USFS Region 4
Wildfire Hazard Report: Methods and Results

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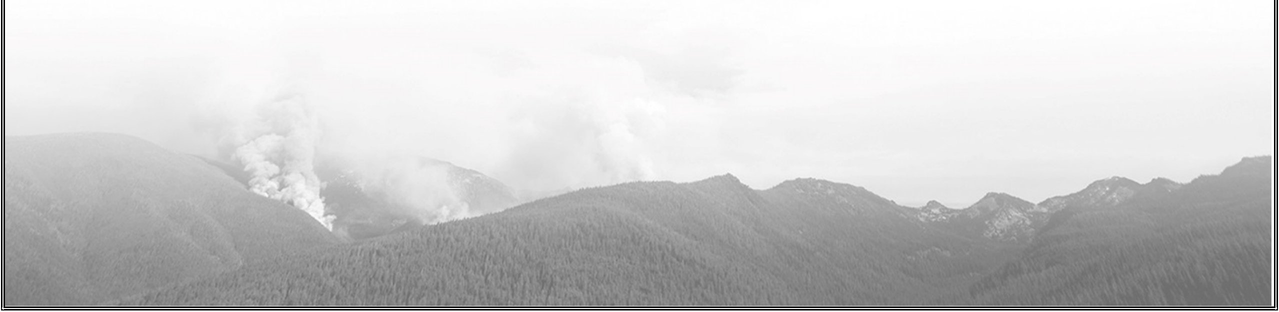

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1 Overview of Region 4

1.1 Purpose of the Assessment

The purpose of the USFS Region 4 Quantitative Wildfire Hazard Report is to provide foundational information about wildfire hazard across the geographic area. Such information supports wildfires, regional fuel management planning decisions, and revisions to land and resource management plans. The R4 analysis considers:

- likelihood of a fire burning,
- the intensity of a fire if one should occur

To manage wildfire in Region 4, it is essential that accurate wildfire hazard data, to the greatest degree possible, is available to drive fire management strategies. These hazard outputs can be used to inform the planning, prioritization and implementation of prevention and mitigation activities, such as prescribed fire and mechanical fuel treatments. In addition, the hazard data can be used to support fire operations and aid in decision making for prioritizing and positioning of firefighting resources.

The purpose of this report is to document the fuel calibration process and wildfire hazard modeling completed by Pyrologix LLC. The remainder of the Region 4 Wildfire Risk Assessment will be covered in a subsequent report.

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 R4 project was initially defined as a 10-kilometer buffer on R4 USFS Administrative lands. This boundary was expanded to include that area as well as the entirety of Utah. All subsequent project boundaries (discussed below) were built from this initial extent. The Region 4 analysis area includes twelve Administrative Forests: Ashley, Boise, Bridger-Teton, Caribou-Targhee, Dixie, Fishlake, Humboldt-Toiyabe, Manti-La Sal, Payette, Salmon-Challis, Sawtooth, and Uinta-Wasatch-Cache.

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 established the FOA extent as a 30-km buffer on the AA. The buffer provides sufficient area to ensure that all fires that could reach the AA are simulated. The Fire Occurrence Area covers roughly 171.5 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 twenty-two 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, and topological boundaries. For consistency with other FSim projects, we numbered these FOAs 450-471.

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 extent, and fuelscape extent are presented in Figure 1.

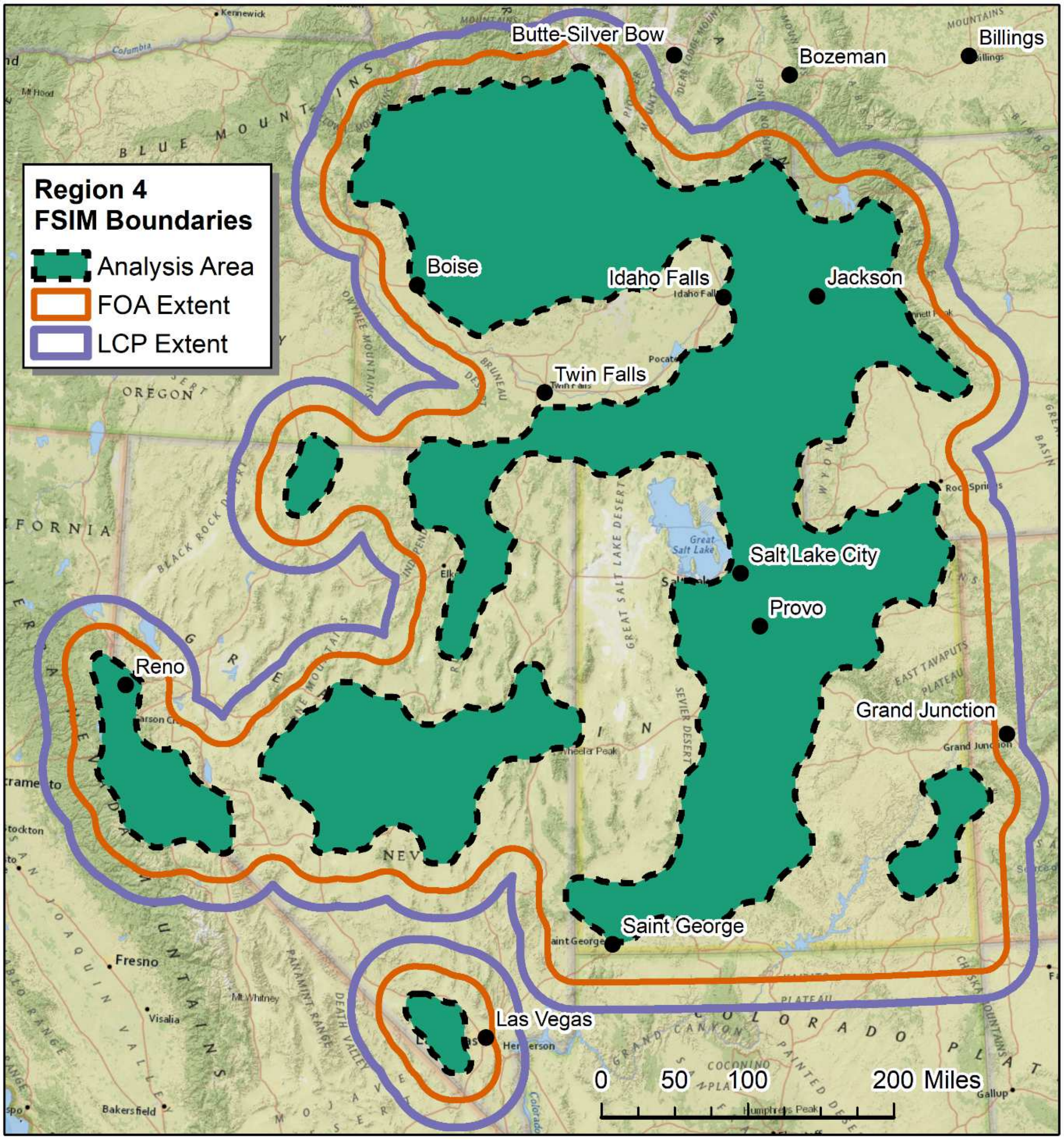

Figure 1. Overview of landscape zones for R4 FSim project. The Analysis Area (AA) is shown in green. The project produces valid BP results within this AA. To ensure valid BP in the AA, we started fires within the Fire Occurrence Area extent, outlined in orange. To prevent fires from reaching the edge of the fuelscape, a buffered fuelscape extent was used, which is represented by the purple outline.

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). We generated the Region 4 fuelscape using the LANDFIRE Total Fuel Change Toolbar (LFTFCT). LFTFCT allows users to input existing vegetation and disturbance data, define fuel rulesets, and generate fuel grids. See the LFTFCT Users Guide for more information (Smail *et al.*, 2011). The resulting LFTFCT output fuel grids can then be combined into a single landscape (LCP) file and used as a fuelscape input in various fire modeling programs. Additional information can be found in the LF data modification guide (Helmbrecht and Blankenship, 2016).

Our LFTFCT vegetation and disturbance inputs were derived from LANDFIRE 2014b 30-m raster data. Both the surface and canopy inputs were updated to reflect fuel disturbances occurring between 2015 and 2018. Wildfire fuel disturbances were incorporated using three difference sources: Monitoring Trends in Burn Severity (MTBS) data, Rapid Assessment of Vegetation Condition after Wildfire (RAVG) data, and GeoSpatial Multi-Agency Coordination (GeoMAC) perimeter data. We gathered severity data as available from MTBS, then RAVG, and where severity data was unavailable, we relied on final perimeters from GeoMAC. We crosswalked MTBS and RAVG severity to the appropriate disturbance code (112, 122, or 132) corresponding with fire disturbances of low, moderate, or high severity, occurring in the past one to five years. GeoMAC perimeters were assigned a severity disturbance code of 122. Finally, a fuelscape review involving input from Regional fire and fuels staff and others familiar with the fuelscape was held remotely on February 8, 2019 to refine the LFTFCT fuel rulesets for this project. The resulting fuelscape generated by LFTFCT is shown by fuel model group in Figure 2.

Additional documentation on the fuelscape processing and edits to LANDFIRE default rules are included in the report Appendix.

