Pacific Northwest Quantitative Wildfire Risk Assessment: Methods and Results

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FIRE, FUELS & AVIATION MANAGEMENT

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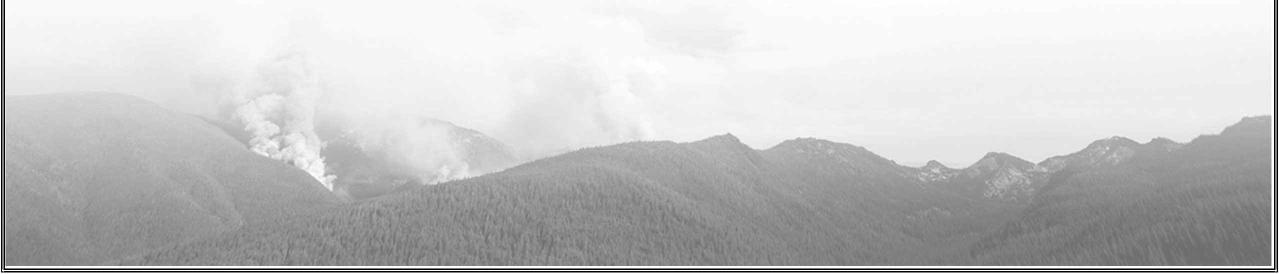

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1 Overview of PNRA

1.1 Purpose of the Assessment

The purpose of the USFS Pacific Northwest Region Wildfire Risk Assessment (PNRA) is to provide foundational information about wildfire hazard and risk to highly valued resources and assets across the geographic area. Such information supports wildfires, regional fuel management planning decisions, and revisions to land and resource management plans. A wildfire risk assessment is a quantitative analysis of the assets and resources across a specific landscape and how they are potentially impacted by wildfire. The PNRA analysis considers several different components, each resolved spatially across the region, including:

- likelihood of a fire burning,
- the intensity of a fire if one should occur,
- the exposure of assets and resources based on their locations, and
- the susceptibility of those assets and resources to wildfire.

Assets are human-made features, such as commercial structures, critical facilities, housing, etc., that have a specific importance or value. Resources are natural features, such as wildlife habitat, federally threatened and endangered plant or animal species, etc. These also have a specific importance or value. Generally, the term “values at risk” has previously been used to describe both assets and resources. For PNRA, the term Highly Valued Resources and Assets (HVRA) is used to describe what has previously been labeled values at risk. There are two reasons for this change in terminology. First, resources and assets are not themselves “values” in any way that term is conventionally defined—they *have* value (importance). Second, while resources and assets may be exposed to wildfire, they are not necessarily “at risk”—that is the purpose of the assessment.

To manage wildfire in the Region, it is essential that accurate wildfire risk data, to the greatest degree possible, is available to drive fire management strategies. These risk outputs can be used to drive the planning, prioritization and implementation of prevention and mitigation activities, such as prescribed fire and mechanical fuel treatments. In addition, the risk data can be used to support fire operations in response to wildfire incidents by identifying those assets and resources most susceptible to fire. This can aid in decision making for prioritizing and positioning of firefighting resources.

1.2 Landscape Zones

1.2.1 *Analysis Area*

The Analysis Area (AA) is the area for which valid burn probability (BP) results are produced. The AA for the Pacific Northwest Region (PNRA) FSim project was initially defined as the Oregon and Washington state boundaries. All subsequent project boundaries (discussed below) were built from this initial extent. After wildfire modeling was underway, it was brought to our attention that the AA did not cover the entire Rogue River-Siskiyou and Wallowa-Whitman National Forests. We later adjusted the AA to include the state boundaries and the full extent of Region 6 National Forests. The PNRA analysis includes 17 Administrative Forests: Colville, Deschutes, Fremont-Winema, Gifford Pinchot, Malheur, Mt. Baker-Snoqualmie, Mt. Hood, Ochoco, Okanogan-Wenatchee, Olympic, Rogue River-Siskiyou, Siuslaw, Umatilla, Umpqua, Wallowa-Whitman, and Willamette National Forests (NF), as well as the Columbia River Gorge National Scenic Area.

1.2.2 *Fire Occurrence Areas*

To ensure valid BP results in the AA and prevent edge effects, it is necessary to allow FSim to start fires outside of the AA and burn into it. This larger area where simulated fires are started is called the Fire Occurrence Area (FOA). We initially established the FOA extent as a 30-km buffer on the AA; however, in the added areas of the Rogue River-Siskiyou and Wallowa-Whitman National Forests, the buffer distance is 17 km (Figure 1). The buffer provides a sufficient area to ensure that all fires that could reach the AA are simulated. The Fire Occurrence Area covers roughly 118 million acres characterized by diverse topographic and vegetation conditions. To more accurately model this large area where historical fire occurrence and fire weather are highly variable, we divided the overall fire occurrence area into 23 FOAs. Individual FOA boundaries were generated using a variety of inputs including: larger fire occurrence boundaries developed for national-level work (National FSim Pyrome boundaries), aggregated level IV EPA Ecoregions, Fire Danger Rating Areas, and Regional fire staff input. For consistency with other FSim projects, we numbered these FOAs 401 through 423.

1.2.3 *Fuelscape Extent*

The available fuelscape extent was determined by adding an additional 30-km buffer to the FOA extent. This buffer allows fires starting within the FOA to grow unhindered by the edge of the fuelscape, which would otherwise truncate fire growth and affect the simulated fire-size distribution and potentially introduce errors in the calibration process. A map of the AA, FOA boundaries and fuelscape extent are presented in Figure 1.

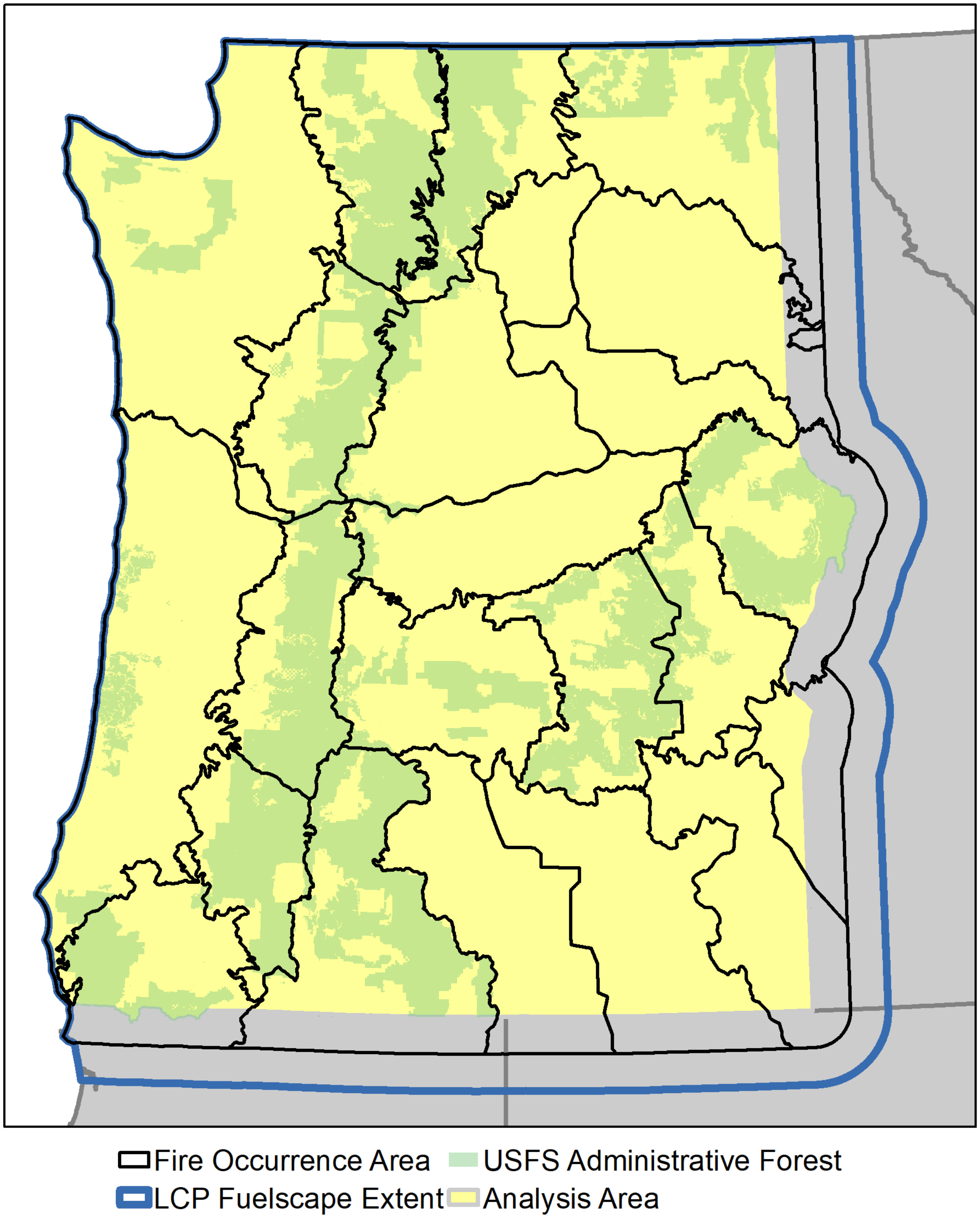

Figure 1. Overview of landscape zones for PNRA FSim project. USFS administrative forests are shown in green, and the Analysis Area (AA) is shown in yellow. The project produces valid BP results within this AA. To ensure valid BP in the AA, we started fires in the twenty-three numbered fire occurrence areas (FOAs), outlined in black. To prevent fires from reaching the edge of the fuelscape, a buffered fuelscape extent was used, which is represented by the blue outline.

1.3 Quantitative Risk Modeling Framework

The basis for a quantitative framework for assessing wildfire risk to highly valued resources and assets (HVRAs) has been established for many years (Finney, 2005; Scott, 2006). The framework has been implemented across a variety of scales, from the continental United States (Calkin et al., 2010), to individual states (Buckley et al., 2014), to a portion of a national forest (Thompson et al., 2013b), to an individual county. In this framework, wildfire risk is a function of two main factors: 1) wildfire hazard and 2) HVRA vulnerability (Figure 2).

Wildfire hazard is a physical situation with potential for causing damage to vulnerable resources or assets. Quantitatively, wildfire hazard is measured by two main factors: 1) burn probability (or likelihood or burning), and; 2) fire intensity (measured as flame length, fireline intensity, or other similar measure). For this analysis, we used the large fire simulator (FSim) to quantify wildfire potential across the landscape at a pixel size of 120 m (approximately 3.5 acres per pixel).

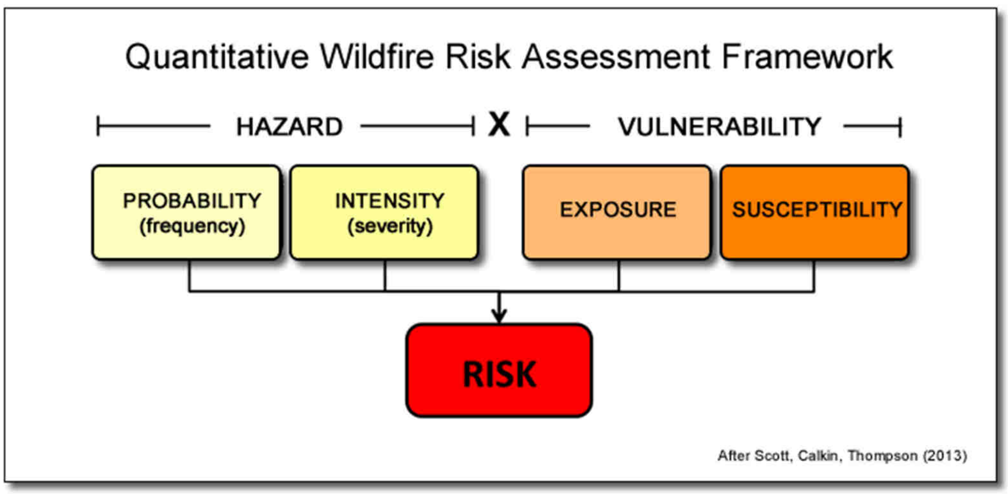

Figure 2. The components of the Quantitative Wildfire Risk Assessment Framework used for PNRA.

HVRA vulnerability is also composed of two factors: 1) exposure and 2) susceptibility. Exposure is the placement (or coincidental location) of an HVRA in a hazardous environment—for example, building a home within a flammable landscape. Some HVRAs, like critical wildlife habitat or endangered plants, are not movable; they are not "placed" in hazardous locations. Still, their exposure to wildfire is the wildfire hazard where the habitat exists. Finally, the susceptibility of an HVRA to wildfire is how easily it is damaged by wildfire of different types and intensities. Some assets are *fire-hardened* and can withstand very intense fires without damage, whereas others are easily damaged by even low-intensity fire.

2 Analysis Methods and Input Data

The FSim large-fire simulator was used to quantify wildfire hazard across the AA at a pixel size of 120 m. FSim is a comprehensive fire occurrence, growth, behavior, and suppression simulation system that uses locally relevant fuel, weather, topography, and historical fire occurrence information to make a spatially resolved estimate of the contemporary likelihood and intensity of wildfire across the landscape (Finney *et al.*, 2011).

2.1 Fuelscape

The fuelscape consists of geospatial data layers representing surface fuel model, canopy base height, canopy bulk density, canopy cover, canopy height and topography characteristics (slope, aspect, elevation). The fuelscape was developed from LANDFIRE 2014 (LF_1.4.0) 30-m raster data and was updated based on resource staff input at the fuels review workshop that took place November 2-3, 2016 in Portland, OR. Additionally, the fuelscape was updated using Rapid Assessment of Vegetation Condition after Wildfire (RAVG) and Monitoring Trends in Burn Severity (MTBS) data, along with Northwest Coordination Center (NWCC) perimeter datasets to account for wildfire disturbances that occurred between 2015 and 2017. The resulting fuelscape by fuel model group is shown in Figure 3.

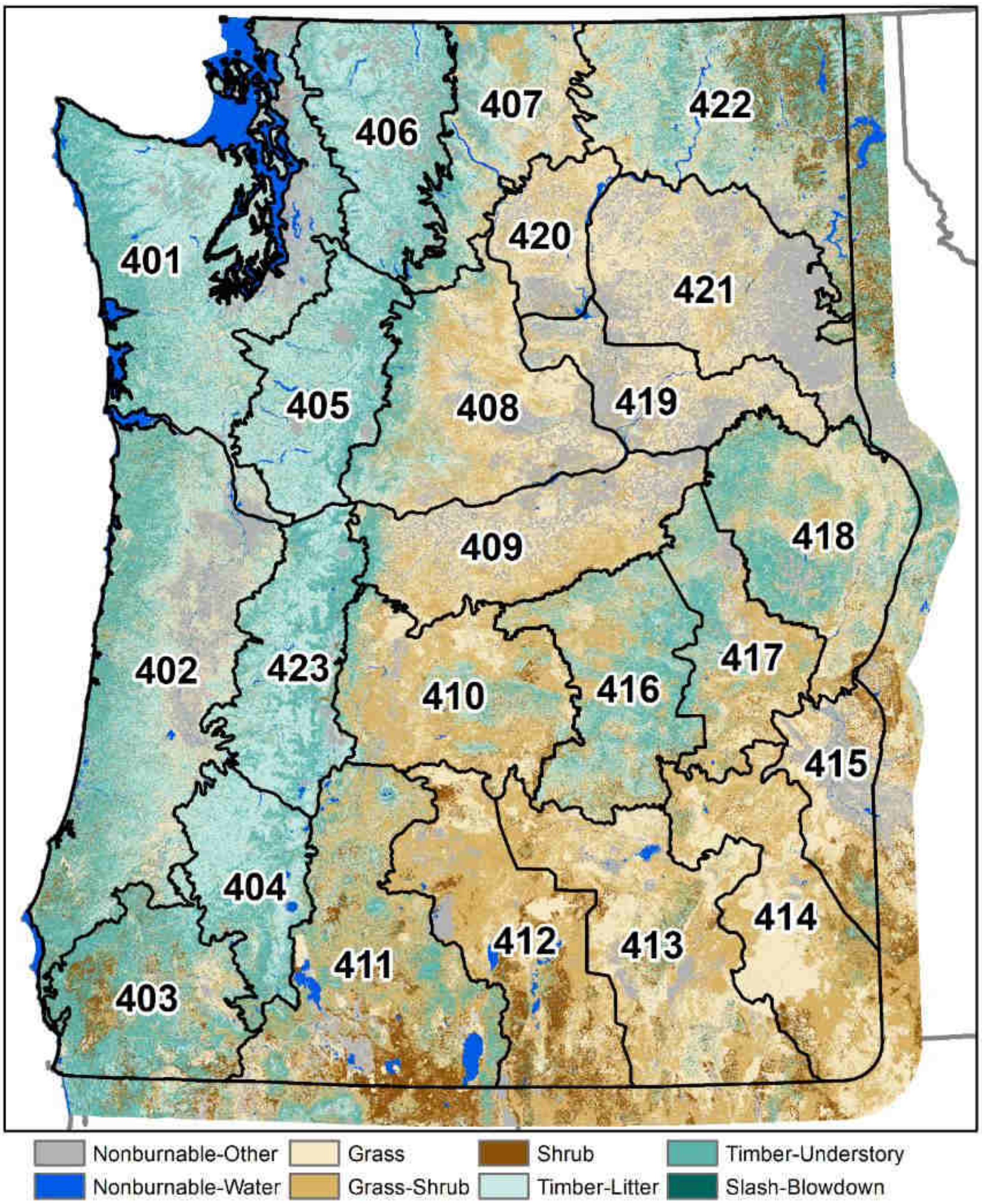

Figure 3. Map of fuel model groups across the PNRA analysis area.

The fuelscape was edited both to mitigate underprediction of crown fire potential inherent in the native LANDFIRE 2014 fuelscape, where canopy base height values were too high to produce crown fire behavior under any modeled weather conditions, and to prevent overprediction of crown fire, specifically in the Timber-understory (TU5) fuel model. Due to the very large landscape size, multiple map zones, and regional focus of the project, a more general approach than the traditional LANDFIRE Total Fuel Change Tool project was needed. We evaluated the most commonly occurring combinations of existing vegetation type (EVT), fuel model, and canopy base height (CBH) to determine where edits were needed to accurately reflect fire behavior potential as described by Regional Fire and Fuels personnel. Figure 4 maps the extent of the fuelscape edits and fire disturbance updates applied to the original LANDFIRE 2014 grids. A summary of the edits made based on the combination of Map Zone, EVT_fuel code, Existing Vegetation Cover (EVC), Existing Vegetation Height (EVH), fuel model, CBH and other attributes is outlined in Table 1.

To bring the fuelscape to the current condition, we updated the surface and canopy fuel to reflect 2015-2017 fire disturbances. We gathered severity data available from RAVG and MTBS and where severity data was unavailable, relied on final perimeters from the Northwest Coordination Center (NWCC) perimeter dataset. We crosswalked RAVG and MTBS to the appropriate disturbance code (112, 122, or 132) corresponding with fire disturbances of low, moderate, or high severity, occurring in the last two to five years.

Because NWCC perimeter data were lacking information about fire severity, we assigned a moderate severity disturbance code to all pixels coincident with recently burned fire perimeters. RAVG provides a percent canopy cover (CC) reduction value, from which a severity level was determined. For MTBS fires, we used the CC reduction midpoint values of 12 for low severity fire, 50 for moderate severity, and 80 for high severity fires. We then used these percent reduction values to increase CBH. For example, a CBH of 0.2 m with a 25 percent CC reduction would be reclassified as 0.25 m and rounded to the nearest integer. This method was used for low severity fires, but for moderate and high severity fires, CBH was set to 10 m to prevent any torching. We reduced canopy bulk density (CBD) by a factor equivalent to the percent CC reduction, with a minimum value of 1 (or 0.01 kg/m3)[1]. Post-disturbance fuel models varied by pre-disturbance fuel model, EVT, fire severity, and to a degree, map zone, and generally slowed spread rate to reflect reduced fire behavior observed in previously burned areas.

[1] Additional documentation on methodology used for recent fire updates can be found in “PNRA Fuel Updates_2015_2017.docx.” This document is included with project deliverables.

Table 1. Table of applied edits developed at fuelscape review workshop.

EVT	Edit to Disturbed/ Undisturbed	Map Zone	EVC	EVH	Original FM	New FM	New CBH (meters x10)
2018	Undisturbed and fdist<=133	1			165	165	LF cbh+10
2018	Undisturbed and fdist<=133	7			165	165	LF cbh+15
2027	Undisturbed and fdist<=133	All			165	165	LF cbh+12
2027	Undisturbed and fdist<=133	All		=108	122	142	no edit
2028	Undisturbed and fdist<=133	All	>=105	>=110	165	162	no edit
2028	Undisturbed	All	>=105	>=110	165	162	int(LF cbh/2)
2036	Undisturbed and fdist<=133	All			162	161	int(LF cbh/2)
2037	Undisturbed	All			185	185	if cbh>2 set to 2
2037	Undisturbed	FOA401/ Olympics			185	185	back to LF cbh
2039	Undisturbed and fdist<=133	1,3,7			165	165	LF cbh<20 set to 20
2039	Undisturbed and fdist<=133	2	<=107		165	162	if cbh>2-->int(cbh/3)
2039	Undisturbed and fdist<=133	2	>107		165	161	if cbh>2-->int(cbh/3)
2041	Undisturbed	All			185	185	LF Round(cbh /3)
2041	Undisturbed	FOA401/ Olympics			185	185	back to LF cbh
2041	All	Slope/Elev. Mask			102	99	
2042	Undisturbed	All			185	185	int(LF cbh/2)
2042	Undisturbed	FOA401/ Olympics			185	185	back to LF cbh
2043	Undisturbed and fdist<=133	All	<103		>143	122	no edit
2043	Undisturbed and fdist<=133	All	>=103	=108	>122 and not 161	142	no edit
2043	Undisturbed and fdist<=133	All	>102 and <=109	>108	165	165	LF cbh+5
2043	Undisturbed and fdist<=133	All	>107 and <=109	>108	165/183	189	no edit
2045	Undisturbed and fdist<=133	All			165	165	LF cbh*2
2045	Undisturbed	All			183	183	LF cbh/3
2045	Undisturbed	All			184	184	int(LF cbh/3)
2045	Undisturbed	All			186	186	if cbh>3 -->cbh-2
2047	Undisturbed and fdist<=133	All			122	142	no edit
2047	Undisturbed and fdist<=133	10			165	162	no edit
2047	Undisturbed and fdist<=133	9			165	165	LF cbh*2
2053	Undisturbed	All			188	188	int(LF cbh/2)
2053	Undisturbed	7			186	186	LF cbh/3
2056	Undisturbed and fdist<=133	10			165	162	LF cbh+4
2056	All	1,7,9			165	162	no edit
2058	Undisturbed and fdist<=133	All			122	182	

Table 1. (Continued) Table of applied edits developed at fuelscape review workshop.

EVT	Edit to Disturbed/ Undisturbed	Map Zone	EVC	EVH	Original FM	New FM	New CBH (meters x10)
2080	Undisturbed	All			145	142	
2167	Undisturbed	7			185	185	int(LF cbh/3)
2171	All	Slope/Elev. Mask			102	99	
2174	Undisturbed and fdist<=133	All			165	165	LF cbh*3
2178	Undisturbed and fdist<=133	All			165	165	LF cbh<20 set to 20
2182	Undisturbed and fdist<=133	1 NW only			101/102	181	
2227	Undisturbed and fdist<=133	All			165	165	LF cbh+4
2227	Undisturbed	10			165	165	LF cbh+6
2227	Undisturbed	All			188	188	int(LF cbh/2)
2967	Undisturbed and fdist<=133	1 NW only			101/102	99	
2967	Undisturbed and fdist<=133	N of 2,7			102	101	
2967	Undisturbed and fdist<=133	S of 2,7 and 3			101/102	102	
FOA418	All	Custom Mask			102/122	101/121	

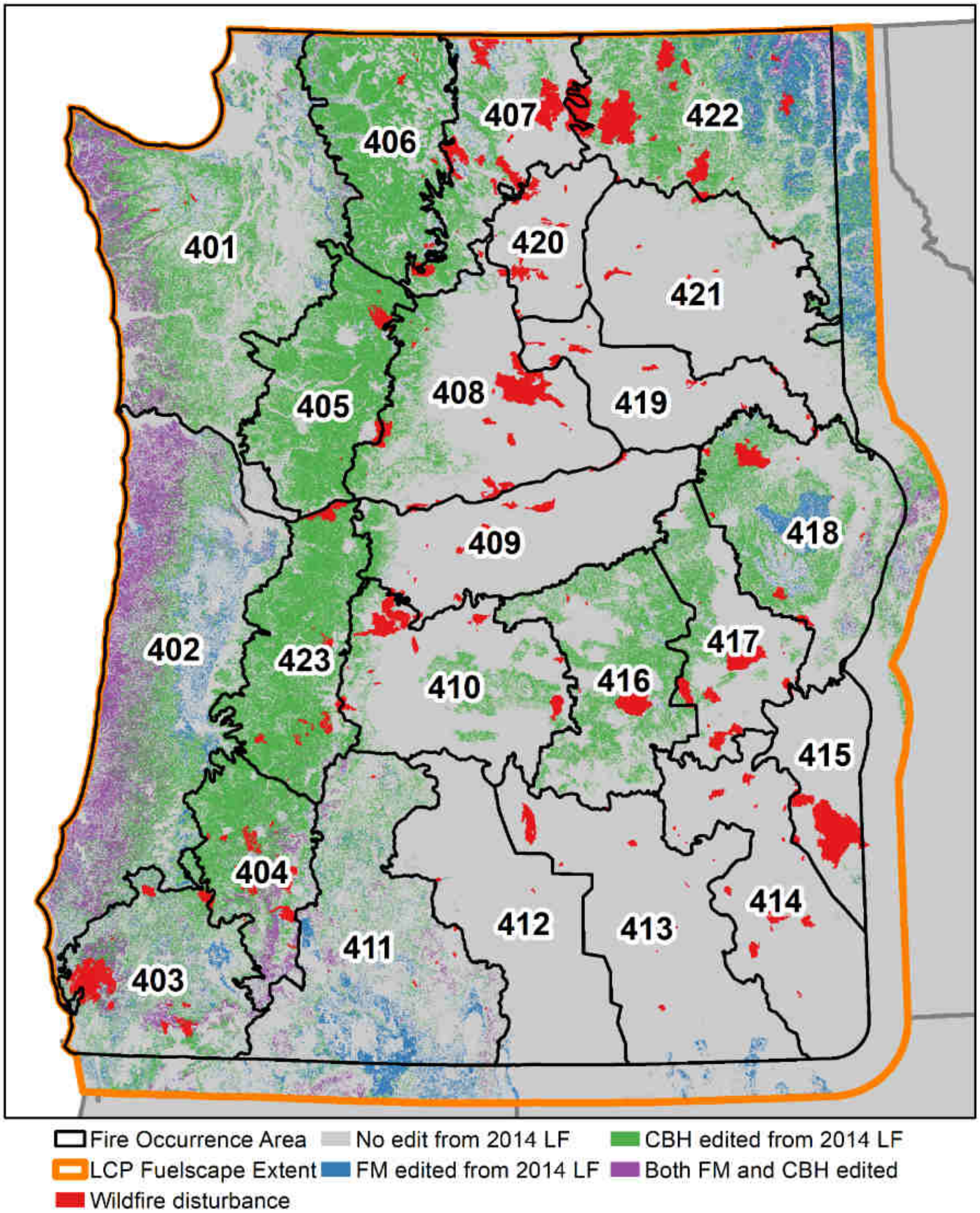

Figure 4. Map of the location of edits made to LANDFIRE 2014 (LF_1.4.0) 30-m raster data based on resource staff input at the fuels review workshop on Nov. 2-3, 2016 in Portland, OR.

2.2 Historical Wildfire Occurrence

Historical wildfire occurrence data were used to develop model inputs (the fire-day distribution file [FDist] and ignition density grid [IDG]) as well as for model calibration. For historical, large-fire occurrence we used the Short (2017) Fire Occurrence Database (FOD), which spans the 24-year period 1992-2015. Table 2 summarizes the annual number of large fires per million acres, along with mean large-fire size, and annual area burned by large fires per million acres. For this analysis, we defined a large fire as one greater than 247.1 acres (100 hectares).

Table 2. Historical large-fire occurrence, 1992-2015, in the PNRA FSim project FOAs.

FOA	Mean annual number of large fires	FOA area (M ac)	Mean annual number of large fires per M ac	Mean large-fire size (ac)	Mean annual large-fire area burned (ac)	FOA-mean burn probability
401	0.5	7.60	0.066	796	398	0.0001
402	0.5	9.81	0.047	1,641	752	0.0001
403	2.8	4.3	0.649	13,372	37,329	0.0087
404	2.0	3.09	0.661	5,786	11,812	0.0038
405	0.8	3.93	0.201	3,027	2,396	0.0006
406	1.8	4.18	0.429	2,043	3,660	0.0009
407	6.5	3.74	1.727	10,558	68,190	0.0182
408	8.5	5.97	1.431	5,614	47,955	0.0080
409	5.9	4.86	1.209	4,333	25,454	0.0052
410	8.1	5.02	1.619	4,972	40,394	0.0080
411	3.8	7.17	0.529	4,450	16,874	0.0024
412	2.5	5.46	0.450	5,208	12,804	0.0023
413	6.8	6.51	1.043	10,038	68,174	0.0105
414	5.9	5.06	1.169	10,432	61,724	0.0122
415	4.8	2.45	1.935	6,465	30,709	0.0125
416	3.8	4.56	0.831	7,839	29,723	0.0065
417	2.4	3.40	0.710	6,065	14,657	0.0043
418	6.3	5.32	1.183	8,671	54,554	0.0103
419	2.9	3.11	0.924	5,136	5,136	0.0047
420	2.2	2.03	1.088	5,322	11,753	0.0058
421	2.9	5.86	0.491	2,430	6,988	0.0012
422	4.3	7.01	0.612	7,322	31,422	0.0045
423	1.9	4.06	0.462	5,072	9,509	0.0023

Historical wildfire occurrence varied widely by FOA, with FOA 415 experiencing the highest annual average of 1.94 large wildfires per million acres. FOA 402 had the least frequent rate of occurrence with an annual average of 0.05 large wildfires per million acres. The size of wildfires ranged from an average large-fire size of 796 ac in FOA 401 to 13,372 ac in FOA 403. In addition to the spatial variability, the largest wildfire year in terms of acres burned was 2015 with a total of 2,027,649 acres burned and the lowest was 1993 with 29,689 acres burned.

To account for the spatial variability in historical wildfire occurrence across the landscape, FSim uses a geospatial layer representing the relative, large-fire ignition density. FSim stochastically places wildfires according to this density grid during simulation. The IDG was generated using a mixed methods approach by averaging the two grids resulting from the Kernel Density tool and the Point Density tool within

ArcGIS for a 2-km cell size and 75-km search radius. All fires equal to or larger than 247.1 acres (100 ha) reported in the FOD were used as inputs to the IDG. Due to the extremely low fire occurrence in FOAs 401 and 402, we built a small-fire IDG using the same methods, but with fires equal to or larger than 20 acres (8.09 ha). The IDGs were divided up for each FOA by setting to zero all area outside of the fire occurrence boundary of that FOA. This allows for a natural blending of results across adjacent FOA boundaries by allowing fires to start only within a single FOA but burn onto adjacent FOAs. The IDG enables FSim to produce a spatial pattern of large-fire occurrence consistent with what was observed historically. Figure 5 shows the ignition density grid for the fire occurrence area.

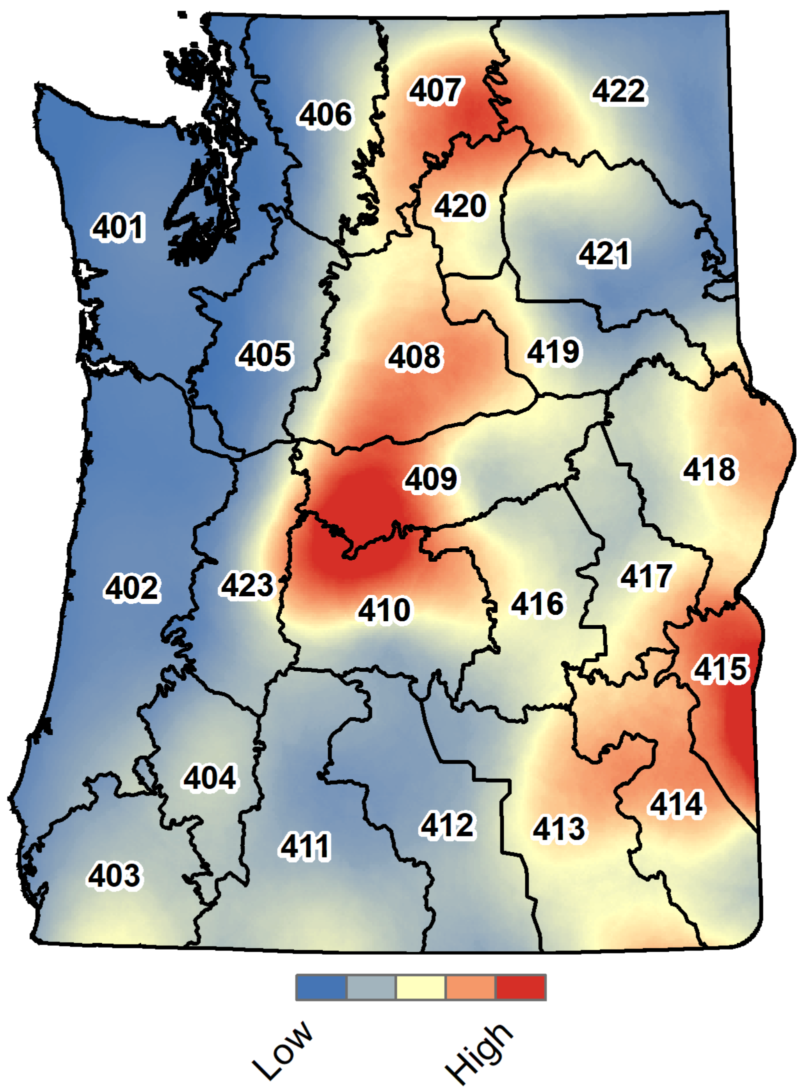

Figure 5. Ignition density grid used in FSim simulations.

