Region 2: San Juan National Forest Quantitative Wildfire Risk Assessment: Methods and Results

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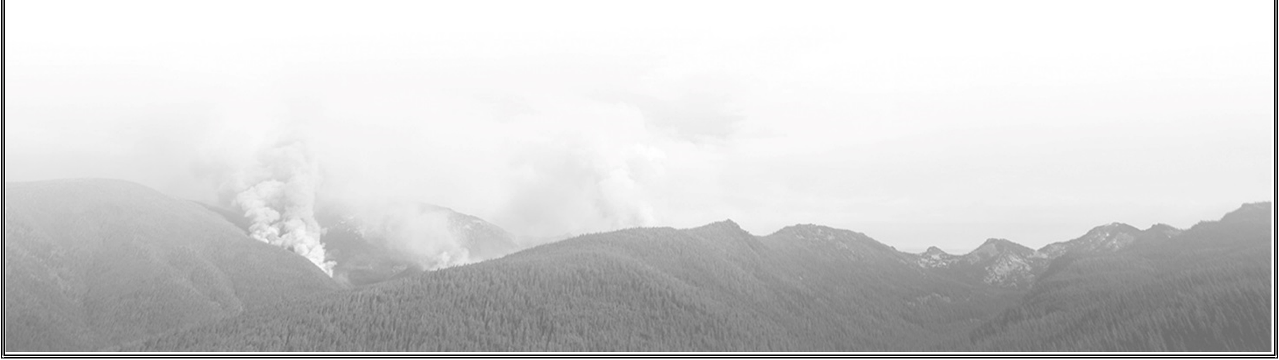

Table of Contents

List of Tables

List of Figures

1 Overview of Region 2: San Juan N.F.

1.1 Purpose of the Assessment

The purpose of the Region 2: San Juan National Forest Risk Assessment (R2SJ) is to provide foundational information about wildfire hazard and risk to highly valued resources and assets across the geographic area. Such information supports wildfires, 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 R2SJ analysis considers several different components, each resolved spatially across the Forest, 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 R2SJ, 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 Forest, 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 Project Analysis Area

The Analysis Area (AA) is the area for which valid burn probability (BP) results are produced. The AA for the Region 2, San Juan (R2SJ) FSim project was initially defined as the San Juan National Forest boundary buffered to a 5 km boundary. After initial review it was realized the buffer may cause irregularities in outputs due to its irregular shape/overlap. Minor boundary modifications were made to mitigate potential issues.

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 1).

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 results from 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).

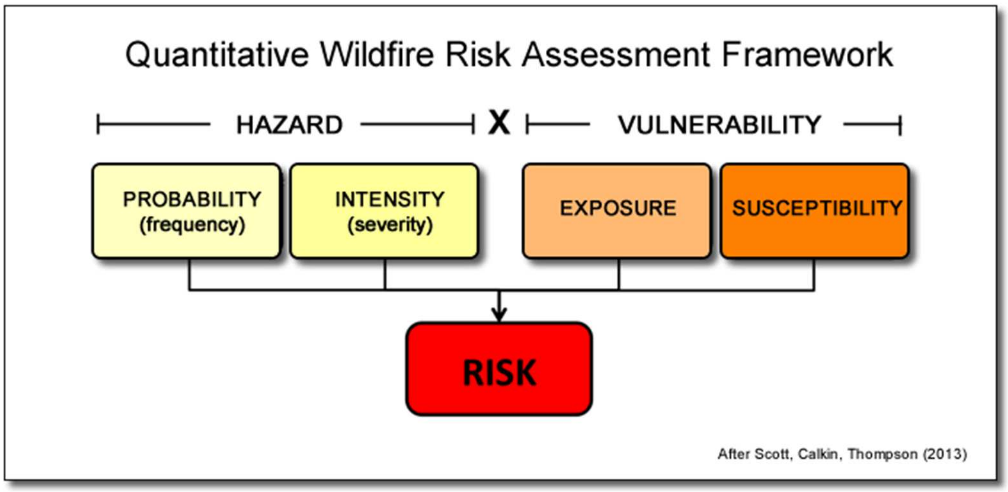

Figure 1. The components of the Quantitative Wildfire Risk Assessment Framework used for R2SJ.

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).

The FSim results used in this assessment were produced as part of the Stochastic Wildfire Simulation for the BLM Colorado Southwest District project. Please reference the final report "BLM-CO-SWD-FSim.pdf" provided with this project's deliverables for information on FSim modeling. The final, pixel based FSim outputs used in the calculations along with the report for the FSim data are included with project deliverables.

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 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 within the scope of the assessment 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 were identified by the San Juan National Forest and provided to Pyrologix for final Effects Analysis. Representatives from the San Juan National Forest identified eight HVRAs in total: two assets and six resources. The complete list of HVRAs and their associated data sources are listed in Table 1.

To the degree possible, HVRAs are mapped to the extent of the Analysis Area boundary (Figure 2). 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 US Forest Service (FS) corporate databases for FS land only).

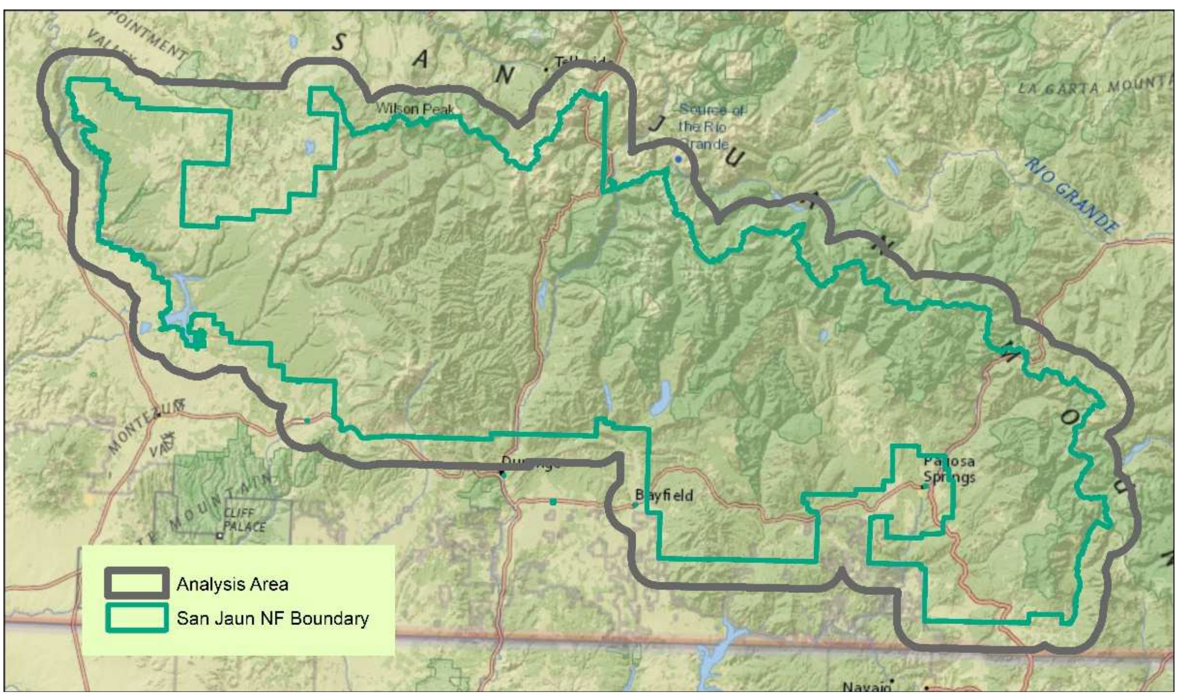

Figure 2. San Juan National Forest: HVRA Analysis Area Extent.

3.2 Response Functions

Each HVRA selected for the assessment must also have an associated response to fire, whether it is positive or negative. Information collected from Forest representatives and Cary Newman, Fire Management Planning Specialist from the San Juan National Forest Headquarters, provided Pyrologix information on 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 2. The response functions (RFs) used in the risk results are shown in Table 3 through Table 27 below.

3.3 Relative Importance

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 assignments were discussed and reviewed during a consultation meeting on May 15, 2019. The focus of this discussion was to review the response functions and importance ranking of the primary HVRAs relative to each other. The People and Property (WUI) HVRA received the greatest share of RI at 21 percent, followed by the Infrastructure HVRAs, receiving 19 percent of the total importance. Drinking Water Collection was allocated 17 percent, Water Condition Framework received 13 percent and Threatened and Endangered Species Habitat 11%. While the Cultural Sites, Limited Habitat and Timber HVRAs received less than 10 percent of the total landscape importance (Figure 3). These importance percentages reflect the overall importance of all mapped HVRA.