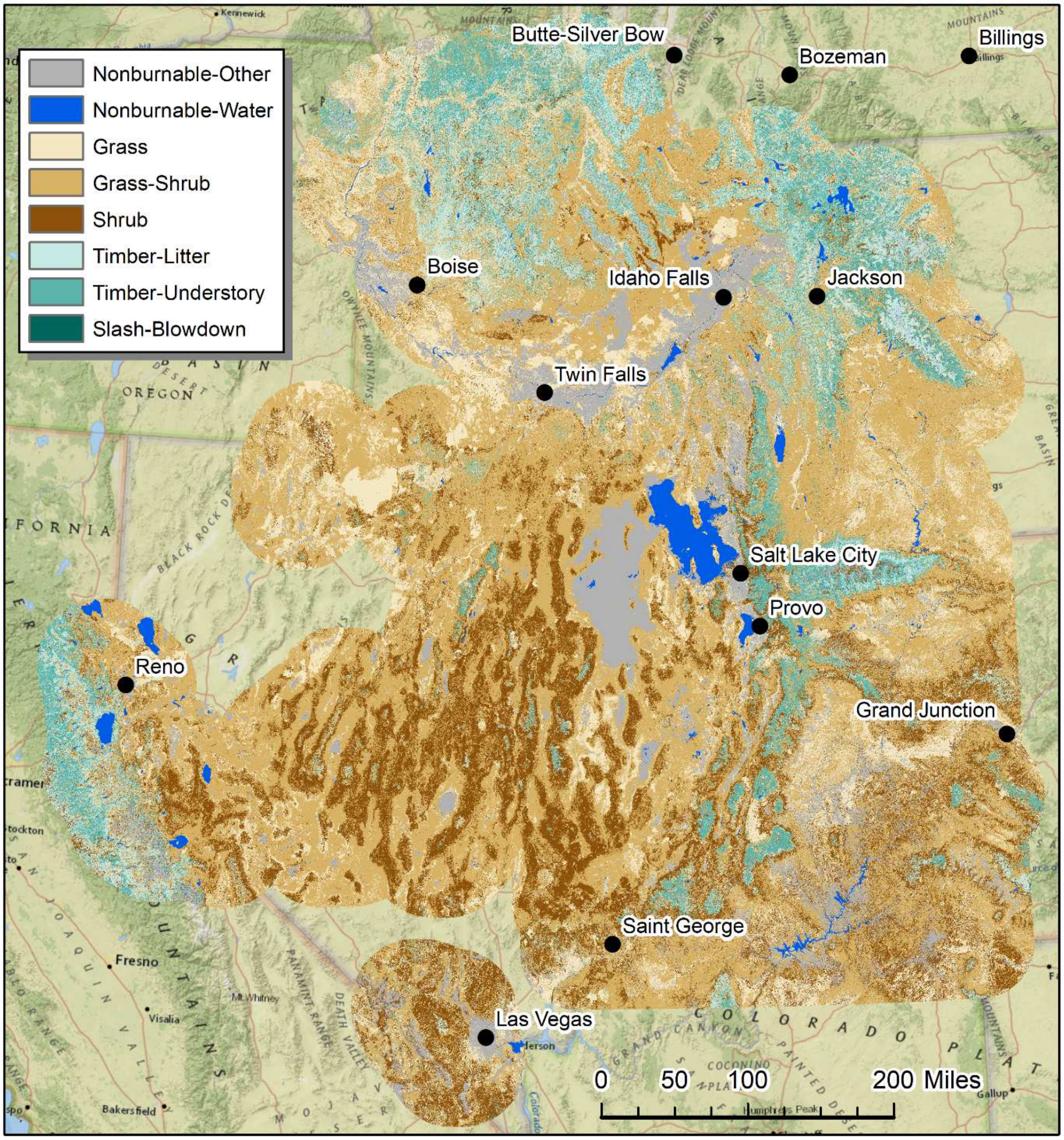

Figure 2. Map of fuel model groups across the Region 4 Fire Occurrence Area.

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 1 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 1. Historical large-fire occurrence, 1992-2015, in the Region 4 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
450	4.2	3.92	1.1	3,052	12,843	0.0033
451	4.7	5.78	0.8	3,613	17,010	0.0029
452	*n/a*	3.23	*n/a*	*n/a*	*n/a*	*n/a*
453	1.5	6.73	0.2	8,014	11,687	0.0017
454	5.7	12.97	0.4	3,923	22,230	0.0017
455	4.7	3.64	1.3	8,026	37,791	0.0104
456	5.9	4.56	1.3	7,272	42,684	0.0094
457	9.4	5.38	1.8	9,399	88,512	0.0165
458	8.0	4.13	1.9	3,347	26,917	0.0065
459	23.1	9.82	2.4	5,901	136,472	0.0139
460	7.0	4.14	1.7	5,615	39,308	0.0095
461	21.1	12.71	1.7	10,788	227,445	0.0179
462	1.5	7.22	0.2	4,057	6,086	0.0008
463	3.2	4.85	0.7	5,062	16,106	0.0033
464	3.5	6.62	0.5	4,371	15,117	0.0023
465	2.5	9.38	0.3	2,457	6,142	0.0007
466	7.0	11.30	0.6	3,209	22,462	0.0020
467	20.5	15.09	1.4	3,896	79,709	0.0053
468	3.6	6.70	0.5	3,041	11,024	0.0016
469	13.0	9.90	1.3	5,079	66,027	0.0067
470	1.7	3.56	0.5	3,187	5,312	0.0015
471	4.9	19.87	0.2	1,675	8,155	0.0004

Historical wildfire occurrence varied widely by FOA (Table 1), with FOA 459 experiencing the highest annual average of 2.4 large wildfires per million acres. FOA 452 had the least frequent rate of occurrence with no observed large wildfires between 1992 and 2015. FOA 461 had the largest mean large-fire size (10,788 ac) and FOA 471 had the smallest (1,675 ac).

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 Ignition Density Grid (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 90-m 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. The IDG was 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 3 shows the ignition density grid for the fire occurrence area.

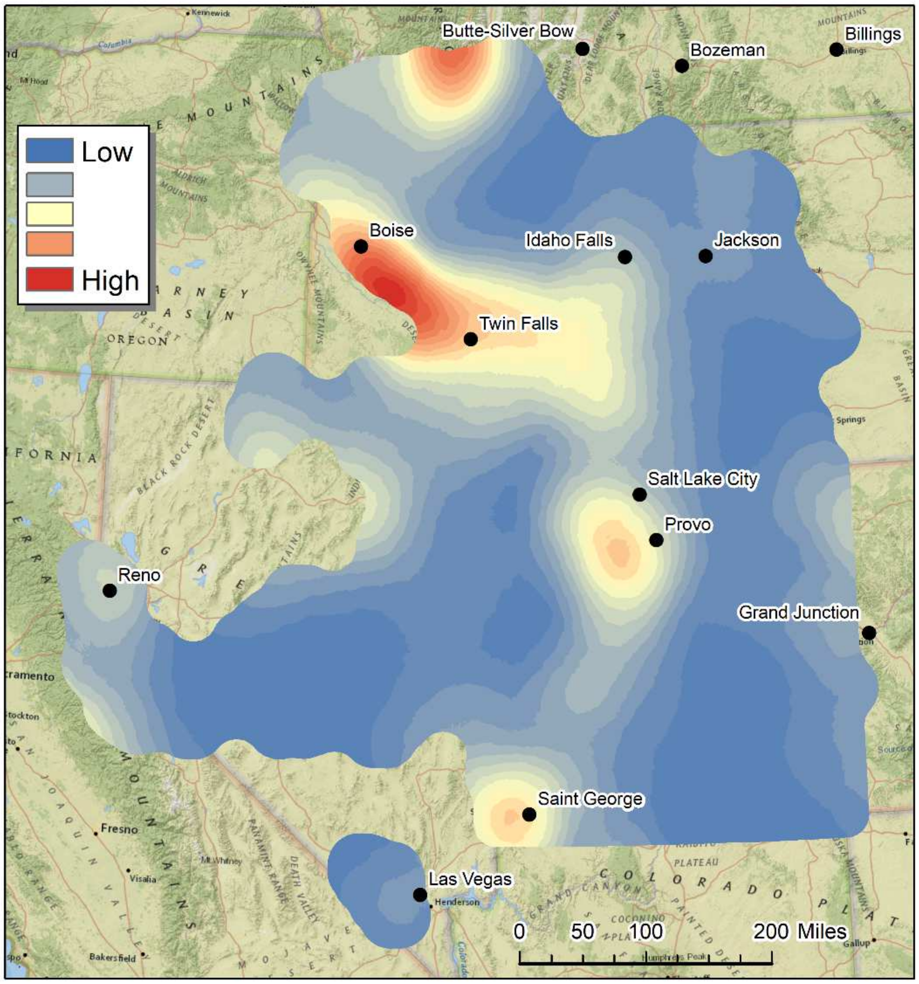

Figure 3. Ignition density grid used in FSim simulations.

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 Remote Automatic Weather Stations (RAWS). 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.

In order to prevent edge effects between FOAs, to address the potential influence of sheltering on RAWS station observations, and to allow for representative wildfire intensity potential, it is occasionally necessary to adjust the wind speed record from individual RAWS stations. FOAs 450, 461, 462, and 471 all received an adjustment to increase wind speed to a mean seasonal windspeed of 9 to 10 mi/h. Additionally, FOA 454 and 468 received an adjustment to decrease wind speed to prevent data seamlines and more accurately model historical wildfire intensities.

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 4, and discussed further in the following sections.