2.3 Historical Weather

FSim requires three weather-related inputs: monthly distribution of wind speed and direction, live and dead fuel moisture content by year-round percentile of the Energy Release Component (ERC) variable of the National Fire Danger Rating System (NFDRS, 2002) for fuel model G (ERC-G) class, and seasonal trend (daily) in the mean and standard deviation of ERC-G. We used two data sources for these weather inputs. For the wind speed and direction distributions we used the hourly (1200 to 2000 hours) 10-minute average values recorded at selected RAWS stations. Station selection was informed by experiential knowledge provided by regional fire and fuels personnel. Stations with relatively long and consistent records and moderate wind activity were preferentially selected to produce the most reasonable and stable FSim results.

Rather than rely on ERC values produced from RAWS data which may be influenced by periods of station inactivity outside of the fire season, we extracted ERC values from Dr. Matt Jolly's historical, gridded ERC rasters for the period 1992-2012 (Jolly, 2014). The RAWS stations selected for winds and ERC sample sites for each FOA are shown in Figure 6.

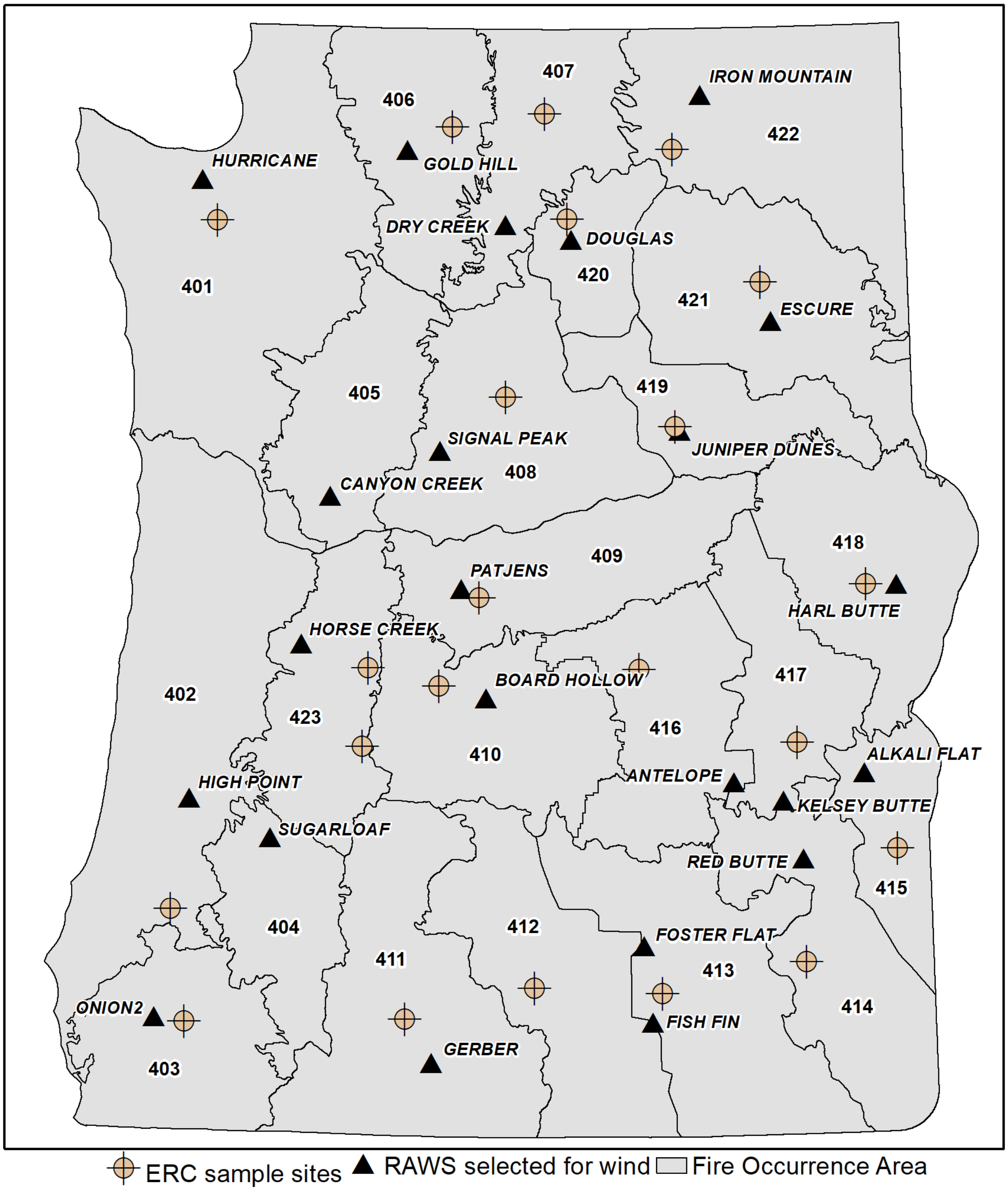

Figure 6. RAWS stations and ERC sample sites used for the PNRA FSim project. RAWS data were used for hourly sustained wind speed.

2.3.1 *Fire-day Distribution File (FDist)*

Fire-day Distribution files are used by FSim to generate stochastic fire ignitions as a function of ERC. The FDist files were generated using an R script that summarizes historical ERC and wildfire occurrence data, performs logistic regression, and then formats the results into the required FDist format.

The FDist file provides FSim with logistic regression coefficients that predict the likelihood of a large fire occurrence based on the historical relationship between large fires and ERC and tabulates the distribution of large fires by large-fire day. A large-fire day is a day when at least one large fire occurred historically. The logistic regression coefficients together describe large-fire day likelihood *P(LFD)* at a given ERC(G) as follows:

$$P(LFD) = \frac{1}{1 + e^{-B_a * - B_b * ERC(G)}}$$

Coefficient *a* describes the likelihood of a large fire at the lowest ERCs, and coefficient *b* determines the relative difference in likelihood of a large fire at lower versus higher ERC values.

2.3.2 *Fire Risk File (Frisk)*

Fire risk files were generated for each RAWS using FireFamilyPlus (FFPlus) and updated to incorporate simulated ERC percentiles (as described in section 2.3.4). These files summarize the historical ERC stream for the FOA, along with wind speed and direction data for the selected RAWS.

The final selection of RAWS stations represents suggestions by regional fire personnel with knowledge of nearby stations and their ability to represent general wind patterns within a FOA. Some of the recommended stations did not produce wind speeds high enough, on average, to produce historically observed fire behavior. Therefore, in FOAs 416 and 422 we adjusted wind speeds to meet our historical calibration targets, while maintaining the wind directions recommended by local experts. In FOA 416, the RAWS station selected for winds was changed to Antelope Flats from Allison. The Allison wind speeds were underpredicting crown fire behavior, but Antelope Flats observations were too high. We reduced Antelope Flats wind speed observations by a factor of 1.35 to bring wind speeds down to a level where historical calibration targets were met, and modeled flame lengths matched adjacent FOAs. FOA 422 received a wind adjustment to increase wind speed observations from the Iron Mountain RAWS by a factor of 1.8 to produce more reasonable fire behavior results.

2.3.3 *Fuel Moisture File (FMS)*

Modeled fire behavior is robust to minor changes in dead fuel moisture, so a standardized set of stylized FMS input files (representing the 80th, 90th, and 97th percentile conditions) for 1-,10-, 100-hour, live herbaceous and live woody fuels was developed. The standard stylized set was used in all but two of the twenty-three FOAs. In FOAs 401 and 402 an updated FMS file was used to increase both live and dead fuel moisture values on all fuel models to capture the coastal influence on fuel moisture.

2.3.4 *Energy Release Component File (ERC)*

We sampled historical ERC-G values from a spatial dataset derived from North American Regional Reanalysis (NARR) 4-km ERC-G dataset (Jolly, 2014). Historical ERC-G grid values are available for the years 1979-2012 and historical fire occurrence data is available for 1992-2015. We used the overlapping years of 1992-2012 to develop a logistic regression of probability of a large-fire day in relation to ERC-G.

ERCs were sampled at an advantageous location within each FOA. Those locations are found on relative flat ground with little or no canopy cover, in the general area within the FOA where large-fires have historically occurred. These historical ERC values were used in conjunction with the FOD to generate

FSim's FDist input file, but not for the Frisk file. ERC percentile information in the Frisk file was generated from the simulated ERC stream, described below. This approach ensures consistency between the simulated and historical ERCs.

For simulated ERCs in FSim, we used a new feature of FSim that allows the user to supply a stream of ERC values for each FOA. Isaac Grenfell, statistician at the Missoula Fire Sciences Lab, has generated 1,000 years of daily ERC values (365,000 ERC values) on the same 4-km grid as Jolly's historical ERCs. The simulated ERC values Grenfell produces are "coordinated" in that a given year and day for one FOA corresponds to the same year and day in all other FOAs—their values only differ due to their location on the landscape. This coordination permits analysis of fire-year information across all FOAs.

2.4 Wildfire Simulation

The FSim large-fire simulator was used to quantify wildfire hazard across the landscape at a pixel size of 120 m (3.5 acres per pixel). FSim is a comprehensive fire occurrence, growth, behavior, and suppression simulation system that uses locally relevant fuel, weather, topography, and historical fire occurrence information to make a spatially resolved estimate of the contemporary likelihood and intensity of wildfire across the landscape (Finney et al., 2011). Figure 7 diagrams the many components needed as inputs to FSim.

Due to the highly varied nature of weather and fire occurrence across the large landscape, we ran FSim for each of the twenty-three FOAs independently, and then compiled the 23 runs into a single data product. For each FOA, we parameterized and calibrated FSim based on the location of historical fire ignitions within the FOA, which is consistent with how the historical record is compiled. We then used FSim to start fires only within each FOA but allowed those fires to spread outside of the FOA. This, too, is consistent with how the historical record is compiled.

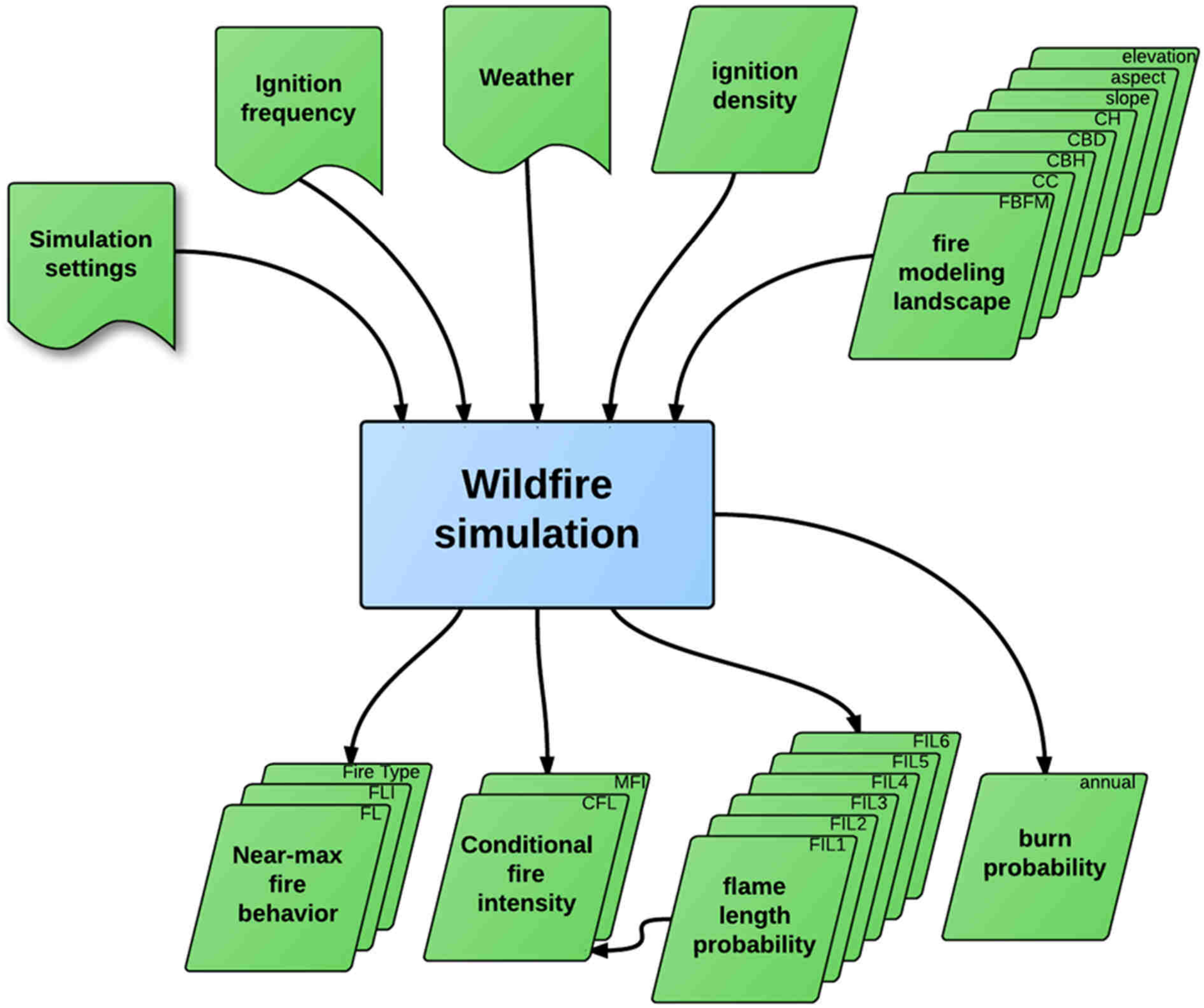

Figure 7. Diagram showing the primary elements used to derive Burn Probability.

2.4.1 *Model Calibration*

FSim simulations for each FOA were calibrated to historical measures of large fire occurrence including: mean historical large-fire size, mean annual burn probability, mean annual number of large fires per million acres, and mean annual area burned per million acres. From these measures, two calculations are particularly useful for comparing against and adjusting FSim results: 1) mean large fire size, and 2) number of large fires per million acres.

To calibrate each FOA, we started with baseline inputs and a starting rate-of-spread adjustment (ADJ) factor file informed by experience on previous projects. The final model inputs can be seen below in Table 3. All runs were completed at 120-m resolution. Each FOA was calibrated separately to well within the 70% confidence interval and final simulations were run with a minimum of 10,000 iterations. The twenty-three FOAs were then integrated into an overall result for the analysis area.

Table 3. Summary of final-run inputs for each FOA.

Final run	Number of Iterations	ADJ file	Trimming factor	Frisk	FDist file	LCP file
401rfV3	60,000	foa401v5	2.0	foa401v1	foa401v5	FOA_401_120
402rfV3	60,000	foa402v5	2.0	foa402v1	foa402v4	FOA_402_120
403rfV3	10,000	PNRAv1	4.0	foa403v1	foa403v2	FOA_403_120
404rfV3	20,000	foa404v4	2.0	foa404v1	foa404v3	FOA_404_120
405rfV3	30,000	PNRAv1	2.0	foa405v1	foa405v3	FOA_405_120
406rfV3	30,000	foa406v2	2.0	foa406v1	foa406v2	FOA_406_120
407rfV3	10,000	foa407v6	2.0	foa407v1	foa407v3	FOA_407_120
408rfV3	10,000	foa408v2	2.0	foa408v1	foa408v3	FOA_408_120
409rfV3	10,000	foa409v2	2.0	foa409v1	foa409v2	FOA_409_120
410rfV3	10,000	foa410v6	2.0	foa410v1	foa410v3	FOA_410_120
411rfV3	10,000	foa411v3	2.0	foa411v1	foa411v3	FOA_411_120
412rfV3	10,000	foa412v2	2.0	foa412v1	foa412v2	FOA_412_120
413rfV3	10,000	foa413v4	2.0	foa413v2	foa413v2	FOA_413_120
414rfV3	10,000	foa414v3	2.0	foa414v1	foa414v2	FOA_414_120
415rfV3	10,000	foa415v2	2.0	foa415v1	foa415v2	FOA_415_120
416rfV3	10,000	foa416v3	2.0	foa416v4	foa416v3	FOA_416_120
417rfV3	10,000	foa417v5	2.0	foa417v2	foa417v1	FOA_417_120
418rfV3	10,000	foa418v3	2.0	foa418v1	foa418v3	FOA_418_120
419rfV3	10,000	PNRAv1	2.0	foa419v1	foa419v3	FOA_419_120
420rfV3	20,000	foa420v2	2.0	foa420v1	foa420v2	FOA_420_120
421rfV3	10,000	foa421v2	2.0	foa421v1	foa421v2	FOA_421_120
422rfV3	10,000	foa422v6	2.0	foa422v3	foa422v2	FOA_422_120
423rfV3	20,000	foa423v5	2.0	foa423v1	foa423v2	FOA_423_120

2.4.2 *Integrating FOAs*

We used the natural-weighting method of integrating adjacent FOAs that we developed on an earlier project (Thompson et al., 2013a). With this method, well within the boundary of a FOA (roughly 30 km from any boundary) the results are influenced only by that FOA. Near the border with another FOA the results will be influenced by that adjacent FOA. The weighting of each FOA is in proportion to its contribution to the overall burn probability (BP) at each pixel.

3 HVRA Characterization

Highly Valued Resources and Assets (HVRA) are the resources and assets on the landscape most likely to be protected from or enhanced by wildfire and those considered in a Land and Resource Management Plans, Fire Management Plans, or in spatial fire planning in the Wildland Fire Decision Support System (WFDSS). The key criterion is that they must be of high value to warrant inclusion in this type of assessment, both for the sake of keeping the assessment regional in focus and to avoid valuing everything to the point nothing is truly *highly* valued.

There are three primary components to HVRA characterization: HVRAs must be identified and their spatial extent mapped, their response to fire (positive, negative, or neutral) must be characterized, and their relative importance with respect to each other must be determined.

3.1 HVRA Identification

A set of HVRA was identified through a workshop held at the Pacific Northwest Region Regional Office (SORO) on November 4, 2016. A group consisting of Fire/Fuels Planners, Resource Specialists, Wildlife Biologists, Geospatial Analysts, and representatives from Oregon Department of Forestry (ODF) and Washington Department of Natural Resources (DNR) identified six HVRAs in total: two assets and four resources. The complete list of HVRAs and their associated data sources are listed in Table 4.

To the degree possible, HVRAs are mapped to the extent of the Analysis Area boundary (Figure 1). This is the boundary used to summarize the final risk results. Some HVRA are limited to the Forest boundary, due to the nature of the data (e.g., extracted from Regional corporate databases for FS land only).

3.2 Response Functions

Each HVRA selected for the assessment must also have an associated response to fire, whether it is positive or negative. We relied on input from Regional Resource Specialists, the Fuels Program Staff, along with Nature Conservancy, BLM, and DNR representatives at a workshop held February 28-March 1, 2017 at the Regional Office. In these workshops, the group discussed how each resource or asset responded to fires of different intensity levels and characterized the HVRA response using values ranging from -100 to +100. The flame length values corresponding to the fire intensity levels reported by FSim are shown in Table 5. The response functions (RFs) used in the risk results are shown in Table 6 through Table 35 below.

3.3 Relative Importance

The relative importance (RI) assignments are needed to integrate results across all HVRAs. Without this input from leadership, all HVRAs would be weighted equally. The RI workshop was held at SORO on May 16, 2017 and was attended by Line Officers or representatives from the states of Oregon and Washington; BLM Field, District or State Office; and Forest Service Ranger District, Forest, or Regional Office. The focus of this workshop was to establish the importance and ranking of the primary HVRAs relative to each other. The People and Property HVRA received the greatest share of RI at 33 percent, followed by the Municipal Watersheds and Infrastructure HVRAs, each receiving 18 percent of the total importance. Timber was allocated 12 percent and Wildlife received 10 percent. Finally, Vegetation Condition received 9 percent of the total landscape importance (Figure 8). These importance percentages reflect the importance per unit area of all mapped HVRA.

Sub-HVRA relative importance was determined by the Regional Fire Planner and Resource Specialists. Sub-RIs are based on both the relative importance per unit area and mapped extent of the Sub-HVRA layers within the primary HVRA category. In Table 6 through Table 35, we provide the share of HVRA relative importance within the primary HVRA.

Relative importance values were generally developed by first ranking the Sub-HVRAs then assigning an RI value to each. The most important Sub-HVRA was assigned RI = 100. Each remaining Sub-HVRA was then assigned an RI value indicating its importance relative to that most important Sub-HVRA.

The RI values apply to the overall HVRA on the assessment landscape as a whole. The calculations need to account for the relative extent of each HVRA to avoid overemphasizing HVRAs that cover many acres. This was accomplished by normalizing the calculations by the relative extent (RE) of each HVRA in the assessment area. Here, relative extent refers to the number of 30-m pixels mapped to each HVRA. In using this method, the relative importance of each HVRA is spread out over the HVRA's extent. An HVRA with few pixels can have a high importance per pixel; and an HVRA with a great many pixels can have a low importance per pixel. A weighting factor (called Relative Importance Per Pixel [RIPP]) representing the relative importance per unit area was calculated for each HVRA.

Table 4. HVRA and sub-HVRA identified for the Pacific Northwest Region wildfire risk assessment and associated data sources.

HVRA & Sub-HVRA	Data source
Infrastructure	
Electric transmission lines – high & low voltage	Electric Power Transmission Lines extracted from the Homeland Security Infrastructure Program (HSIP) database.
Railroads	Railroad features extracted from the Homeland Security Infrastructure Program (HSIP) database.
Roads – Interstates and State highways	Interstates and highways extracted from the Homeland Security Infrastructure Program (HSIP) database. Removed smaller roads (SHIELD_CL=0) from highways.
Communication sites and cell towers	Communication sites, towers, and antennas and cell towers extracted from the Homeland Security Infrastructure Program (HSIP) database.
Seed orchards	Extracted from the Pacific Northwest Region Corporate database to represent seed orchard assets across the Region.
Sawmills	Wood Product Manufacturing Facilities extracted from the Homeland Security Infrastructure Program (HSIP) database.
High and low developed rec sites	Recreation sites/structures mapped by USFS, USFWS, NPS, BLM, ODF, and DNR and including state, county, and local parks and campgrounds. High vs. low investment level assigned based on dataset attributes.
Ski Areas	OR and WA ski area boundaries, digitized outer edge and infrastructure using Google Earth imagery
Historic buildings	Historic buildings as recorded by the National Register of Historic Places
People and Property	
Where People Live (WPL) by density class	Housing density classes as developed by the West Wide Wildfire Risk Assessment project
USFS Private Inholdings	Private inholdings on USFS lands extracted from the Basic Ownership layer by querying "NON-FS". NPS lands were removed from the NON-FS lands before including in this dataset. Refined to private ownership using BLM Ownership (OWNERSHIP_POLY) and BLM Surface Management Agency (BLM_SMA_FS_update).
Timber	
USFS Active Management and NWFP Matrix Lands	A Spatial Database for Restoration Management Capability on National Forests in the Pacific Northwest USA, (Ringo *et al.*, 2016). Matrix lands in OR and WA from Northwest Forest Plan.
Tribal Owned/Colville Reservation Commercial Timber	American Indian/Alaska Native/Native Hawaiian (AIANNH) Areas Shapefile from U.S. Census Bureau as Tribal ownership overlay along with Colville Reservation Commercial forestland
Private Industrial	Privately owned, industrial timber lands extracted from the Atterbury Consultants ownership maps for Oregon and Washington (selected attributes containing IFPC, REIT, and TIMO)
BLM Harvestable/Potential	Harvest Land Base from the ROD for western OR, O&C lands, Coos Bay Wagon Rd, Public Domain lands, and the BLM-owned polygons from the E. WA Resource Management Plan.
State owned for Oregon and Washington	State-owned lands in OR and WA excluding State Parks, State Fish and Wildlife lands, and Parks and Recreation lands.
Fire Regime Groups 1,3,4/5	R6 Forest Structure Restoration Needs Update Analysis – (DeMeo *et al.*, In Press)
Size classes <10in., 10-20in., >20in.	R6 Forest Structure Restoration Needs Update Analysis – (DeMeo *et al.*, In Press)
Vegetation Condition	
Seral state departure by FRG group	R6 Forest Structure Restoration Needs Update Analysis – (DeMeo *et al.*, In Press)

Table 4. (Continued) HVRA and sub-HVRA identified for the Pacific Northwest Region wildfire risk assessment and associated data sources.

Watersheds	
Watersheds	Washington Drinking Water System Boundaries for watershed boundaries and surface water intake locations Oregon Surface Drinking Water Source Areas and intake locations from EPA Safe Drinking Water Information System (SDWIS)
Erosion potential	Developed by USFS Remote Sensing Applications Center (RSAC)
Wildlife	
Marbled murrelet	U.S. Fish and Wildlife Service, Endangered Species Program, ECOS Joint Development Team
Northern spotted owl	Predicted habitat suitability map (Glenn *et al.*, 2017)
Sage grouse habitat	Wildland Fire Decision Support System (WFDSS) - 2015 greater sage grouse (GRSG) Land Use Plan (LUPs) Allocations
Resistance/Resilience class	USDA - Natural Resources Conservation Service, Index of Relative Ecosystem Resilience and Resistance across Sage-Grouse Management Zones
Bull trout	StreamNet Generalized Fish Distribution, Bull Trout (January 2012)
Chinook salmon	U.S. Fish and Wildlife Service, Endangered Species Program, ECOS Joint Development Team
Coho salmon	U.S. Fish and Wildlife Service, Endangered Species Program, ECOS Joint Development Team
Steelhead trout	U.S. Fish and Wildlife Service, Endangered Species Program, ECOS Joint Development Team
Redband trout	Non-Anadromous Redband Trout (RBT) Range-wide Database - ODFW
Coastal cutthroat trout	StreamNet Generalized Fish Distribution, Coastal Cutthroat Trout (January 2012) -
Lahontan cutthroat trout	StreamNet Generalized Fish Distribution, Lahontan Cutthroat Trout (January 2012)

Table 5. Flame length values corresponding to Fire Intensity Levels used in assigning response functions.

Fire Intensity Level (FIL)	1	2	3	4	5	6
Flame Length Range (feet)	0-2	2-4	4-6	6-8	8-12	12+

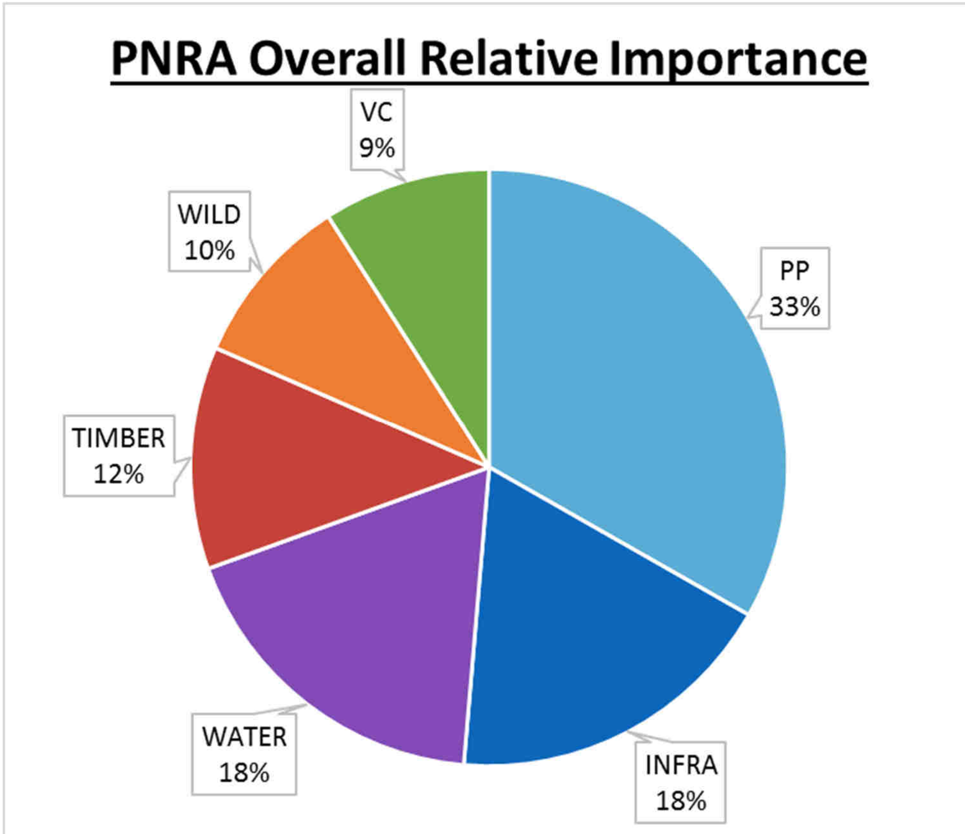

Figure 8. Overall HVRA Relative Importance for the primary HVRAs included in PNRA.

3.4 HVRA Characterization Results

Each HVRA was characterized by one or more data layers of sub-HVRA and, where necessary, further categorized by an appropriate covariate. Covariates include data such as erosion potential or habitat age/ quality/disturbance level, and population density classes. The main HVRAs in the PNRA Assessment are mapped below along with a table with the set of response functions assigned, the within-HVRA share of relative importance, and total acres for each sub-HVRA. These components are used along with fire behavior results from FSim in the wildfire risk calculations described in section 3.5.1.

3.4.1 *Infrastructure*

3.4.1.1 Electric Transmission Lines

Electrical transmission lines mapped for PNRA are shown in Figure 9. We selected "in service" transmission lines from the Homeland Security Infrastructure Program (HSIP) database, converted to 30-m raster, and expanded out 3 pixels on either side to capture the area impacted by wildfire. High voltage (≥230 kV) electric transmission lines respond favorably to fire in FIL 1, where low intensity fires are thought to have a fuel treatment effect. High voltage lines have a neutral response in FILs 2-3, but an increasingly negative response in FILs 4-6 (Table 6). Low voltage lines (230 kV) are thought to be mostly wooden poles, and therefore, respond negatively to fires of increasing intensity.

Due to the number of acres mapped on the landscape and their importance to infrastructure, electric transmission lines received 58 percent of the share of the Infrastructure HVRA importance. The share of HVRA importance is based on relative importance per unit area and mapped extent.

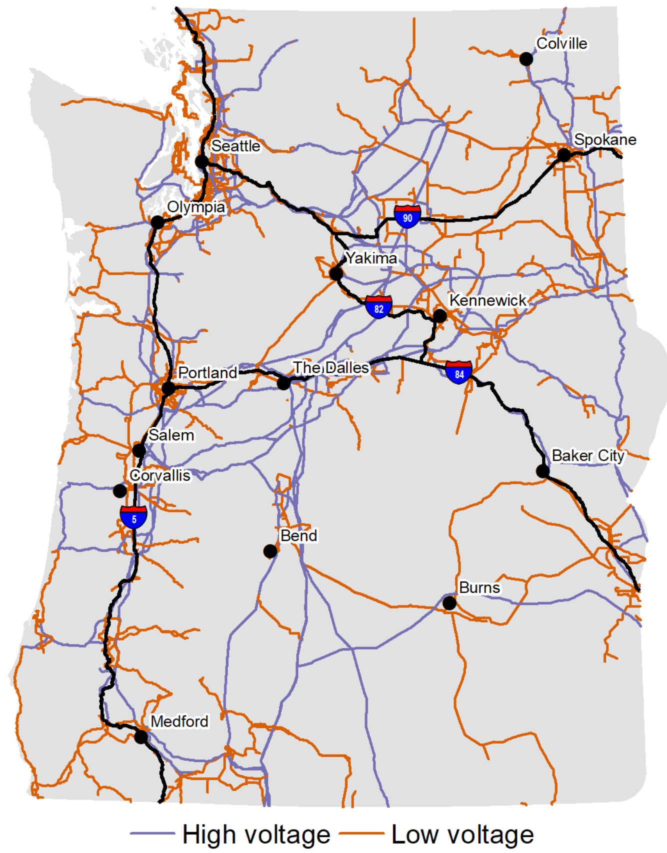

Figure 9. Map of electric transmission lines in the PNRA analysis area

Table 6. Response functions for the Infrastructure HVRA to highlight electric transmission lines.

Sub-HVRA	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6	Share of RI[1]	Acres
Trans-Line- High voltage	10	0	0	-10	-50	-70	40.86%	905,585
Trans-Line- Low voltage	-10	-20	-50	-70	-80	-90	16.79%	743,972
Railroads	-10	-20	-30	-40	-50	-50	16.57%	612,073
Interstates	0	-5	-10	-15	-20	-30	4.74%	175,191
State Highways	0	-5	-10	-15	-20	-30	12.98%	958,745
Communication Sites/Cell Towers	-10	-30	-60	-80	-100	-100	3.65%	80,924
Seed Orchards	-50	-90	-100	-100	-100	-100	0.02%	2,704
Sawmills	-10	-20	-30	-40	-60	-80	0.10%	1,448
Ski Areas	0	-10	-20	-40	-60	-80	0.44%	16,175
Recreation High Developed	-10	-30	-70	-90	-100	-100	1.93%	26,793
Recreation Low Developed	-10	-30	-70	-90	-100	-100	1.17%	129,886
Historic Structures	-30	-50	-70	-100	-100	-100	0.73%	8,140

[1] Within-HVRA relative importance.