Pyrologix worked with the Forest Fire Planner to adjust sub-HVRA relative importance. 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 3 through Table 27, 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 the 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 1. HVRA and sub-HVRA identified for the Region 2: San Juan wildfire risk assessment and associated data sources.

HVRA & Sub-HVRA	Data source
Infrastructure (Investments)	
Exposed Utilities	Exposed utilities (substations, ditches and transmission lines) dataset provided by San Juan NF.
Communication Sites	Communication sites, towers, antennas and cell towers dataset provided by San Juan NF.
High-Investment Building/Recreation Sites	Locations representing high-investment buildings and developed recreation sites. Including admin sites, lodging/cabins, campgrounds, boating sites, lookouts and residences); dataset provided by San Juan NF.
High-Investment Permitted Private Development	Locations representing high-investment permitted private development sites (residences, ski areas, tanks, sheds); dataset provided by San Juan NF
Low/Moderate-Investment Building/Recreation Sites	Locations representing low-investment buildings and developed recreation sites (weather stations, air quality, stream gauge, interpretive sites, fishing sites, picnic); dataset provided by San Juan NF.
Low/Moderate-Investment Permitted Private Development	Locations representing low-investment permitted private development sites (cow camps, cabins, sheds/storage); dataset provided by San Juan NF
People & Property (WUI)	
WUI	Housing density classes; data extracted from San Juan NF Structures geodatabase; assignments based on dataset attributes.
Timber Production	
Plantations	Locations of timber plantations; data layer provided by San Juan NF
Suitable Timber	Lands suitable for timber production; data layer provided by San Juan NF
Drinking Water Collection	
Drinking Water Collection	Southwest drinking watershed erosion hazard assignments provided by San Juan NF representing low risk of sediment with high, moderate and low erosion
Water Condition	
Watershed Condition Framework	Water condition framework dataset extracted from USDA Erosion Hazard database; representing watershed conditions of impaired, at risk and functional with high/moderate/low erosion risk
T&E Species and Designated (FWS) Critical Habitat	
Pagosa Skyrocket	Habitat delineation provided by San Juan NF
Greenback Cutthroat Trout	Habitat delineation provided by San Juan NF
New Mexico Meadow Jumping Mouse	Habitat delineation provided by San Juan NF
Yellow-Billed Cuckoo	Habitat delineation provided by San Juan NF
Canadian Lynx	Habitat delineation provided by San Juan NF
Colorado River cutthroat trout	Habitat delineation provided by San Juan NF
Cultural	
Archeological Districts	Locations representing archeological Districts of importance; provided by San Juan NF
Archeological Sites – High Fire Sensitivity	Archeological site locations (sites and historic routes) flagged for high fire sensitivity
Archeological Sites – Low Fire Sensitivity	Archeological site locations (sites and historic routes) flagged for low fire sensitivity
Limited Habitat (Species w/High Economic Value)	
Bighorn sheep winter concentration	Limited habitat delineation provided by San Juan NF
Mule deer severe winter range	Limited habitat delineation provided by San Juan NF
Mule deer winter concentration	Limited habitat delineation provided by San Juan NF
Elk severe winter range	Limited habitat delineation provided by San Juan NF
Elk winter concentration	Limited habitat delineation provided by San Juan NF

Table 2. 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+

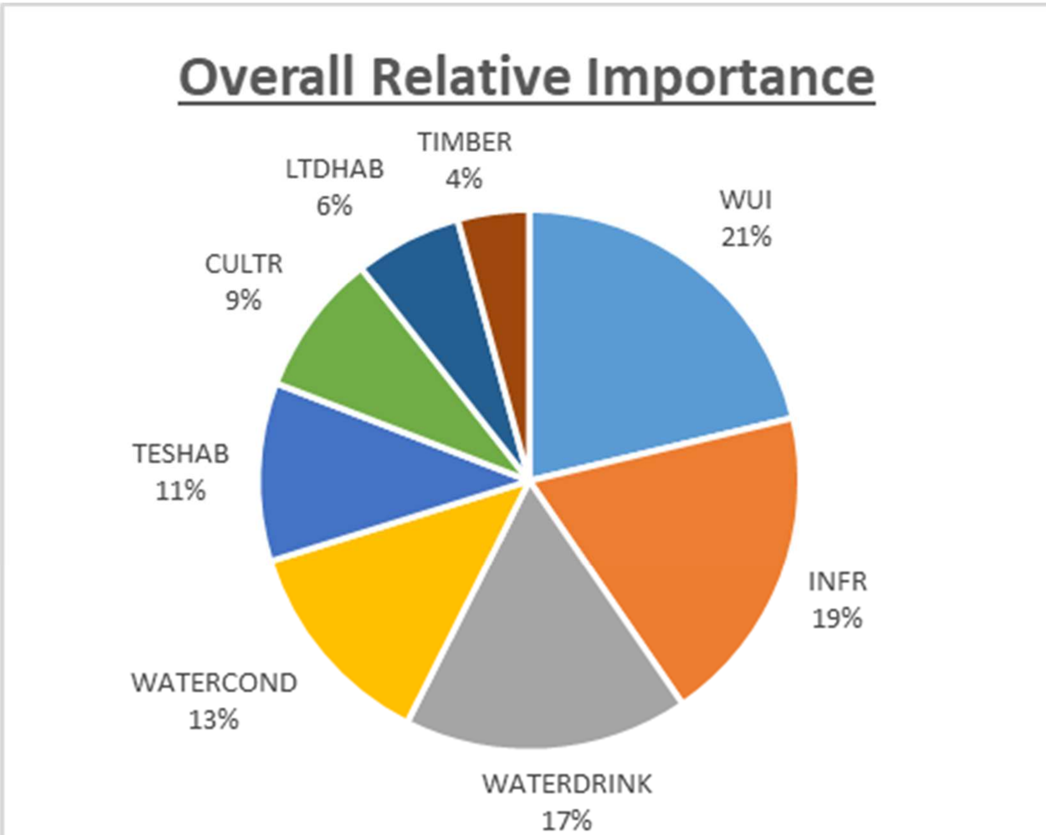

Figure 3. Overall HVRA Relative Importance for the primary HVRAs included in San Juan, NF.

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 R2SJ Assessment are mapped below along with a table containing the set of assigned response functions, 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 Communication Sites

Communication sites in the San Juan National Forest are mapped in Figure 4. The site locations represented were extracted from a geodatabase provided by the National Forest. To account for mapping uncertainties the site locations were converted to 30-m pixels and expanded out two pixels using the Annulus Neighborhood of the ArcGIS *Focal Statistics* tool.

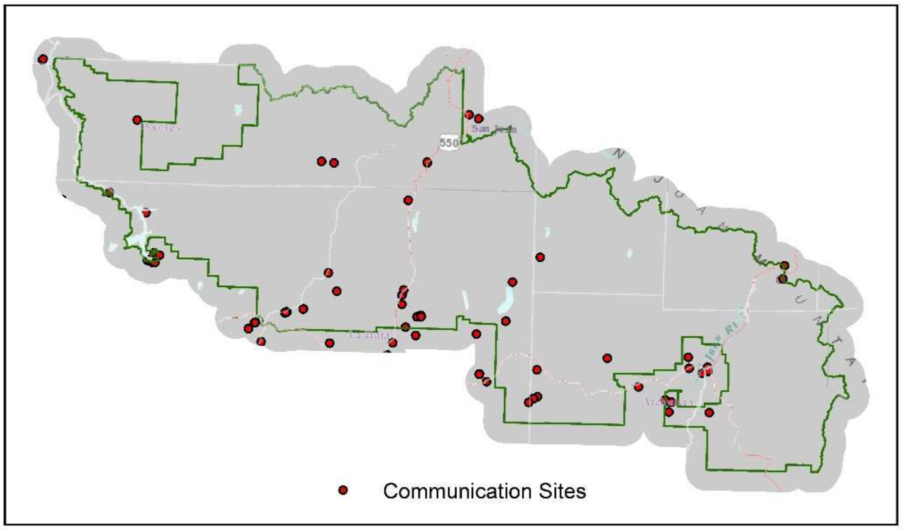

Figure 4. Map of Communication Sites in the R2SJ analysis area.

The RF for communication sites show a low negative response function at FIL1, increasing with increasing fire intensity and showing a max negative response for FILs 4-6 (Table 3).

Communication Sites received 1.45 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.