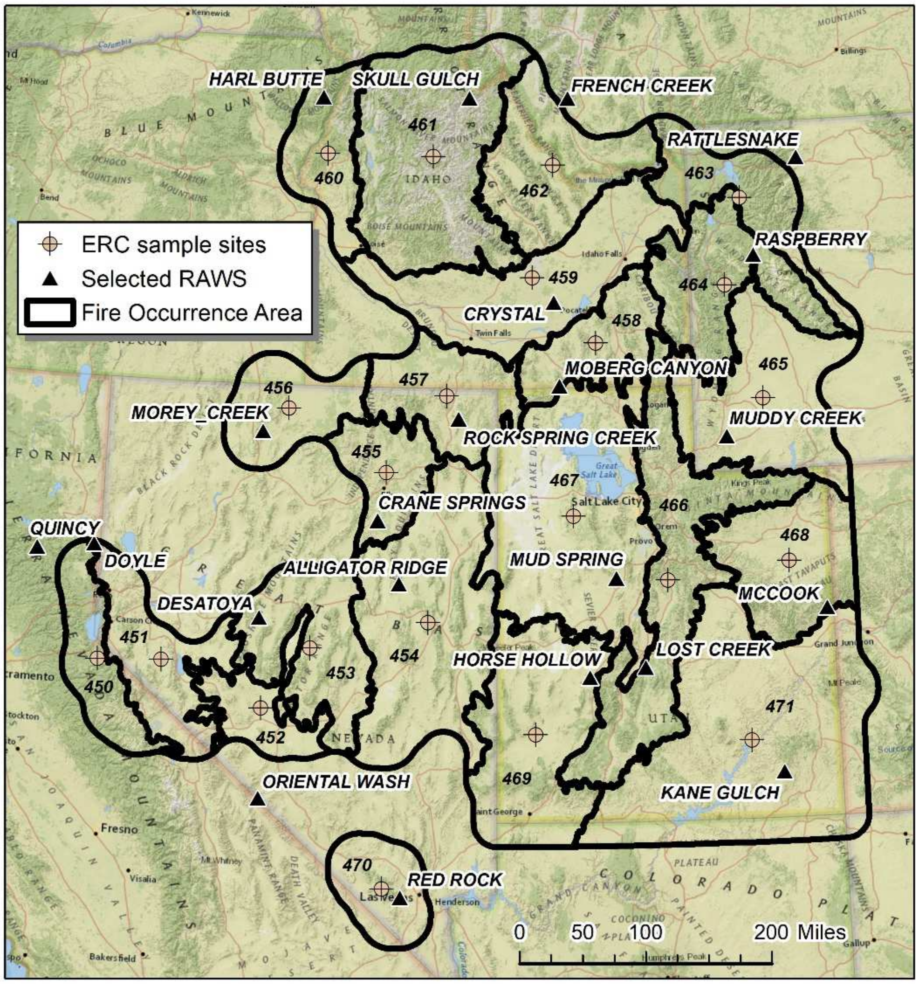

Figure 4. RAWS stations and ERC sample sites used for the R4 FSim project. RAWS data were used for hourly sustained wind speed.

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. RAWS were selected based on their ability to represent general wind patterns within a FOA. Some of the selected stations did not produce wind speeds high enough, on average, to produce historically observed fire behavior. Therefore, in FOAs 450, 454, 458, 461, 462, and 471 we adjusted wind speeds upwards to meet historical calibration targets, while still maintaining the wind directions in the recorded observations.

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.

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.

Historical 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 to generate 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 (4 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 5 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-two FOAs independently, and then compiled the twenty-two 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.

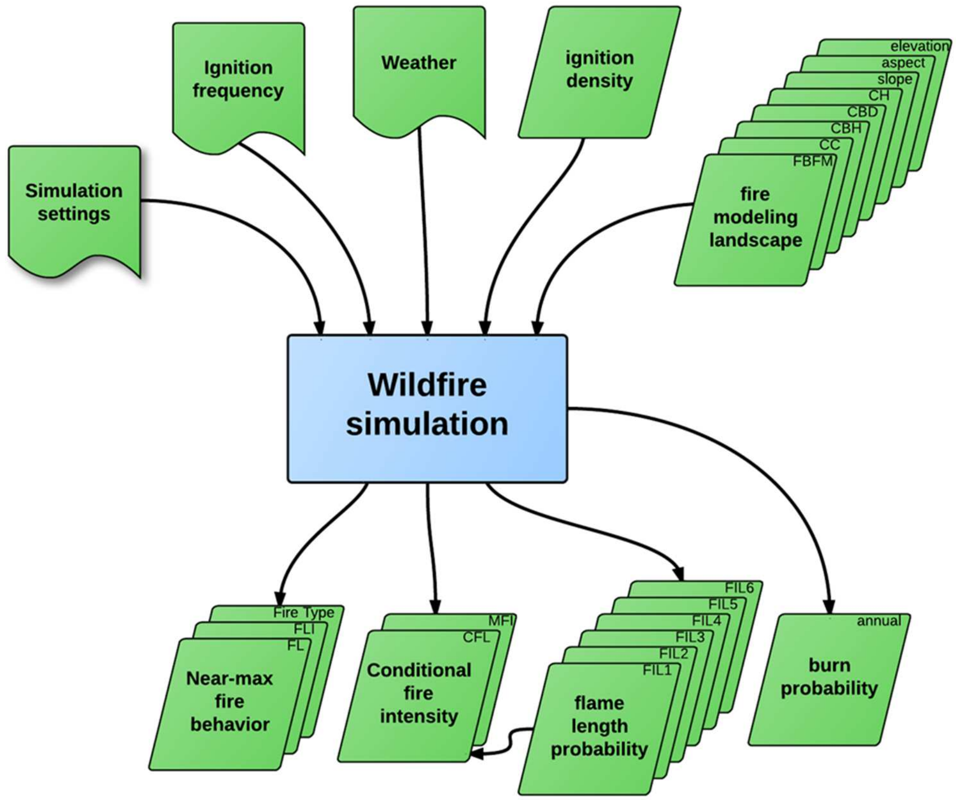

Figure 5. Diagram showing the primary elements used to derive Burn Probability.

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 2. All simulations were completed at 120-m resolution. Each FOA was calibrated separately to well within the 70% confidence interval and final simulations were run with 10,000 iterations except for FOA 452 that was run for 100,000 iterations. The twenty-two FOAs were then integrated into an overall result for the analysis area.

Table 2. Summary of final-run inputs for each FOA.

Final run	Number of Iterations	ADJ file	Trimming factor	FRISK	FDist file	LCP file
450r10	10,000	V2	2.0	V3	V3	FOA_450_120v3.lcp
451r10	10,000	V3	2.0	V3	V4	FOA_451_120v3.lcp
452r10	100,000	V2	2.0	V3	V1_0.5	FOA_452_120v3.lcp
453r10	10,000	V4	2.0	V3	V2	FOA_453_120v3.lcp
454r10	10,000	V5	2.0	V3	V5	FOA_454_120v3.lcp
455r10	10,000	V6	2.0	V3	V4	FOA_455_120v3.lcp
456r11	10,000	V5	2.0	V3	V4	FOA_456_120v3.lcp
457r10	10,000	V7	2.0	V3	V2	FOA_457_120v3.lcp
458r11	10,000	V4	2.0	V3	V5	FOA_458_120v3.lcp
459r11	10,000	V7	2.0	V3	V5	FOA_459_120v3.lcp
460r10	10,000	V4	2.0	V3	V3	FOA_460_120v3.lcp
461r10	10,000	V5	2.0	V4	V5	FOA_461_120v3.lcp
462r10	10,000	V5	2.0	V4	V2	FOA_462_120v3.lcp
463r10	10,000	V4	2.0	V3	V5	FOA_463_120v3.lcp
464r10	10,000	V4	2.0	V3	V4	FOA_464_120v3.lcp
465r10	10,000	V3	2.0	V3	V2	FOA_465_120v3.lcp
466r10	10,000	V9 + V10	2.0	V3	V4	FOA_466_120v3.lcp
467r10	10,000	V3	2.0	V3	V4	FOA_467_120v3.lcp
468r10	10,000	V3	2.0	V3	V4	FOA_468_120v3.lcp
469r10	10,000	V4	2.0	V3	V4	FOA_469_120v3.lcp
470r10	10,000	V3	2.0	V3	V3	FOA_470_120v3.lcp
471r10	10,000	V2	2.0	V3	V5	FOA_471_120v3.lcp

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 Analysis Results

3.1 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-two FOAs independently, and then compiled the twenty-two 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.

3.2 FSim Results

FSim burn probability, flame length exceedance probability, and conditional flame length model results are presented for the Region 4 analysis area in sections 3.2.1, 3.2.2, and 3.2.3, respectively. Additionally, all FSim results are presented in the Deliverables folder and are described in further detail in section 5. 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-two FOAs were combined using the calculations described above to produce integrated maps of wildfire hazard for the entire analysis area.

Section 5 details the individual attributes of all generated FSim results. To improve simulation run time FOAs were modeled with 3-9 'Sub-FOAs'. Non-mosaiced results are delivered by individual Sub-FOA. The use of Sub-FOAs has no impact on model calibration.