3.4.1.2 Railroads

Railroads mapped for PNRA are shown in Figure 10. We selected all railroads represented in the HSIP database within the assessment area, converted to 30-m raster and expanded out 3 pixels on either side to capture the area impacted by wildfire. In this assessment, railroads are said to have an increasingly negative response to fires of increasing intensity (Table 7) but tend to be more resilient to higher intensity fires than other infrastructure HVRA, according to the RFs below.

Railroads received 16.57 percent of the total Infrastructure HVRA relative importance. The share of HVRA importance is based on relative importance per unit area and mapped extent.

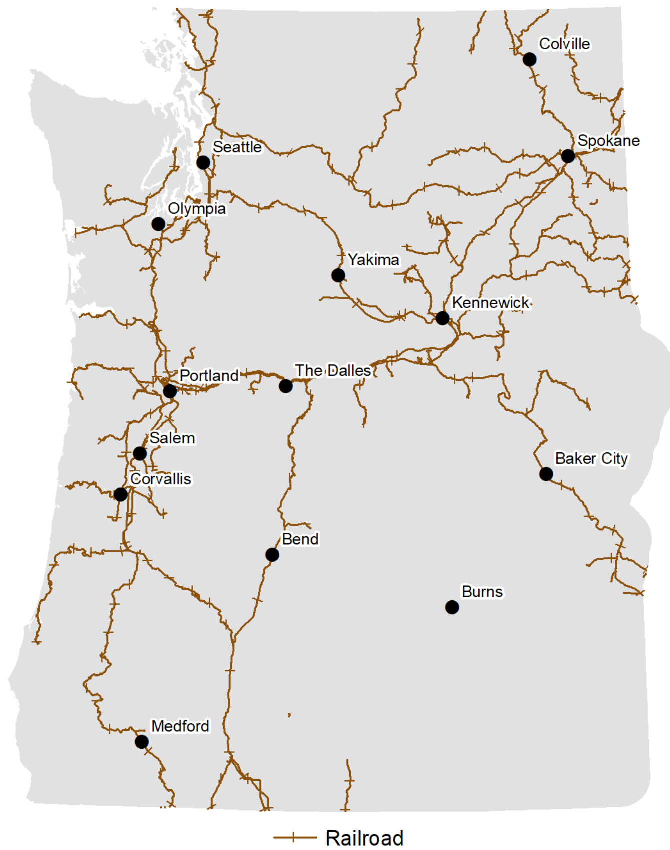

Figure 10. Map of railroads in the PNRA analysis area

Table 7. Response functions for the Infrastructure HVRA to highlight railroads.

Sub-HVRA	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6	Share of RI[1]	Acres
Trans-Line- High voltage	10	0	0	-10	-50	-70	40.86%	905,585
Trans-Line- Low voltage	-10	-20	-50	-70	-80	-90	16.79%	743,972
Railroads	-10	-20	-30	-40	-50	-50	16.57%	612,073
Interstates	0	-5	-10	-15	-20	-30	4.74%	175,191
State Highways	0	-5	-10	-15	-20	-30	12.98%	958,745
Communication Sites/Cell Towers	-10	-30	-60	-80	-100	-100	3.65%	80,924
Seed Orchards	-50	-90	-100	-100	-100	-100	0.02%	2,704
Sawmills	-10	-20	-30	-40	-60	-80	0.10%	1,448
Ski Areas	0	-10	-20	-40	-60	-80	0.44%	16,175
Recreation High Developed	-10	-30	-70	-90	-100	-100	1.93%	26,793
Recreation Low Developed	-10	-30	-70	-90	-100	-100	1.17%	129,886
Historic Structures	-30	-50	-70	-100	-100	-100	0.73%	8,140

[1] Within-HVRA relative importance.

3.4.1.3 Interstates and State Highways

Interstates and state highways mapped for PNRA are shown in Figure 11. We selected all interstates and state highways with "SHIELD_CL">0 represented in the HSIP database within the assessment area. These lines were converted to 30-m raster and expanded out 3 pixels on either side to capture the area impacted by wildfire. In this assessment, roads are said to have a neutral response to FIL1 and a slightly more negative response with each increasing intensity level (Table 8). The RF shows mild susceptibility of roadways to wildfire, primarily to capture the temporal nature of road closures due to wildfire.

Together, interstates and state highways received 17.72 percent of the total Infrastructure HVRA relative importance. The share of HVRA importance is based on relative importance per unit area and mapped extent.

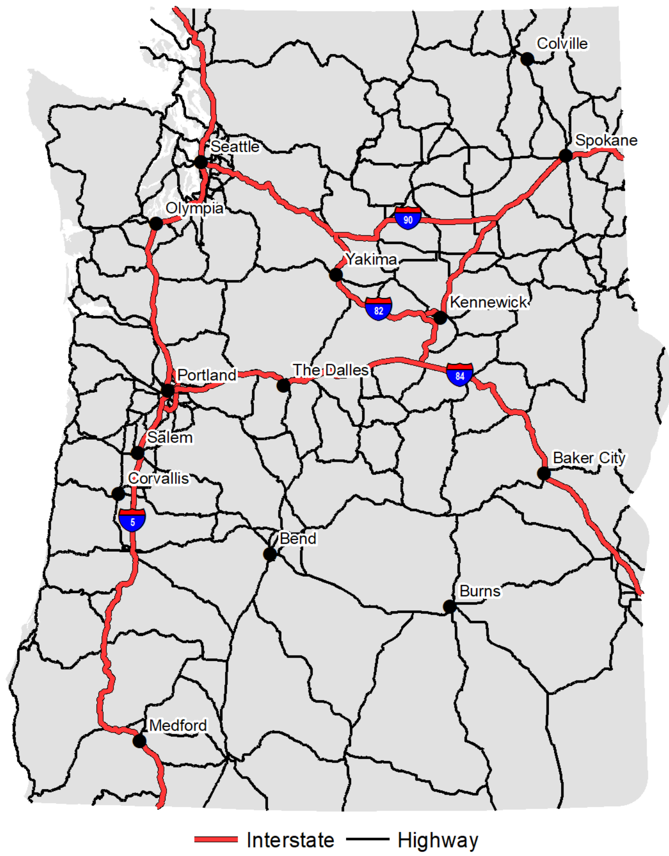

Figure 11. Map of interstates and state highways in the PNRA analysis area.

Table 8. Response functions for the Infrastructure HVRA to highlight interstates and state highways.

Sub-HVRA	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6	Share of RI[1]	Acres
Trans-Line- High voltage	10	0	0	-10	-50	-70	40.86%	905,585
Trans-Line- Low voltage	-10	-20	-50	-70	-80	-90	16.79%	743,972
Railroads	-10	-20	-30	-40	-50	-50	16.57%	612,073
Interstates	0	-5	-10	-15	-20	-30	4.74%	175,191
State Highways	0	-5	-10	-15	-20	-30	12.98%	958,745
Communication Sites/Cell Towers	-10	-30	-60	-80	-100	-100	3.65%	80,924
Seed Orchards	-50	-90	-100	-100	-100	-100	0.02%	2,704
Sawmills	-10	-20	-30	-40	-60	-80	0.10%	1,448
Ski Areas	0	-10	-20	-40	-60	-80	0.44%	16,175
Recreation High Developed	-10	-30	-70	-90	-100	-100	1.93%	26,793
Recreation Low Developed	-10	-30	-70	-90	-100	-100	1.17%	129,886
Historic Structures	-30	-50	-70	-100	-100	-100	0.73%	8,140

[1] Within-HVRA relative importance.

3.4.1.4 Communication Sites and Cell Towers

Communication sites and cell towers mapped for PNRA are shown in Figure 12. We included all types of communication sites and cell towers represented in the HSIP database except for "InternetExchangePoints", "InternetServiceProviders", and "IT_LocPortals" which were mainly urban buildings, coincident with non-burnable fuel. These points were converted to 120-m pixels and then resampled to 30 m to allow for mapping uncertainties in the HVRA location and/or fuel mapping.

In this assessment, communication sites have a slightly negative response to FIL1 but respond more negatively with each increasing intensity level (Table 9).

Communication sites and cell towers received 3.65 percent of the total Infrastructure HVRA relative importance. The share of HVRA importance is based on relative importance per unit area and mapped extent.

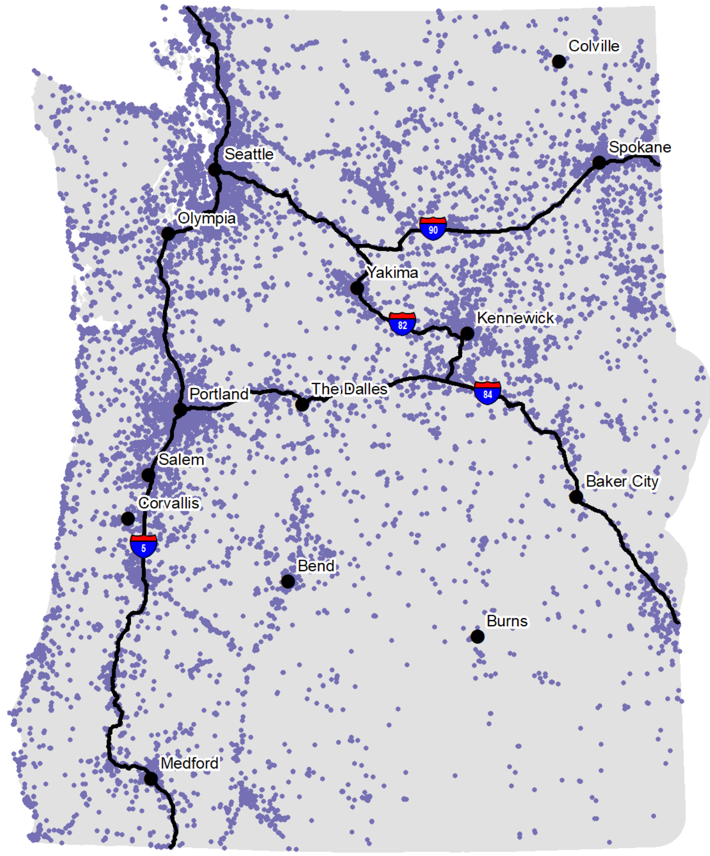

Figure 12. Map of all communication and cell tower sites in the PNRA analysis area.

Table 9. Response functions for the Infrastructure HVRA to highlight communication sites and cell towers.

Sub-HVRA	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6	Share of RI[1]	Acres
Trans-Line- High voltage	10	0	0	-10	-50	-70	40.86%	905,585
Trans-Line- Low voltage	-10	-20	-50	-70	-80	-90	16.79%	743,972
Railroads	-10	-20	-30	-40	-50	-50	16.57%	612,073
Interstates	0	-5	-10	-15	-20	-30	4.74%	175,191
State Highways	0	-5	-10	-15	-20	-30	12.98%	958,745
Communication Sites/Cell Towers	-10	-30	-60	-80	-100	-100	3.65%	80,924
Seed Orchards	-50	-90	-100	-100	-100	-100	0.02%	2,704
Sawmills	-10	-20	-30	-40	-60	-80	0.10%	1,448
Ski Areas	0	-10	-20	-40	-60	-80	0.44%	16,175
Recreation High Developed	-10	-30	-70	-90	-100	-100	1.93%	26,793
Recreation Low Developed	-10	-30	-70	-90	-100	-100	1.17%	129,886
Historic Structures	-30	-50	-70	-100	-100	-100	0.73%	8,140

[1] Within-HVRA relative importance.

3.4.1.5 Seed Orchards

Seed orchards mapped for PNRA are shown in Figure 13. Seed orchard polygons were provided by the Regional Botanist for inclusion in the assessment. These small polygons were converted to 120-m pixels and then resampled to 30 m to allow for mapping uncertainties in the HVRA location and/or fuel mapping.

The RF for seed orchards indicates a negative response for all intensity levels, but especially for FILs 3-6 (Table 10).

Seed orchards received 0.02 percent of the total Infrastructure HVRA relative importance because there are so few pixels relative to the other Infrastructure HVRA. The share of HVRA importance is based on relative importance per unit area and mapped extent.

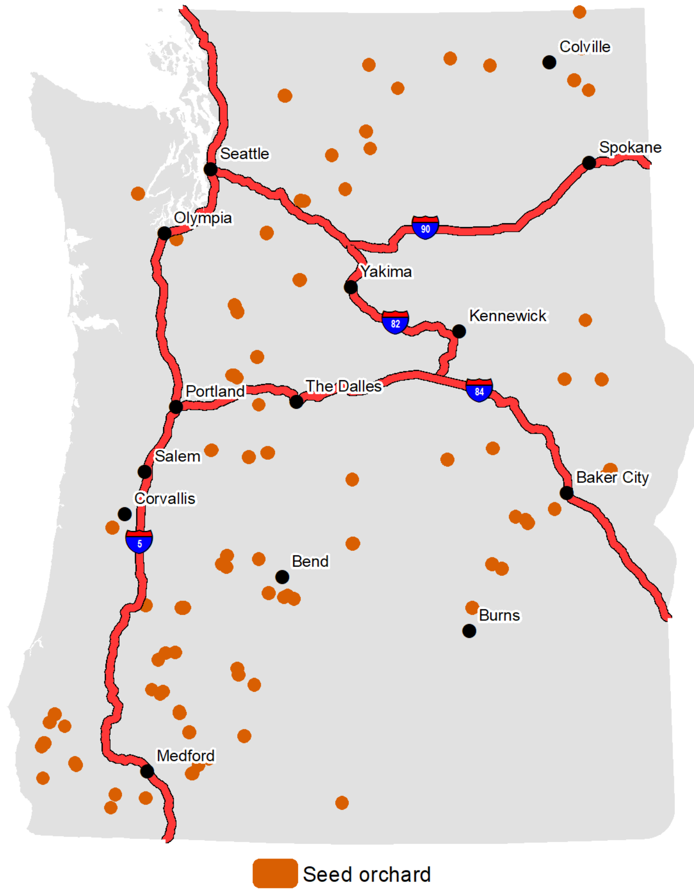

Figure 13. Map of tree seed orchards in the PNRA analysis area.

Table 10. Response functions for the Infrastructure HVRA to highlight seed orchards.

Sub-HVRA	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6	Share of RI[1]	Acres
Trans-Line- High voltage	10	0	0	-10	-50	-70	40.86%	905,585
Trans-Line- Low voltage	-10	-20	-50	-70	-80	-90	16.79%	743,972
Railroads	-10	-20	-30	-40	-50	-50	16.57%	612,073
Interstates	0	-5	-10	-15	-20	-30	4.74%	175,191
State Highways	0	-5	-10	-15	-20	-30	12.98%	958,745
Communication Sites/Cell Towers	-10	-30	-60	-80	-100	-100	3.65%	80,924
Seed Orchards	-50	-90	-100	-100	-100	-100	0.02%	2,704
Sawmills	-10	-20	-30	-40	-60	-80	0.10%	1,448
Ski Areas	0	-10	-20	-40	-60	-80	0.44%	16,175
Recreation High Developed	-10	-30	-70	-90	-100	-100	1.93%	26,793
Recreation Low Developed	-10	-30	-70	-90	-100	-100	1.17%	129,886
Historic Structures	-30	-50	-70	-100	-100	-100	0.73%	8,140

[1] Within-HVRA relative importance.

3.4.1.6 Sawmills

Sawmills mapped for PNRA are shown in Figure 14. Sawmills were extracted from the Wood Product Manufacturing Facilities layer in the HSIP database. The points were converted to 120-m pixels and then resampled to 30 m to allow for mapping uncertainties in the HVRA location and/or fuel mapping.

The RF for sawmills indicates a negative response for all intensity levels, increasing with increasing intensity (Table 11).

Sawmills received 0.1 percent of the total Infrastructure HVRA relative importance because there are so few pixels relative to the other Infrastructure HVRA. The share of HVRA importance is based on relative importance per unit area and mapped extent.

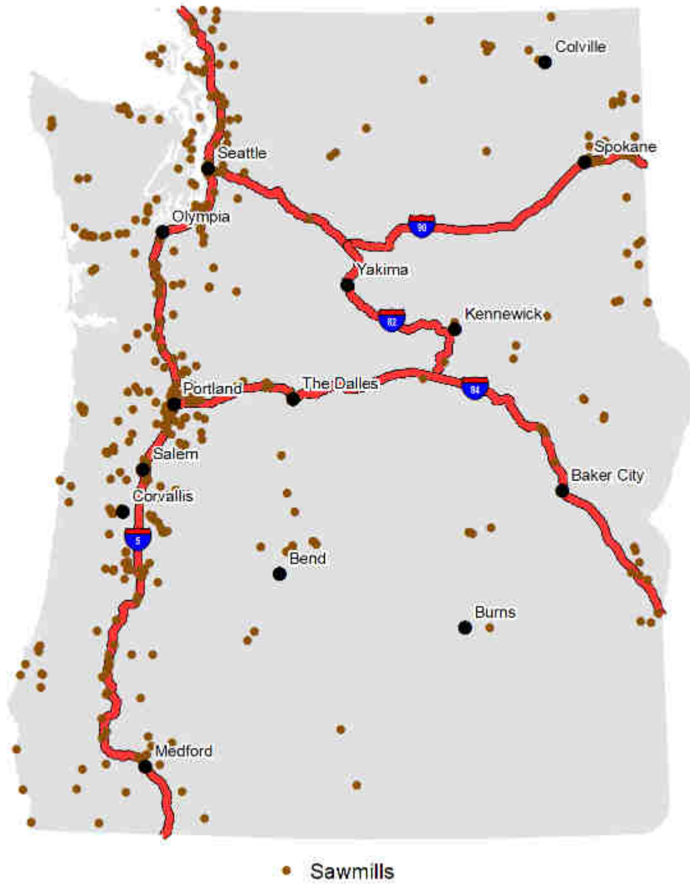

Figure 14. Map of the location of sawmills in the PNRA analysis area.

Table 11. Response functions for the Infrastructure HVRA to highlight sawmills.

Sub-HVRA	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6	Share of RI[1]	Acres
Trans-Line- High voltage	10	0	0	-10	-50	-70	40.86%	905,585
Trans-Line- Low voltage	-10	-20	-50	-70	-80	-90	16.79%	743,972
Railroads	-10	-20	-30	-40	-50	-50	16.57%	612,073
Interstates	0	-5	-10	-15	-20	-30	4.74%	175,191
State Highways	0	-5	-10	-15	-20	-30	12.98%	958,745
Communication Sites/Cell Towers	-10	-30	-60	-80	-100	-100	3.65%	80,924
Seed Orchards	-50	-90	-100	-100	-100	-100	0.02%	2,704
Sawmills	-10	-20	-30	-40	-60	-80	0.10%	1,448
Ski Areas	0	-10	-20	-40	-60	-80	0.44%	16,175
Recreation High Developed	-10	-30	-70	-90	-100	-100	1.93%	26,793
Recreation Low Developed	-10	-30	-70	-90	-100	-100	1.17%	129,886
Historic Structures	-30	-50	-70	-100	-100	-100	0.73%	8,140

[1] Within-HVRA relative importance.

3.4.1.7 Developed Recreation Sites

Recreation sites mapped for PNRA are shown in Figure 15. These data are from a variety of sources (Table 4) with varying degrees of attribute information to classify into high- versus low-levels of development. The points were converted to 120-m pixels and then resampled to 30 m to allow for mapping uncertainties in the HVRA location and/or fuel mapping.

Recreation sites consist of points from: ODF Buildings, FS Buildings, DNR Buildings, DNR Recreation, BLM Recreation Sites, BLM Structure Points, FS Recreation Sites, NPS Recreation Sites, State/County/Local Parks, Nonfederal Campgrounds, USFWS Recreation and USFWS Buildings. In general, buildings and sites like visitor centers, lodges, resorts, developed campgrounds, and cabins were considered high-development recreation sites. Backcountry and horse campsites, vault/pit/other toilets, and trailheads, where less developed infrastructure exists, are considered low-development recreation sites.

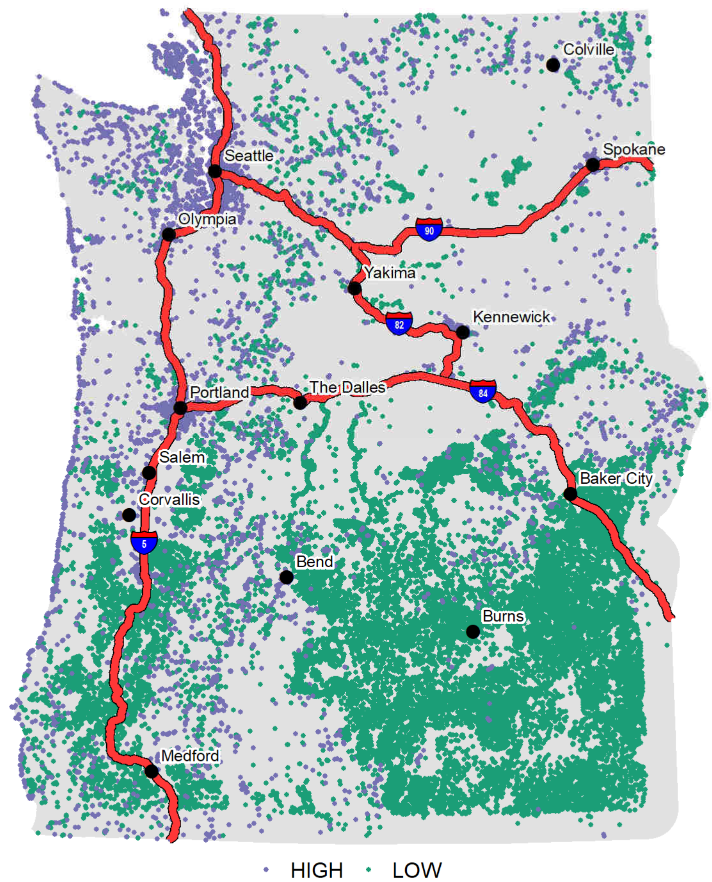

Figure 15. Map of high and low developed recreation sites in the PNRA analysis area.

The RFs for recreation sites are the same for both high- and low-levels of development. Response to fire is slightly negative at FILs 1-2 but becomes strongly negative for FILs 3-6 (Table 12).

Recreation sites, in total, received 3.11 percent of the total Infrastructure HVRA relative importance. The per-unit-importance for high-level of development was eight times greater than that for low-level development, but because there are nearly five times more low-level sites, they received a similar share of the HVRA relative importance. The share of HVRA importance is based on relative importance per unit area and mapped extent.

Table 12. Response functions for the Infrastructure HVRA to highlight recreation sites.

Sub-HVRA	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6	Share of RI[1]	Acres
Trans-Line- High voltage	10	0	0	-10	-50	-70	40.86%	905,585
Trans-Line- Low voltage	-10	-20	-50	-70	-80	-90	16.79%	743,972
Railroads	-10	-20	-30	-40	-50	-50	16.57%	612,073
Interstates	0	-5	-10	-15	-20	-30	4.74%	175,191
State Highways	0	-5	-10	-15	-20	-30	12.98%	958,745
Communication Sites/Cell Towers	-10	-30	-60	-80	-100	-100	3.65%	80,924
Seed Orchards	-50	-90	-100	-100	-100	-100	0.02%	2,704
Sawmills	-10	-20	-30	-40	-60	-80	0.10%	1,448
Ski Areas	0	-10	-20	-40	-60	-80	0.44%	16,175
Recreation High Developed	-10	-30	-70	-90	-100	-100	1.93%	26,793
Recreation Low Developed	-10	-30	-70	-90	-100	-100	1.17%	129,886
Historic Structures	-30	-50	-70	-100	-100	-100	0.73%	8,140

[1] Within-HVRA relative importance.

3.4.1.8 Ski Areas

Ski area boundaries in Oregon and Washington are mapped in Figure 16. The boundaries represented were derived using Google Earth imagery to digitize the outer edge of the ski area and infrastructure.

The RF for ski areas show a neutral response at the lowest flame lengths (FIL1) and a negative response for FILs 2-6, increasing with increasing intensity (Table 13).

Ski areas received 0.44 percent of the total Infrastructure HVRA relative importance because there are so few acres mapped relative to the other Infrastructure HVRA. The share of HVRA importance is based on relative importance per unit area and mapped extent.

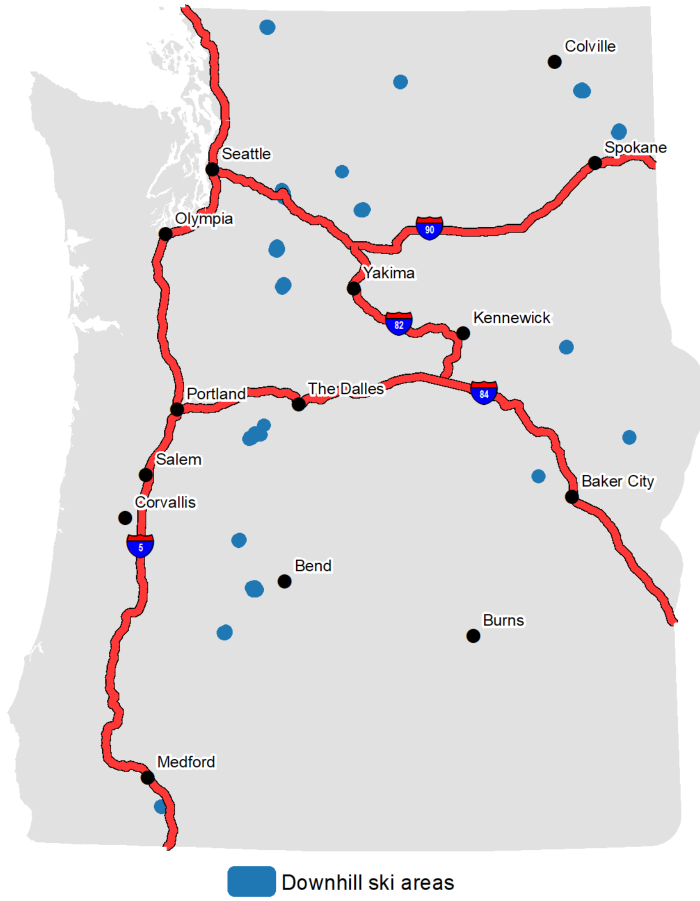

Figure 16. Map of downhill ski area boundaries and infrastructure in the PNRA analysis area.

Table 13. Response functions for the Infrastructure HVRA to highlight ski areas.

Sub-HVRA	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6	Share of RI[1]	Acres
Trans-Line- High voltage	10	0	0	-10	-50	-70	40.86%	905,585
Trans-Line- Low voltage	-10	-20	-50	-70	-80	-90	16.79%	743,972
Railroads	-10	-20	-30	-40	-50	-50	16.57%	612,073
Interstates	0	-5	-10	-15	-20	-30	4.74%	175,191
State highways	0	-5	-10	-15	-20	-30	12.98%	958,745
Communication Sites/Cell Towers	-10	-30	-60	-80	-100	-100	3.65%	80,924
Seed Orchards	-50	-90	-100	-100	-100	-100	0.02%	2,704
Sawmills	-10	-20	-30	-40	-60	-80	0.10%	1,448
Ski Areas	0	-10	-20	-40	-60	-80	0.44%	16,175
Recreation High Developed	-10	-30	-70	-90	-100	-100	1.93%	26,793
Recreation Low Developed	-10	-30	-70	-90	-100	-100	1.17%	129,886
Historic Structures	-30	-50	-70	-100	-100	-100	0.73%	8,140

[1] Within-HVRA relative importance.

3.4.1.9 Historic Structures

Historic structures, as recorded by the National Register of Historic Places, are shown for the PNRA analysis area in Figure 17. The points were converted to 120-m pixels and then resampled to 30 m to allow for mapping uncertainties in the HVRA location and/or fuel mapping.

The RF for historic structures show a negative response at low flame lengths (FILs 1-2) and a strongly negative response for FILs 3-6 (Table 14).

Historic structures received 0.73 percent of the total Infrastructure HVRA relative importance because there are so few acres mapped relative to the other Infrastructure HVRA. The share of HVRA importance is based on relative importance per unit area and mapped extent.

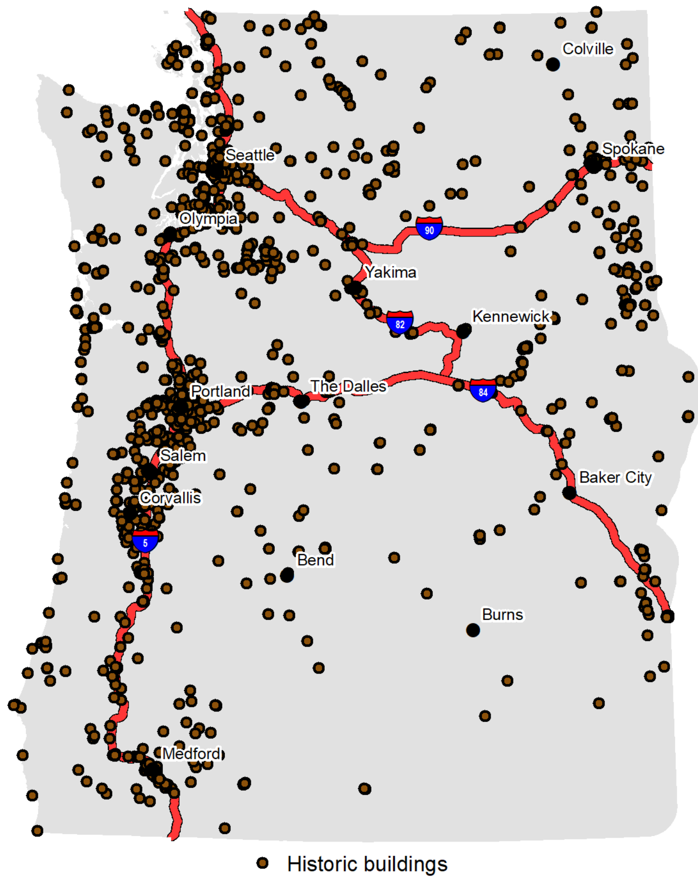

Figure 17. Map of historic structures in the PNRA analysis area.

Table 14. Response functions for the Infrastructure HVRA to highlight historic structures.

Sub-HVRA	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6	Share of RI[1]	Acres
Trans-Line- High voltage	10	0	0	-10	-50	-70	40.86%	905,585
Trans-Line- Low voltage	-10	-20	-50	-70	-80	-90	16.79%	743,972
Railroads	-10	-20	-30	-40	-50	-50	16.57%	612,073
Interstates	0	-5	-10	-15	-20	-30	4.74%	175,191
State Highways	0	-5	-10	-15	-20	-30	12.98%	958,745
Communication Sites/Cell Towers	-10	-30	-60	-80	-100	-100	3.65%	80,924
Seed Orchards	-50	-90	-100	-100	-100	-100	0.02%	2,704
Sawmills	-10	-20	-30	-40	-60	-80	0.10%	1,448
Ski Areas	0	-10	-20	-40	-60	-80	0.44%	16,175
Recreation High Developed	-10	-30	-70	-90	-100	-100	1.93%	26,793
Recreation Low Developed	-10	-30	-70	-90	-100	-100	1.17%	129,886
Historic Structures	-30	-50	-70	-100	-100	-100	0.73%	8,140

[1] Within-HVRA relative importance.

3.4.2 *People and Property*

3.4.2.1 Housing Density and Private Inholdings

The People and Property HVRA consisted of both the Where People Live (WPL) dataset and USFS inholdings within USFS administered lands (Figure 18). We classified WPL into seven housing density classes ranging from very dense (>3 housing units per acre) to very sparse (<1 housing unit per 40 acres). Pixels in the highest density classes (tan and brown) are concentrated around the major cities, while pixels in the lower density classes (turquoise and light green) are scattered throughout the project area. USFS inholdings (mapped in black) are privately-owned parcels (according to BLM ownership layers listed in Table 4) within the administrative boundaries of the U.S. Forest Service.

Response functions were increasingly negative for all housing densities across FILs 1-6 (Table 15), with slightly more loss assigned to the higher density classes due to the impact to more houses and possibly overwhelmed suppression resources with high population exposure. Because USFS inholding parcels may contain seasonal dwellings or structures not represented by WPL, they were given a slightly lower response at FILs 4-6 than the lowest density WPL class.

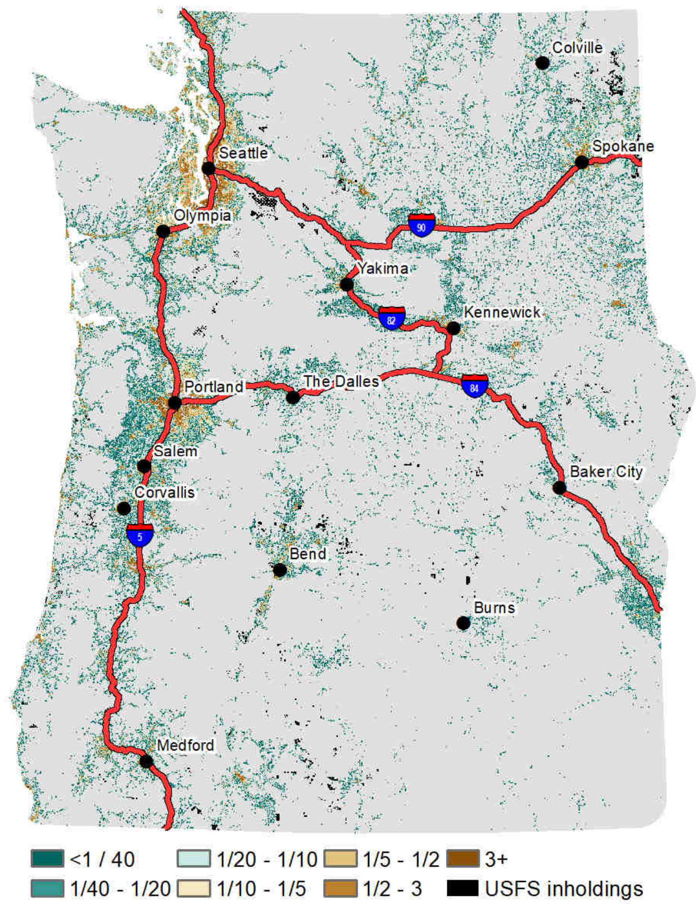

Figure 18. Map of housing density per acre and USFS inholdings in the PNRA analysis area.

