Streams, Non-fish Perennial Stream,s and Non-fish Seasonal Streams, Assuming 100 Percent Protection is Provided by a 200-foot No-harvest Buffer.

Alternative	All Streams	Fish-bearing Streams	Non-fish Perennial Streams	Non-fish Seasonal Streams
Western Washington				
No Action Alternative 1-Scenario 2	0.65	0.71	0.60	0.60
No Action Alternative 1-Scenario 1, Alternative 2, Alternative 3	0.73	0.81	0.68	0.63
Alternative 4	0.94	1.00	0.91	0.79
Eastern Washington				
No Action Alternative 1-Scenario 2	0.67	0.67	0.66	0.66
No Action Alternative 1-Scenario 1, Alternative 2, Alternative 3	0.72	0.73	0.70	0.68
Alternative 4	0.98	1.00	0.92	0.82