3.2.1 *Burn Probability*

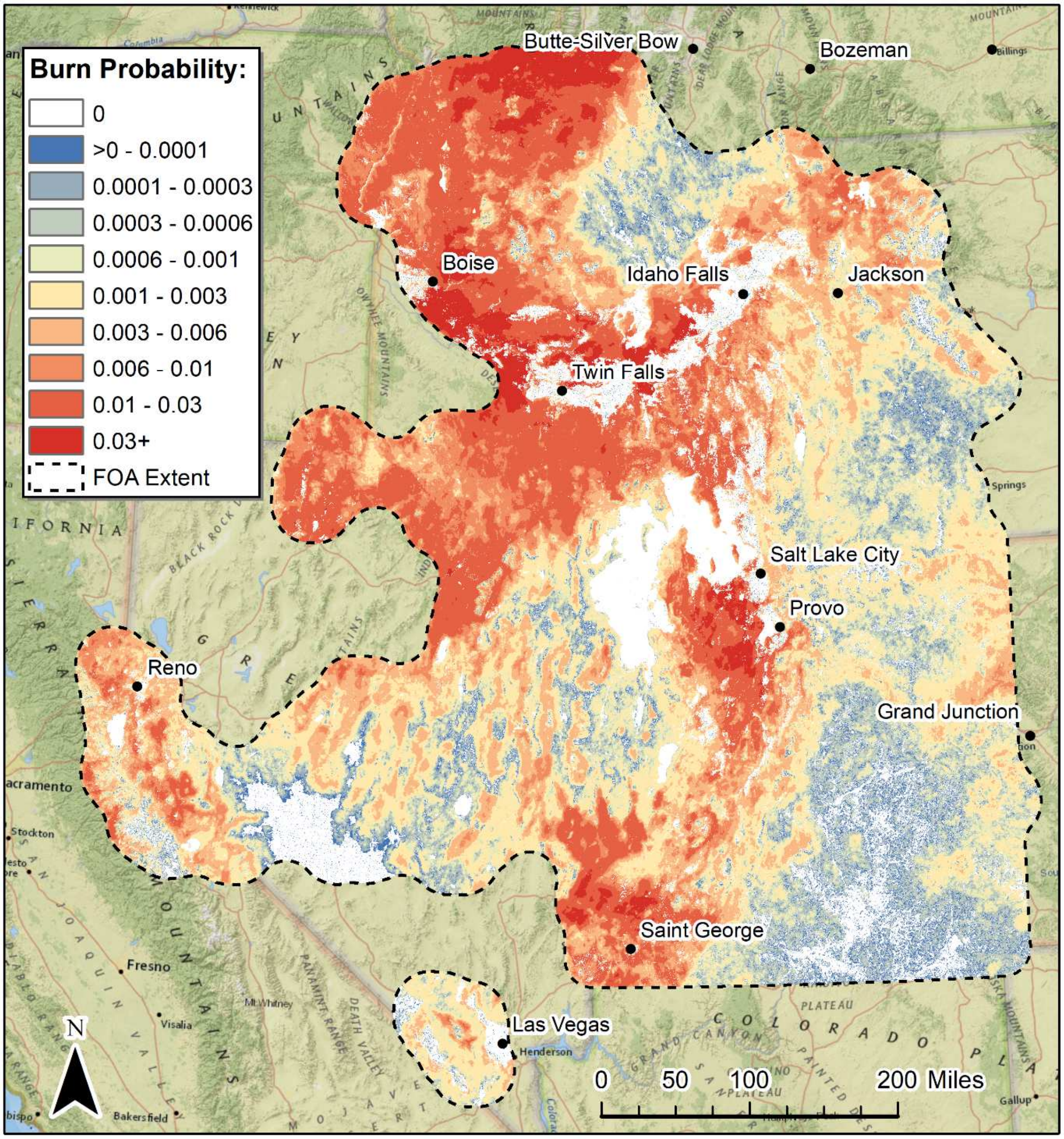

Figure 6. Map of integrated FSim burn probability results for the Region 4 Fire Occurrence Area.

3.2.2 *Flame Length Exceedance Probability*

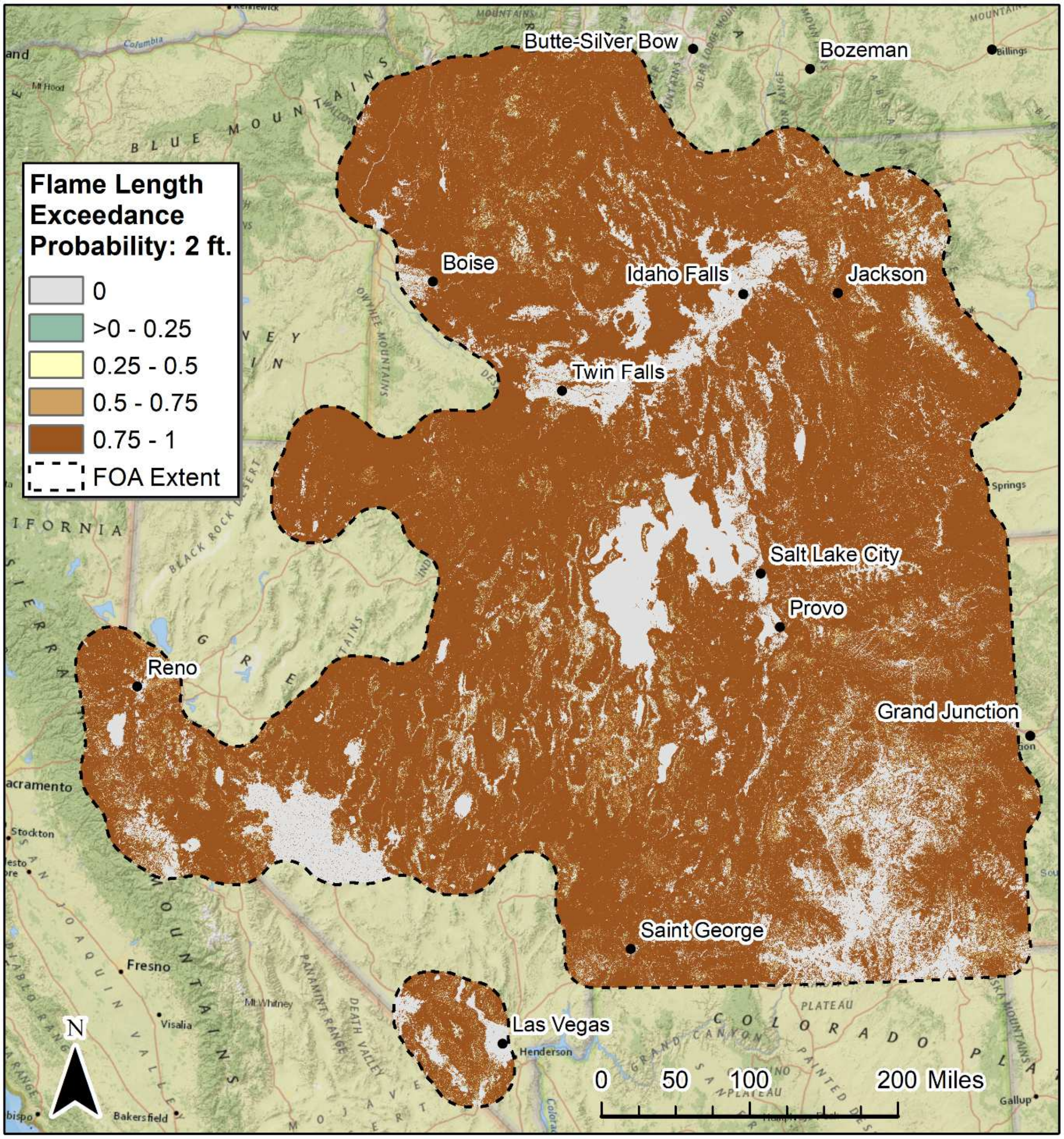

Figure 7. Map of FSim flame length exceedance probability: 2-ft. results for the Region 4 Fire Occurrence Area.

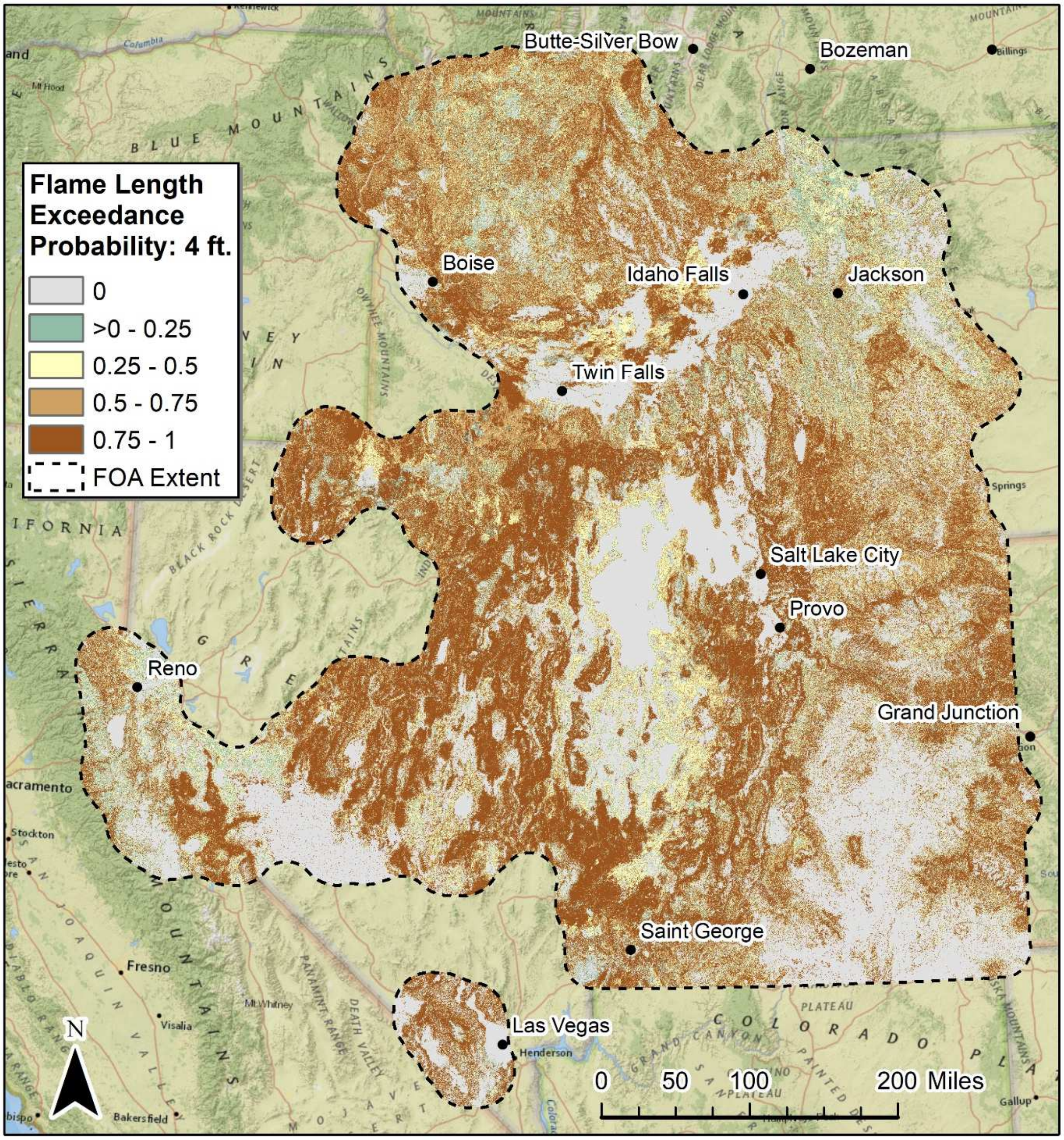

Figure 8. Map of FSim flame length exceedance probability: 4-ft. results for the Region 4 Fire Occurrence Area.