Table 3. Response functions for the Infrastructure HVRA to highlight communication sites

Sub-HVRA	% of HVRA	Acres	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6
Communication Sites	1.45%	234	-10	-50	-80	-100	-100	-100
Exposed Utilities	89.22%	16,218	-10	-50	-70	-80	-100	-100
High-investment Building and Developed Recreation Sites (agency owned)	7.22%	1,312	-10	-50	-80	-100	-100	-100
Low/Moderate-investment Building and Developed Recreation Sites (agency owned)	0.86%	313	-10	-40	-60	-80	-100	-100
High-investment Permitted Private Developments	1.10%	177	-10	-50	-80	-100	-100	-100
Low/Moderate-investment Permitted Private Developments	0.16%	78	-10	-40	-60	-80	-100	-100

[1] Within-HVRA relative importance.

3.4.1.2 Exposed Utilities

Exposed utilities (point and line features) for San Juan National Forest are mapped in Figure 5. The mapped features were extracted from a geodatabase provided by the National Forest. To account for mapping uncertainties in the HVRA location and/or fuel mapping point features were converted to 30-m pixels and expanded out two pixels using the Annulus Neighborhood of the ArcGIS *Focal Statistics* tool. Linear features (utility lines) were converted to 30-m raster and expanded 1 pixel using the ArcGIS *Expand* tool.

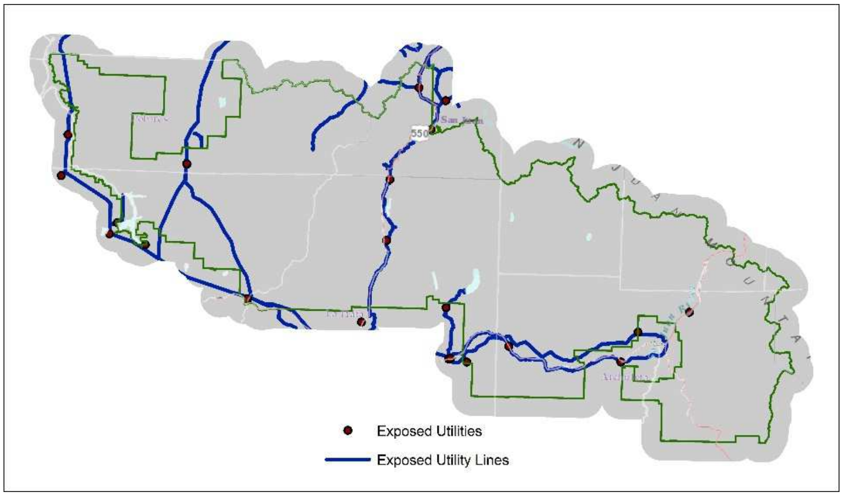

Figure 5. Map of Exposed Utilities in the R2SJ analysis area.

The RF for exposed utilities shows a low negative response function at the lowest flame lengths (FIL1), increasing with increasing intensity. A maximum negative response of 100 was shown for FILs 5-6 (Table 4).

Exposed utilities received 89.22 percent of the total Infrastructure HVRA relative importance due to the large number of acres mapped relative to the other Infrastructure HVRA. The share of HVRA importance is based on relative importance per unit area and mapped extent.

Table 4. Response functions for the Infrastructure HVRA to highlight exposed utilities.

Sub-HVRA	% of HVRA	Acres	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6
Communication Sites	1.45%	234	-10	-50	-80	-100	-100	-100
Exposed Utilities	89.22%	16,218	-10	-50	-70	-80	-100	-100
High-investment Building and Developed Recreation Sites (agency owned)	7.22%	1,312	-10	-50	-80	-100	-100	-100
Low/Moderate-investment Building and Developed Recreation Sites (agency owned)	0.86%	313	-10	-40	-60	-80	-100	-100
High-investment Permitted Private Developments	1.10%	177	-10	-50	-80	-100	-100	-100
Low/Moderate-investment Permitted Private Developments	0.16%	78	-10	-40	-60	-80	-100	-100

[1] Within-HVRA relative importance.

3.4.1.3 High-investment Building and Developed Recreation Sites

High-investment buildings and developed recreation sites mapped for R2SJ are shown in Figure 6. Locations were converted to 30-m pixels and expanded out two pixels using the Annulus Neighborhood of the ArcGIS *Focal Statistics* tool allowing for mapping uncertainties in the HVRA location and/or fuel mapping. Included are locations representing administration buildings, lodging/cabins, campgrounds, boating sites, lookouts and residences.

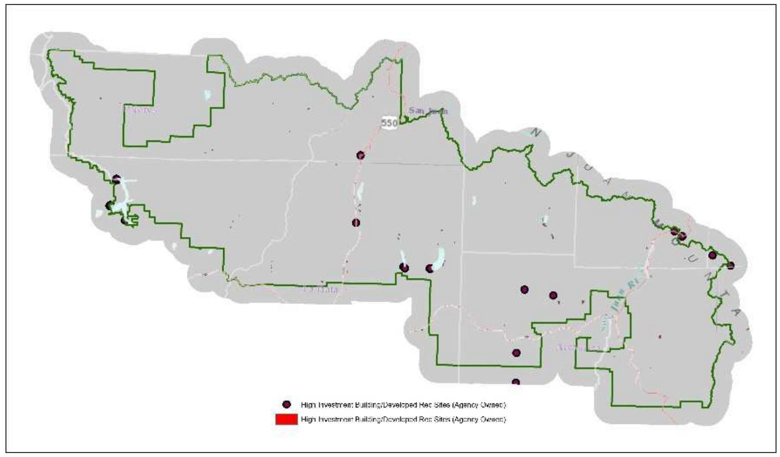

Figure 6. Map of High-Investment Building and Developed Recreation Sites (agency owned) in the R2SJ analysis area.

In this assessment, high-investment building/recreation sites have a slightly negative response to FIL1, becoming increasingly negative with increasing intensity levels (Table 5).

High-investment building and developed recreation sites received 7.22 percent of the total Infrastructure HVRA relative importance. The share of HVRA importance is based on relative importance per unit area and mapped extent.

Table 5. Response functions for the Infrastructure HVRA to highlight high-Investment developed recreation sites (agency owned).

Sub-HVRA	% of HVRA	Acres	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6
Communication Sites	1.45%	234	-10	-50	-80	-100	-100	-100
Exposed Utilities	89.22%	16,218	-10	-50	-70	-80	-100	-100
High-Investment Building and Developed Recreation Sites (agency owned)	7.22%	1,312	-10	-50	-80	-100	-100	-100
Low/Moderate-Investment Building and Developed Recreation Sites (agency owned)	0.86%	313	-10	-40	-60	-80	-100	-100
High-Investment Permitted Private Developments	1.10%	177	-10	-50	-80	-100	-100	-100
Low/Moderate-Investment Permitted Private Developments	0.16%	78	-10	-40	-60	-80	-100	-100

[1] Within-HVRA relative importance.

3.4.1.4 Low/Moderate-Investment Building and Developed Recreation Sites

Agency owned low/moderate-investment sites mapped for R2SJ are shown in Figure 7. Site locations were converted to 30-m pixels and expanded out two pixels using the Annulus Neighborhood of the ArcGIS *Focal Statistics* tool allowing for mapping uncertainties in the HVRA location and/or fuel mapping. Site locations represent residences, sheds, tanks, ski areas and ski lifts

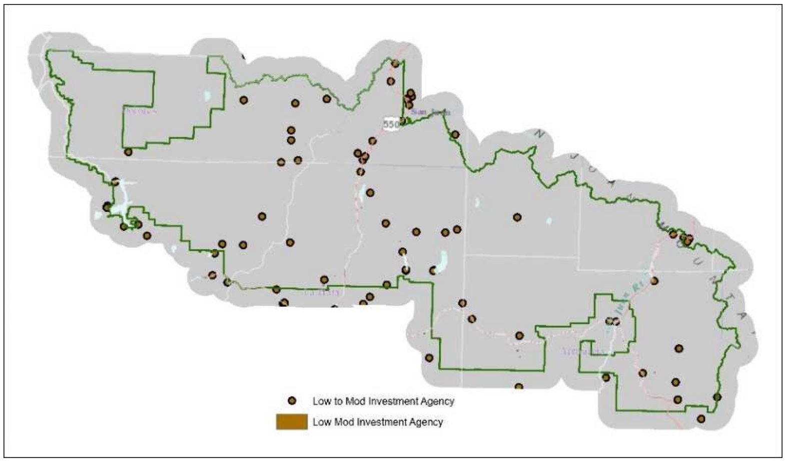

Figure 7. Map of Low/Moderate-investment Building and Developed Recreation Sites (agency owned) in the R2SJ analysis area.