The relative importance per unit area is in proportion to the housing density class, but the share of the People and Property HVRA importance held by the most-densely populated class is only 6.62 percent, while the next density class holds the greatest share at 56.66 percent (Table 15) due to the differences in acres present on the landscape. The remaining classes each hold a share in proportion to density and mapped extent. USFS inholdings received 1.81 percent of the share of RI. The importance per unit area of inholdings is equivalent to 5 percent of the highest density importance per unit area.

Table 15. Response functions for the People and Property HVRA

Sub-HVRA	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6	Share of RI[1]	Acres
Where People Live; <1 / 40 ac	-10	-20	-40	-80	-100	-100	2.30%	1,360,902
Where People Live; 1/40 - 1/20	-10	-20	-40	-80	-100	-100	2.31%	1,021,933
Where People Live; 1/20 - 1/10	-10	-20	-40	-80	-100	-100	4.94%	1,094,175
Where People Live; 1/10 - 1/5	-10	-20	-40	-80	-100	-100	9.22%	1,020,777
Where People Live; 1/5 - 1/2	-10	-30	-50	-80	-100	-100	16.27%	840,538
Where People Live; 1/2 to 3/ac	-20	-40	-60	-80	-100	-100	56.87%	479,794
Where People Live; 3+/ac	-30	-50	-70	-100	-100	-100	6.64%	32,692
USFS Inholdings	-10	-20	-40	-60	-80	-80	1.44%	142,220

[1] Within-HVRA relative importance.

3.4.3 *Timber*

The Timber HVRA (Figure 19) includes multiple sub-variables including land ownership, Fire Regime Group (FRG), and size class or Quadratic Mean Diameter (QMD). The size-class variable factored into both RF and RI assignment with smaller size classes considered less valuable and more susceptible to fire, in general. The largest size class, QMD >20," is the most valuable but the least common on the landscape.

A pixel of timber land has the same value regardless of land owner, but differed with respect to the "merchantability" of the timber. Therefore, where harvestable, merchantable, or active management timber land was identified, a slightly higher per-unit-importance was assigned. The mean (across all ownerships and management types) per-pixel importance is listed in Table 16. In the subsequent sections we will break out the Timber HVRA by land ownership, FRG, and size class.

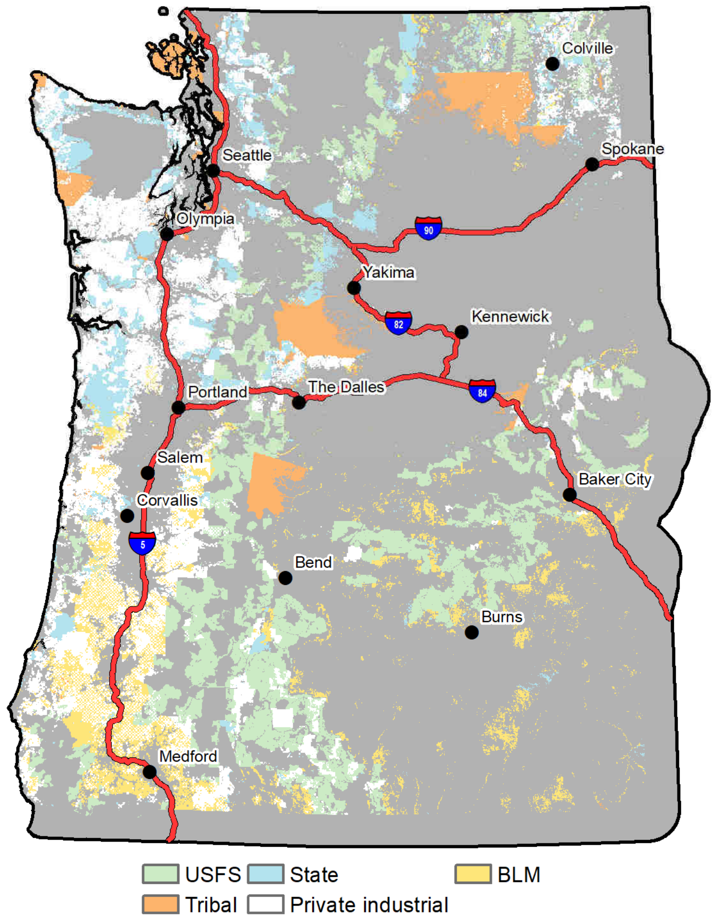

Figure 19. Map of timber land ownership in the PNRA analysis area

Table 16. Response functions for the Timber HVRA

Sub-HVRA	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6	Mean RI[1]	Acres
FRG1 – QMD <10"	10	-20	-50	-100	-100	-100	0.41	2,796,729
FRG1 – QMD 10-20"	50	30	0	-30	-75	-100	0.60	4,804,470
FRG1 – QMD >20"	40	30	0	-10	-50	-100	0.79	1,400,623
FRG3 – QMD <10"	0	-30	-60	-100	-100	-100	0.41	2,811,317
FRG3 – QMD 10-20"	20	0	-40	-80	-80	-100	0.60	3,907,703
FRG3 – QMD >20"	30	10	-20	-80	-80	-100	0.79	1,910,682
FRG4/5 – QMD <10"	-20	-40	-80	-100	-100	-100	0.41	2,488,706
FRG4/5 – QMD 10-20"	-20	-40	-60	-80	-100	-100	0.60	3,294,514
FRG4/5 – QMD >20"	-20	-40	-60	-80	-100	-100	0.79	1,657,844

[1] Within-HVRA relative importance per unit area.

3.4.3.1 USFS Active Management

USFS Timber includes polygons categorized as active management by Ringo *et al.* (2016) along with polygons mapped in the Northwest Forest Plan matrix lands which were identified as areas missing from the mapped USFS timber by the Regional Wildlife Biologist (Figure 20).

Because these areas are extensively mapped on this landscape and fall in the merchantable timber category, the USFS timber holds approximately 35 percent of the total Timber HVRA importance (Table 16).

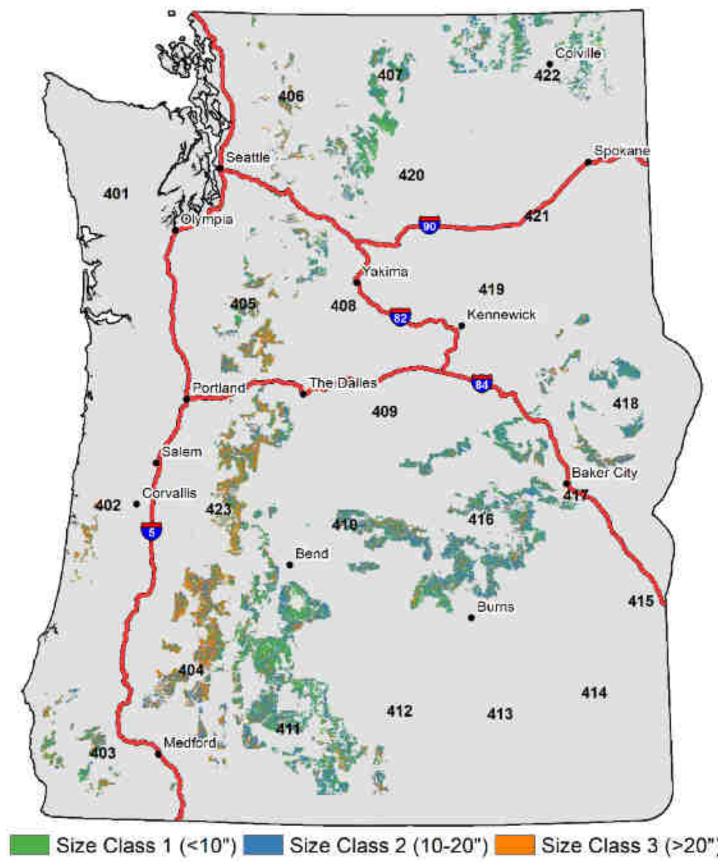

Figure 20. Map of timber by size class on USFS lands designated as active management within the PNRA study area

Table 17. Response functions for the USFS Timber Sub-HVRA.

Sub-HVRA	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6	Share of RI[1]	Acres
USFS FRG1 – QMD <10"	10	-20	-50	-100	-100	-100	3.37%	1,052,080
USFS FRG1 – QMD 10-20"	50	30	0	-30	-75	-100	8.66%	1,800,745
USFS FRG1 – QMD >20"	40	30	0	-10	-50	-100	3.65%	569,807
USFS FRG3 – QMD <10"	0	-30	-60	-100	-100	-100	2.43%	758,474
USFS FRG3 – QMD 10-20"	20	0	-40	-80	-80	-100	6.51%	1,353,776
USFS FRG3 – QMD >20"	30	10	-20	-80	-80	-100	4.90%	763,639
USFS FRG4/5 – QMD <10"	-20	-40	-80	-100	-100	-100	1.23%	384,229
USFS FRG4/5 – QMD 10-20"	-20	-40	-60	-80	-100	-100	2.06%	428,662
USFS FRG4/5 – QMD >20"	-20	-40	-60	-80	-100	-100	2.10%	327,458

[1] Within-HVRA relative importance.

3.4.3.2 Tribal Owned

Data were unavailable to map timber-specific lands on all tribal lands other than the Colville Reservation in northeast Washington. To best represent timber values in other tribal ownerships across the PNRA area, we used tribal land boundaries from the U.S. Census Bureau as an overlay with the FRG and size class layers (Figure 21).

This general tribal land received a lower per-pixel importance than the land identified as commercial timber on the Colville Reservation.

In total, the area mapped as tribal timber received 6.35 percent of the total Timber HVRA importance (Table 18).

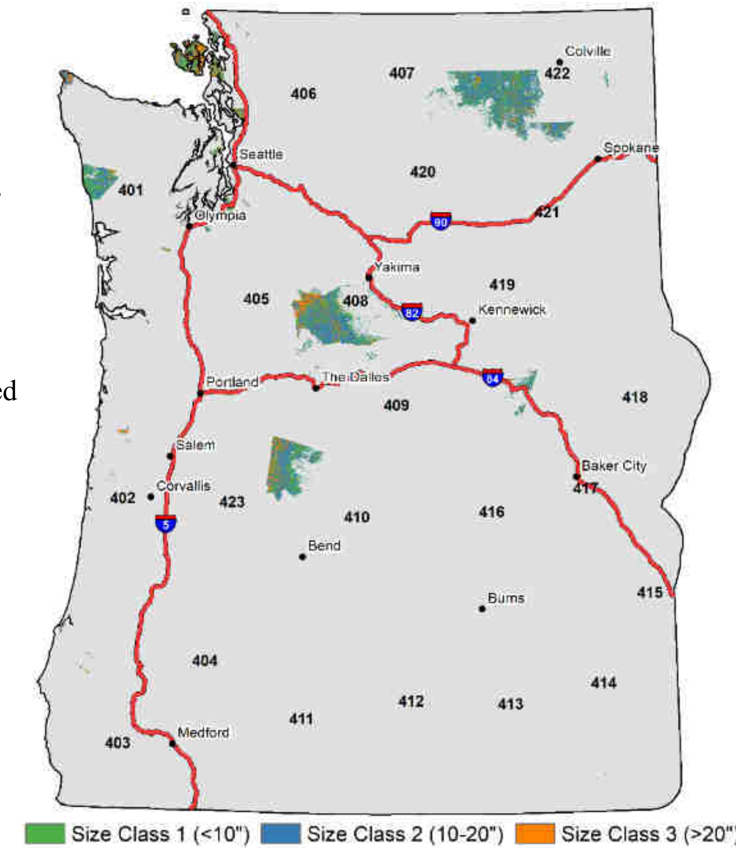

Figure 21. Map of timber by size class on tribal lands within the PNRA study area.

Table 18. Response functions for the Tribal Timber Sub-HVRA

Sub-HVRA	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6	Share of RI[1]	Acres
Tribal Merch Timber; FRG1 - QMD <10"	10	-20	-50	-100	-100	-100	0.40%	124,588
Tribal Merch Timber; FRG1 – QMD 10-20"	50	30	0	-30	-75	-100	1.31%	271,736
Tribal Merch Timber; FRG1 - QMD >20"	40	30	0	-10	-50	-100	0.25%	39,038
Tribal Merch Timber; FRG3 - QMD <10"	0	-30	-60	-100	-100	-100	0.03%	9,911
Tribal Merch Timber; FRG3 - QMD 10-20	20	0	-40	-80	-80	-100	0.08%	16,632
Tribal Merch Timber; FRG3 - QMD >20"	30	10	-20	-80	-80	-100	0.02%	2,422
Tribal Merch Timber; FRG4/5 - QMD <10"	-20	-40	-80	-100	-100	-100	0.06%	18,268
Tribal Merch Timber; FRG4/5 - QMD 10-20"	-20	-40	-60	-80	-100	-100	0.12%	24,364
Tribal Merch Timber; FRG4/5 - QMD >20"	-20	-40	-60	-80	-100	-100	0.06%	8,729
Tribal Other; FRG1 - QMD <10"	10	-20	-50	-100	-100	-100	0.39%	200,882
Tribal Other; FRG1 - QMD 10-20"	50	30	0	-30	-75	-100	1.04%	404,144
Tribal Other; FRG1 - QMD >20"	40	30	0	-10	-50	-100	0.26%	80,260
Tribal Other; FRG3 - QMD <10"	0	-30	-60	-100	-100	-100	0.35%	182,428
Tribal Other; FRG3 - QMD 10-20"	20	0	-40	-80	-80	-100	0.68%	264,877
Tribal Other; FRG3 - QMD >20"	30	10	-20	-80	-80	-100	0.41%	128,745
Tribal Other; FRG4/5 - QMD <10"	-20	-40	-80	-100	-100	-100	0.25%	131,006
Tribal Other; FRG4/5 - QMD 10-20"	-20	-40	-60	-80	-100	-100	0.37%	145,406
Tribal Other; FRG4/5 - QMD >20"	-20	-40	-60	-80	-100	-100	0.29%	90,878

[1] Within-HVRA relative importance.

3.4.3.3 Private Industrial

Private timberlands by size class are mapped in Figure 22. The private timber layer was created by selecting the categories IFPC, REIT, and TIMO from the Atterbury Consultants ownership maps for Oregon and Washington.

This private timberland received the higher relative importance rank because it is land managed for timber production.

In total, the area mapped as private industrial timber received 42.63 percent of the total Timber HVRA importance (Table 19) due to the abundance of acres mapped in the analysis area and the high importance per unit area.

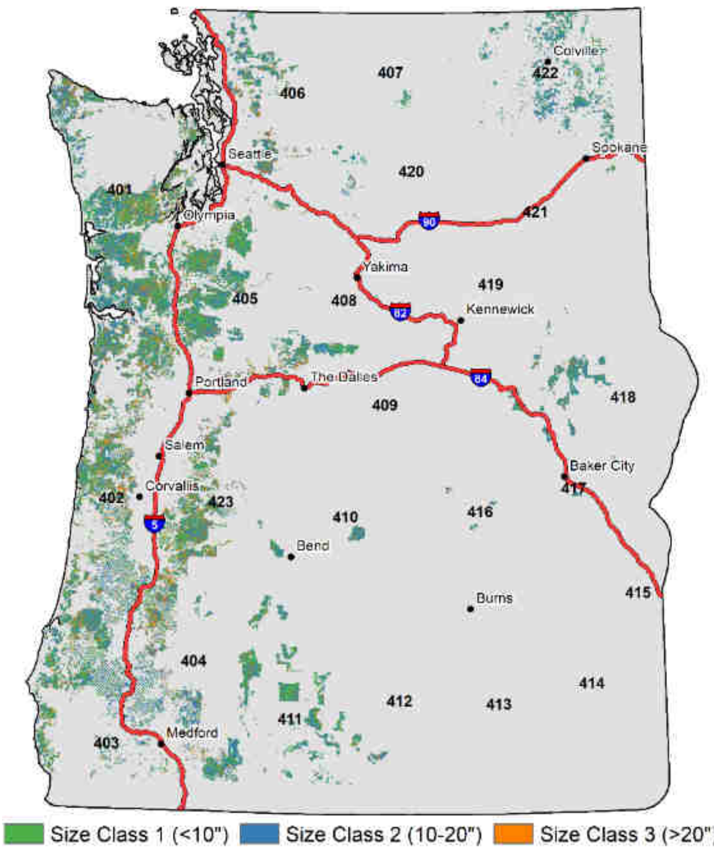

Figure 22. Map of timber by size class on private industrial lands within the PNRA study area.

Table 19. Response functions for Private Industrial Timber Sub-HVRA

Sub-HVRA	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6	Share of RI[1]	Acres
Private Industrial; FRG1 – QMD <10"	10	-20	-50	-100	-100	-100	2.84%	887,595
Private Industrial; FRG1 – QMD 10-20"	50	30	0	-30	-75	-100	5.93%	1,232,911
Private Industrial; FRG1 – QMD >20"	40	30	0	-10	-50	-100	1.85%	289,009
Private Industrial; FRG3 – QMD <10"	0	-30	-60	-100	-100	-100	4.63%	1,445,348
Private Industrial; FRG3 – QMD 10-20"	20	0	-40	-80	-80	-100	7.10%	1,476,268
Private Industrial; FRG3 – QMD >20"	30	10	-20	-80	-80	-100	3.11%	485,752
Private Industrial; FRG4/5 – QMD <10"	-20	-40	-80	-100	-100	-100	4.95%	1,544,913
Private Industrial; FRG4/5 – QMD 10-20"	-20	-40	-60	-80	-100	-100	8.55%	1,779,269
Private Industrial; FRG4/5 – QMD >20"	-20	-40	-60	-80	-100	-100	3.65%	569,855

[1] Within-HVRA relative importance.

3.4.3.4 BLM Harvestable and Potential Timber

BLM timberlands by size class are mapped in Figure 23. The BLM timber layer was created by combining various BLM-owned lands, valued for their timber potential or harvestability. The harvestable timber category consists of polygon features labeled with "Harvestable Land Base" (HLB). The potential category consists of Public Domain lands, along with Revested Oregon and California Railroad lands (O&C), Revested Coos Bay Wagon Road lands (CB), and FORVIS (Forest Vegetation Information System) lands in Washington. FORVIS was the only available data for BLM in Washington at the time this project was completed.

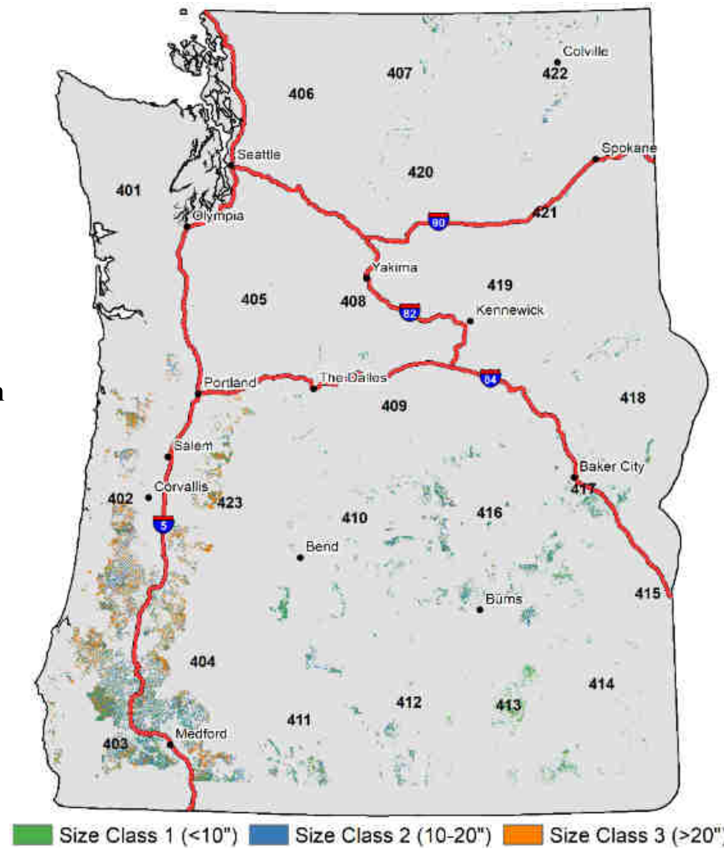

Figure 23. Map of timber by size class on BLM lands in the PNRA analysis area.

The two BLM timber categories received different relative importance rankings. The harvestable timberlands received the higher relative importance rank because it is land managed for timber production while the potential land received a lower ranking, indicating it was land managed with other objectives than timber only.

In total, the area mapped as BLM timber received 8.18 percent of the total Timber HVRA importance (

Table 20) due to fewer acres mapped in the analysis area as compared with other timber ownerships.

Table 20. Response functions for BLM Timber Sub-HVRA

Sub-HVRA	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6	Share of RI[1]	Acres
BLM - Harvestable Timber; FRG1 - QMD <10"	10	-20	-50	-100	-100	-100	0.19%	59,276
BLM - Harvestable Timber; FRG1 – QMD 10-20"	50	30	0	-30	-75	-100	0.79%	164,464
BLM - Harvestable Timber; FRG1 - QMD >20"	40	30	0	-10	-50	-100	0.41%	64,390
BLM - Harvestable Timber; FRG3 - QMD <10"	0	-30	-60	-100	-100	-100	0.08%	24,292
BLM - Harvestable Timber; FRG3 - QMD 10-20	20	0	-40	-80	-80	-100	0.31%	64,136
BLM - Harvestable Timber; FRG3 - QMD >20"	30	10	-20	-80	-80	-100	0.32%	49,714
BLM - Harvestable Timber; FRG4/5 - QMD <10"	-20	-40	-80	-100	-100	-100	0.03%	9,863
BLM - Harvestable Timber; FRG4/5 - QMD 10-20"	-20	-40	-60	-80	-100	-100	0.14%	28,962
BLM - Harvestable Timber; FRG4/5 - QMD >20"	-20	-40	-60	-80	-100	-100	0.13%	20,912
BLM - Potential Timber; FRG1 - QMD <10"	10	-20	-50	-100	-100	-100	0.50%	258,878
BLM - Potential Timber; FRG1 - QMD 10-20"	50	30	0	-30	-75	-100	1.50%	585,056
BLM - Potential Timber; FRG1 - QMD >20"	40	30	0	-10	-50	-100	0.92%	287,894
BLM - Potential Timber; FRG3 - QMD <10"	0	-30	-60	-100	-100	-100	0.26%	136,234
BLM - Potential Timber; FRG3 - QMD 10-20"	20	0	-40	-80	-80	-100	0.69%	270,096
BLM - Potential Timber; FRG3 - QMD >20"	30	10	-20	-80	-80	-100	0.71%	221,841
BLM - Potential Timber; FRG4/5 - QMD <10"	-20	-40	-80	-100	-100	-100	0.15%	75,662
BLM - Potential Timber; FRG4/5 - QMD 10-20"	-20	-40	-60	-80	-100	-100	0.44%	173,154
BLM - Potential Timber; FRG4/5 - QMD >20"	-20	-40	-60	-80	-100	-100	0.60%	187,228

[1] Within-HVRA relative importance.

3.4.3.5 State Owned

State-owned potential timber lands are mapped in Figure 24. The ownership layer was built by selecting State ownership in Oregon and Washington from the Atterbury Consultants data.

In Washington, we queried "Label = State" and excluded land labeled 'State Fish and Wildlife' and 'State Parks.'

In Oregon, we selected "Att_OwnerClass=State" and then excluded all records where "Att_LandOwner" was Oregon Department of Fish & Wildlife, Oregon Department of Parks and Recreation, Oregon Parks & Recreation Department, Oregon Parks and Recreation Department.

Because we were unable to query out state lands managed specifically for timber, state-owned potential timber lands were assigned the lower relative importance score, equal to the other 'potential' timber categories.

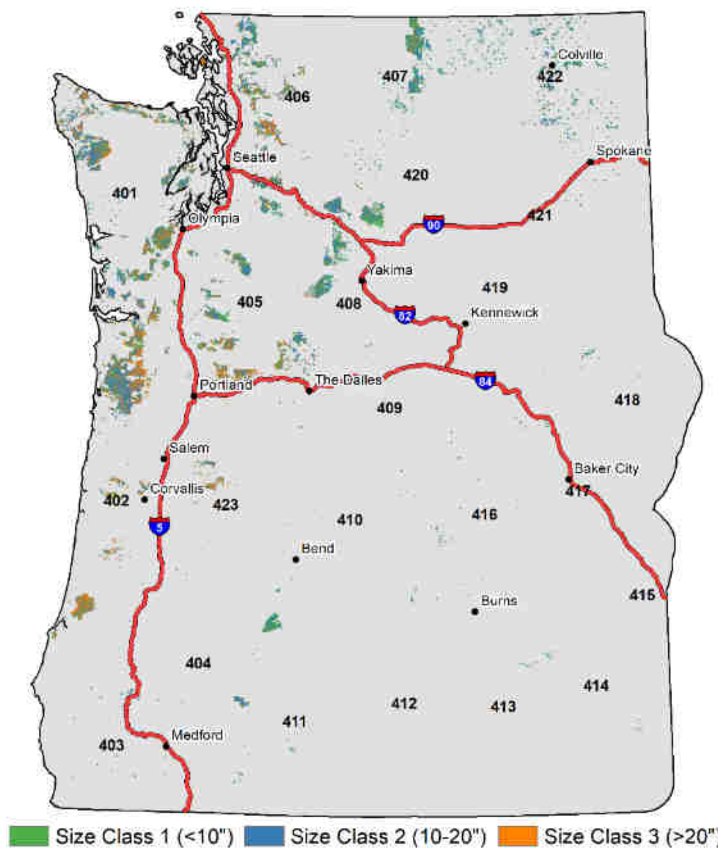

Figure 24. Map of timber by size class on state lands within the PNRA study area.

In total, the area mapped as State-owned timber received 7.93 percent of the total Timber HVRA importance (Table 21) due to fewer acres mapped in the analysis area as compared with other timber ownerships and the lower relative importance ranking for potential timber.

Table 21. Response functions for State Timber Sub-HVRA

Sub-HVRA	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6	Share of RI[1]	Acres
FRG1 – QMD <10"	10	-20	-50	-100	-100	-100	0.41%	213,429
FRG1 – QMD 10-20"	50	30	0	-30	-75	-100	0.89%	345,415
FRG1 – QMD >20"	40	30	0	-10	-50	-100	0.23%	70,224
FRG3 – QMD <10"	0	-30	-60	-100	-100	-100	0.49%	254,629
FRG3 – QMD 10-20"	20	0	-40	-80	-80	-100	1.18%	461,918
FRG3 – QMD >20"	30	10	-20	-80	-80	-100	0.83%	258,569
FRG4/5 – QMD <10"	-20	-40	-80	-100	-100	-100	0.62%	324,765
FRG4/5 – QMD 10-20"	-20	-40	-60	-80	-100	-100	1.83%	714,697
FRG4/5 – QMD >20"	-20	-40	-60	-80	-100	-100	1.45%	452,784

[1] Within-HVRA relative importance.

3.4.4 *Vegetation Condition*

3.4.4.1 Seral State Departure by FRG Group

The Vegetation condition HVRA was developed using the data from the R6 Forest Structure Restoration Needs Update Analysis (DeMeo *et al.*, In Press). This HVRA covers forested areas across Oregon and Washington and provides information about historical vegetation and reference conditions, from which the degree of current departure can be estimated.

To keep a high-level, regional focus in developing this HVRA, the S-Class transition matrix describing the effect of fire on forest succession was characterized at the Fire Regime Group (FRG) level rather than at the finer level of a specific biophysical setting (BpS) within that FRG. However, biophysical settings were used to look up the Fire Regime Group associated with each biophysical setting. FRG for the PNRA study area is shown in Figure 25. For each BpS within an ecologically relevant landscape unit (as defined by DeMeo *et al.* (In Press)), we acquired the associated S-Class and departure status.

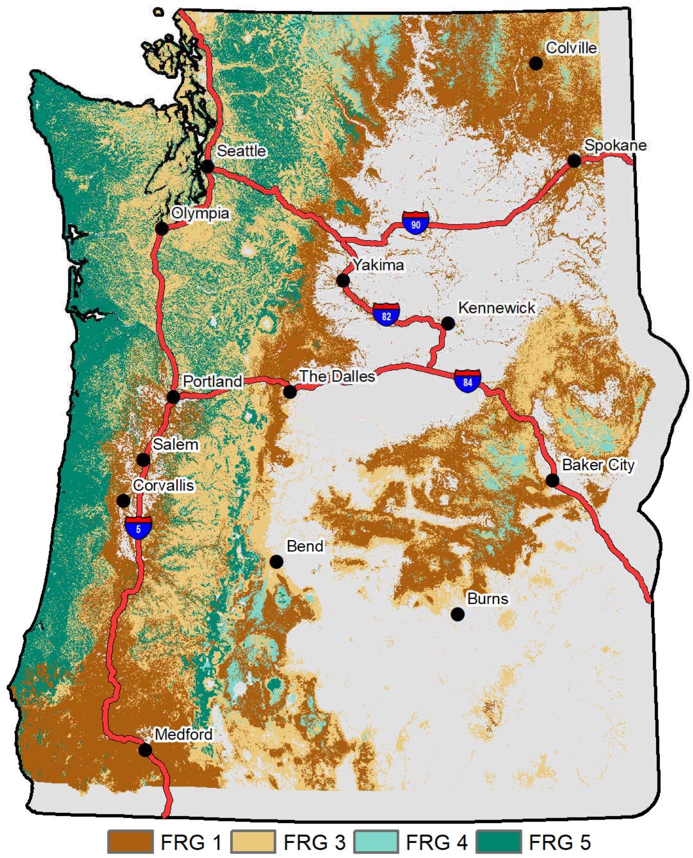

Figure 25. Map of FRG used in the Vegetation Condition HVRA within the PNRA analysis area.

RFs were developed for the combination of Fire Regime Group, S-Class, and Departure Status. One set of RFs was used for the standard, five-box BpS Models and another for any non-standard BpS Models. In order to assign a RF, we combined values for FRG, information on whether it was a standard five-box model BpS, and S-Class for every pixel on the landscape, and from that information looked up the transition S-Class for each FIL (1-6). The S-Class transition matrix is shown in Table 22. The Departure Status (Deficit, Similar, or Surplus) information was then added to the combined information.

Using this information, we made a new combination of variables with the “To S-Class” for each FIL class and looked up the departure status of that S-Class in the current landscape. With the full combination of “To” and “From” variables, we could then look up the appropriate RF from Table 23 for the standard, five-box BpS models, and Table 24 for the non-standard BpS models for each possible transition in all FILs. This table of response function values was then joined back to the original combined raster layer to map RFs back to the landscape.

The Vegetation Condition HVRA received nine percent of the total landscape importance (Figure 8).

Table 22. S-Class transition matrix used for the Vegetation Condition HVRA. S-Classes for standard, five-box BpS models are defined in Table 23.

FRG	Standard 5-box 1= yes, 0= no	From S-Class	To S-Class					
			FIL1 (0-2ft)	FIL2 (2-4ft)	FIL3 (4-6ft)	FIL4 (6-8ft)	FIL5 (8-12ft)	FIL6 (12+ft)
1	1	A	A	A	A	A	A	A
1	1	B	B	B	C	A	A	A
1	1	C	C	C	C	A	A	A
1	1	D	D	D	D	D	A	A
1	1	E	E	E	D	A	A	A
3	1	A	A	A	A	A	A	A
3	1	B	B	C	A	A	A	A
3	1	C	C	C	A	A	A	A
3	1	D	D	D	D	A	A	A
3	1	E	E	E	D	A	A	A
4	1	A	A	A	A	A	A	A
4	1	B	C	A	A	A	A	A
4	1	C	C	A	A	A	A	A
4	1	D	D	D	A	A	A	A
4	1	E	E	D	A	A	A	A
5	1	A	A	A	A	A	A	A
5	1	B	C	A	A	A	A	A
5	1	C	C	A	A	A	A	A
5	1	D	D	D	A	A	A	A
5	1	E	E	D	A	A	A	A
3	0	A	A	A	A	A	A	A
3	0	B	B	B	C	A	A	A
3	0	C	C	C	C	A	A	A
4	0	A	A	A	A	A	A	A
4	0	B	A	A	A	A	A	A
4	0	C	C	B	B	B	B	B
4	0	D	D	B	B	B	B	B
4	0	E	E	D	B	B	B	B
5	0	A	A	A	A	A	A	A
5	0	B	D	A	A	A	A	A
5	0	C	D	A	A	A	A	A
5	0	D	D	A	A	A	A	A
5	0	E	E	D	A	A	A	A

Table 23. Response function matrix for the standard, five-box BpS models in the Vegetation Condition HVRA.