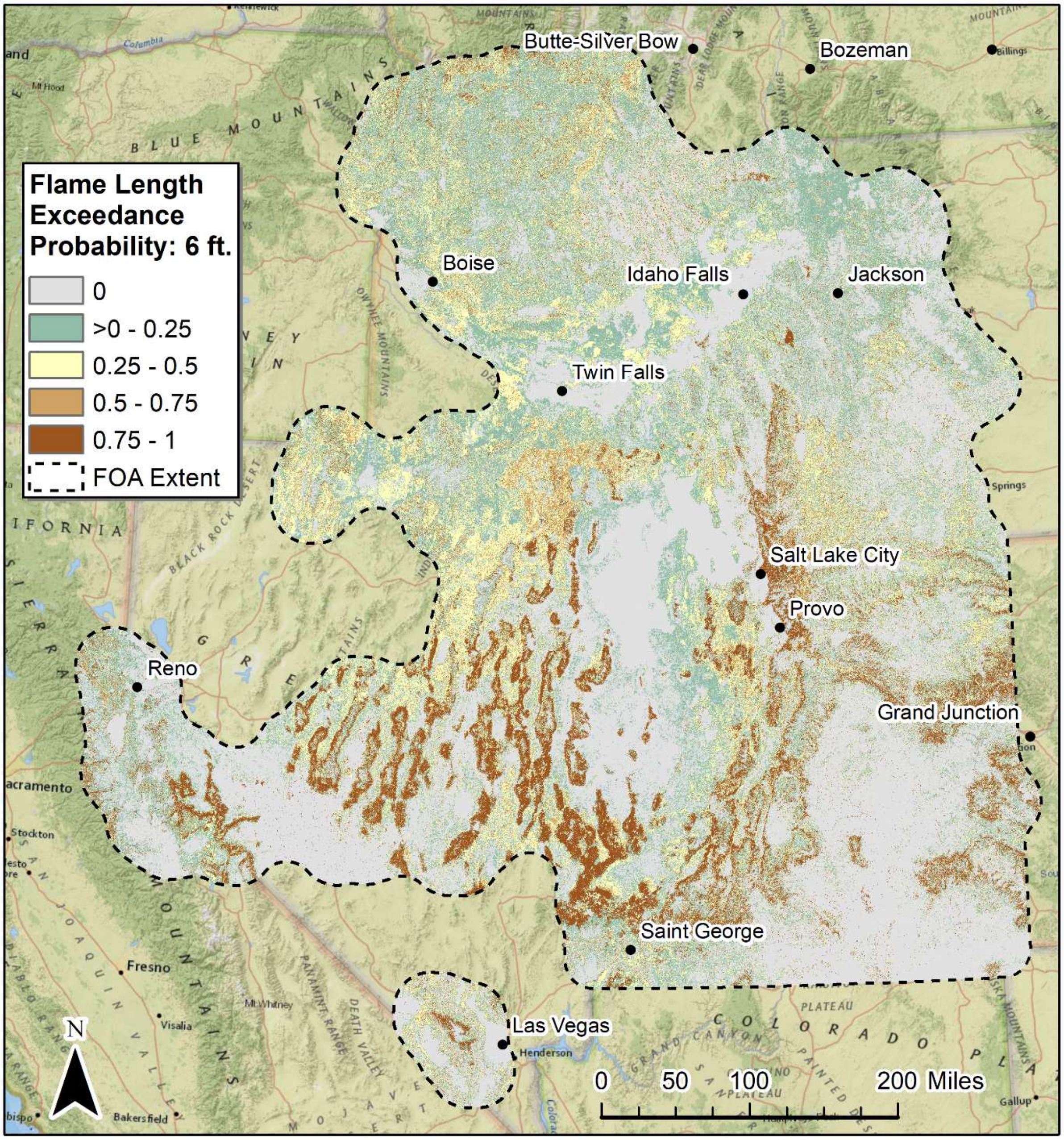

Figure 9. Map of FSim flame length exceedance probability: 6-ft. results for the Region 4 Fire Occurrence Area.

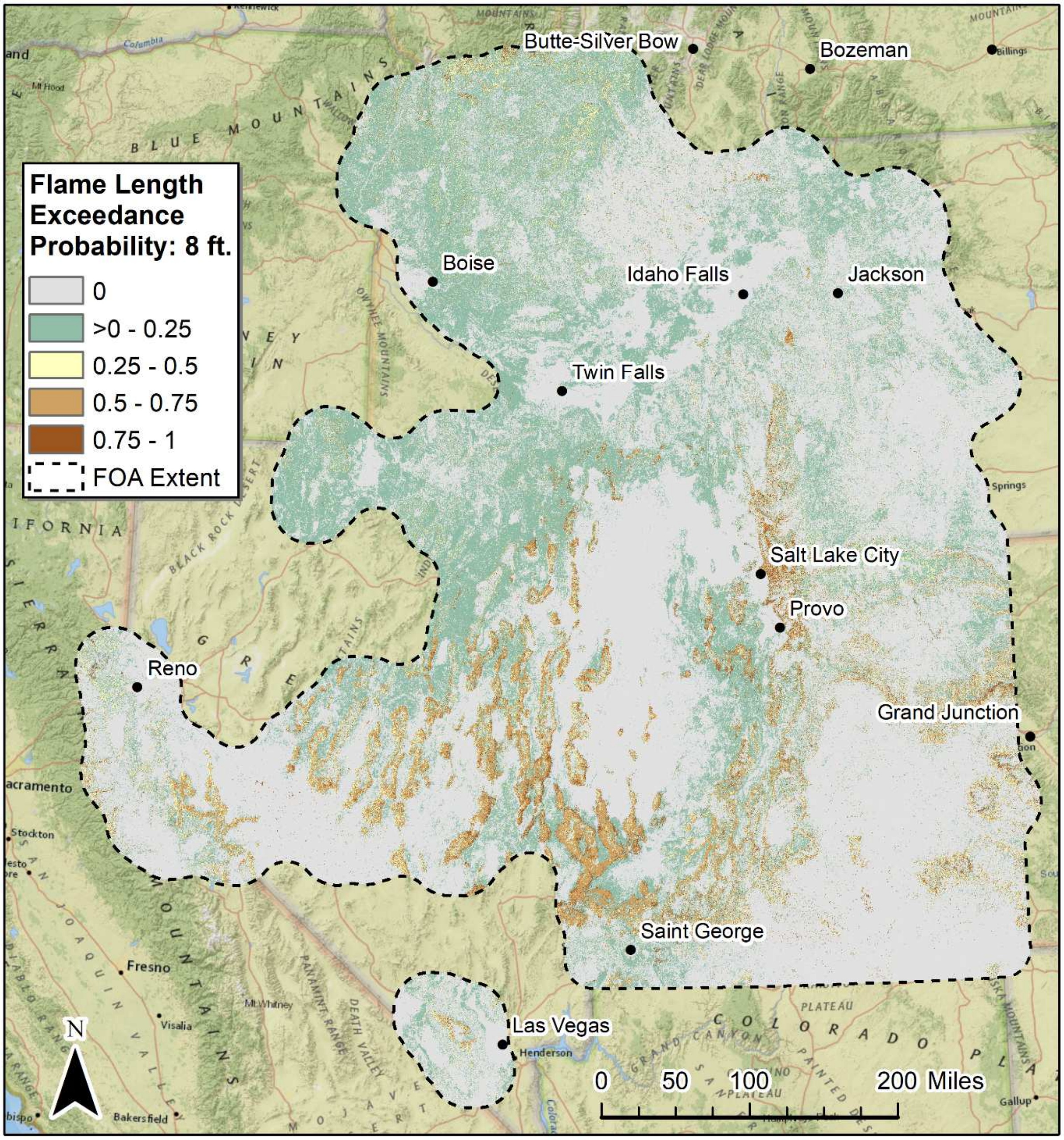

Figure 10. Map of FSim flame length exceedance probability: 8-ft. results for the Region 4 Fire Occurrence Area.