In this assessment, low/moderate-investment building/recreations sites are said to have a negative response to wildfire. FIL1 demonstrate a low negative response; becoming increasingly negative with increasing fire intensity levels (Table 6).

Agency owned low/moderate-investment building and developed recreate sites received 0.86 percent of the total Infrastructure HVRA relative importance. The share of HVRA importance is based on relative importance per unit area and mapped extent.

Table 6. Response functions for the Infrastructure HVRA to highlight low/moderate-investment developed recreation sites (agency owned).

Sub-HVRA	% of HVRA	Acres	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6
Communication Sites	1.45%	234	-10	-50	-80	-100	-100	-100
Exposed Utilities	89.22%	16,218	-10	-50	-70	-80	-100	-100
High-investment Building and Developed Recreation Sites (agency owned)	7.22%	1,312	-10	-50	-80	-100	-100	-100
Low/Moderate-investment Building and Developed Recreation Sites (agency owned)	0.86%	313	-10	-40	-60	-80	-100	-100
High-investment Permitted Private Developments	1.10%	177	-10	-50	-80	-100	-100	-100
Low/Moderate-investment Permitted Private Developments	0.16%	78	-10	-40	-60	-80	-100	-100

[1] Within-HVRA relative importance.

3.4.1.5 High-investment Permitted Private Developments

Permitted high-investment private developments mapped for R2SJ are shown in Figure 8. The points were converted to 30-m pixels and expanded out two pixels using the Annulus Neighborhood of the ArcGIS *Focal Statistics* tool allowing for mapping uncertainties in the HVRA location and/or fuel mapping. Site locations represent residences, sheds, tanks, ski areas and ski lifts

In this assessment, high-investment permitted private developments are said to have an increasingly negative response relative to increasing intensity (Table 7).

High-investment permitted developments received 1.10 percent of the total Infrastructure HVRA relative importance. The share of HVRA importance is based on relative importance per unit area and mapped extent.

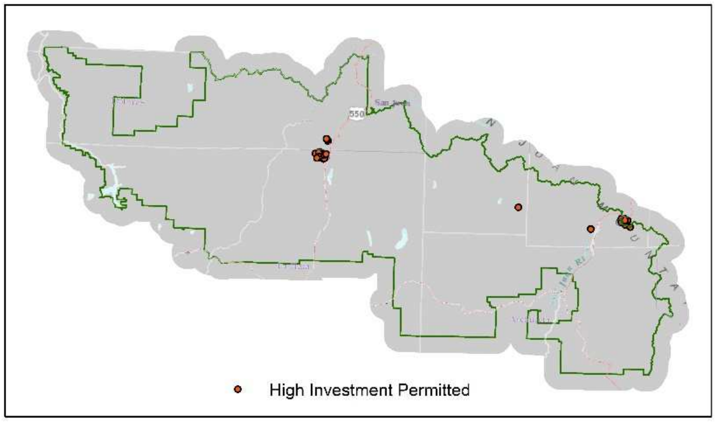

Figure 8. Map of High-investment Permitted Private Developments in the R2SJ analysis area

Table 7. Response functions for the Infrastructure HVRA to highlight high-investment permitted private developments.

Sub-HVRA	% of HVRA	Acres	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6
Communication Sites	1.45%	234	-10	-50	-80	-100	-100	-100
Exposed Utilities	89.22%	16,218	-10	-50	-70	-80	-100	-100
High-investment Building and Developed Recreation Sites (agency owned)	7.22%	1,312	-10	-50	-80	-100	-100	-100
Low/Moderate-investment Building and Developed Recreation Sites (agency owned)	0.86%	313	-10	-40	-60	-80	-100	-100
High-investment Permitted Private Developments	1.10%	177	-10	-50	-80	-100	-100	-100
Low/Moderate-investment Permitted Private Developments	0.16%	78	-10	-40	-60	-80	-100	-100

[1] Within-HVRA relative importance.

3.4.1.6 Low/Moderate-investment Permitted Private Developments

Private low/moderate-investment permitted development sites mapped for R2SJ are shown in Figure 9. The points were converted to 30-m pixels and expanded out two pixels using the Annulus Neighborhood of the ArcGIS *Focal Statistics* tool allowing for mapping uncertainties in the HVRA location and/or fuel mapping. The recreation sites consist of points representing cow camps, cabins, sheds and barns.

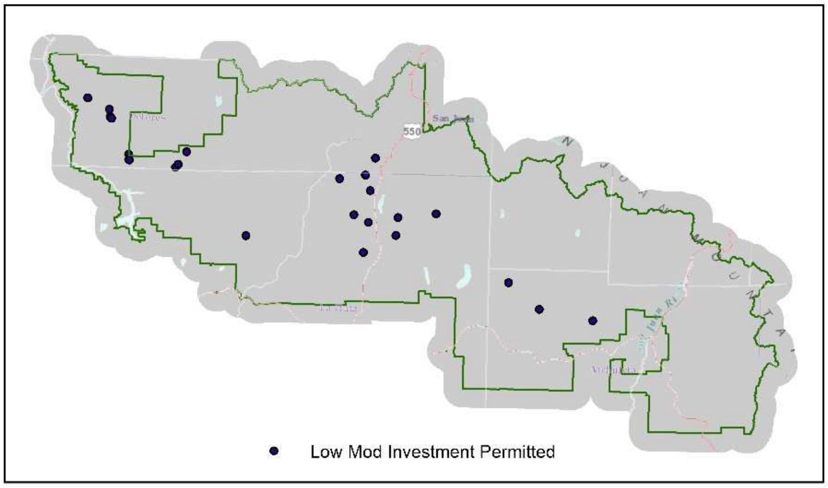

Figure 9. Map of Low/Moderate Permitted Private Developments in the R2SJ analysis area.

In this assessment, private low/moderate-investment permitted developments are said to have an increasingly negative response to fires of increasing intensity (Table 7).

Low/moderate-investment permitted developments received 0.16 percent of the total Infrastructure HVRA relative importance. The share of HVRA importance is based on relative importance per unit area and mapped extent

Table 8. Response functions for the Infrastructure HVRA to low/moderate-investment permitted private developments.

Sub-HVRA	% of HVRA	Acres	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6
Communication Sites	1.45%	234	-10	-50	-80	-100	-100	-100
Exposed Utilities	89.22%	16,218	-10	-50	-70	-80	-100	-100
High-investment Building and Developed Recreation Sites (agency owned)	7.22%	1,312	-10	-50	-80	-100	-100	-100
Low/Moderate-investment Building and Developed Recreation Sites (agency owned)	0.86%	313	-10	-40	-60	-80	-100	-100
High-investment Permitted Private Developments	1.10%	177	-10	-50	-80	-100	-100	-100
Low/Moderate-investment Permitted Private Developments	0.16%	78	-10	-40	-60	-80	-100	-100

[1] Within-HVRA relative importance.

3.4.2 *People and Property/WUI*

3.4.2.1 Residential Structures (WUI)

The Residential Structures or WUI HVRA consisted of private, residential, and commercial development sites. An initial dataset was provided by San Juan NF. To derive a raster dataset at 30-m, ArcGIS *Point Statistics* was used to sum structures within a circle with a 227-meter radius (determined by converting 40 acres to square meters). We then classified the structures into seven housing density classes ranging from very dense (>120 housing units per 40 acres) to very sparse (<1 housing unit per 40 acres) (Figure 10). We used the ArcGIS *Zonal Statistics as Table* tool to calculate the density class midpoints used in RI calculations (Table 9). Pixels in the highest density classes (dark and light blue) are concentrated around the more populated areas, while pixels in the lower density classes (turquoise and light green) are scattered throughout the project area.

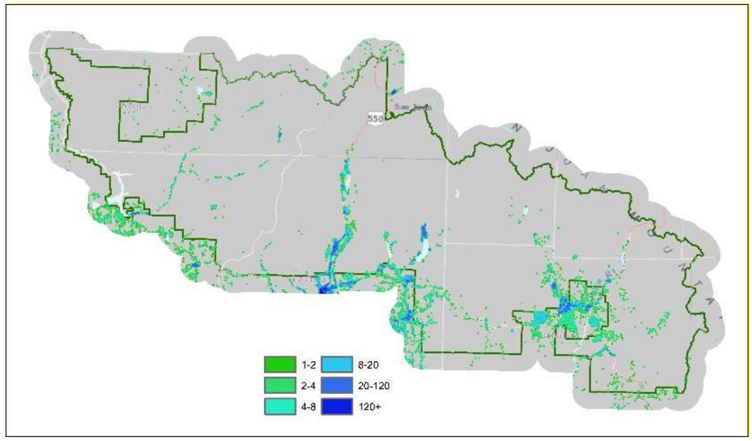

Figure 10. Map of WUI density per acre in the R2SJ analysis area.