For standard 5-box BpS			TO														
			A - Early			B - Mid Closed			C - Mid Open			D - Late Open			E - Late Closed		
			Deficit	Similar	Surplus	Deficit	Similar	Surplus	Deficit	Similar	Surplus	Deficit	Similar	Surplus	Deficit	Similar	Surplus
FROM	Early	Deficit	75	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Similar	NA	50	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Surplus	NA	NA	-40	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Mid-closed	Deficit	0	-50	-100	75	NA	NA	50	40	30	NA	NA	NA	NA	NA	NA
		Similar	30	-10	-50	NA	50	NA	75	50	40	NA	NA	NA	NA	NA	NA
		Surplus	75	20	-30	NA	NA	20	90	75	50	NA	NA	NA	NA	NA	NA
	Mid-open	Deficit	0	-50	-80	NA	NA	NA	80	NA	NA	NA	NA	NA	NA	NA	NA
		Similar	30	-10	-75	NA	NA	NA	NA	70	NA	NA	NA	NA	NA	NA	NA
		Surplus	60	20	-40	NA	NA	NA	NA	NA	50	NA	NA	NA	NA	NA	NA
	Late-open	Deficit	-50	-100	-100	NA	NA	NA	NA	NA	NA	100	NA	NA	NA	NA	NA
		Similar	10	-75	-100	NA	NA	NA	NA	NA	NA	NA	80	NA	NA	NA	NA
		Surplus	20	-30	-50	NA	NA	NA	NA	NA	NA	NA	NA	20	NA	NA	NA
	Late-Closed	Deficit	-50	-100	-100	NA	NA	NA	NA	NA	NA	20	0	0	80	NA	NA
		Similar	10	-75	-100	NA	NA	NA	NA	NA	NA	75	50	0	NA	70	NA
		Surplus	20	-30	-50	NA	NA	NA	NA	NA	NA	100	75	50	NA	NA	30

Table 24. Response function matrix for all other BpS models in the Vegetation Condition HVRA.

For all other BpS			TO								
			Early			Mid			Late		
			Deficit	Similar	Surplus	Deficit	Similar	Surplus	Deficit	Similar	Surplus
FROM	Early	Deficit	0	-15	-50	NA	NA	NA	NA	NA	NA
		Similar	30	10	-25	NA	NA	NA	NA	NA	NA
		Surplus	50	10	-15	NA	NA	NA	NA	NA	NA
	Mid	Deficit	0	-25	-75	10	0	-10	NA	NA	NA
		Similar	50	30	-25	50	30	0	NA	NA	NA
		Surplus	100	60	-25	80	60	20	NA	NA	NA
	Late	Deficit	-50	-80	-100	-20	-50	-70	20	0	0
		Similar	10	-50	-75	30	-20	-40	50	20	0
		Surplus	20	-20	-75	50	10	-40	100	75	50

3.4.5 *Watershed*

3.4.5.1 Erosion Hazard Class

Watershed resources were mapped using a custom approach to determine the importance of each pixel within a basin based on population served and distance to intake. We calculated the Euclidean distance, using the ArcGIS 10.2 Euclidean Distance Tool, to the drinking water intake for each pixel within its associated watershed. We then divided the Euclidean distance of each pixel by one-third of the distance to the intake and multiplied by the population served by that intake. Because a single pixel can belong to one or more overlapping watersheds, the values are cumulative across any overlapping watersheds. The resulting importance map is shown in Figure 26.

Because each pixel has a unique importance per unit area, we have not summarized the share of HVRA importance within each erosion class. Importance varies across the landscape, irrespective of erosion potential.

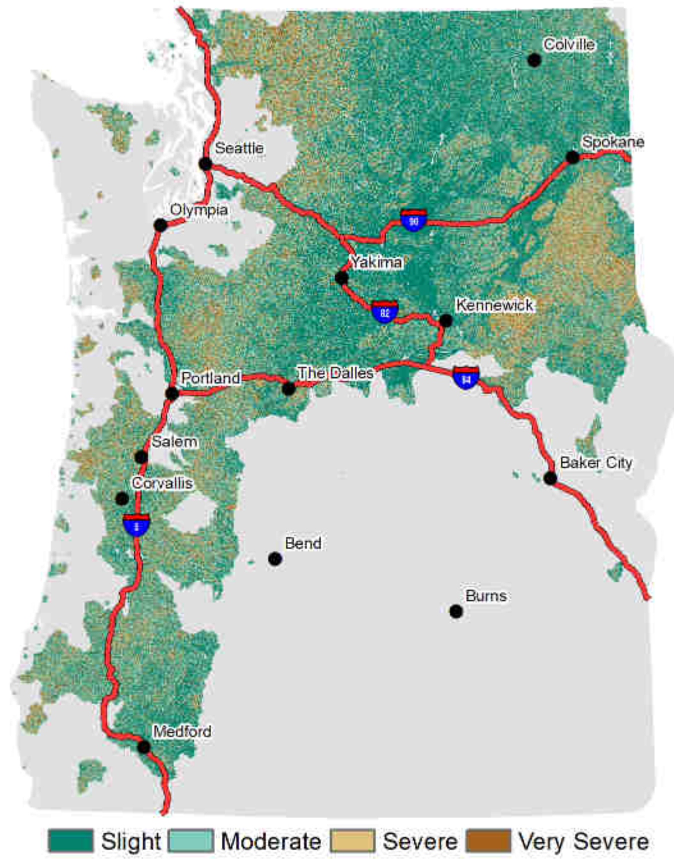

Figure 26. Map of erosion potential by hazard class within the PNRA analysis area.

The response functions shown in Table 25 are for four erosion classes: Slight, Moderate, Severe, and Very Severe. These categories were derived from data produced by the Remote Sensing Applications Center (RSAC) of modeled erosion and deposition potential maps based on the current condition landscape. We used only erosional pixels less than zero from the modeled results and calculated percentiles on the remaining pixel values across the landscape. We chose to classify the data with the lowest 50 percent of pixels in the "slight" category (<50th percentile), the next 25 percent of pixels in the "Moderate" category (50-75th percentile), the next 15 percent in the "Severe" category (75th-90th percentile), and finally, the top 10 percent as "Very Severe" (>90th percentile).

Table 25. Response functions for the Watershed HVRA.

Sub-HVRA	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6	Share of RI[1]	Acres
Erosion - Slight	0	0	-5	-10	-15	-20	-	9,509,725
Erosion - Moderate	0	0	-5	-15	-30	-40	-	7,470,301
Erosion - Severe	0	0	-10	-25	-40	-60	-	4,759,404
Erosion - Very Severe	0	-5	-10	-50	-100	-100	-	3,169,230

[1] Within-HVRA relative importance.

3.4.6 *Terrestrial and Aquatic Wildlife Habitat*

3.4.6.1 Marbled Murrelet

Marbled murrelet habitat is mapped across the western portions of both Oregon and Washington (Figure 27). The critical habitat map was obtained from the U.S. Fish and Wildlife Service, Endangered Species Program, critical habitat shapefile and clipped to the analysis area boundary.

The RF indicates that marbled murrelet habitat benefits from lower intensity fires in FILs 1-2, responds only slightly negatively to FIL3, and responds strongly negatively to FILs 4-6 (Table 26).

Marbled murrelet habitat received 25.17 percent of the total Wildlife HVRA relative importance due to its importance as a listed species and associated high relative importance ranking, as well as the number of acres mapped in the analysis area. The share of HVRA importance is based on relative importance per unit area and mapped extent.

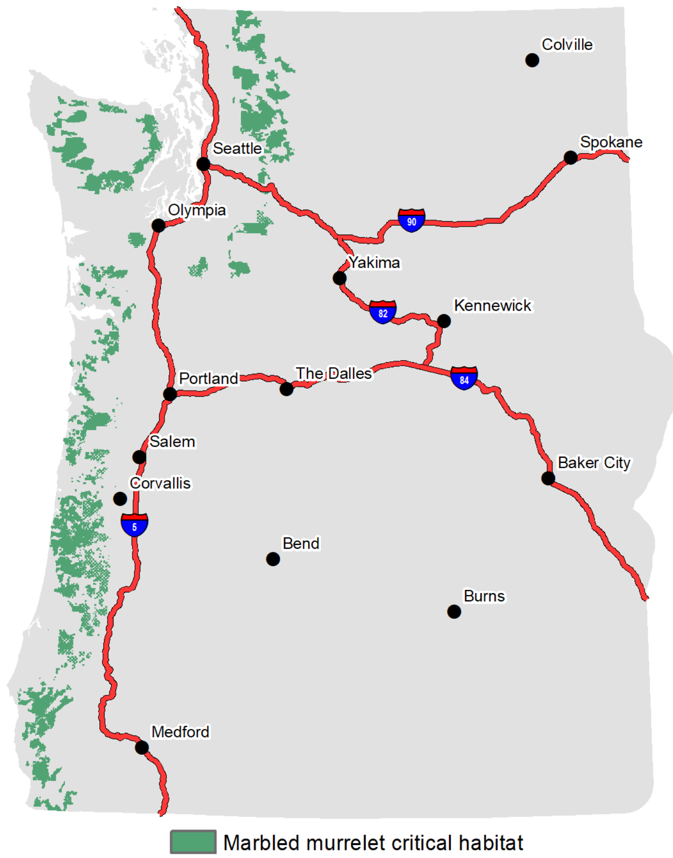

Figure 27. Map of marbled murrelet critical habitat in the PNRA analysis area

Table 26. Response functions for the Marbled Murrelet Sub-HVRA.

Sub-HVRA	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6	Share of RI[1]	Acres
Marbled Murrelet	40	20	-10	-60	-100	-100	25.17%	3,188,846

[1] Within-HVRA relative importance.

3.4.6.2 Northern Spotted Owl

Northern spotted owl habitat is mapped across the western and middle portions of both Oregon and Washington (Figure 28). The predicted habitat suitability map was obtained from the Glenn *et al.* (2017) analysis shapefile provided by the Regional Wildlife Biologist and clipped to the analysis area boundary.

The RF indicates that northern spotted owl habitat benefits from lower intensity fires in FILs 1-2, responds only slightly negatively to FIL3, and responds strongly negatively to FILs 4-6 (Table 27).

Spotted owl habitat received 28.16 percent of the total Wildlife HVRA relative importance due to its importance as a listed species and associated high relative importance ranking, as well as its abundant suitable habitat within the analysis area. The share of HVRA importance is based on relative importance per unit area and mapped extent.

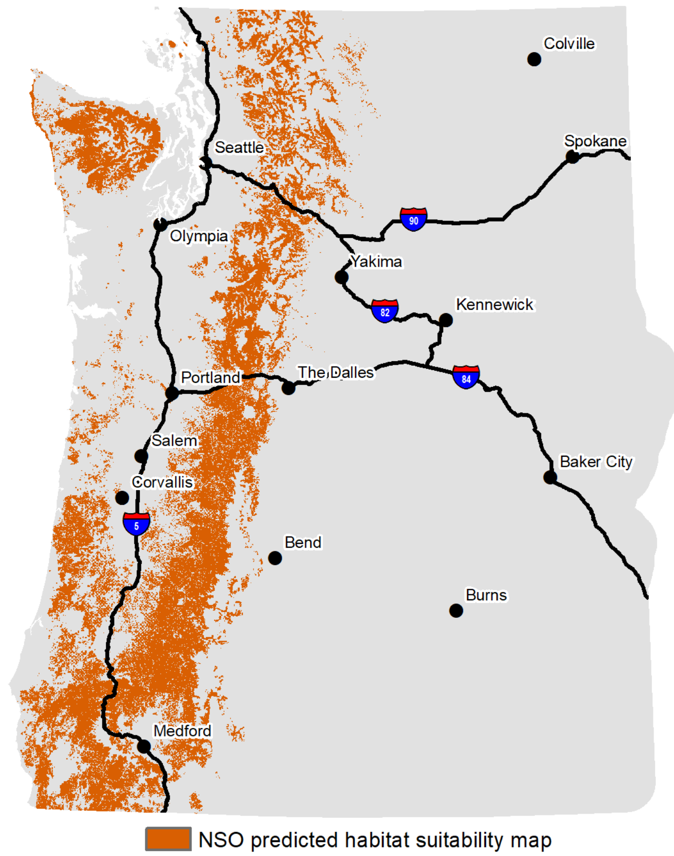

Figure 28. Map of predicted northern spotted owl suitable habitat in the PNRA analysis area.

Table 27. Response functions for the Northern Spotted Owl Sub-HVRA.

Sub-HVRA	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6	Share of RI[1]	Acres
Northern Spotted Owl	40	20	-10	-60	-80	-100	28.16%	7,135,435

[1] Within-HVRA relative importance.

3.4.6.3 Greater Sage-grouse

The greater sage-grouse habitat map for the PNRA analysis area is shown in Figure 29. The habitat data was obtained from the Wildland Fire Decision Support System (WFDSS) - 2015 greater sage-grouse (GRSG) Land Use Plan (LUP) Allocations layer. The Regional Fire Ecologist advised grouping habitat into three levels in order from highest quality to lowest quality habitat: Focal areas, Priority habitat, and General habitat. Habitat importance per-unit-area was determined by these categories.

Habitat was further stratified according to the USDA Natural Resources Conservation Service, Index of Relative Ecosystem Resilience and Resistance (RR) across Sage-Grouse Management Zones. The High, Moderate, and Low RR categories were used to refine sage-grouse habitat response function. Table 28 shows that High RR habitat benefits from fires in FILs 1-2, has a neutral response to FIL3, and responds with an increasingly negative response to FILs 4-6. Moderate RR habitat shows a neutral response only to FIL1, and an increasingly negative response to FILs 2-6. Low RR habitat shows a negative response across all FILs.

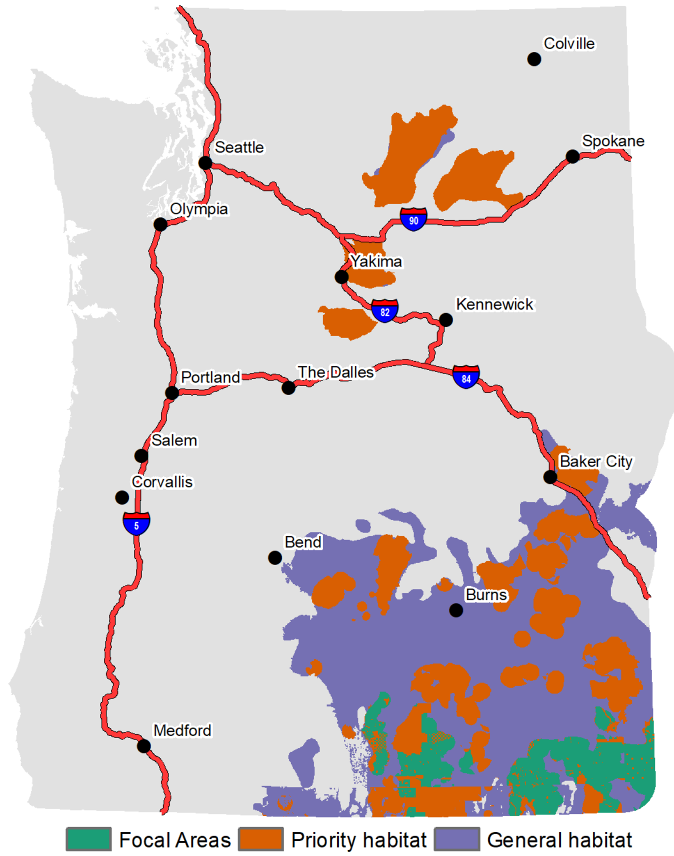

Figure 29. Map of greater sage-grouse land use plan allocations in the PNRA analysis area.

Sage-grouse habitat received 20.5 percent of the total Wildlife HVRA relative importance. The share of HVRA importance is based on relative importance per unit area and mapped extent.

Table 28. Response functions for Greater Sage-Grouse Sub-HVRA

Sub-HVRA	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6	Share of RI[1]	Acres
Focal Areas; RR - High	30	10	0	-30	-50	-90	0.25%	128,885
Focal Areas; RR - Mod	0	-10	-30	-60	-100	-100	1.99%	1,010,523
Focal Areas; RR - Low	-10	-30	-70	-100	-100	-100	1.45%	735,277
PHMA; RR - High	30	10	0	-30	-50	-90	2.12%	1,340,245
PHMA; RR - Mod	0	-10	-30	-60	-100	-100	3.82%	2,417,936
PHMA; RR - Low	-10	-30	-70	-100	-100	-100	5.89%	3,729,228
GHMA; RR - High	30	10	0	-30	-50	-90	1.16%	2,932,795
GHMA; RR - Mod	0	-10	-30	-60	-100	-100	1.84%	4,658,635
GHMA; RR - Low	-10	-30	-70	-100	-100	-100	1.99%	5,040,090

[1] Within-HVRA relative importance.

3.4.6.4 Bull Trout

Bull trout distribution for the PNRA analysis area is shown in Figure 30. Bull trout were included in the assessment because of concern over species isolation and ability to recolonize following a severe wildfire. The distribution data was obtained from the StreamNet Generalized Fish Distribution layer for bull trout. These lines were converted to 30-m raster and expanded out 3 pixels on either side to capture the area impacted by wildfire.

The bull trout response to fire is characterized as slightly beneficial for FILs 1-3 but shows an increasingly negative response in FILs 4-6 – flame lengths greater than 6 ft. (Table 29).

Bull trout habitat received 6.16 percent of the total Wildlife HVRA relative importance. The share of HVRA importance is based on relative importance per unit area and mapped extent.

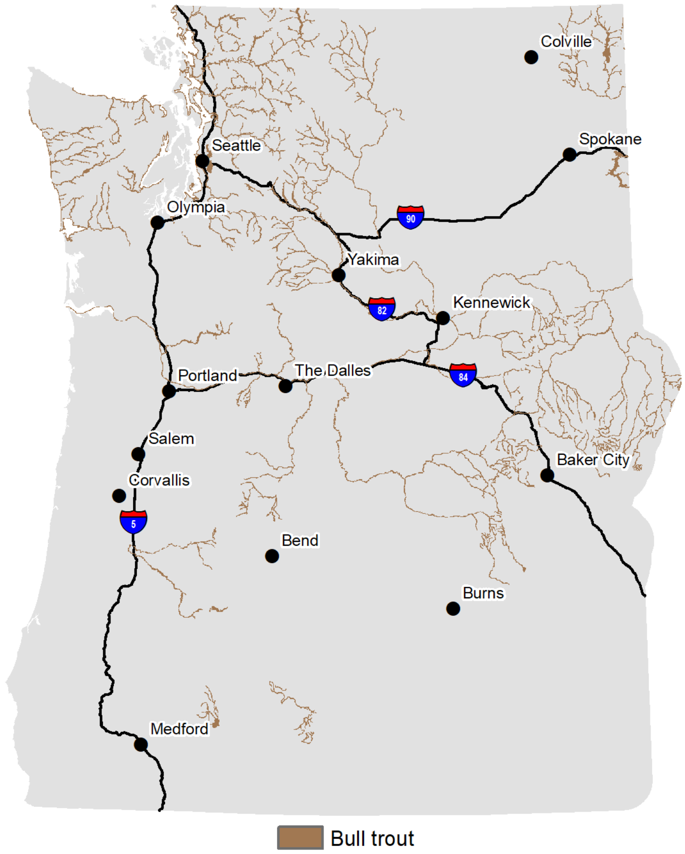

Figure 30. Map of bull trout distribution in the PNRA analysis area.

Table 29. Response functions for trout Sub-HVRAs to highlight bull trout.

Sub-HVRA	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6	Share of RI[1]	Acres
Bull trout	20	20	10	-10	-20	-50	6.16%	1,115,646
Steelhead trout	20	20	10	-10	-30	-60	5.29%	1,340,056
Redband trout	20	20	10	-10	-20	-50	5.40%	854,616
Coastal cutthroat trout	20	20	10	-10	-20	-50	0.30%	42,621
Lahontan cutthroat trout	20	20	10	-10	-20	-50	0.10%	13,206

[1] Within-HVRA relative importance.

3.4.6.5 Chinook Salmon

Chinook salmon USFWS critical habitat (not general species distribution) for the PNRA analysis area is shown in Figure 31. Chinook critical habitat was included in the assessment due to the species' listed status and economic importance to the Region. The critical habitat map was obtained from the U.S. Fish and Wildlife Service, Endangered Species Program, critical habitat shapefile and clipped to the analysis area boundary. These lines were converted to 30-m raster and expanded out 3 pixels on either side to capture the area impacted by wildfire.

The chinook salmon response to fire is characterized as slightly beneficial for FILs 1-3 but shows an increasingly negative response in FILs 4-6 – flame lengths greater than 6 ft. (Table 30).

Chinook habitat received 2.95 percent of the total Wildlife HVRA relative importance. The share of HVRA importance is based on relative importance per unit area and mapped extent.

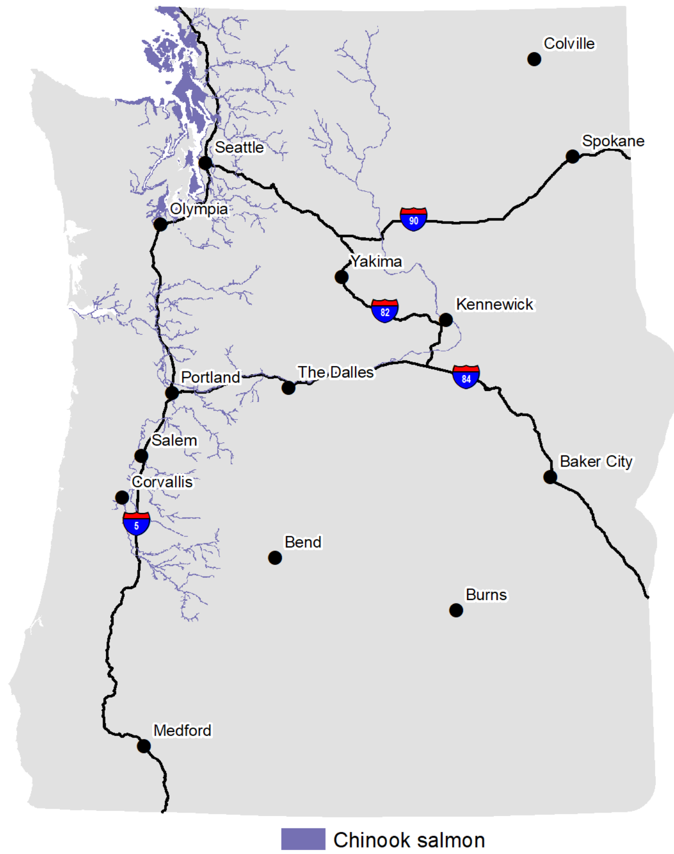

Figure 31. Map of chinook salmon critical habitat in the PNRA analysis area.

Table 30. Response functions for salmon Sub-HVRAs to highlight chinook salmon.

Sub-HVRA	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6	Share of RI[1]	Acres
Coho	20	20	10	-10	-20	-50	5.97%	1,260,079
Chinook	20	20	10	-10	-20	-50	2.95%	933,818

[1] Within-HVRA relative importance.

3.4.6.6 Coho Salmon

Oregon coastal coho salmon critical habitat (not general species distribution) for the PNRA analysis area is shown in Figure 32. Coho critical habitat was included in the assessment due to the species' listed status and economic importance to the Region. The critical habitat map was obtained from the U.S. Fish and Wildlife Service, Endangered Species Program, critical habitat shapefile and clipped to the analysis area boundary. These lines were converted to 30-m raster and expanded out 3 pixels on either side to capture the area impacted by wildfire.

The coho salmon response to fire is characterized as slightly beneficial for FILs 1-3 but shows an increasingly negative response in FILs 4-6 – flame lengths greater than 6ft. (Table 31).

Coho habitat received 5.97 percent of the total Wildlife HVRA relative importance. The share of HVRA importance is based on relative importance per unit area and mapped extent.

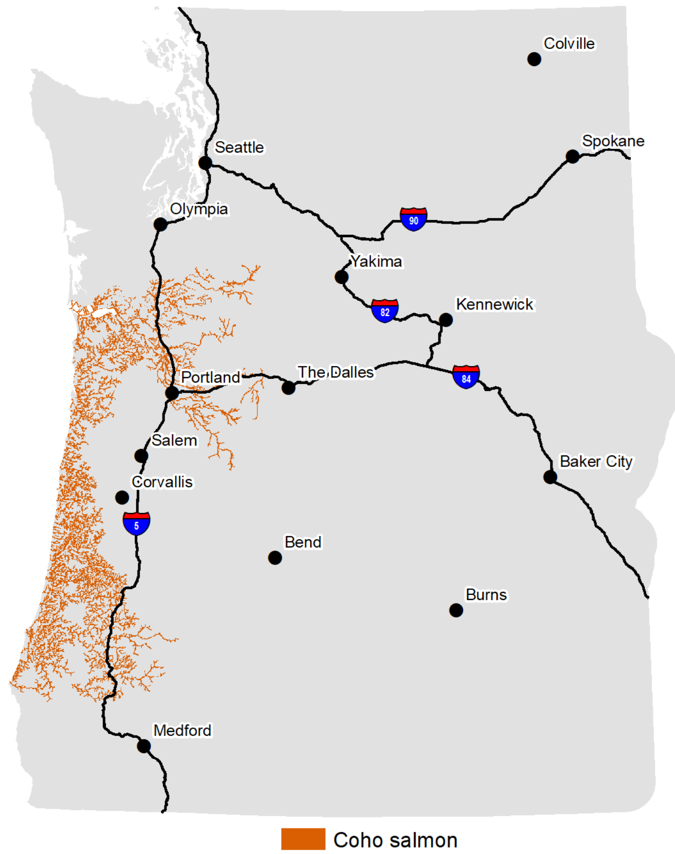

Figure 32. Map of Oregon coastal coho salmon critical habitat in the PNRA analysis area.

Table 31. Response functions for salmon Sub-HVRAs to highlight coho salmon.

Sub-HVRA	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6	Share of RI[1]	Acres
Coho	20	20	10	-10	-20	-50	5.97%	1,260,079
Chinook	20	20	10	-10	-20	-50	2.95%	933,818

[1] Within-HVRA relative importance.

3.4.6.7 Steelhead Trout

Steelhead trout USFWS critical habitat (not general species distribution) for the PNRA analysis area is shown in Figure 33. Steelhead critical habitat was included in the assessment due to the species' listed status and economic importance to the Region. The critical habitat data was obtained from the U.S. Fish and Wildlife Service, Endangered Species Program, critical habitat shapefile and clipped to the analysis area boundary. These lines were converted to 30-m raster and expanded out 3 pixels on either side to capture the area impacted by wildfire.

The steelhead trout response to fire is characterized as slightly beneficial for FILs 1-3 but shows an increasingly negative response in FILs 4-6 – flame lengths greater than 6 ft. (Table 32).

Steelhead habitat received 5.29 percent of the total Wildlife HVRA relative importance. The share of HVRA importance is based on relative importance per unit area and mapped extent.

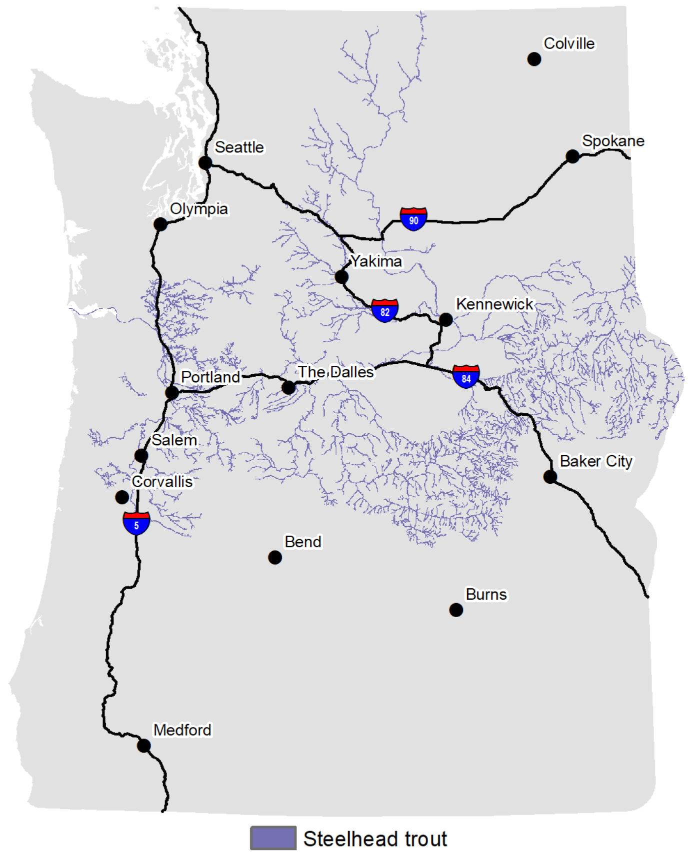

Figure 33. Map of steelhead trout critical habitat in the PNRA analysis area.

Table 32. Response functions for trout Sub-HVRAs to highlight steelhead trout.

Sub-HVRA	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6	Share of RI[1]	Acres
Bull trout	20	20	10	-10	-20	-50	6.16%	1,115,646
Steelhead trout	20	20	10	-10	-30	-60	5.29%	1,340,056
Redband trout	20	20	10	-10	-20	-50	5.40%	854,616
Coastal cutthroat trout	20	20	10	-10	-20	-50	0.30%	42,621
Lahontan cutthroat trout	20	20	10	-10	-20	-50	0.10%	13,206

[1] Within-HVRA relative importance.

3.4.6.8 Redband Trout

Redband trout distribution for the PNRA analysis area is shown in Figure 34. Redband trout were included in the assessment because of concern over species isolation and ability to recolonize following a severe wildfire. The habitat data was obtained from the Non-Anadromous Redband Trout (RBT) Range-wide Database and clipped to the analysis area boundary. These lines were converted to 30-m raster and expanded out 3 pixels on either side to capture the area impacted by wildfire.

The redband trout response to fire is characterized as slightly beneficial for FILs 1-3 but shows an increasingly negative response in FILs 4-6 – flame lengths greater than 6 ft. (Table 33).

Redband trout habitat received 5.4 percent of the total Wildlife HVRA relative importance. The share of HVRA importance is based on relative importance per unit area and mapped extent.

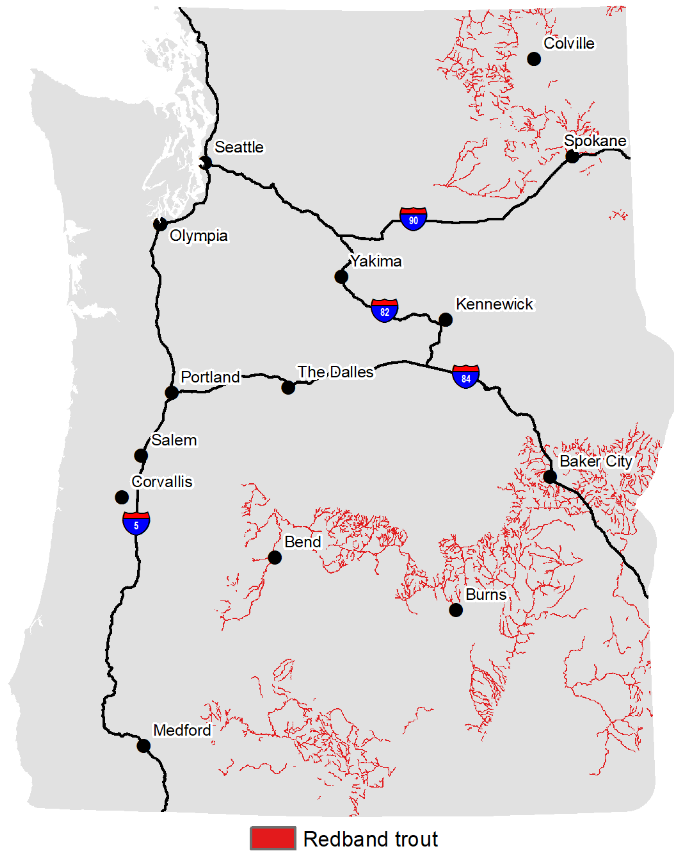

Figure 34. Map of redband trout distribution in the PNRA analysis area.

Table 33. Response functions for trout Sub-HVRAs to highlight redband trout.

Sub-HVRA	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6	Share of RI[1]	Acres
Bull trout	20	20	10	-10	-20	-50	6.16%	1,115,646
Steelhead trout	20	20	10	-10	-30	-60	5.29%	1,340,056
Redband trout	20	20	10	-10	-20	-50	5.40%	854,616
Coastal cutthroat trout	20	20	10	-10	-20	-50	0.30%	42,621
Lahontan cutthroat trout	20	20	10	-10	-20	-50	0.10%	13,206

[1] Within-HVRA relative importance.

3.4.6.9 Coastal Cutthroat Trout

Coastal cutthroat trout habitat for the PNRA analysis area is shown in Figure 35. Coastal cutthroat trout were included in the assessment because of concern over species isolation and ability to recolonize following a severe wildfire. The distribution data was obtained from the StreamNet Generalized Fish Distribution layer for coastal cutthroat trout. These lines were converted to 30-m raster and expanded out 3 pixels on either side to capture the area impacted by wildfire.

The coastal cutthroat trout response to fire is characterized as slightly beneficial for FILs 1-3 but shows an increasingly negative response in FILs4-6 – flame lengths greater than 6 ft. (Table 34).

Coastal cutthroat trout habitat received 0.3 percent of the total Wildlife HVRA relative importance. The share of HVRA importance is based on relative importance per unit area and mapped extent.