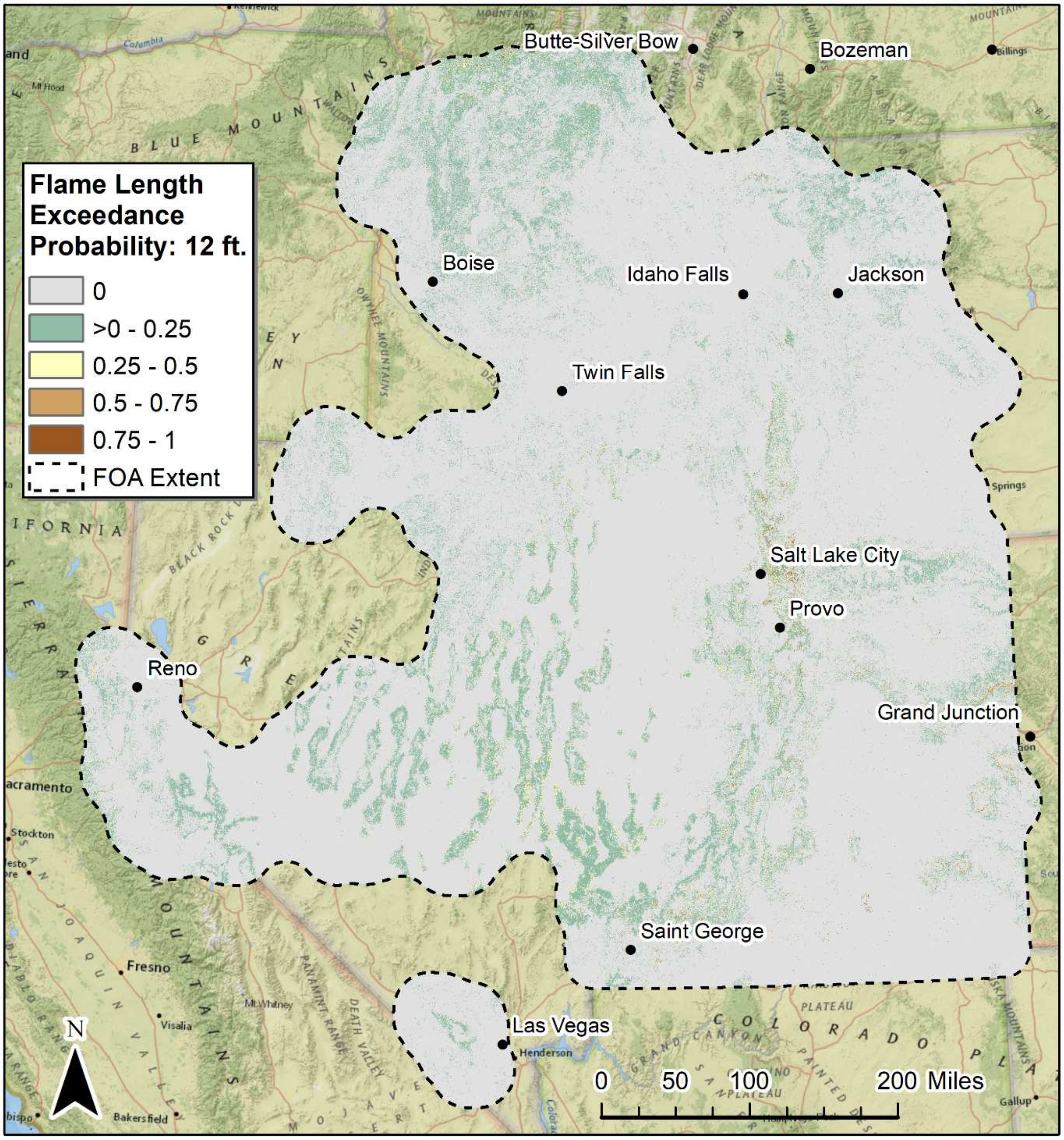

Figure 11. Map of FSim flame length exceedance probability: 12-ft. results for the Region 4 Fire Occurrence Area.

3.2.3 *Conditional Flame Length*

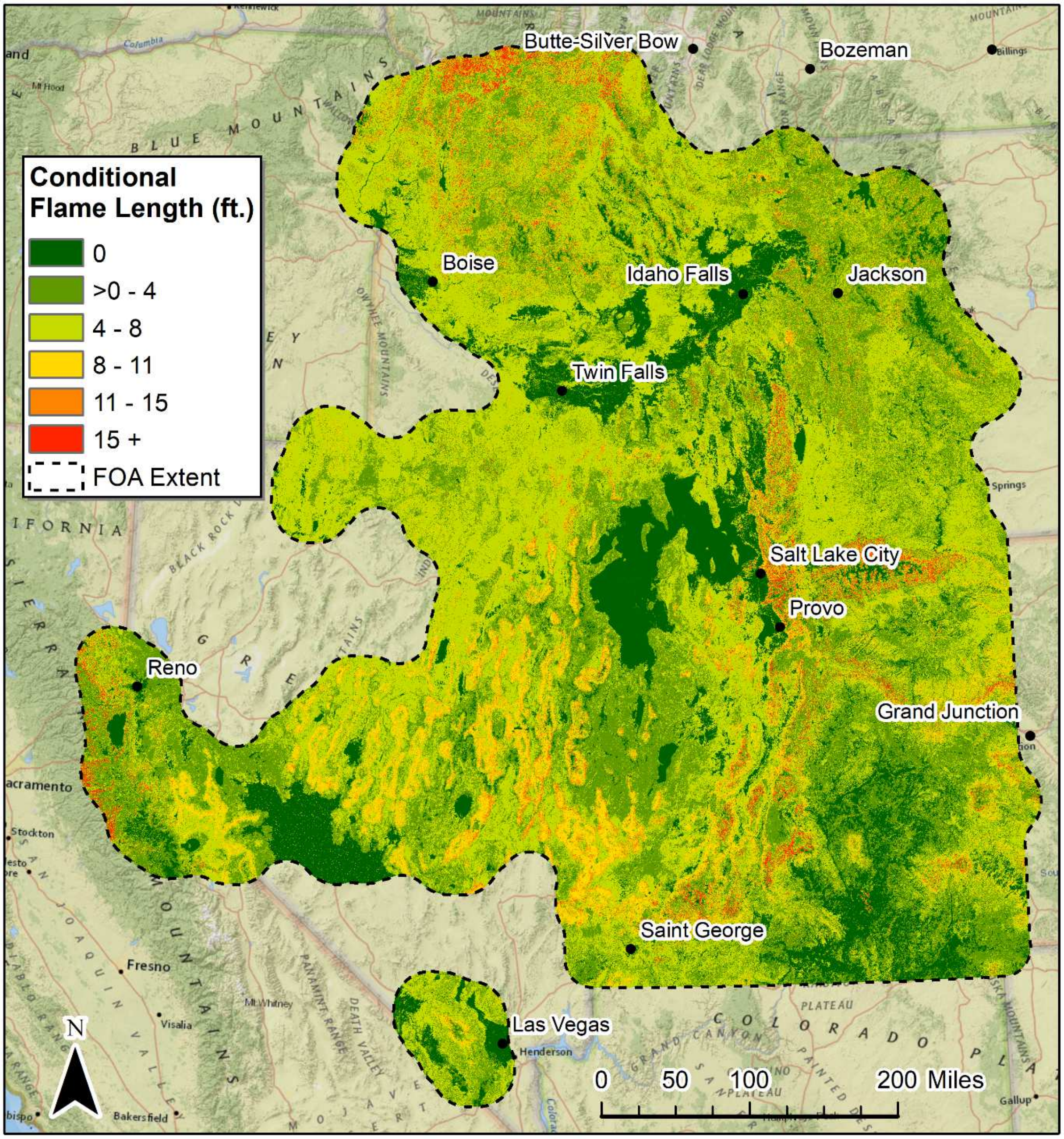

Figure 12. Map of integrated FSim conditional flame length results for the Region 4 Fire Occurrence Area.

4 Analysis Summary

The Region 4 Wildfire Hazard Assessment provides foundational information about wildfire hazard to facilitate calculations of wildfire risk to highly valued resources and assets across Region. The results represent the best available science in large-fire simulation modeling. The burn probability results are calibrated to historical mean fire occurrence and area burned to within the 70 percent confidence interval. Lastly, this analysis should be viewed as a living document. While the effort to parameterize and to calibrate wildfire hazard model inputs should remain static, the landscape file should be periodically revisited and updated to account for future forest disturbances.

5 Data Dictionary

5.1 FSim Results

- FSim modeling results are presented in three geodatabases:
  - **Region4_FSIM_120m.gdb** – FSim Mosaic results for the twenty-two FOAs in the R4 project area.
  - **Region4_Perims.gdb** – Event set outputs from FSim that includes all simulated wildfire perimeters.
  - **Region4_Ignitions.gdb** – Event set outputs from FSim that include the start location of all simulated wildfire perimeters.

1. **Region4_FSIM_120m.gdb** – This geodatabase contains 14 rasters representing mosaic results from the FSim simulations in the twenty-two FOAs within the R4 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_2 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.

   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. **FLEP_12** – see FLEP_2 description above
   f. **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.

   g. **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 (ft.). 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).

   h. **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.

i. **iFLP_FIL2** – see iFLP_FIL1 description above
j. **iFLP_FIL3** – see iFLP_FIL1 description above
k. **iFLP_FIL4** – see iFLP_FIL1 description above
l. **iFLP_FIL5** – see iFLP_FIL1 description above
m. **iFLP_FIL6** – see iFLP_FIL1 description above
n. **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. **Region4_Perims.gdb –** This dataset represents the simulated wildfire perimeters within each of the twenty-two Fire Occurrence Areas (FOA) that comprise the R4 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 wildfire size (acres) generated within FSim based on raster pixel 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. **Region4_Ignitions.gdb –** This dataset represents the simulated fire start locations within each of the twenty-two Fire Occurrence Areas (FOA) that comprise the R4 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 wildfire 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.

6 References

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7 Appendix

7.1 Fuelscape Edits

The LANDFIRE program assigns fuel model and canopy characteristics using two primary input layers: Existing Vegetation Type (EVT) and Map Zone (MZ). Using these inputs (and information about the fuel disturbance(s), vegetation height and cover, and biophysical setting), a rule is queried from the LANDFIRE ruleset database to assign surface fuel model and, if applicable, canopy characteristics for the given EVT and MZ. When working with a large project extent, such as Region 4, many MZs are present. The challenge in fuelscape calibration is to produce a set of output grids without artificial seamlines across multiple MZ. In order to do so, the rules from many MZs must be reconciled and filtered to allow only one ruleset per EVT across the entire fuelscape. As an unbiased way to reconcile rules from multiple MZs, we determined which MZ holds the greatest share of each EVT on the landscape and imported those rules to apply across the landscape.