Response functions were increasingly negative for all housing densities across FILs 1-6 (Table 9), showing slightly higher negative response functions associated with the higher density classes due to the impact to more houses and possibly overwhelmed suppression resources with high population exposure.

The relative importance per unit area is in proportion to the housing density class, but the share of the WUI importance held by the most-densely populated class is only 7.75 percent, while the next density class holds the greatest share at 39.42 percent (Table 9) due to the differences in acres present on the landscape. The remaining classes each hold a share in proportion to density and mapped extent.

Table 9. Response functions for the People and Property HVRA

Sub-HVRA	% of HVRA	Acres	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6
Res. Structures >120/40 acres	7.75%	738	-10	-50	-80	-100	-100	-100
Res. Structures 20/40 - 120/40 acres	39.42%	14,742	-10	-50	-80	-100	-100	-100
Res. Structures 8/40 - to 20/40 acres	20.47%	25,354	-10	-40	-60	-80	-100	-100
Res. Structures 4/40 - 8/40 acres	14.16%	35,726	-10	-40	-60	-80	-100	-100
Res. Structures 2/40 - 4/40 acres	9.10%	41,585	-10	-30	-50	-80	-100	-100
Res. Structures 1/40 - 2/40 acres	9.10%	104,677	-10	-30	-50	-80	-100	-100

[1] Within-HVRA relative importance.

3.4.3 *Water*

3.4.3.1 Drinking Water Collection

Drinking water risk associated with low sediment and erosion criteria for R2SJ are shown in Figure 11. Data was provided by San Juan NF and converted to a 30-m raster.

The RF for drinking water collection indicates a positive response for all erosion levels for FIL1. All Erosion classifications continue showing positive/neutral responses for FIL2 with the high erosion sub HVRA showing higher negative RFs due to the expectation that greater fire intensity is associated with greater erosion risk. (Table 10).

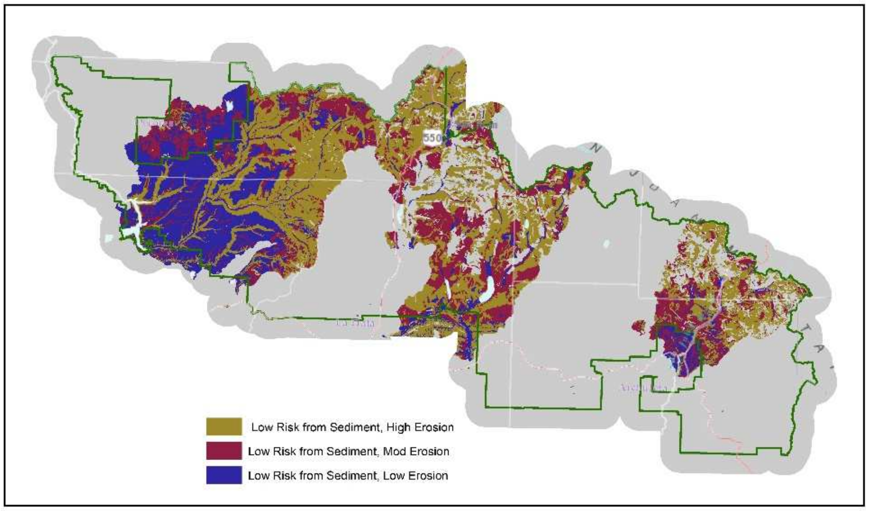

Figure 11. Map of Drinking Water Collection in the R2SJ analysis area.

Drinking water with high erosion received 46.70 percent of the HVRA. The remaining classes (moderate and low) each hold a share in percent of the total Drinking Water HVRA relative importance. The share of HVRA importance is based on relative importance per unit area and mapped extent.

Table 10. Response functions for the Drinking Water Collection HVRA

Sub-HVRA	% of HVRA	Acres	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6
Drinking Water Collection, Low Risk from Sediment, High Erosion	46.70%	508,477	20	0	-40	-60	-100	-100
Drinking Water Collection, Low Risk from Sediment, Mod Erosion	27.93%	304,111	20	10	-20	-40	-60	-80
Drinking Water Collection, Low Risk from Sediment, Low Erosion	25.37%	276,254	20	20	0	-20	-40	-60

[1] Within-HVRA relative importance.

3.4.3.2 Water Condition Framework

The 2011 Watershed Condition Framework (WCF) response functions are shown in Table 11. The dataset set was provided by San Juan NF, attributed for each condition class/erosion risk and converted to a 30-m raster. Three condition classes were present: Impaired, At Risk and Functional; each with an Erosion assignment: Low, Moderate and High.

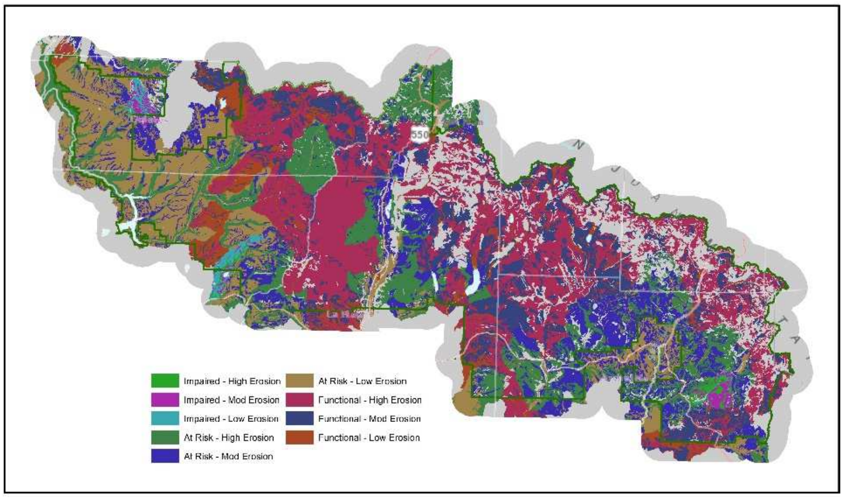

Figure 12. Map of Water Conditioning Framework in the R2SJ analysis area.

The RFs for water condition framework show the same pattern across all water condition classes, with the variability in RFs due to erosion classification. A positive or neutral response is assigned at lower intensity levels (FIL1 and FIL2) along with a neutral response in FIL3 in the low erosion class. All other classes show increasingly negative responses as fire intensity and erosion risk increase (Table 10).

The largest representation is present in At Risk-High Erosion, At Risk-Low Erosion and At Risk-Mod Erosion. Receiving 26.23, 24.32 and 21.39 percent of the total Infrastructure HVRA relative importance. The share of HVRA importance is based on relative importance per unit area and mapped extent.

Table 11. Response functions for the Water Conditioning HVRA

Sub-HVRA	% of HVRA	Acres	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6
WCF Impaired - High Erosion	1.27%	11,635	20	0	-40	-60	-100	-100
WCF Impaired - Mod Erosion	2.10%	19,311	20	10	-20	-40	-60	-80
WCF Impaired - Low Erosion	2.02%	18,590	20	20	0	-20	-40	-60
WCF At Risk - High Erosion	26.23%	401,946	20	0	-40	-60	-100	-100
WCF At Risk - Mod Erosion	21.39%	327,833	20	10	-20	-40	-60	-80
WCF At Risk - Low Erosion	24.32%	372,792	20	20	0	-20	-40	-60
WCF Functional - High Erosion	12.88%	592,342	20	0	-40	-60	-100	-100
WCF Functional - Mod Erosion	6.93%	318,537	20	10	-20	-40	-60	-80
WCF Functional - Low Erosion	2.86%	131,463	20	20	0	-20	-40	-60

[1] Within-HVRA relative importance.

3.4.4 *Threatened and Endangered Species Habitat*

3.4.4.1 Pagosa Skyrocket

Pagosa Skyrocket habitat is concentrated in the southeastern portion of San Juan NF. The habitat extent was provided by San Juan NF in a geodatabase. For use in the analysis, the dataset was extracted and converted to a 30-m raster.

Due to the threated/endangered status of the species, the RFs indicate Pagosa skyrocket habitat responds strongly negatively to all FILs (Table 12).