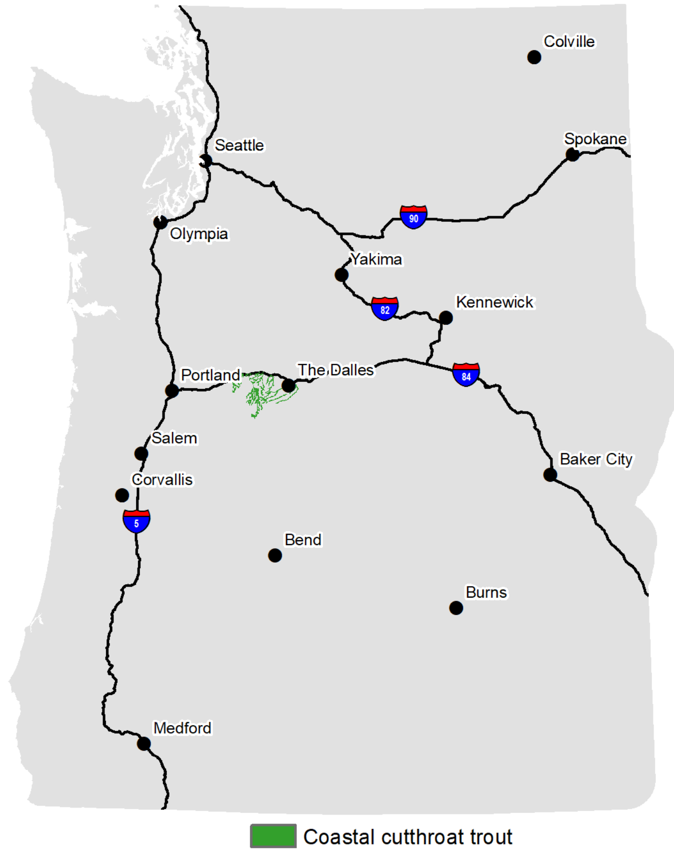

Figure 35. Map of coastal cutthroat trout distribution in the PNRA analysis area.

Table 34. Response functions for trout Sub-HVRAs to highlight coastal cutthroat trout.

Sub-HVRA	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6	Share of RI[1]	Acres
Bull trout	20	20	10	-10	-20	-50	6.16%	1,115,646
Steelhead trout	20	20	10	-10	-30	-60	5.29%	1,340,056
Redband trout	20	20	10	-10	-20	-50	5.40%	854,616
Coastal cutthroat trout	20	20	10	-10	-20	-50	0.30%	42,621
Lahontan cutthroat trout	20	20	10	-10	-20	-50	0.10%	13,206

[1] Within-HVRA relative importance.

3.4.6.10 Lahontan Cutthroat Trout

Lahontan cutthroat trout habitat for the PNRA analysis area is shown in Figure 36. Lahontan cutthroat trout were included in the assessment because of concern over species isolation and ability to recolonize following a severe wildfire. The distribution data was obtained from the StreamNet Generalized Fish Distribution layer for Lahontan cutthroat trout. These lines were converted to 30-m raster and expanded out 3 pixels on either side to capture the area impacted by wildfire.

The Lahontan cutthroat trout response to fire is characterized as slightly beneficial for FILs 1-3 but shows an increasingly negative response in FILs 4-6 – flame lengths greater than 6 ft. (Table 35).

Lahontan cutthroat trout habitat received 0.1 percent of the total Wildlife HVRA relative importance. The share of HVRA importance is based on relative importance per unit area and mapped extent.

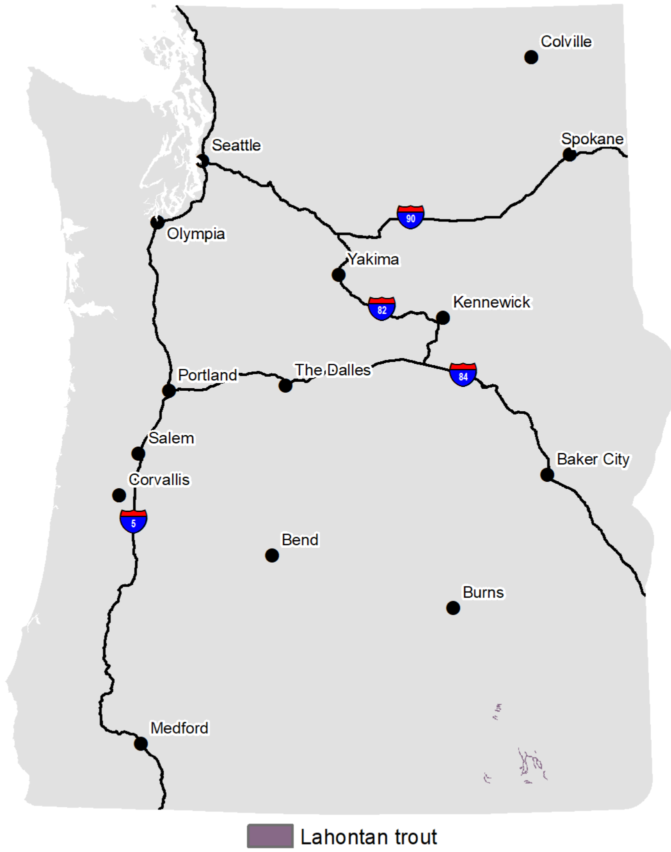

Figure 36. Map of Lahontan trout distribution in the PNRA analysis area.

Table 35. Response functions for trout Sub-HVRAs to highlight Lahontan cutthroat trout.

Sub-HVRA	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6	Share of RI[1]	Acres
Bull trout	20	20	10	-10	-20	-50	6.16%	1,115,646
Steelhead trout	20	20	10	-10	-30	-60	5.29%	1,340,056
Redband trout	20	20	10	-10	-20	-50	5.40%	854,616
Coastal cutthroat trout	20	20	10	-10	-20	-50	0.30%	42,621
Lahontan cutthroat trout	20	20	10	-10	-20	-50	0.10%	13,206

[1] Within-HVRA relative importance.

3.5 Effects Analysis Methods

An effects analysis quantifies wildfire risk as the expected value of net response (Finney, 2005; Scott et al., 2013b) also known as expected net value change (eNVC). This approach has been applied at a national scale (Calkin et al., 2010), in regional and sub-regional assessments (Thompson et al., 2015; Thompson et al., 2016) and several forest-level assessments of wildfire risk (Scott and Helmbrecht, 2010; Scott et al., 2013a). Effects analysis relies on input from resource specialists to produce a tabular response function for each HVRA occurring in the analysis area. A response function is a tabulation of the relative change in value of an HVRA if it were to burn in each of six flame-length classes. A positive value in a response function indicates a benefit, or increase in value; a negative value indicates a loss, or decrease in value. Response function values ranged from -100 (greatest possible loss of resource value) to +100 (greatest possible increase in value).

3.5.1 *Effects Analysis Calculations*

Integrating HVRAs with differing units of measure (for example, habitat vs. homes) requires relative importance (RI) values for each HVRA/sub-HVRA. These values were identified in the RI workshop, as discussed in Section 3. The final importance weight used in the risk calculations is a function of overall HVRA importance, sub-HVRA importance, and relative extent (pixel count) of each sub-HVRA. This value is therefore called relative importance per pixel (RIPP).

The RF and RIPP values were combined with estimates of the flame-length probability (FLP) in each of the six flame-length classes to estimate conditional NVC (cNVC) as the sum-product of flame-length probability (FLP) and response function value (RF) over all the six flame-length classes, with a weighting factor adjustment for the relative importance per unit area of each HVRA, as follows:

$$cNVC_j = \sum_{i}^{n} FLP_i * RF_{ij} * RIPP_j$$

where i refers to flame length class (n = 6), j refers to each HVRA, and RIPP is the weighting factor based on the relative importance and relative extent (number of pixels) of each HVRA. The cNVC calculation shown above places each pixel of each resource on a common scale (relative importance), allowing them to be summed across all resources to produce the total cNVC at a given pixel:

$$cNVC = \sum_{j}^{m} cNVC_j$$

where cNVC is calculated for each pixel in the analysis area. Finally, eNVC for each pixel is calculated as the product of cNVC and annual BP:

$$eNVC = cNVC * BP$$

3.5.2 *Downscaling FSim Results for Effects Analysis*

FSim's stochastic simulation approach can be computationally intensive and therefore time constraining on large landscapes. A resulting challenge is to determine a resolution sufficiently fine to retain detail in fuel and terrain features yet produce calibrated results in a reasonable timeframe. Moreover, HVRA are often mapped at the same resolution as the final BP and FLPs produced by FSim. To enable greater resolution on HVRA mapping, we chose to downscale the FSim results to 30 m, consistent with HVRA mapping at 30 m.

We downscaled FSim results using a multi-step process. First, we resampled the original, 120-m BP and FLP grids to 30 m. Next, we used the Focal Statistics tool in ESRI's ArcGIS to calculate the mean BP and FLP, of burnable pixels only, within a 7-pixel by 7-pixel moving window. Finally, we used the smoothed BP and FLP values to "backfill" burnable pixels at 30 m that were coincident with non-burnable fuel at 120 m. The final smoothed grids resulted in original FSim values for pixels that were burnable at both 120 m and 30 m, non-zero burn probability values in burnable pixels that were non-burnable at 120 m, and a BP of zero in non-burnable, 30-m pixels.

4 Analysis Results

4.1 Model Calibration to Historical Occurrence

Due to the highly varied nature of weather and fire occurrence across the large landscape, we ran FSim for each of the twenty-three FOAs independently, and then compiled the 23 runs into a single data product. For each FOA, we parameterized and calibrated FSim based on the location of historical fire ignitions within the FOA, which is consistent with how the historical record is compiled. We then used FSim to start fires only within each FOA, but allowed those fires to spread outside of the FOA. This, too, is consistent with how the historical record is compiled. All FOAs were calibrated to well within the 70% confidence interval for average wildfire size and frequency. Additionally, we calibrated each FOA to accurately mimic the distribution of wildfire sizes in the historical record to allow for future fireshed, WUI housing risk, or other types of analyis that utilize the perimiter event set.

4.2 FSim Results

FSim burn probability and flame length exceedance probability model results are presented for the PNRA analysis area in sections 4.2.1 and 4.2.2, respectively. Additionally, all FSim results are presented in the Deliverables folder and are described in further detail in section 6. FSim produced wildfire hazard results for each FOA, including burn probability and conditional flame length probability. From the base FSim outputs, flame length exceedance probabilities were calculated for each FOA. The twenty-three FOAs were combined using the calculations described above to produce integrated maps of wildfire hazard for the entire analysis area.

4.2.1 *Burn Probability*

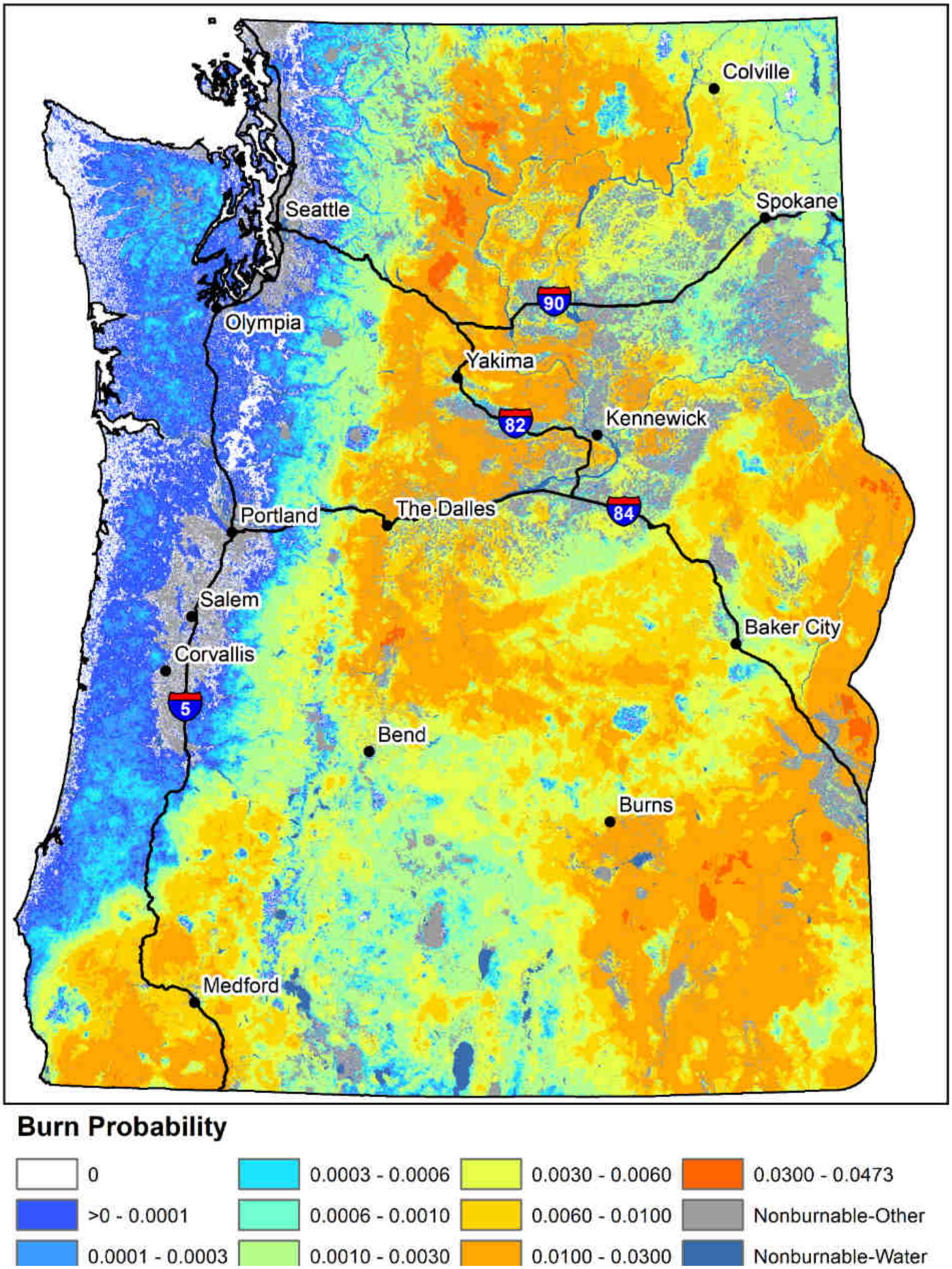

Figure 37. Map of integrated FSim burn probability results for the PNRA study area.

4.2.2 *Flame Length Exceedance Probability*

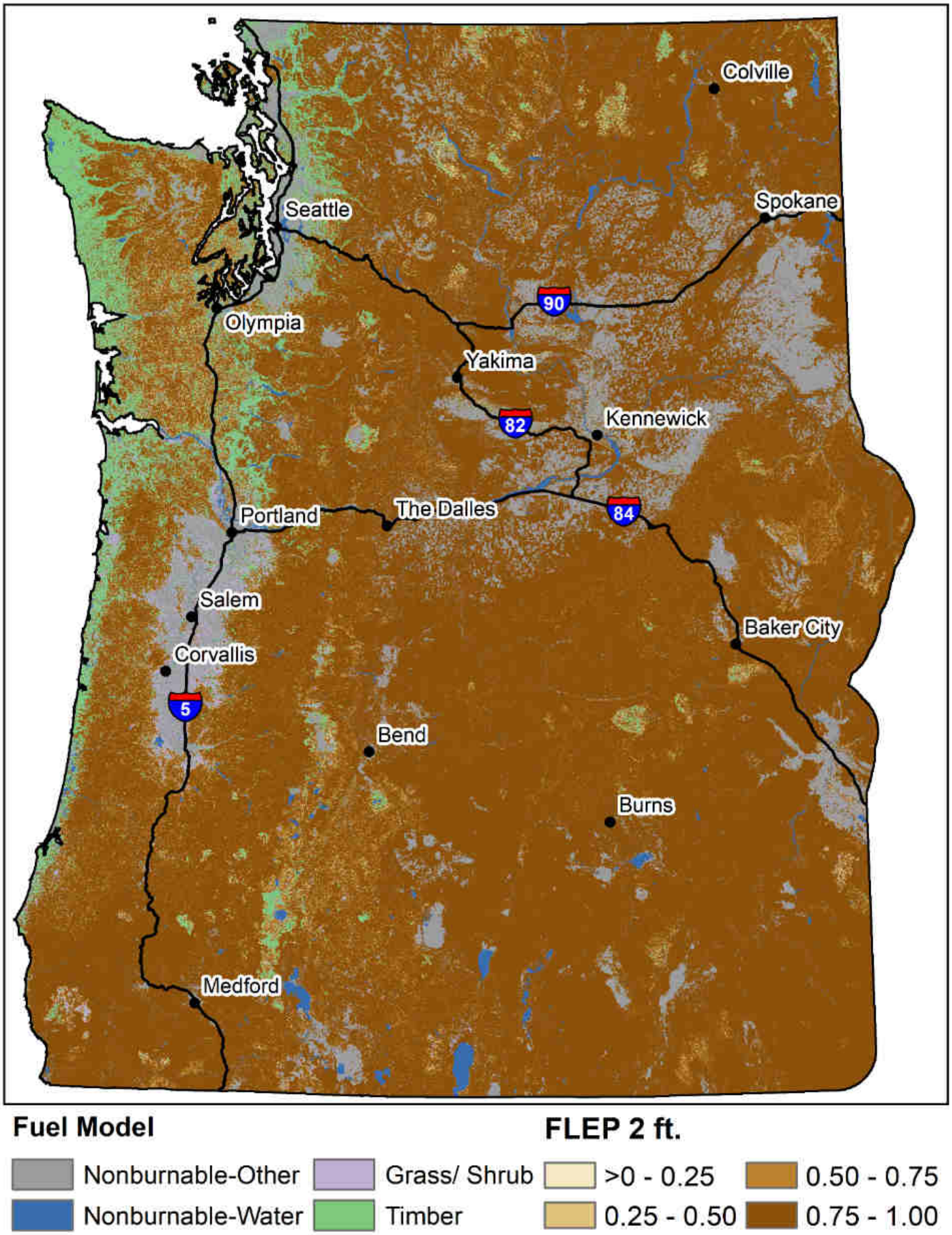

Figure 38. Map of FSim flame length exceedance probability: 2-ft. results for the PNRA study area.

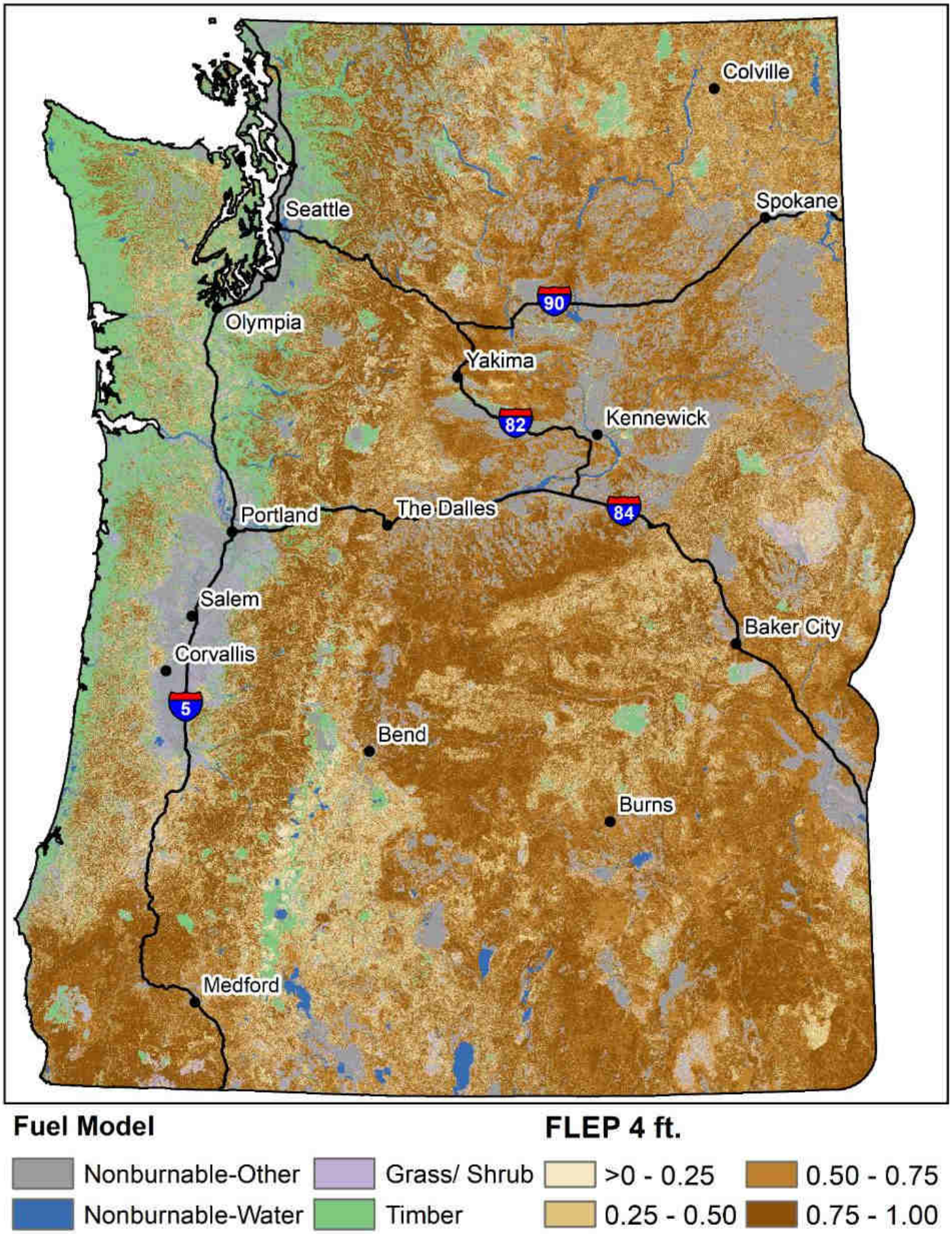

Figure 39. Map of FSim flame length exceedance probability: 4-ft. results for the PNRA study area.

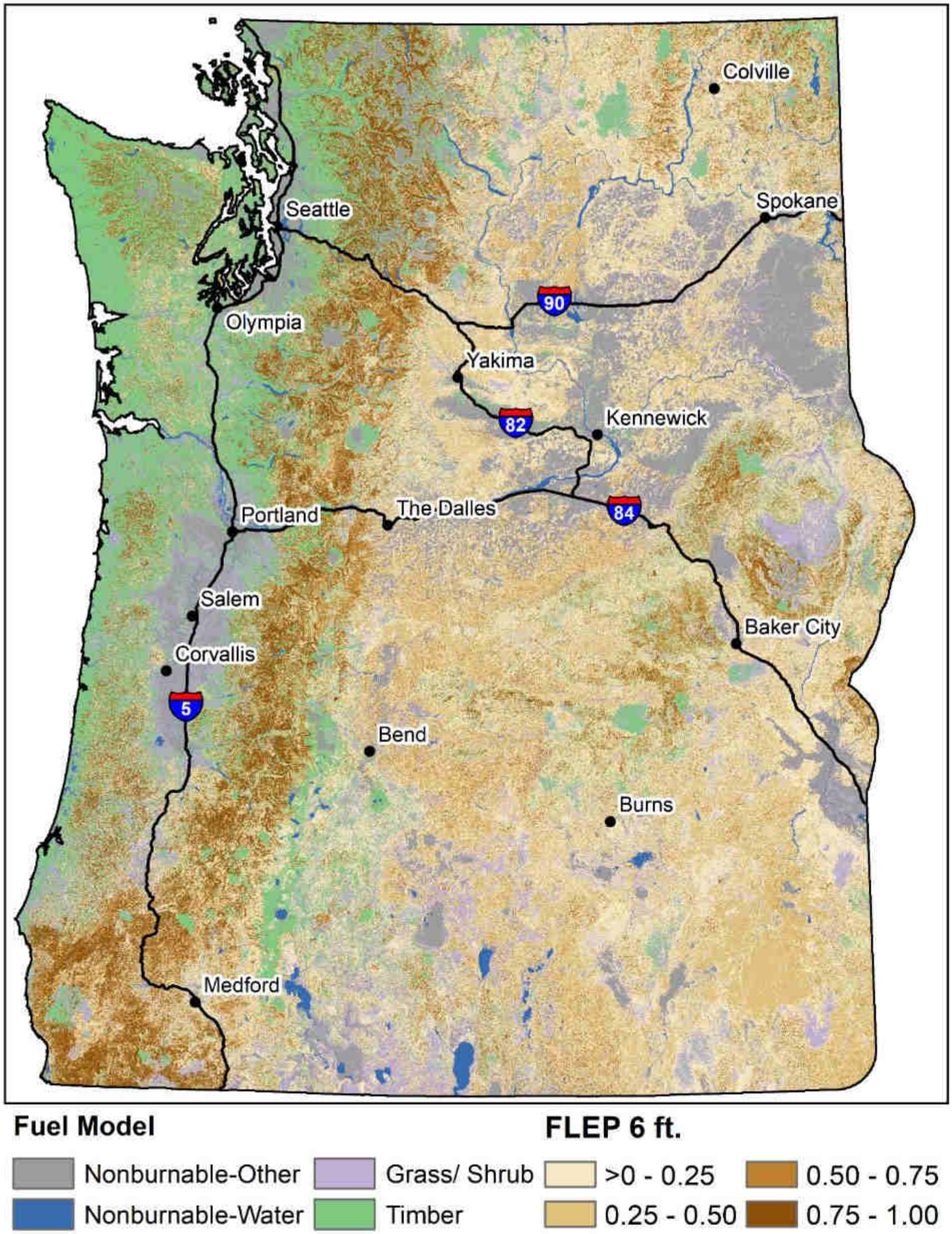

Figure 40. Map of FSim flame length exceedance probability: 6-ft. results for the PNRA study area.

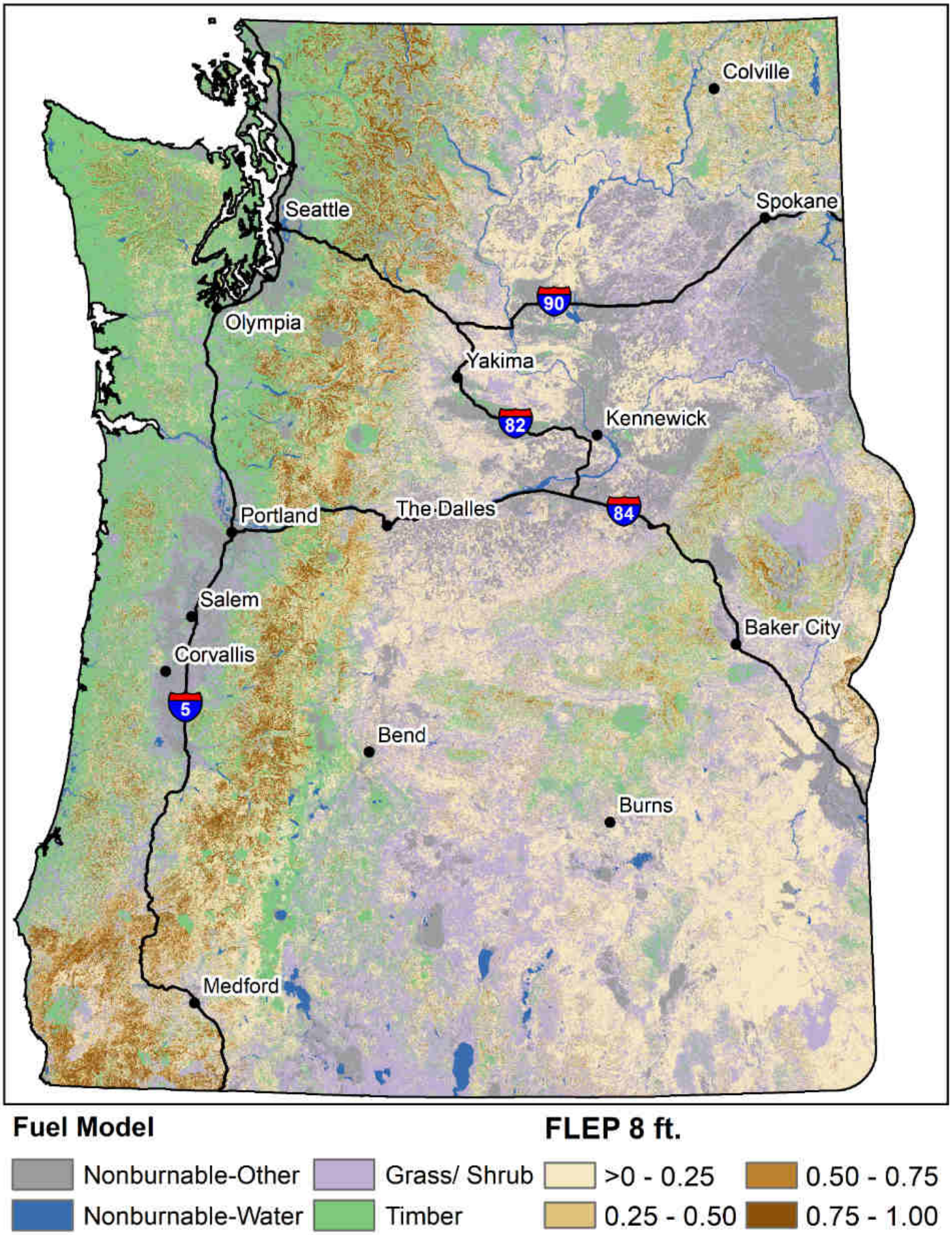

Figure 41. Map of FSim flame length exceedance probability: 8-ft. results for the PNRA study area.

4.2.3 *FSim Zonal Summary Results*

FSim results were summarized using zonal statistics for the 17 national forests in the PNRA analysis area as well as for a 2-km buffer between each of those forests and lands administered by other ownerships. Figure 42 below demonstrates an example of the 2-km buffer surrounding the Fremont-Winema National Forest that was used in the zonal summary analysis. Note that the buffer does not include areas where two national forests are adjoining. The 2-km buffer can be viewed as a surrogate for the national forest-wildland-urban interface although this analysis does not consider the relative density of structures. Figure 43, Figure 45, and Figure 47 depict zonal summaries of the FSim results for the 17 national forests in the PNRA analysis area while Figure 44, Figure 46, and Figure 48 depict zonal summaries for the 2-km buffer around those forests.

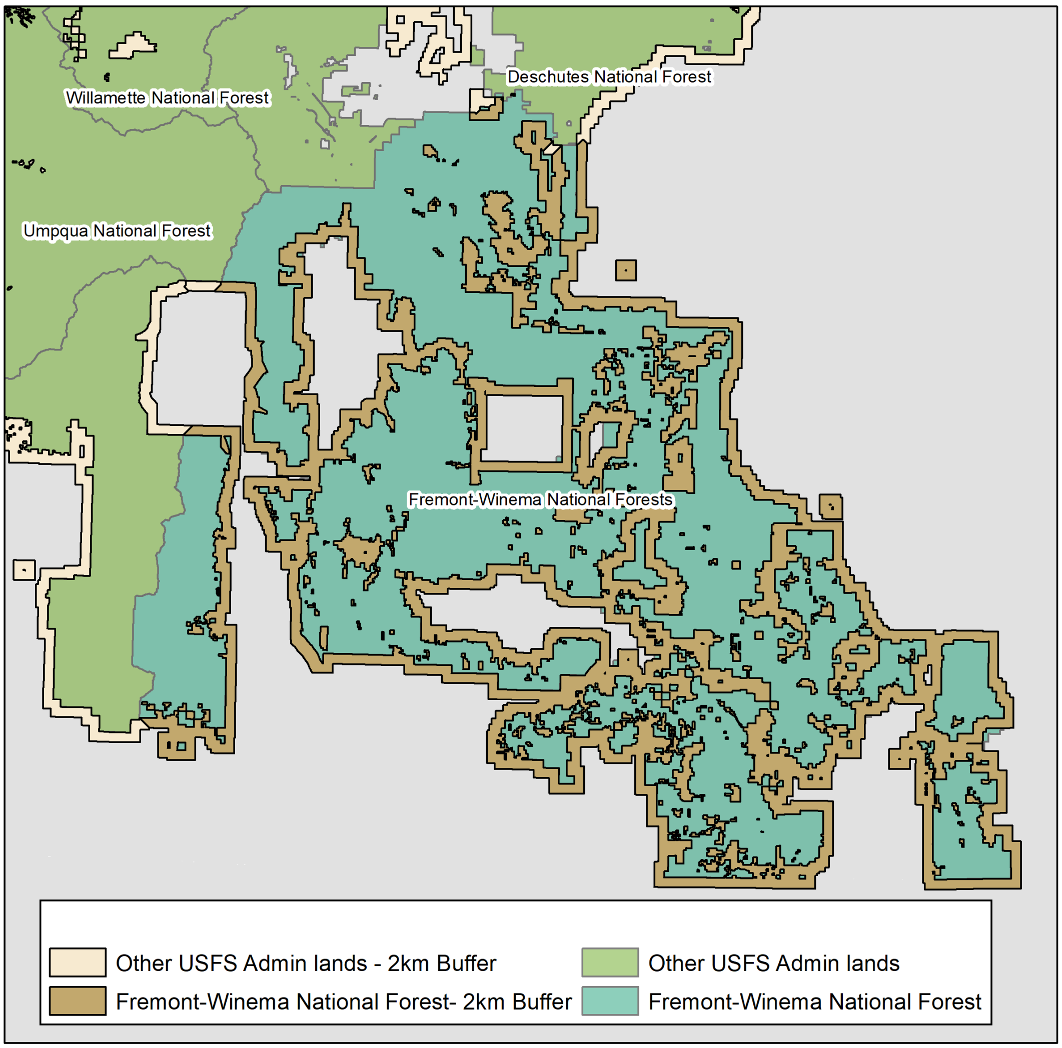

Figure 42. Map illustrating the 2-km buffer area used in the zonal summaries. The 2-km buffer represents the area between USFS lands and non-USFS lands. The area where two national forests meet is not included.

Additionally, Appendices A1-A3 provide numerical data summaries of FSim results for individual national forests, the 2-km buffer around national forests, and individual national forest ranger districts. These summaries allow for a comparison between forests of the relative likelihood of wildfire occurrence, the probability of high intensity wildfire behavior, as well as an effects analysis described below in section 4.3.