The landscape resulting from that filtered collection of rulesets was used in a preliminary FSim modeling effort and used to run gNexus – the spatial implementation of the fire behavior calculator software, NEXUS. The gNexus process produces maps of Rate of Spread (ROS), Heat Per Unit Area (HPUA), Flame Length (FL), Fireline Intensity (FIL), Crown Fraction Burned (CFRB), Torching Index (TI), and Crowning Index (CI). These maps can then be summarized by each rule of the LFTFCT database for landscape critique and evaluation.

The set of EVTs reviewed in fuel calibration were identified as being among the top ten most abundant EVTs, EVTs that encompass a large portion of the Analysis Area, and EVTs with issues in Torching Index (i.e. one part of the rule allows torching at all windspeeds and another portion of the rule never allows for torching). The sections below list each EVT that was reviewed along with its original rule, modified rule, and rationale for change.

An important note of consideration in reviewing the fuel model revisions, though TU2 is named a “humid climate” fuel model, it has a fuel moisture of extinction of 30 percent – only 5 percent greater than TU5 which is named a “dry climate” fuel model. Fuel models should be selected based solely on the fire behavior they produce and not on the name, climate description, or photograph included in the fuel model publication (Scott 2005-2019, personal communication).

EVT: 2006 Rocky Mountain Alpine/Montane Sparsely Vegetated Systems

- Edited from NB/sparse to TL1/181 because fire disturbances were present and therefore reasoned that the fuel was indeed burnable

EVT: 2011 Rocky Mountain Aspen Forest and Woodland

- Reviewed but no edits

EVT: 2218 North American Warm Desert Sparsely Vegetated Systems II

- Edited from NB/sparse to SH1/141 because fire disturbances were present and therefore reasoned that the fuel was indeed burnable

EVT: 2219 Inter-Mountain Basins Sparsely Vegetated Systems II

- Edited from NB/sparse to SH1/141 because fire disturbances were present and therefore reasoned that the fuel was indeed burnable

EVT: 2221 Mediterranean California Sparsely Vegetated Systems II

- Edited from NB/sparse to SH1/141 because fire disturbances were present and therefore reasoned that the fuel was indeed burnable

EVT: 2222 Rocky Mountain Alpine/Montane Sparsely Vegetated Systems II

- Edited from NB/sparse to SH1/141 because fire disturbances were present and therefore reasoned that the fuel was indeed burnable

EVT 2016: Colorado Plateau Pinyon-Juniper Woodland

- Original rule

Fuel Model for FDIST 000	CL	CH	HL	HH	BPS	CG	CBH	FDIST0
GS2 / 122	101	102	108	110	any	1	9999	122
SH5 / 145	103	103	108	109	any	1	9999	145
TL3 / 183	103	103	110	110	any	1	3	183
TL3 / 183	104	109	108	111	any	1	3	183

- Final rule

Fuel Model for FDIST 000	CL	CH	HL	HH	BPS	CG	CBH	FDIST0
GS2 / 122	101	102	108	111	any	2	9999	122
SH5 / 145	103	104	108	111	any	2	9999	145
TL3 / 183	105	109	108	111	any	1	2	183

- Rationale for change:
    - The original rule for TL3 with a CBH of 0.3 meters produced an average Torching Index of 36 mi/h which is too high to ever be produced by FSim. We reduced CBH for TL3 to 0.2 meters (mean TI of 21 mi/h) which occurs occasionally in the area.
    - During fuelscape review, the group thought the original cover range for SH5 was too narrow and it should be extended to 49 percent.
    - The original rule had a Canopy Guide (CG) of 1, but after using this in simulations, the flame lengths were extremely high. We edited this to CG=2 to set a higher default canopy base height value and use the wind reduction factor produced when canopy cover/fuels are present.

EVT 2019: Great Basin Pinyon-Juniper Woodland

- Original rule

Fuel Model for FDIST 000	CL	CH	HL	HH	BPS	CG	CBH	FDIST0
GS2/122	101	101	108	111	any	1	9999	122
SH5/145	102	102	108	111	any	1	9999	145
TL3/183	103	108	108	111	any	1	3	183

- Final rule

Fuel Model for FDIST 000	CL	CH	HL	HH	BPS	CG	CBH	FDIST0
GS2/122	101	101	108	111	any	2	9999	122
SH5/145	102	104	108	111	any	2	9999	145
TL3/183	105	108	108	111	any	1	2	183

- Rationale for change:
  - The original rule for TL3 with a CBH of 0.3 meters produced an average Torching Index of 36 mi/h which is too high to ever be produced by FSim. We reduced CBH for TL3 to 0.2 meters (mean TI of 21 mi/h) which occurs occasionally in the area.
  - During fuelscape review, the group thought the original cover range for SH5 was too narrow and it should be extended to 49%
  - The original rule had a Canopy Guide (CG) of 1, but after using this in simulations, the flame lengths were extremely high. We edited this to CG=2 to set a higher default canopy base height value and use the wind reduction factor produced when canopy cover/fuels are present.

EVT: 2045 Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest

- Original rule

Fuel Model for FDIST 000	CL	CH	HL	HH	BPS	CG	CBH	FDIST0
GR2 / 102	101	101	108	111	any	1	9999	102
GS2 / 122	102	104	108	111	any	1	9999	122
TU5 / 165	105	105	109	111	any	1	9999	165
GS2 / 122	105	109	108	108	any	0	9999	122
TU1 / 161	106	109	109	110	any	1	9999	161
TU5 / 165	106	109	111	111	any	1	9999	165

- Final rule

Fuel Model for FDIST 000	CL	CH	HL	HH	BPS	CG	CBH	FDIST0
GR2 / 102	101	101	108	111	any	1	9999	102
GS2 / 122	102	104	108	111	any	1	9999	122
TU5 / 162	105	105	109	111	any	1	9999	162
GS2 / 122	105	109	108	108	any	0	9999	122
TU1 / 161	106	109	109	110	any	1	9999	161

TU5 / 162	**106**	**109**	**111**	**111**	any	**1**	**9999**	**162**

- Rationale for change:
    - The original rules with TU5 produced a mean TI of 0 mi/h which means that crown fire could be initiated at any windspeeds. We edited the fuel model to TU2 which has a similar (or greater) spread rate and produces lower flame lengths than TU5. The change to TU2 also is more consistent with the cover and height range mapped as TU1, though still produces moderate to high fire behavior. We did not edit TU1 because it made up a very small proportion of the EVT and an even smaller proportion of the overall landscape.

EVT: 2046 Northern Rocky Mountain Subalpine Woodland and Parkland

- Original rule

Fuel Model for FDIST 000	CL	CH	HL	HH	BPS	CG	CBH	FDIST0
GR1 / 101	101	101	108	111	any	1	9999	101
GS2 / 122	102	102	108	111	any	1	9999	122
TU5 / 165	103	109	108	111	any	1	9999	165

- Final rule

Fuel Model for FDIST 000	CL	CH	HL	HH	BPS	CG	CBH	FDIST0
GR1 / 101	101	101	108	111	any	1	9999	101
GS2 / 122	102	102	108	111	any	1	9999	122
TU2 / 162	103	109	108	111	any	1	4	162

- Rationale for change:
  - The original rules with TU5 produced a mean TI of 0 mi/h which means that crown fire could be initiated at any windspeeds. We edited the fuel model to TU2 which has a similar (or greater) spread rate and produces lower flame lengths than TU5.
  - The default CBH values were too high to allow crown fire so were lowered to 0.4 meters across the board.

EVT: 2050 Rocky Mountain Lodgepole Pine Forest

- Original rule

Fuel Model for FDIST 000	CL	CH	HL	HH	BPS	CG	CBH	FDIST0
TU5 / 165	101	103	109	111	any	1	9999	165
GS2 / 122	101	109	108	108	any	0	9999	122
TL3 / 183	104	109	109	111	any	1	9999	183

- Final rule

Fuel Model for FDIST 000	CL	CH	HL	HH	BPS	CG	CBH	FDIST0
GS2 / 122	101	109	108	108	any	0	9999	122
TU2 / 162	101	103	109	109	any	1	3	162
TU2 / 162	101	103	110	111	any	1	4	162
TL5 / 185	104	109	109	111	any	1	2	185

- Rationale for change:
  - The original rules with TU5 produced a mean TI of 0 mi/h which means that crown fire could be initiated at any windspeeds. We edited the fuel model to TU2 which has a similar (or greater) spread rate and produces lower flame lengths than TU5.
  - Default CBH values were too high to allow torching in TU2, so reduced to 0.3 m for heights less than 10 m and 0.4 m for heights greater than 10 m. These edits produced a mean TI of 6 mi/h across all TU2 values in this EVT and with FDIST=0.
  - We edited TL3 to TL5 to increase both flame length and spread rate. The original mean TI in TL3 was 98 mi/h, meaning the fuel mapped as TL3 would never experience crown fire. With the fuel model change and a reduction in CBH to 0.2 m, the new TI is 6-7 mi/h on average.

EVT: 2055 Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland

- Original rule

Fuel Model for FDIST 000	CL	CH	HL	HH	BPS	CG	CBH	FDIST0
TU1 / 161	**101**	**103**	**109**	**111**	any	**1**	**9999**	**161**
GS2 / 122	**101**	**109**	**108**	**108**	any	**0**	**9999**	**122**
TU5 / 165	**104**	**109**	**109**	**111**	any	**1**	**9999**	**165**

- Final rule

Fuel Model for FDIST 000	CL	CH	HL	HH	BPS	CG	CBH	FDIST0
TU1 / 161	**101**	**103**	**109**	**111**	any	**1**	**9999**	**161**
GS2 / 122	**101**	**109**	**108**	**108**	any	**0**	**9999**	**122**
TU2 / 162	**104**	**109**	**109**	**111**	any	**1**	**4**	**162**

- Rationale for change:
  - The original rule with TU5 produced a mean TI of 0 mi/h which means that crown fire could be initiated at any windspeed. We edited the fuel model to TU2 which has a similar (or greater) spread rate and produces lower flame lengths than TU5.
  - Default CBH values were too high to allow torching in TU2, so reduced to 0.4 m. These edits produced a mean TI of 3.8 mi/h across all TU2 values in this EVT and with FDIST=0.