Pagosa skyrocket habitat received 3.87 percent of the total Threatened and Endangered Species (TES) Habitat HVRA relative importance because there are so few acres mapped relative to the other TES HVRA. The share of HVRA importance is based on relative importance per unit area and mapped extent.

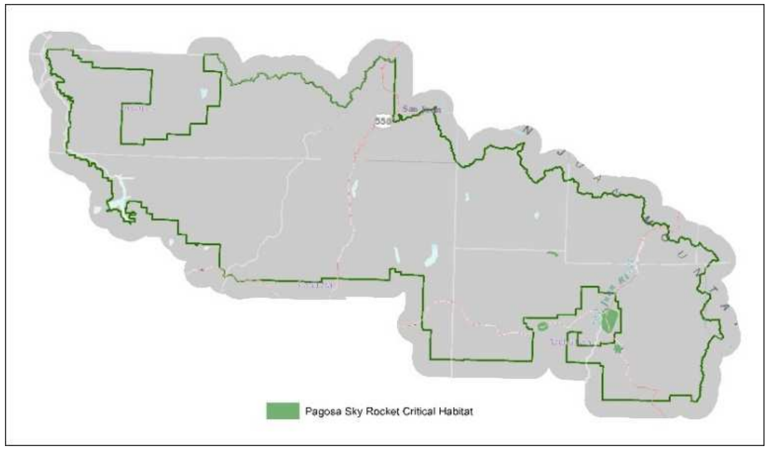

Figure 13. Map of Pagosa Skyrocket habitat in the R2SJ analysis area

Table 12. Response functions for Pagosa Skyrocket

Sub-HVRA	% of HVRA	Acres	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6
Pagosa skyrocket critical habitat(E)	3.87%	9,639	-100	-100	-100	-100	-100	-100
Greenback cutthroat trout (T) - High Erosion	7.46%	26,570	20	0	-40	-60	-100	-100
Greenback cutthroat trout (T) - Mod Erosion	2.60%	9,259	20	10	-20	-40	-60	-80
Greenback cutthroat trout (T) - Low Erosion	1.34%	4,785	20	20	0	-20	-40	-60
New Mexico meadow jumping mouse (E)	4.63%	17,309	-100	-100	-100	-100	-100	-100
Yellow-billed cuckoo (T)	1.42%	6,346	-50	-100	-100	-100	-100	-100
Canada lynx (T)	63.71%	357,187	10	0	-20	-80	-100	-100
Colorado River cutthroat trout - High Erosion	10.24%	85,011	20	0	-40	-60	-100	-100
Colorado River cutthroat trout - Mod Erosion	4.19%	34,760	20	10	-20	-40	-60	-80
Colorado River cutthroat trout - Low Erosion	0.54%	4,482	20	20	0	-20	-40	-60

[1] Within-HVRA relative importance.

3.4.4.2 Greenback Cutthroat Trout

Greenback Cutthroat trout distribution for the R2SJ analysis area are shown in Figure 14. The distribution data was obtained from San Juan NF; providing watersheds with erosion classification to capture the area impacted by wildfire. For use in the analysis, the dataset was extracted and converted to a 30-m raster.

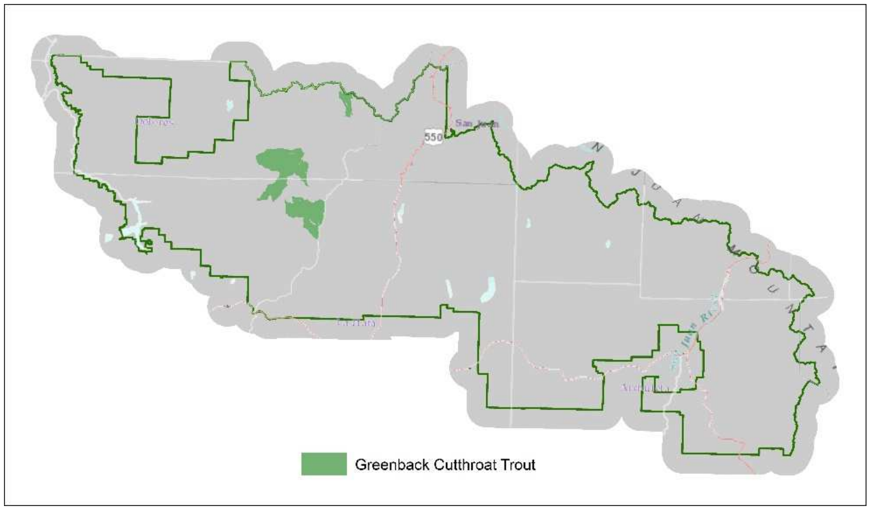

Figure 14. Map of Greenback Cutthroat Trout habitat in the R2SJ analysis area

The greenback cutthroat trout's response to fire is characterized by a positive or neutral response at lower intensity levels (FIL1 and FIL2) along with a neutral response in FIL3 in the low erosion class. All other classes show increasingly negative responses as fire intensity and erosion risk increase (Table 13).

Greenback cutthroat trout habitat received 11.41 percent of the total TES Habitat HVRA relative importance. The share of HVRA importance is based on relative importance per unit area and mapped extent.

Table 13. Response functions for Greenback Cutthroat Trout HVRA

Sub-HVRA	% of HVRA	Acres	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6
Pagosa skyrocket critical habitat(E)	3.87%	9,639	-100	-100	-100	-100	-100	-100
Greenback cutthroat trout (T) - High Erosion	7.46%	26,570	20	0	-40	-60	-100	-100
Greenback cutthroat trout (T) - Mod Erosion	2.60%	9,259	20	10	-20	-40	-60	-80
Greenback cutthroat trout (T) - Low Erosion	1.34%	4,785	20	20	0	-20	-40	-60
New Mexico meadow jumping mouse (E)	4.63%	17,309	-100	-100	-100	-100	-100	-100
Yellow-billed cuckoo (T)	1.42%	6,346	-50	-100	-100	-100	-100	-100
Canada lynx (T)	63.71%	357,187	10	0	-20	-80	-100	-100
Colorado River cutthroat trout - High Erosion	10.24%	85,011	20	0	-40	-60	-100	-100
Colorado River cutthroat trout - Mod Erosion	4.19%	34,760	20	10	-20	-40	-60	-80
Colorado River cutthroat trout - Low Erosion	0.54%	4,482	20	20	0	-20	-40	-60

[1] Within-HVRA relative importance.

3.4.4.3 New Mexico Meadow Jumping Mouse

Listed as an endangered species, habitat distribution for the New Mexico meadow jumping mouse was provided by San Juan NF and converted to a 30-m raster (Figure 14).

The New Mexico meadow jumping mouse response to fire is characterized as extremely negative due to their limited habitat range, only utilizing riparian community types (Figure 15). This limited habitat range is captured by the RFs, showing extreme negative response functions across all FILs.

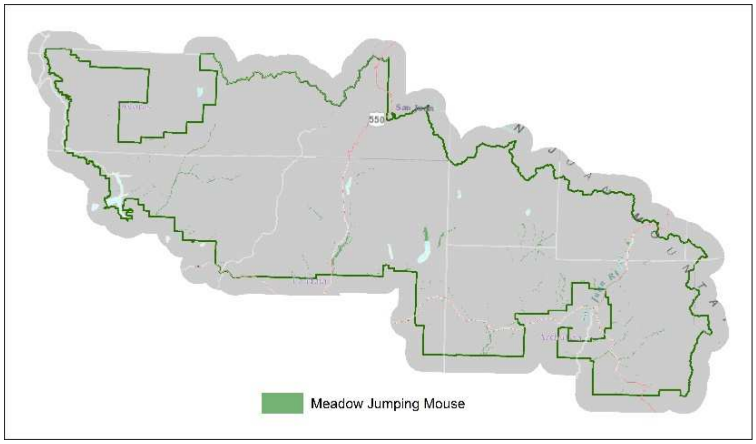

Figure 15. Map of New Mexico Meadow Jumping Mouse habitat in the R2SJ analysis area

New Mexico meadow jumping mouse habitat received 4.63 percent of the total TES Habitat HVRA relative importance. The share of HVRA importance is based on relative importance per unit area and mapped extent.