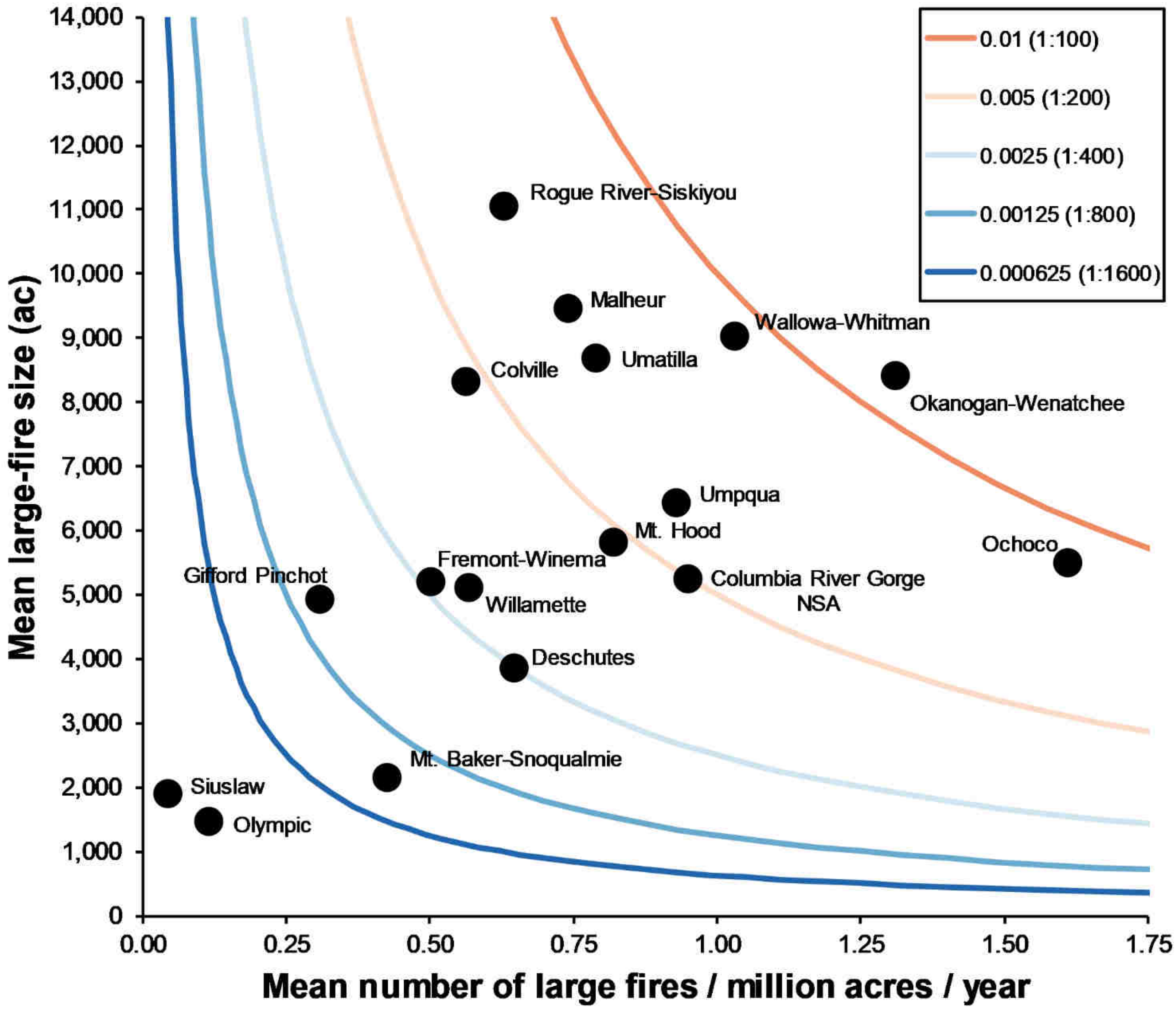

Figure 43. Simulated mean large-fire size and mean number of large fires per million acres per year for the 17 national forests in the PNRA study area. The curved lines represent lines of equal burn probability.

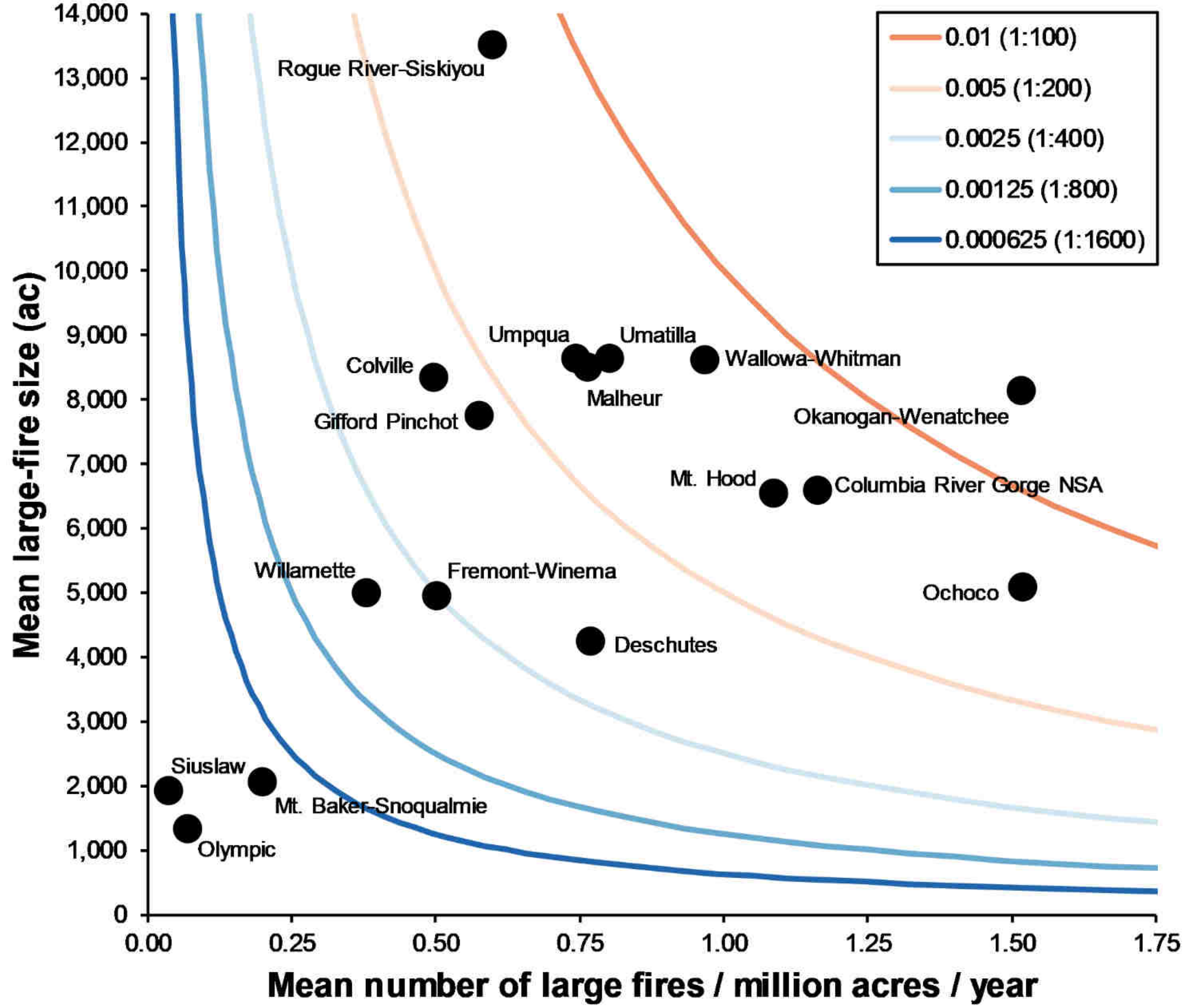

Figure 44. Simulated mean large-fire size and mean number of large fires per million acres per year for a 2-kilometer buffer around the 17 national forests in the PNRA study area. The curved lines represent lines of equal burn probability.

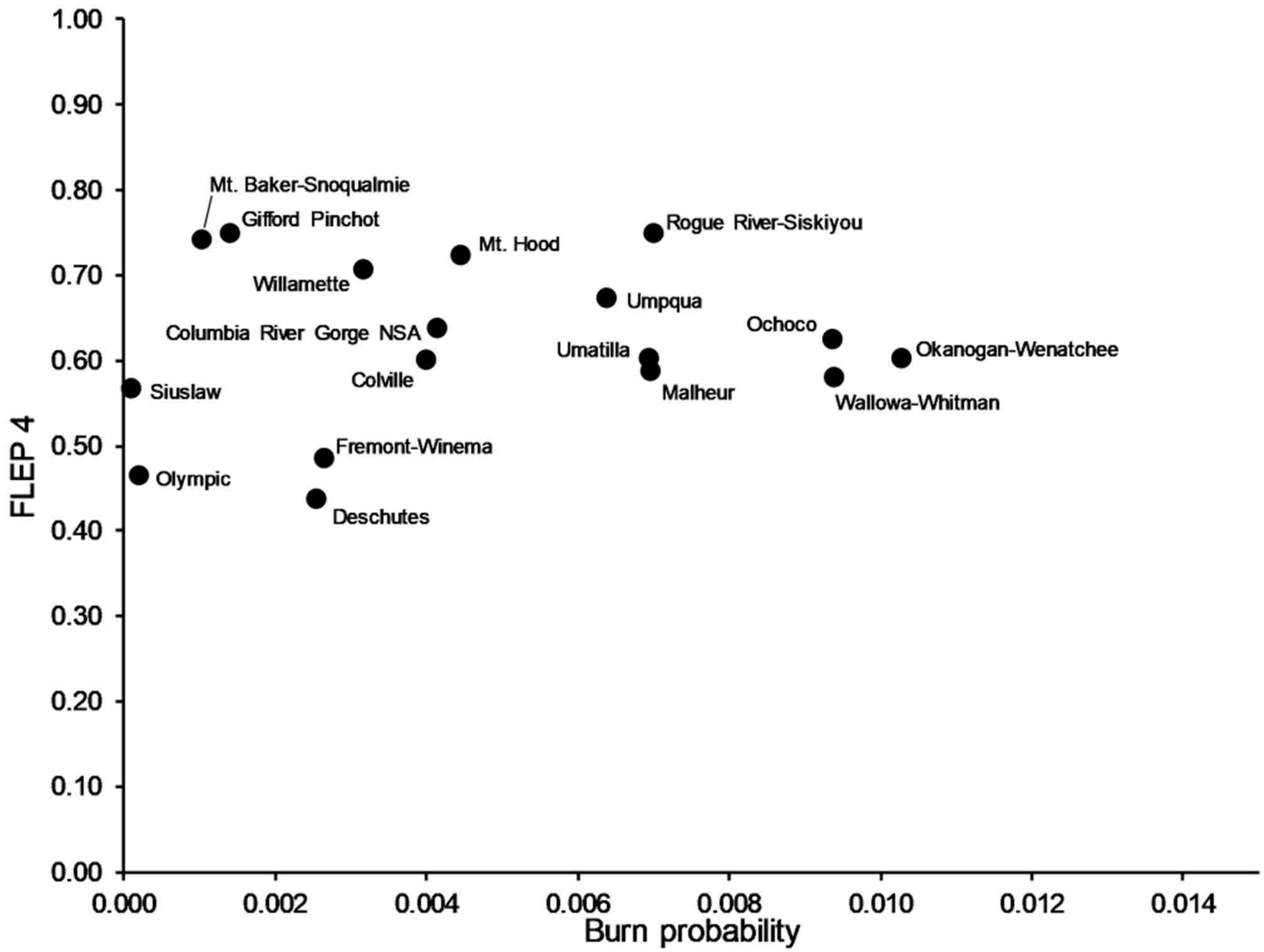

Figure 45. Graph of the 4-foot flame length exceedance probability and burn probability for the 17 national forests in the PNRA study area.

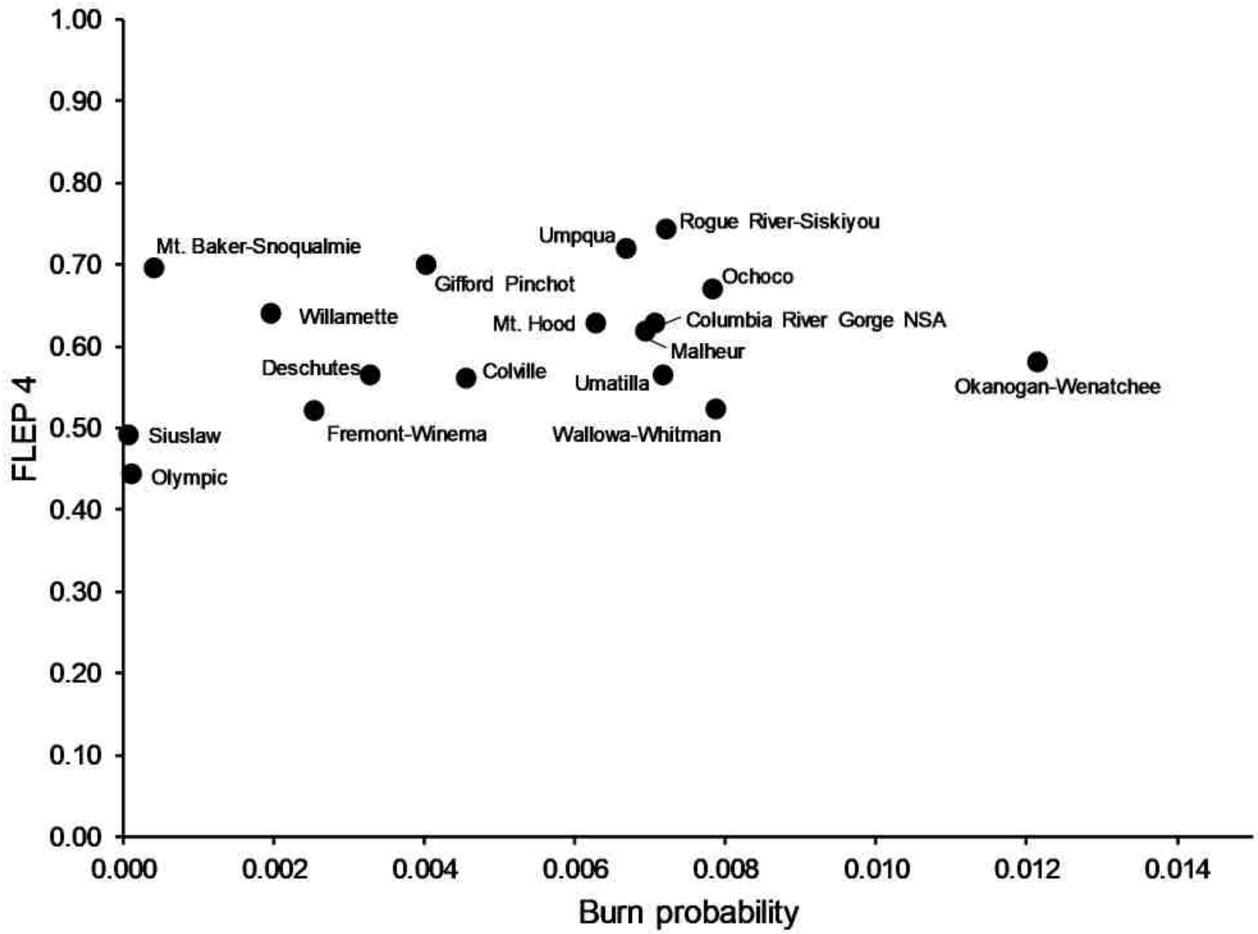

Figure 46. Graph of the 4-foot flame length exceedance probability and burn probability for a 2-kilometer buffer around the 17 national forests in the PNRA study area.

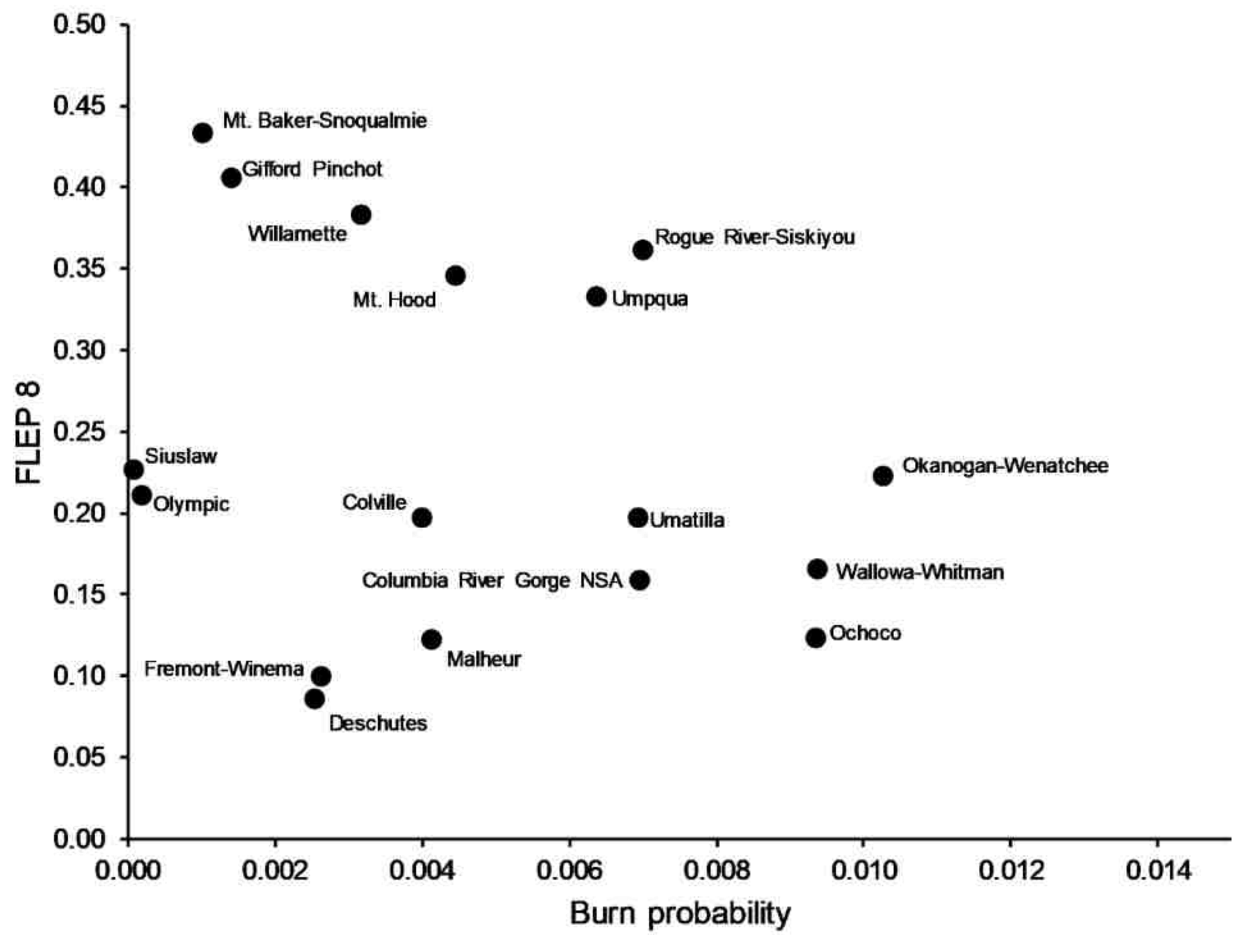

Figure 47 . Graph of the 8-foot flame length exceedance probability and burn probability for the 17 national forests in the PNRA study area.

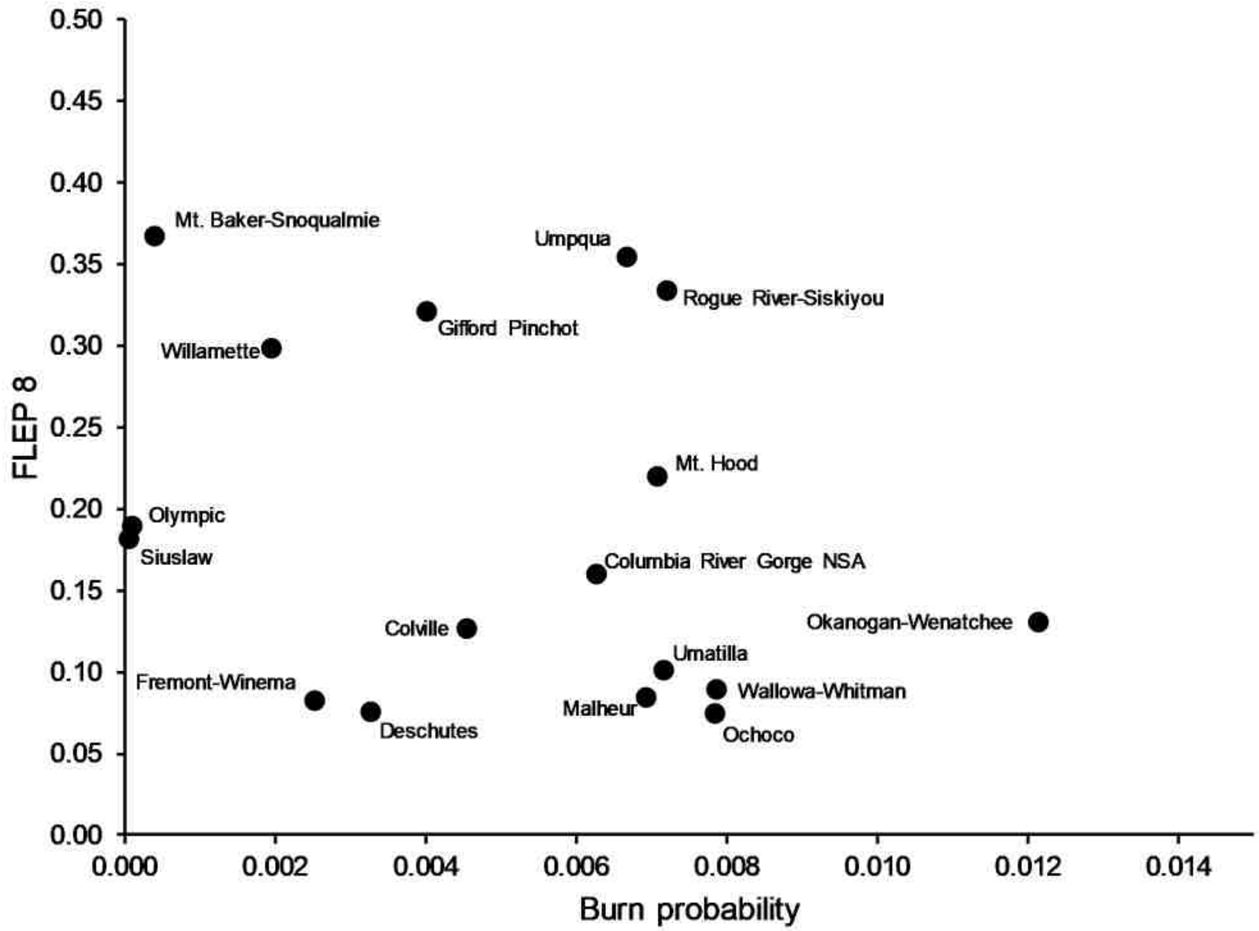

Figure 48 . Graph of the 8-foot flame length exceedance probability and burn probability for a 2-kilometer buffer around the 17 national forests in the PNRA study area.

4.3 Effects Analysis

The cumulative results of the wildfire risk calculations described in section 3.5.1 are the spatial grids of cNVC and eNVC, representing both the conditional and expected change in value from wildfire disturbance to all HVRAs included in the analysis. Results are therefore limited to those pixels that have at least one HVRA and a non-zero burn probability. Both cNVC and eNVC reflect an HVRAs' response to fire and their relative importance within the context of the assessment, while eNVC additionally captures the relative likelihood of wildfire disturbance. Cumulative effects of wildfire vary by HVRA (Figure 49) with a net positive eNVC for Vegetation condition, a relatively minimal net negative eNVC for Municipal watersheds, and an increasingly negative eNVC for Infrastructure and Recreation, Wildlife, and Timber, with People/Property showing the most negative net eNVC result. Figure 50 shows cNVC results across the analysis area, with beneficial effects shown in light blue and negative effects shown in dark red. Adjusting cNVC by fire likelihood (i.e., burn probability) narrows the range of values for both negative and positive outcomes as seen in the eNVC map in Figure 51.

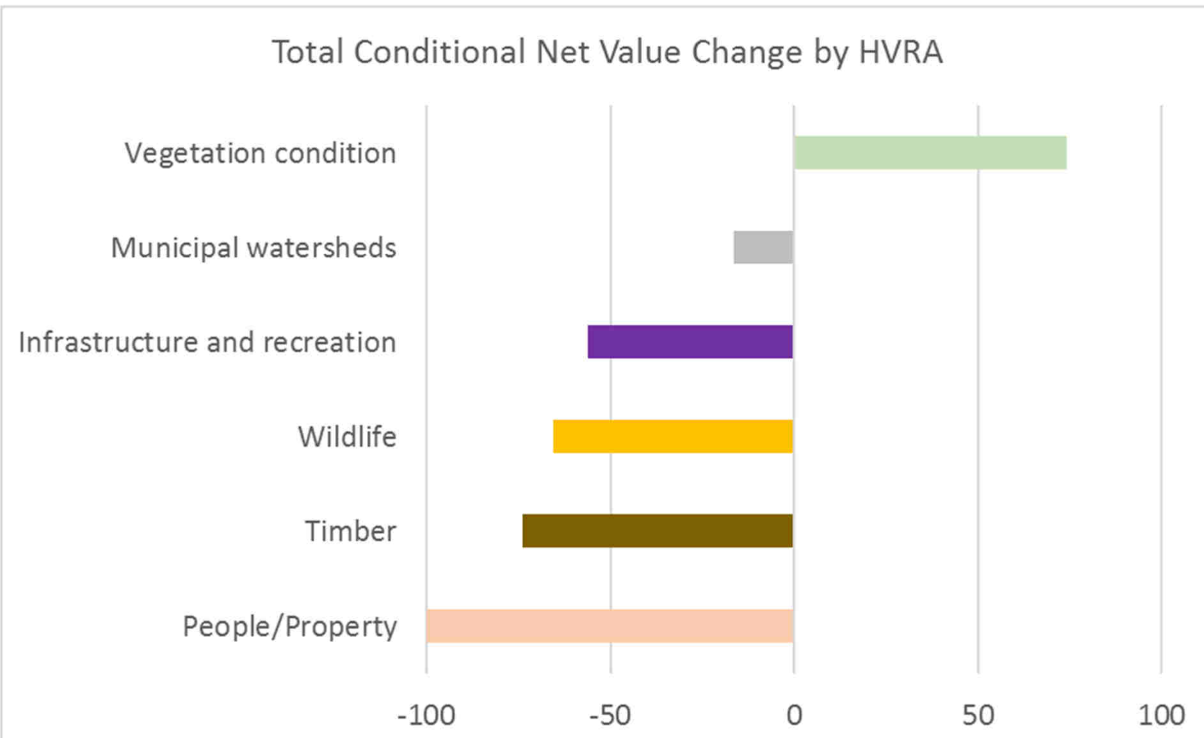

Figure 49: Weighted net response over all highly valued resources and assets (HVRAs) in the assessment. HVRAs are listed in order from greatest expected positive net value change (response) at the top, to greatest negative net value change at the bottom.

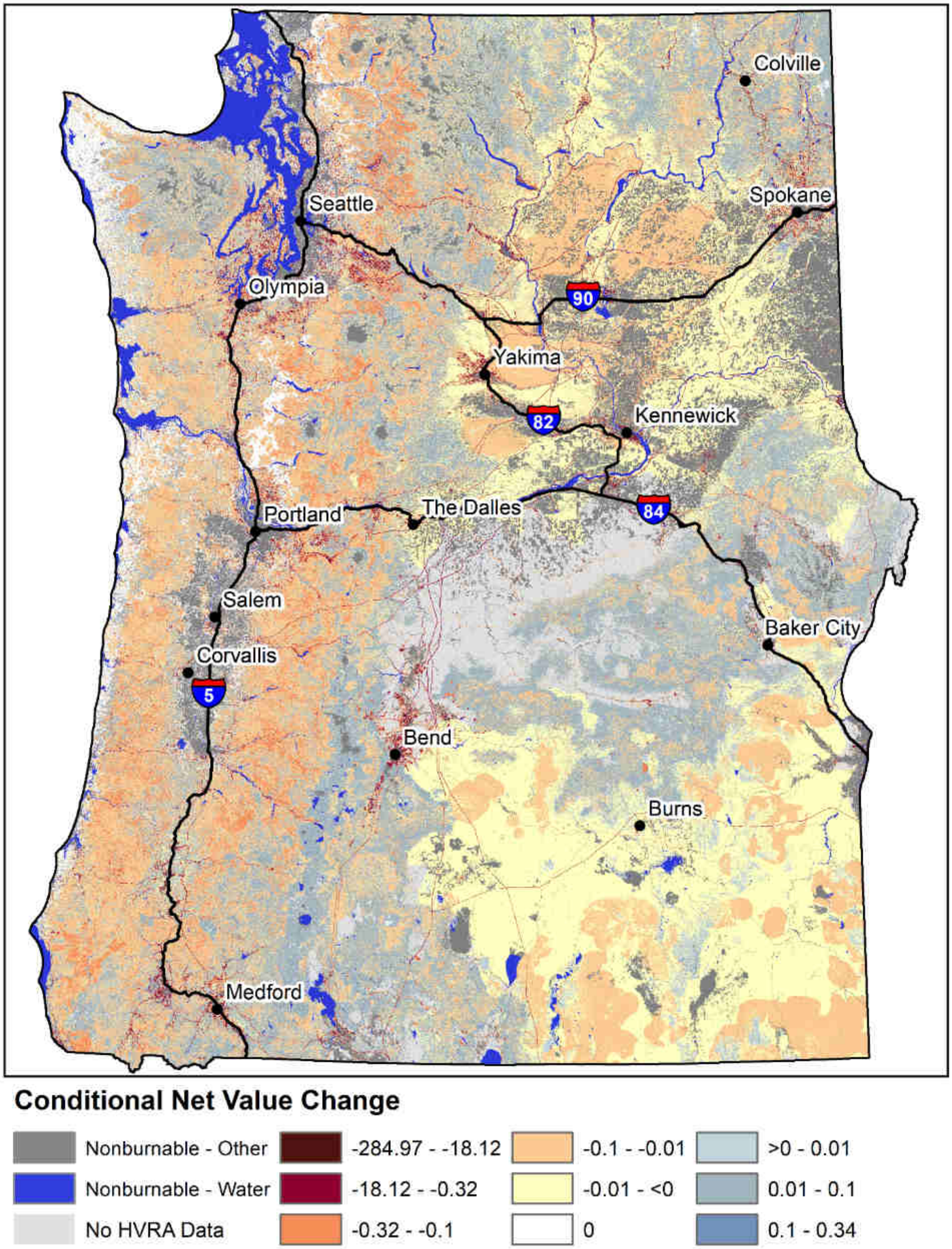

Figure 50: Map of Conditional Net Value Change (cNVC) for the PNRA analysis area.

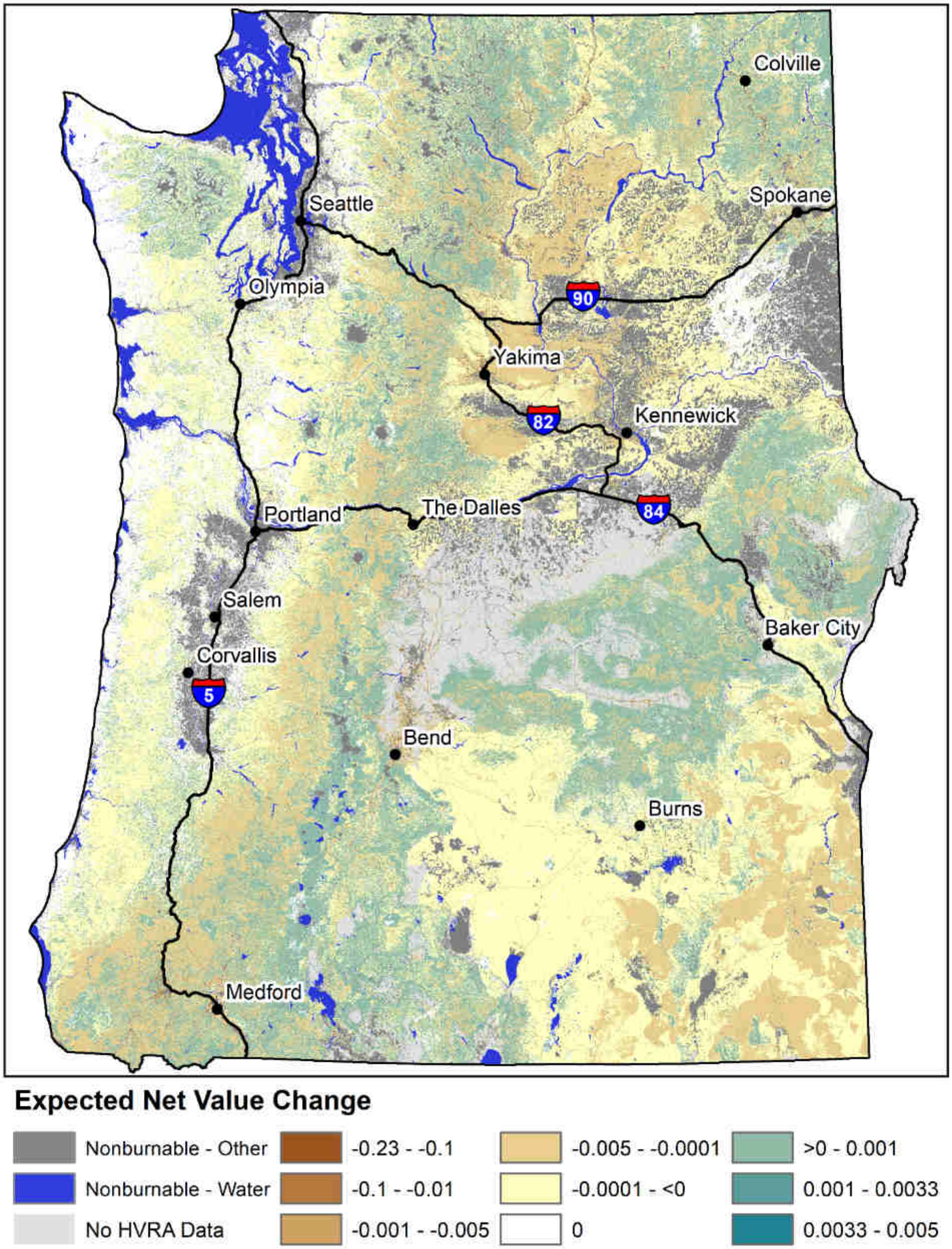

Figure 51: Map of Expected Net Value Change (eNVC) for the PNRA analysis area.