EVT: 2056 Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland

- Original rule

Fuel Model for FDIST 000	CL	CH	HL	HH	BPS	CG	CBH	FDIST0
TL3 / 183	**101**	**103**	**108**	**111**	any	**1**	**9999**	**183**
TU5 / 165	**104**	**109**	**108**	**111**	any	**1**	**9999**	**165**

- Final rule

Fuel Model for FDIST 000	CL	CH	HL	HH	BPS	CG	CBH	FDIST0
TL5 / 185	**101**	**103**	**108**	**111**	any	**1**	**2**	**185**
TU2 / 162	**104**	**109**	**108**	**111**	any	**1**	**9999**	**162**

- Rational for change:
  - The original rule with TU5 produced a mean TI of 0 mi/h which means that crown fire could be initiated at any windspeed. We edited the fuel model to TU2 which has a similar (or greater) spread rate and produces lower flame lengths than TU5. Default CBH values produced a TI of 1 mi/h, so did not edit.
  - We edited TL3 to TL5 to increase both flame length and spread rate. The original mean TI in TL3 was 41 mi/h, meaning the fuel mapped as TL3 would never experience crown fire. With the fuel model change and a reduction in CBH to 0.2 m, the new TI is 4 mi/h on average.

EVT: 2061 Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland

- Original rule

Fuel Model for FDIST 000	CL	CH	HL	HH	BPS	CG	CBH	FDIST0
GS1 / 121	101	103	108	111	any	0	9999	121
TU1 / 161	104	104	109	111	any	1	9999	161
GS2 / 122	104	108	108	108	any	0	9999	122
TU5 / 165	105	109	109	111	any	1	9999	165

- Final rule

Fuel Model for FDIST 000	CL	CH	HL	HH	BPS	CG	CBH	FDIST0
GS1 / 121	101	103	108	111	any	0	9999	121
TU1 / 161	104	104	109	111	any	1	2	161
GS2 / 122	104	108	108	108	any	0	9999	122
TU5 / 165	105	109	109	111	any	1	9999	165

- Rational for change:
    - Kept original ruleset, but reduced default CBH in TU1/161 to bring TI from 75 mi/h to 4 mi/h.

EVT: 2079 Great Basin Xeric Mixed Sagebrush Shrubland

- No edits to FDIST0, but where original rule had GR1 going to non-burnable (NB99), we kept GR1
- Rational for change:
    - Fuel recovery during the time period of the assessment should return to GR1

EVT: 2080 Inter-Mountain Basins Big Sagebrush Shrubland

- Original rule

Fuel Model for FDIST 000	CL	CH	HL	HH	BPS	CG	CBH	FDIST0
GR2 / 102	111	111	104	104	any	0	9999	102
GS2 / 122	111	112	105	107	any	0	9999	122
GS2 / 122	112	112	104	104	any	0	9999	122
SH5 / 145	113	119	104	107	any	0	9999	145

- Final rule

Fuel Model for FDIST 000	CL	CH	HL	HH	BPS	CG	CBH	FDIST0
GS1 / 121	111	112	104	105	any	0	9999	121
GS2 / 122	113	119	104	105	any	0	9999	122
GS2 / 122	111	117	106	107	any	0	9999	122
SH5 / 145	118	118	106	107	any	0	9999	145
SH7 / 147	119	119	106	107	any	0	9999	147

- Rational for change:
    - The original rule had SH5/145 mapped for all height classes from 30-100 percent cover and GS2/122 mapped below 30 percent cover, except for the lowest cover/height class (GR2).
    - We restructured the ruleset to reflect the slower spreading short and sparse sagebrush (GS1/121), followed by GS2/122 for all but the two highest cover and height classes where we assigned SH5/145 for 80-90 percent cover and SH7/147 for 90-100 percent cover.
    - During fuel review the group questioned whether SH5 should be extended to the 70-80 percent and greater than 1 m boxes, but this only added 1000 pixels which was undetectable on the map and would not influence overall fuel mapping/fire behavior in the slightest, so we did not implement the change.

EVT: 2081 Inter-Mountain Basins Mixed Salt Desert Scrub

- No edits to FDIST0, but where original rule had GR1 going to non-burnable (NB99), we kept GR1
- Rational for change:
    - Fuel recovery during the time period of the assessment should return to GR1

EVT: 2082 Mojave Mid-Elevation Mixed Desert Scrub

- Original rule

Fuel Model for FDIST 000	CL	CH	HL	HH	BPS	CG	CBH	FDIST0
GR2 / 102	111	113	104	104	any	0	9999	102
GS2 / 122	111	113	105	105	any	0	9999	122
SH2 / 142	111	118	106	107	any	0	9999	142
SH2 / 142	114	118	104	105	any	0	9999	142

- Final rule

Fuel Model for FDIST 000	CL	CH	HL	HH	BPS	CG	CBH	FDIST0
GR1 / 101	111	113	104	104	any	0	9999	101
GS1 / 121	111	113	105	105	any	0	9999	121
SH2 / 142	111	118	106	107	any	0	9999	142
SH2 / 142	114	118	104	105	any	0	9999	142

- Rational for change:
    - Reduced fire behavior in the lower cover and height classes from GR2 and GS2 which are very fast spreading for desert scrub (with very low historical fire occurrence) and do not match the fire behavior logic of SH2 in the higher cover and height classes.
    - Instead we edited GR2 to GR1 and GS2 to GS1 to reduce spread rates.

EVT: 2125 Inter-Mountain Basins Big Sagebrush Steppe

- Reviewed but no edits

EVT: 2126 Inter-Mountain Basins Montane Sagebrush Steppe

- Reviewed but no edits

EVT: 2153 Inter-Mountain Basins Greasewood Flat

- Reviewed but no edits

EVT: 2220 Artemisia tridentata ssp. vaseyana Shrubland Alliance

- Original rule

Fuel Model for FDIST 000	CL	CH	HL	HH	BPS	CG	CBH	FDIST0
GS2 / 122	111	111	104	107	any	0	9999	122
SH7 / 147	112	119	104	107	any	0	9999	147

- Final rule

Fuel Model for FDIST 000	CL	CH	HL	HH	BPS	CG	CBH	FDIST0
GS1 / 121	111	112	104	105	any	0	9999	121
GS2 / 122	113	119	104	105	any	0	9999	122
GS2 / 122	111	117	106	107	any	0	9999	122
SH5 / 145	118	119	106	107	any	0	9999	145

- Rational for change:
    - The original rule had SH7/147 mapped for all height classes from 20-100 percent cover and GS2/122 mapped at percent cover. This produced very high spread rates and flame lengths and appeared to drastically overstate expected fire behavior in this EVT.
    - We restructured the ruleset (much like EVT2080) to reflect the slower spreading short and sparse sagebrush (GS1/121), followed by GS2/122 for all but the two highest cover and height classes where we assigned SH5/145 for 80-100 percent cover.

EVT: 2227 Pseudotsuga menziesii Forest Alliance

- Original rule

Fuel Model for FDIST 000	CL	CH	HL	HH	BPS	CG	CBH	FDIST0
GR2 / 102	101	101	109	111	any	1	9999	102
SH7 / 147	101	109	108	108	any	0	9999	147
TL8 / 188	102	104	109	111	any	1	9999	188
GS2 / 122	102	106	109	111	449	1	9999	122
TU5 / 165	105	109	109	111	any	1	9999	165

- Final rule

Fuel Model for FDIST 000	CL	CH	HL	HH	BPS	CG	CBH	FDIST0
GS2 / 122	**101**	**105**	**108**	**108**	any	**0**	**9999**	**122**
GR2 / 102	**101**	**101**	**109**	**111**	any	**1**	**9999**	**102**
TL8 / 188	**102**	**104**	**109**	**111**	any	**1**	**5**	**188**
TU5 / 162	**105**	**109**	**109**	**109**	any	**1**	**3**	**162**
TU5 / 162	**105**	**109**	**110**	**111**	any	**1**	**4**	**162**
SH7 / 147	**106**	**109**	**108**	**108**	any	**0**	**9999**	**147**
GS2 / 122	**102**	**106**	**109**	**111**	449	**1**	**9999**	**122**

- Rational for change:
    - The original rule mapped SH7/147 across all cover classes for forest height less than 5 m. To tone down this fire behavior, we kept SH7 only for cover classes 60 percent and greater and edited the fuel model below 60 percent to GS2/122.
    - The fuel review group was concerned that there was still too much SH7, but only 57 pixels remained so did not edit further.
    - The original rule with TU5 produced a mean TI of 0 mi/h which means that crown fire could be initiated at any windspeed. We edited the fuel model to TU2 which has a similar (or greater) spread rate and produces lower flame lengths than TU5. Default CBH values were too high to see much torching in TU2, so reduced to 0.3 m for less than 10 m and 0.4 m for heights greater than 10 m. These edits produced a mean TI of less than 1 mi/h across all TU2 values in this EVT and with FDIST=0.
    - We lowered the CBH in TL8 to 0.5 m to allow more frequent torching. The edits produced a mean TI of less than 1 mi/h.
    - Though the torching index is very low in both TL8 and TU2, the FSim intensities were lower than expected in this EVT. Upon further examination, we attributed this to the low canopy bulk density values present in this EVT.