Table 14. Response functions for New Mexico Meadow Jumping Mouse HVRA

Sub-HVRA	% of HVRA	Acres	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6
Pagosa skyrocket critical habitat(E)	3.87%	9,639	-100	-100	-100	-100	-100	-100
Greenback cutthroat trout (T) - High Erosion	7.46%	26,570	20	0	-40	-60	-100	-100
Greenback cutthroat trout (T) - Mod Erosion	2.60%	9,259	20	10	-20	-40	-60	-80
Greenback cutthroat trout (T) - Low Erosion	1.34%	4,785	20	20	0	-20	-40	-60
New Mexico meadow jumping mouse (E)	4.63%	17,309	-100	-100	-100	-100	-100	-100
Yellow-billed cuckoo (T)	1.42%	6,346	-50	-100	-100	-100	-100	-100
Canada lynx (T)	63.71%	357,187	10	0	-20	-80	-100	-100
Colorado River cutthroat trout - High Erosion	10.24%	85,011	20	0	-40	-60	-100	-100
Colorado River cutthroat trout - Mod Erosion	4.19%	34,760	20	10	-20	-40	-60	-80
Colorado River cutthroat trout - Low Erosion	0.54%	4,482	20	20	0	-20	-40	-60

[1] Within-HVRA relative importance.

3.4.4.4 Yellow-Billed Cuckoo

Yellow-Billed cuckoo habitat is mapped sporadically throughout the San Juan NF (Figure 16). The layer was provided by the National Forest and predominantly coincides with streams or riparian areas. For use in the HVRA analysis, the dataset was extracted from a geodatabase and converted to a 30-m raster,

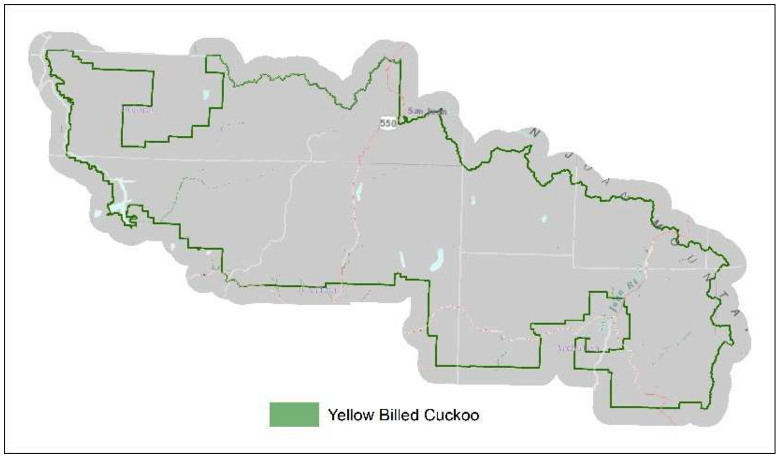

Figure 16. Map of Yellow-Billed Cuckoo habitat in the R2SJ analysis area

The response to fire is characterized as extremely negative due to their limited habitat range (Table 15). Showing a negative response function for FIL1 and increasing to extremely negative by FIL2.

Yellow-Billed cuckoo habitat received 1.42 percent of the total TES Habitat HVRA relative importance because there are so few acres mapped relative to the other TES Habitat HVRA. The share of HVRA importance is based on relative importance per unit area and mapped extent.

Table 15. Response functions for Yellow-Billed Cuckoo HVRA

Sub-HVRA	% of HVRA	Acres	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6
Pagosa skyrocket critical habitat(E)	3.87%	9,639	-100	-100	-100	-100	-100	-100
Greenback cutthroat trout (T) - High Erosion	7.46%	26,570	20	0	-40	-60	-100	-100
Greenback cutthroat trout (T) - Mod Erosion	2.60%	9,259	20	10	-20	-40	-60	-80
Greenback cutthroat trout (T) - Low Erosion	1.34%	4,785	20	20	0	-20	-40	-60
New Mexico meadow jumping mouse (E)	4.63%	17,309	-100	-100	-100	-100	-100	-100
Yellow-billed cuckoo (T)	1.42%	6,346	-50	-100	-100	-100	-100	-100
Canada lynx (T)	63.71%	357,187	10	0	-20	-80	-100	-100
Colorado River cutthroat trout - High Erosion	10.24%	85,011	20	0	-40	-60	-100	-100
Colorado River cutthroat trout - Mod Erosion	4.19%	34,760	20	10	-20	-40	-60	-80
Colorado River cutthroat trout - Low Erosion	0.54%	4,482	20	20	0	-20	-40	-60

[1] Within-HVRA relative importance.

3.4.4.5 Canadian Lynx

Canadian lynx habitat is mapped across a large portion of the San Juan NF. The habitat data layer was obtained from the National Forest. For use in the analysis, the dataset was clipped to the analysis area boundary and converted to a 30-m raster (Figure 17).

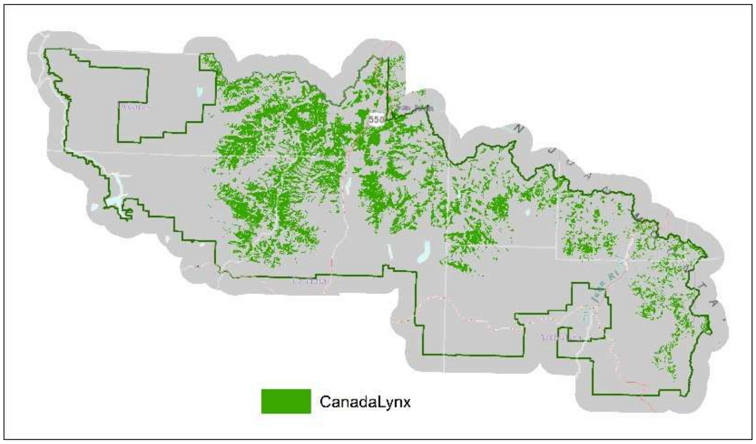

Figure 17. Map of Canadian Lynx habitat in the R2SJ analysis area

Response functions indicate Canadian lynx benefit from lower intensity fires (FIL1), showing a neutral response at FIL2 and an increasingly negative response moving from FIL3-to-FIL6 (Table 16).

The Lynx received 63.71 percent of the total TES Habitat 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.

Table 16. Response functions for Canadian Lynx HVRA

Sub-HVRA	% of HVRA	Acres	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6
Pagosa skyrocket critical habitat(E)	3.87%	9,639	-100	-100	-100	-100	-100	-100
Greenback cutthroat trout (T) - High Erosion	7.46%	26,570	20	0	-40	-60	-100	-100
Greenback cutthroat trout (T) - Mod Erosion	2.60%	9,259	20	10	-20	-40	-60	-80
Greenback cutthroat trout (T) - Low Erosion	1.34%	4,785	20	20	0	-20	-40	-60
New Mexico meadow jumping mouse (E)	4.63%	17,309	-100	-100	-100	-100	-100	-100
Yellow-billed cuckoo (T)	1.42%	6,346	-50	-100	-100	-100	-100	-100
Canada lynx (T)	63.71%	357,187	10	0	-20	-80	-100	-100
Colorado River cutthroat trout - High Erosion	10.24%	85,011	20	0	-40	-60	-100	-100
Colorado River cutthroat trout - Mod Erosion	4.19%	34,760	20	10	-20	-40	-60	-80
Colorado River cutthroat trout - Low Erosion	0.54%	4,482	20	20	0	-20	-40	-60

[1] Within-HVRA relative importance.

3.4.4.6 Colorado River Cutthroat Trout

Colorado River cutthroat trout distribution for the San Juan NF is shown in Figure 18. Colorado River cutthroat trout were included in the assessment due to concern over their sensitive habitat. The mapping distribution was provided by San Juan NF and converted to 30-m raster.

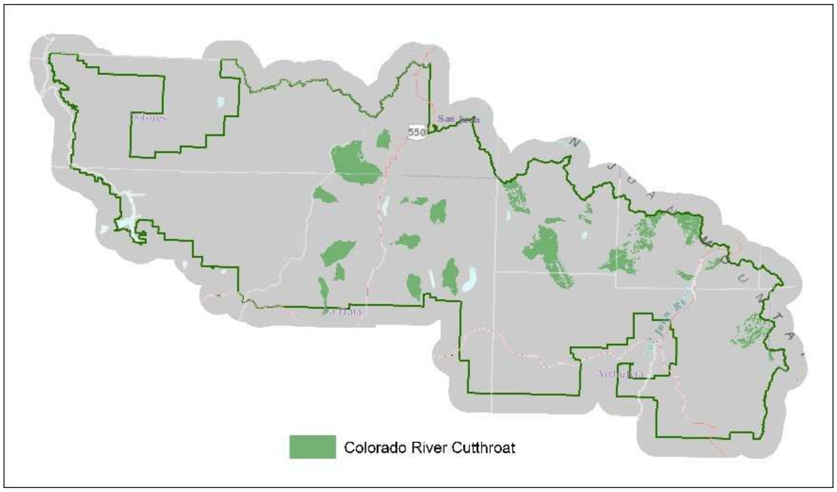

Figure 18. Map of Colorado River Cutthroat Trout Sensitive Habitat HVRA within the R2SJ analysis area.