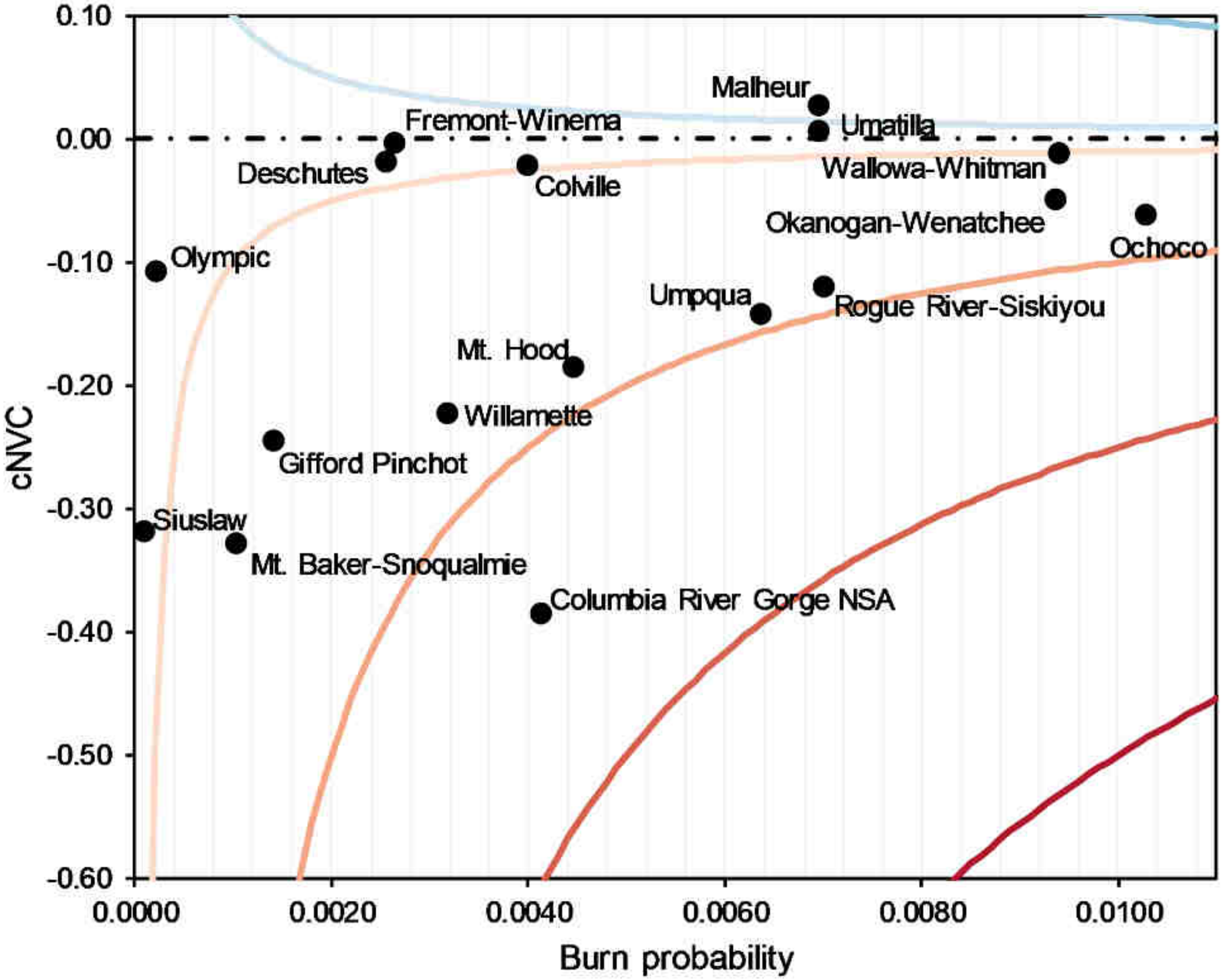

Figure 52. Graph of conditional net value change and burn probability for the 17 national forests in the PNRA study area. The curved lines represent lines of equal expected net value change.

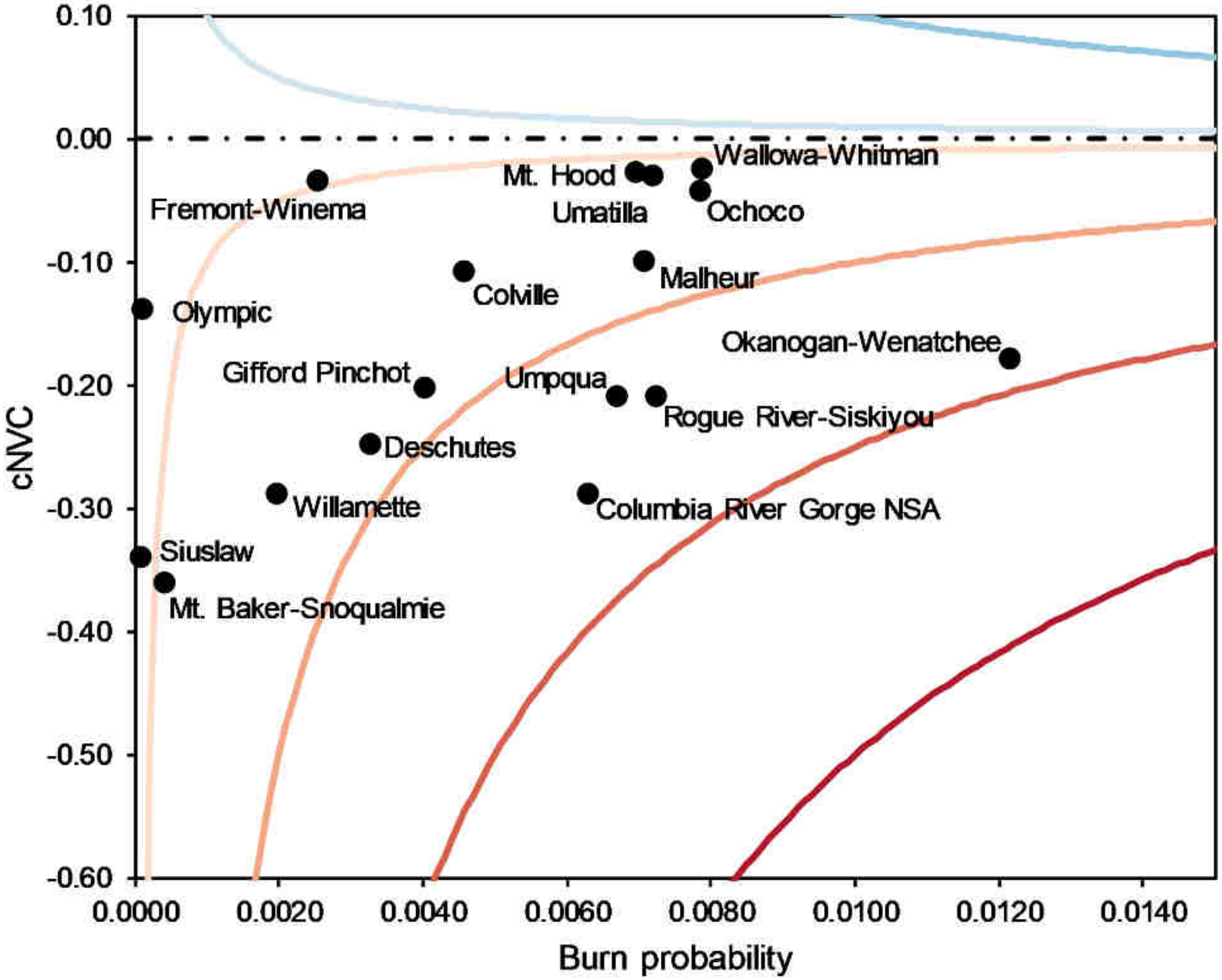

Figure 53. Graph of conditional net value change and burn probability for a 2-kilometer buffer around the 17 national forests in the PNRA study area. The curved lines represent lines of equal expected net value change.

5 Analysis Summary

The Pacific Northwest QWRA provides foundational information about wildfire hazard and risk to highly valued resources and assets across the Region. The results represent the best available science across a range of disciplines. While this report was generated by Pyrologix LLC, the overall analysis was developed as a collaborative effort with numerous USFS, BLM, TNC, ODF, and WA DNR, Fire/Fuels Planners, Resource Specialists, Wildlife Biologists, Geospatial Analysts, and Information Specialists. This analysis can provide great utility in a range of applications including: resource planning, prioritization and implementation of prevention and mitigation activities and wildfire incident response planning. Lastly, this analysis should be viewed as a living document. While the effort to parameterize and to calibrate model inputs should remain static, the landscape file should be periodically revisited and updated to account for future forest disturbances. Additionally, the HVRA mapping may also need to be updated to account for forthcoming resource challenges and needs within the geographic area.

6 Data Dictionary

- FSim modeling results are presented in three geodatabases:
  - **PNRA_120m_V3_Final.gdb** – Mosaic FSim results for the twenty-three FOAs in the PNRA project area.
  - **PNRA_rfV3_AllPerims.gdb** – Event set outputs from FSim that includes all simulated wildfire perimeters.
  - **PNRA_rfV3_AllIgnitions.gdb** – Event set outputs from FSim that include the start location of all simulated wildfire perimeters.

1. **PNRA_120m_V3_Final.gdb** – This geodatabase contains 13 rasters representing mosaic data results from the FSim simulations in the 23 FOAs within the PNRA project area:
   a. **FLEP_2 –**

      This dataset represents the conditional probability of exceeding a nominal flame-length value (also known as flame-length exceedance probability, or FLEP). There are five FLEP rasters. FLEP_GT2 is the conditional probability of exceeding a flame length of 2 feet; it is calculated as the sum of iFLP_FIL2 through iFLP_FIL6. FLEP_GT4 is the conditional probability of exceeding a flame length of 4 feet; it is calculated as the sum of iFLP_FIL3 through iFLP_FIL6. FLEP_GT6 is the conditional probability of exceeding a flame length of 6 feet; it is calculated as the sum of iFLP_FIL4 through iFLP_FIL6. FLEP_GT8 is the conditional probability of exceeding a flame length of 8 feet; it is calculated as the sum of iFLP_FIL5 and iFLP_FIL6. There is no raster for FLEP_GT0 because, by definition, for all burnable pixels there is a 100 percent probability that flame length will exceed 0, given that a fire occurs.

      The iFLP_FILx rasters are the integrated (project wide) conditional probabilities of observing flame length in each of six classes: iFLP_FIL1 represents flame lengths from 0 - 2 ft., iFLP_FIL2 represents flame lengths from 2 - 4 ft., iFLP_FIL3 represents flame lengths from 4 - 6 ft., iFLP_FIL4 represents flame lengths from 6 - 8 ft., iFLP_FIL5 represents flame lengths from 8 - 12 ft., and iFLP_FIL6 represents flame lengths >12 ft.

   b. **FLEP_4** – see FLEP_2 description above
   c. **FLEP_6** – see FLEP_2 description above
   d. **FLEP_8** – see FLEP_2 description above
   e. iBP –

      This dataset is a 120-m cell size raster representing annual burn probability across the project area. The individual-FOA BPs were integrated into this overall result for the project area using a natural-weighting method that Pyrologix developed on an earlier project and subsequently published (Thompson and others 2013; "Assessing Watershed-Wildfire Risks on National Forest System Lands in the Rocky Mountain Region of the United States"). With this method, BP values for pixels well within the boundary of a FOA are influenced only by that FOA. Near the border with another FOA the results are influenced by that adjacent FOA. The weighting of each FOA is in proportion to its contribution to the overall BP at each pixel.

   f. **iCFL –**

      This dataset is a 120-m cell size raster representing the mean conditional flame length (given that a fire occurs). It is a measure of the central tendency of flame length. This raster was calculated as the sum-product of iFLP_FILx and the midpoint flame length of each of the six iFLP_FILs. For iFLP_FIL6, for which there is no midpoint, we used a surrogate flame length of 100 feet (representing torching trees).

g. **iFLP_FIL1 –**

This dataset is a 120-m cell size raster representing the mean conditional flame length (given that a fire occurs). This is also called the flame-length probability (FLP) and is a measure of the central tendency of flame length. This raster was calculated as the sum-product of the probability at each flame-length class and the midpoint flame length value of each of the six FILs. For FIL6, for which there is no midpoint, we used a surrogate flame length of 100 feet (representing torching trees) in timber fuel models and a flame length of 20 feet in all in grass, grass-shrub and shrub fuel types.

The individual-FOA iFLP_FILx rasters were integrated into this overall result for the project area using a natural-weighting method that Pyrologix developed on an earlier project and subsequently published (Thompson and others 2013; "Assessing Watershed-Wildfire Risks on National Forest System Lands in the Rocky Mountain Region of the United States"). With this method, the iFLP_FILx values for pixels well within the boundary of a FOA are influenced only by that FOA. Near the border with another FOA the results are also influenced by that adjacent FOA. The weighting of each FOA is in proportion to its contribution to the overall BP at each pixel.

h. **iFLP_FIL2** – see iFLP_FIL1 description above
i. **iFLP_FIL3** – see iFLP_FIL1 description above
j. **iFLP_FIL4** – see iFLP_FIL1 description above
k. **iFLP_FIL5** – see iFLP_FIL1 description above
l. **iFLP_FIL6** – see iFLP_FIL1 description above
m. iMFI –

This dataset is a 120-m cell size raster representing the mean conditional fireline intensity (kW/m) given that a fire occurs. It is a measure of the central tendency of fireline intensity. The individual-FOA MFI rasters were integrated into this overall result for the project area using a natural-weighting method that Pyrologix developed on an earlier project and subsequently published (Thompson and others 2013; "Assessing Watershed-Wildfire Risks on National Forest System Lands in the Rocky Mountain Region of the United States"). With this method, the iMFI values for pixels well within the boundary of a FOA are influenced only by that FOA. Near the border with another FOA the results are also influenced by that adjacent FOA. The weighting of each FOA is in proportion to its contribution to the overall BP at each pixel.

2. **PNRA_rfV3_AllPerims.gdb –** This dataset represents the simulated wildfire perimeters within each of the twenty-three Fire Occurrence Areas (FOA) that comprise the PNRA project area. Each _Perims feature class includes an attribute table with the following attributes:

a. **FIRE_NUMBE** - the unique fire number for a simulation
b. **THREAD_NUM** - the thread number that simulated the fire (the number of threads is determined by the number of CPUs in the workstation, the number of processing cores per CPU, and whether the cores are hyperthreaded.)
c. **ERC_STARTD** - the ERC(G) value on the start day of the fire
d. **ERC_PERCEN** - the ERC(G) percentile associated with ERC_STARTD. The ERC_PERCEN is a simple lookup from the ERC_STARTD from the "percentiles" section of the .frisk file.
e. **NUM_BURNDA** - the number of days the fire burned during the simulation. This does not include any no-burn days (days below the 80th percentile ERC
f. **START_DAY** - the Julian day of the fire start

g. **YEAR** - the iteration number (year) for which the fire was simulated
h. **Xcoord/Ycoord** - the coordinates of the fire's ignition point
i. **CONTAIN** - the reason for the cessation of fire growth on the simulated fire
j. **FOA** – the FOA number where the ignition is located
k. **UNQ_ID** – concatenation of FOA number and FIRE_NUMBE
l. **NumIterations** – the number of iterations within a simulation. Individual FOAs were run with 10,000 iterations. When generating additional analytical products from the FSim event set, results must be weighted by iteration number to avoid introducing error
m. **GIS_SizeAc** – the final wildfire size (acres) generated as an ArcGIS calculation based on feature geometry
n. **GIS_SizeHa** – the final wildfire size (hectares) generated as an ArcGIS calculation based on feature geometry
o. **FSim_SizeAc** - is the final fire size (acres) generated within FSim based on raster count. Best-practice is to calculate GIS acres for each perimeter instead of relying on SizeAc, especially if subsequent analyses will be based on GIS acres
p. **NumParts** – Number of geometry parts in the simulated wildfire perimeter
q. **ContainsIgn** – True/False value (1,0) that describes if the location of the ignition point is contained within the simulated wildfire perimeter polygon. The ignition may not be included within the simulated perimeter due to how FSIM converts pixel geometry to polygon geometry or as a result of a post processing script that removed small artifacts generated from the FSim trimming suppression algorithm.

3. **PNRA_rfV3_AllIgnitions.gdb –** This dataset represents the simulated fire start locations within each of the twenty-three Fire Occurrence Areas (FOA) that comprise the PNRA project area. Each _AllIgnitions feature class includes an attribute table with the following attributes:

a. **FIRE_NUMBE** - the unique fire number for a simulation
b. **THREAD_NUM** - the thread number that simulated the fire (the number of threads is determined by the number of CPUs in the workstation, the number of processing cores per CPU, and whether the cores are hyperthreaded.)
c. **ERC_STARTD** - the ERC(G) value on the start day of the fire
d. **ERC_PERCEN** - the ERC(G) percentile associated with ERC_STARTD. The ERC_PERCEN is a simple lookup from the ERC_STARTD from the "percentiles" section of the .frisk file.
e. **NUM_BURNDA** - the number of days the fire burned during the simulation. This does not include any no-burn days (days below the 80th percentile ERC
f. **START_DAY** - the Julian day of the fire start
g. **YEAR** - the iteration number (year) for which the fire was simulated
h. **Xcoord/Ycoord** - the coordinates of the fire's ignition point
i. **CONTAIN** - the reason for the cessation of fire growth on the simulated fire
j. **FOA** – the FOA number where the ignition is located
k. **UNQ_ID** – concatenation of FOA number and FIRE_NUMBE
l. **NumIterations** – the number of iterations within a simulation. Individual FOAs were run with 10,000 iterations. When generating additional analytical products from the FSim event set, results must be weighted by iteration number to avoid introducing error
m. **GIS_SizeAc** – the final wildfire size (acres) generated as an ArcGIS calculation based on feature geometry
n. **GIS_SizeHa** – the final wildfire size (hectares) generated as an ArcGIS calculation based on feature geometry

o. **FSim_SizeAc** - is the final fire size (acres) generated within FSim based on raster count. Best-practice is to calculate GIS acres for each perimeter instead of relying on SizeAc, especially if subsequent analyses will be based on GIS acres
p. **NumParts** – Number of geometry parts in the simulated wildfire perimeter
q. **ContainsIgn** – True/False value (1,0) that describes if the location of the ignition point is contained within the simulated wildfire perimeter polygon. The ignition may not be included within the simulated perimeter due to how FSim converts pixel geometry to polygon geometry or as a result of a post processing script that removed small artifacts generated from the FSim trimming suppression algorithm.

7 References

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8 Appendices

Table A1. Zonal summaries of FSim and HVRA data for the 17 national forests within the PNRA analysis area

Forest	Area_AC (Million)	Lrg-Fire/ mill ac/yr	Mean BP	Avg 4' FLEP/BP	Avg 8' FLEP/BP	Mean cNVC	Sum eNVC	Maj Import HVRA	% of Ovrl Import
Columbia River Gorge NSA	0.23	0.95	0.0041	0.64	0.12	-0.3860	-365	INFRA	0.45
Colville	1.10	0.56	0.0040	0.60	0.20	-0.0229	-123	WATER	0.37
Deschutes	1.75	0.65	0.0025	0.44	0.09	-0.0199	-88	TIMBER	0.33
Fremont-Winema	2.20	0.50	0.0026	0.48	0.10	-0.0039	-23	TIMBER	0.56
Gifford Pinchot	1.28	0.31	0.0014	0.75	0.41	-0.2454	-445	WILD	0.28
Malheur	1.71	0.74	0.0070	0.59	0.16	0.0255	304	TIMBER	0.52
Mt. Baker-Snoqualmie	1.84	0.43	0.0010	0.74	0.43	-0.3293	-621	WATER	0.44
Mt. Hood	0.99	0.82	0.0045	0.72	0.35	-0.1858	-821	WATER	0.54
Ochoco	0.89	1.61	0.0094	0.62	0.12	-0.0500	-418	TIMBER	0.41
Okanogan-Wenatchee	3.83	1.31	0.0103	0.60	0.22	-0.0621	-2442	WATER	0.49
Olympic	0.68	0.12	0.0002	0.46	0.21	-0.1081	-15	WILD	0.65
Rogue River-Siskiyou	1.83	0.63	0.0070	0.75	0.36	-0.1204	-1539	WILD	0.40
Siuslaw	0.61	0.04	0.0001	0.57	0.23	-0.3195	-19	WILD	0.63
Umatilla	1.40	0.79	0.0069	0.60	0.20	0.0058	57	VC	0.42
Umpqua	0.98	0.93	0.0064	0.67	0.33	-0.1432	-892	TIMBER	0.36
Wallowa-Whitman	2.29	1.03	0.0094	0.58	0.17	-0.0127	-273	TIMBER	0.42
Willamette	1.63	0.57	0.0032	0.71	0.38	-0.2231	-1152	TIMBER	0.26

Table A2. Zonal summaries of FSim and HVRA data for a 2-km buffer around the 17 national forests within the PNRA analysis area.

Forest	Area_AC (Million)	Lrg-Fire/ mill ac/yr	Mean BP	Avg 4' FLEP/BP	Avg 8' FLEP/BP	Mean cNVC	Sum eNVC	Maj Import HVRA	% of Ovrl Import
Columbia River Gorge NSA	0.15	1.16	0.0063	0.63	0.16	-0.2884	-264	PP	0.55
Colville	0.64	0.50	0.0046	0.56	0.13	-0.1089	-238	INFRA	0.25
Deschutes	0.23	0.77	0.0033	0.56	0.08	-0.2490	-187	PP	0.76
Fremont-Winema	1.19	0.50	0.0025	0.52	0.08	-0.0347	-99	TIMBER	0.32
Gifford Pinchot	0.16	0.57	0.0040	0.70	0.32	-0.2022	-126	TIMBER	0.33
Malheur	0.58	0.76	0.0069	0.62	0.08	-0.0280	-113	PP	0.36
Mt. Baker-Snoqualmie	0.54	0.20	0.0004	0.70	0.37	-0.3613	-79	WATER	0.49
Mt. Hood	0.23	1.09	0.0071	0.63	0.22	-0.1001	-162	WATER	0.42
Ochoco	0.35	1.52	0.0079	0.67	0.07	-0.0437	-119	PP	0.40
Okanogan-Wenatchee	0.63	1.52	0.0122	0.58	0.13	-0.1792	-1373	PP	0.33
Olympic	0.38	0.07	0.0001	0.44	0.19	-0.1391	-6	TIMBER	0.24
Rogue River-Siskiyou	0.52	0.60	0.0072	0.74	0.33	-0.2101	-793	PP	0.30
Siuslaw	0.53	0.04	0.0001	0.49	0.18	-0.3401	-14	PP	0.36
Umatilla	0.50	0.80	0.0072	0.56	0.10	-0.0306	-111	PP	0.27
Umpqua	0.18	0.74	0.0067	0.72	0.35	-0.2102	-251	TIMBER	0.36
Wallowa-Whitman	0.80	0.97	0.0079	0.52	0.09	-0.0251	-158	PP	0.25
Willamette	0.27	0.38	0.0020	0.64	0.30	-0.2883	-150	TIMBER	0.34

Table A3. Zonal summaries of FSim and HVRA data for each USFS Ranger District within the PNRA analysis area.

Forest / Ranger District	Area_AC (Million)	Lrg-Fire/ mill ac/yr	Mean BP	Avg 4' FLEP/BP	Avg 8' FLEP/BP	Mean cNVC	Sum eNVC	Maj Import HVRA	% of Ovrl Import
Colville									
Newport	0.15	0.34	0.0031	0.59	0.19	-0.0603	-48	WATER	0.35
Republic	0.22	0.78	0.0067	0.57	0.15	-0.0054	-9	WATER	0.42
Sullivan Lake	0.24	0.28	0.0022	0.60	0.22	-0.0149	-10	WATER	0.37
Three Rivers	0.48	0.47	0.0042	0.63	0.22	-0.0244	-56	WATER	0.36
Deschutes									
Bend/Fort Rock	0.91	0.50	0.0021	0.39	0.06	0.0005	1	TIMBER	0.36
Crescent	0.39	0.60	0.0027	0.38	0.06	-0.0248	-26	TIMBER	0.36
Sisters	0.30	1.09	0.0037	0.55	0.15	-0.0472	-64	PP	0.35
Fremont-Winema									
Bly	0.33	0.53	0.0029	0.55	0.11	-0.0144	-14	TIMBER	0.53
Chemult	0.39	0.43	0.0022	0.37	0.07	-0.0167	-14	TIMBER	0.64
Chiloquin	0.46	0.46	0.0020	0.45	0.08	0.0131	12	TIMBER	0.57
Klamath	0.20	0.53	0.0023	0.45	0.11	-0.0247	-11	TIMBER	0.33
Lakeview	0.31	0.71	0.0049	0.55	0.13	0.0092	14	TIMBER	0.64
Paisley	0.24	0.45	0.0028	0.52	0.10	0.0004	0	TIMBER	0.50
Silver Lake	0.29	0.32	0.0019	0.41	0.06	-0.0171	-9	TIMBER	0.58
Gifford Pinchot									
Cowlitz Valley	0.56	0.30	0.0012	0.72	0.40	-0.1854	-121	WILD	0.36
Mount St. Helens	0.09	0.07	0.0002	0.54	0.25	-0.0692	-1	WATER	0.54
Mt. Adams	0.63	0.35	0.0018	0.77	0.41	-0.2824	-323	TIMBER	0.32
Malheur									
Blue Mountain	0.70	0.80	0.0083	0.60	0.18	0.0159	93	TIMBER	0.48
Emigrant Creek	0.63	0.65	0.0052	0.53	0.09	0.0462	151	TIMBER	0.59
Prairie City	0.38	0.77	0.0074	0.62	0.19	0.0216	61	TIMBER	0.43
Mt. Baker-Snoqualmie									
Darrington	0.51	0.51	0.0012	0.76	0.48	-0.2185	-131	WILD	0.60
Mt. Baker	0.49	0.31	0.0007	0.70	0.37	-0.2535	-83	WILD	0.61
Skykomish	0.33	0.61	0.0014	0.74	0.43	-0.3091	-143	WILD	0.37
Snoqualmie	0.51	0.33	0.0010	0.74	0.42	-0.5344	-263	WATER	0.68

Table A3. (Continued) Zonal summaries of FSim and HVRA data for each USFS Ranger District within the PNRA analysis area.

Forest / Ranger District	Area_AC (Million)	Lrg-Fire/ mill ac/yr	Mean BP	Avg 4' FLEP/BP	Avg 8' FLEP/BP	Mean cNVC	Sum eNVC	Maj Import HVRA	% of Ovrl Import
Mt. Hood									
Barlow	0.17	1.67	0.0106	0.72	0.32	-0.0826	-146	TIMBER	0.48
Clackamas River	0.40	0.71	0.0036	0.70	0.33	-0.2580	-375	TIMBER	0.43
Hood River	0.18	0.69	0.0036	0.75	0.39	-0.2795	-181	TIMBER	0.32
Zigzag	0.25	0.52	0.0022	0.74	0.39	-0.2164	-119	WATER	0.84
Ochoco									
Crooked River	0.16	2.00	0.0084	0.76	0.07	-0.3100	-417	PP	0.51
Lookout Mountain	0.50	1.53	0.0091	0.57	0.11	-0.0134	-43	TIMBER	0.47
Paulina	0.24	1.52	0.0100	0.62	0.15	0.0112	42	TIMBER	0.61
Okanogan-Wenatchee									
Chelan	0.33	1.57	0.0105	0.52	0.11	-0.0539	-185	WATER	0.62
Cle Elum	0.43	1.10	0.0093	0.74	0.37	-0.0670	-271	WATER	0.28
Entiat	0.25	1.82	0.0178	0.55	0.12	-0.0786	-349	WATER	0.53
Methow Valley	1.20	1.33	0.0096	0.51	0.15	0.0147	169	WATER	0.48
Naches	0.53	0.98	0.0072	0.74	0.34	-0.1269	-483	WATER	0.57
Tonasket	0.39	1.17	0.0083	0.48	0.09	0.0222	72	WATER	0.44
Wenatchee River	0.70	1.44	0.0126	0.69	0.33	-0.1578	-1397	WATER	0.48
Olympic									
Hoodsport	0.22	0.17	0.0003	0.41	0.19	-0.0488	-3	WILD	0.73
Quilcene	0.15	0.13	0.0003	0.47	0.19	-0.1086	-5	WILD	0.57
Forks	0.16	0.04	0.0001	0.54	0.26	-0.1742	-2	WILD	0.53
Quinault	0.15	0.11	0.0002	0.52	0.26	-0.1900	-6	WILD	0.74
Rogue River-Siskiyou									
Gold Beach	0.49	0.37	0.0042	0.81	0.45	-0.3049	-625	WILD	0.61
High Cascades	0.45	0.85	0.0052	0.55	0.18	-0.0126	-29	TIMBER	0.35
Powers	0.16	0.12	0.0006	0.71	0.38	-0.3224	-33	WILD	0.60
Siskiyou Mountains	0.22	0.94	0.0126	0.76	0.37	-0.0295	-83	VC	0.33
Wild Rivers	0.50	0.70	0.0109	0.80	0.40	-0.1402	-768	VC	0.34
Siuslaw									
Central Coast	0.46	0.05	0.0001	0.58	0.24	-0.3426	-19	WILD	0.63
Hebo	0.15	0.02	0.0000	0.38	0.13	-0.0836	0	WILD	0.65

Table A3. (Continued) Zonal summaries of FSim and HVRA data for each USFS Ranger District within the PNRA analysis area.

Forest / Ranger District	Area_AC (Million)	Lrg-Fire/ mill ac/yr	Mean BP	Avg 4' FLEP/BP	Avg 8' FLEP/BP	Mean cNVC	Sum eNVC	Maj Import HVRA	% of Ovrl Import
Umatilla									
Heppner	0.21	0.90	0.0071	0.53	0.10	0.0190	28	TIMBER	0.52
North Fork John Day	0.46	0.67	0.0067	0.57	0.15	0.0163	51	VC	0.52
Pomeroy	0.34	0.87	0.0067	0.62	0.24	0.0295	67	VC	0.57
Walla Walla	0.38	0.80	0.0074	0.65	0.26	-0.0314	-89	VC	0.32
Umpqua									
Cottage Grove	0.09	0.69	0.0054	0.79	0.52	-0.4851	-229	TIMBER	0.57
Diamond Lake	0.31	0.88	0.0047	0.53	0.22	-0.1355	-196	TIMBER	0.40
North Umpqua	0.26	0.99	0.0078	0.70	0.39	-0.0922	-183	WILD	0.35
Tiller	0.33	0.99	0.0071	0.71	0.32	-0.1220	-284	TIMBER	0.40
Wallowa-Whitman									
Eagle Cap	0.32	0.88	0.0067	0.65	0.27	0.0300	64	VC	0.64
Hells Canyon	0.60	1.49	0.0140	0.54	0.11	0.0067	56	VC	0.45
La Grande	0.44	0.73	0.0073	0.62	0.20	-0.0641	-206	TIMBER	0.52
Wallowa Valley	0.31	1.30	0.0112	0.55	0.16	-0.0473	-163	TIMBER	0.58
Whitman	0.63	0.75	0.0069	0.61	0.19	-0.0054	-23	TIMBER	0.46
Willamette									
Detroit	0.30	0.74	0.0035	0.70	0.38	-0.2134	-220	TIMBER	0.39
McKenzie River	0.47	0.46	0.0023	0.73	0.41	-0.2292	-252	WATER	0.53
Middle Fork	0.67	0.59	0.0038	0.69	0.37	-0.2301	-588	TIMBER	0.39
Sweet Home	0.19	0.48	0.0025	0.75	0.42	-0.1928	-92	WILD	0.31

9 Report Change Log

Table A4. Change log for edits made to this report after the original 1-12-18 release date.

Date	Author	Changes made
1/25/2018	JGD, KV	Added section 3.4.4 on Veg condition HVRA and methods, edited table captions for Infrastructure HVRA and fish species to highlight the relevant HVRA, fixed broken cross-reference links to figures/sections
1/29/2018	KV	Updated figures to reduce overall file size and improve print quality
3/5/2018	JGD	Incorporate minor edits from Katie Hetts
2/26/2018	JGD	Add “Quantitative” to report title
3/6/2018	JGD	Add clarification on fish species data sources and refinement of USFS private inholdings to remove non-private ownerships
3/6-3/13/2018	JGD, KV	Update report text and figures with new model results including the 2017 fire footprints
4/6/2018 & 4/9/2018	JGD	Incorporate edits from Rick Stratton
8/28/2018	KV	Add Quantum logo
6/18/2019	KV	Update title page to include all authors and organizations and saved file as “PNRA_QuantitiateWildfireRiskReport_04_09_18v2”