The Colorado River cutthroat trout response to fire is characterized by a positive or neutral response at lower intensity levels (FIL1 and FIL2) along with a neutral response in FIL3 in the low erosion class. All other classes show increasingly negative responses as fire intensity and erosion risk increase (Table 17).

Colorado River cutthroat trout habitat received 14.96 percent of the total TES Habitat HVRA relative importance. The share of HVRA importance is based on relative importance per unit area and mapped extent.

Table 17. Response functions for Colorado River Cutthroat Trout HVRA

Sub-HVRA	% of HVRA	Acres	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6
Pagosa skyrocket critical habitat(E)	3.87%	9,639	-100	-100	-100	-100	-100	-100
Greenback cutthroat trout (T) - High Erosion	7.46%	26,570	20	0	-40	-60	-100	-100
Greenback cutthroat trout (T) - Mod Erosion	2.60%	9,259	20	10	-20	-40	-60	-80
Greenback cutthroat trout (T) - Low Erosion	1.34%	4,785	20	20	0	-20	-40	-60
New Mexico meadow jumping mouse (E)	4.63%	17,309	-100	-100	-100	-100	-100	-100
Yellow-billed cuckoo (T)	1.42%	6,346	-50	-100	-100	-100	-100	-100
Canada lynx (T)	63.71%	357,187	10	0	-20	-80	-100	-100
Colorado River cutthroat trout - High Erosion	10.24%	85,011	20	0	-40	-60	-100	-100
Colorado River cutthroat trout - Mod Erosion	4.19%	34,760	20	10	-20	-40	-60	-80
Colorado River cutthroat trout - Low Erosion	0.54%	4,482	20	20	0	-20	-40	-60

[1] Within-HVRA relative importance.

3.4.5 *Cultural Sites*

3.4.5.1 Archeological Districts

Archeological districts recorded by San Juan NF were provided as a spatial data layer and converted to a 30-m raster. Distribution is focused to southern sections of the National Forest, representing districts or areas of archeological importance. The resulting importance map is shown in Figure 19.

Response functions indicate a positive response to fire at FIL1 and FIL2; transitioning to negative response starting with FIL3. All FILs above FIL3 show an extremely negative response to fire (Table 18).

Archeological districts received 66.48 percent of the total Cultural HVRA relative importance due to its high relative importance ranking and number of acres mapped in the analysis area. The share of HVRA importance is based on relative importance per unit area and mapped extent

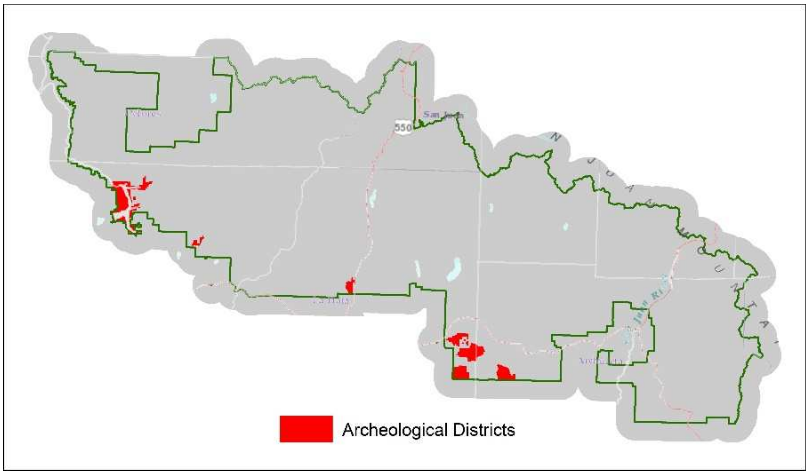

Figure 19. Map of Archeological Districts within the R2SJ analysis area.

Table 18. Response functions for Archeological Districts HVRA.

Sub-HVRA	% of HVRA	Acres	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6
Archeological Districts	66.48%	27,094	30	10	-30	-100	-100	-100
High Fire Sensitivity	2.56%	627	-100	-100	-100	-100	-100	-100
Low Fire Sensitivity	30.96%	37,856	0	-30	-70	-100	-100	-100

[1] Within-HVRA relative importance.

3.4.5.2 Archeological Areas with High Fire Sensitivity

Archaeological areas with high fire sensitivity were mapped by San Juan NF and provided as a spatial data layer (Figure 20). The site locations were converted to 30-m pixels; separate point locations were not used due to uncertainness in the data.

As the name suggests, archeological sites designated with high fire sensitivity demonstrate extremely negative responses to fire; all FILs demonstrate the same RF.

High fire sensitivity archeological areas received 2.56 percent of the total Cultural HVRA relative importance because there are so few acres mapped relative to the other Cultural HVRA. The share of HVRA importance is based on relative importance per unit area and mapped extent.

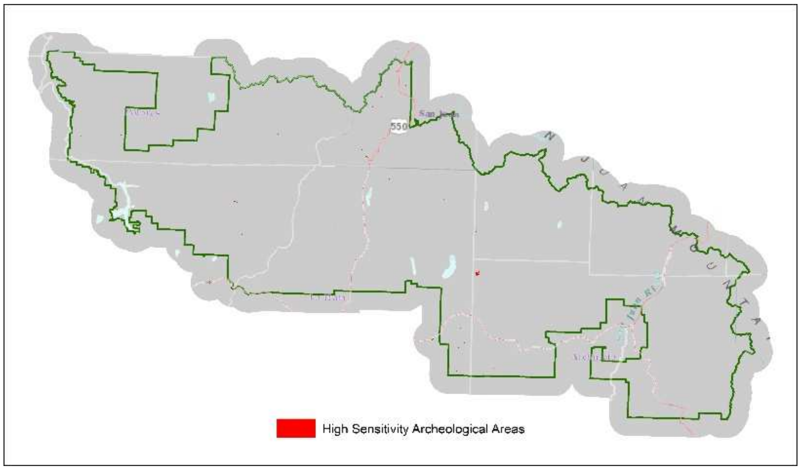

Figure 20. Map of Archeological Areas with High Fire Sensitivity within the R2SJ analysis area.

Table 19. Response functions for Archeological Areas with High Fire Sensitivity HVRA.

Sub-HVRA	% of HVRA	Acres	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6
Archeological Districts	66.48%	27,094	30	10	-30	-100	-100	-100
High Fire Sensitivity	2.56%	627	-100	-100	-100	-100	-100	-100
Low Fire Sensitivity	30.96%	37,856	0	-30	-70	-100	-100	-100

[1] Within-HVRA relative importance.

3.4.5.3 Archeological Areas with Low Fire Sensitivity

Archaeological areas with low fire sensitivity were mapped by San Juan NF and provided as a spatial data layer (Figure 21). The areas were converted to 30-m pixels; no separate point locations were provided.

Archeological areas designated with low fire sensitivity demonstrated neutral response to fire for FIL1, with increasingly negative responses in FIL2 thru FIL3 and extreme negative responses for FIL4-FIL6

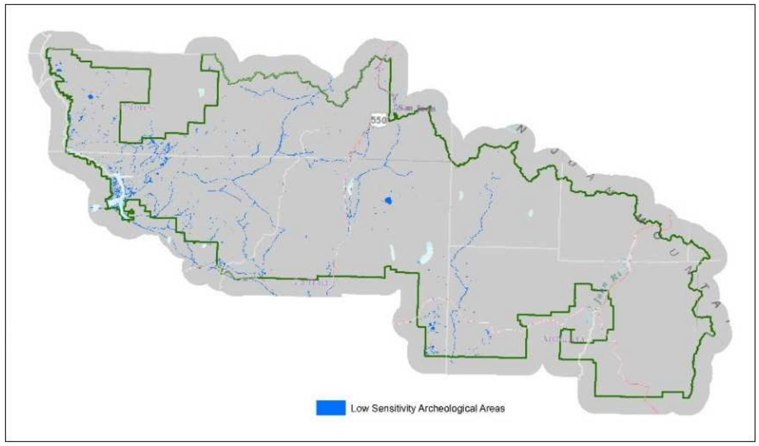

Figure 21. Map of Archeological Areas with Low Fire Sensitivity within the R2SJ analysis area.

Low fire sensitivity archeological areas received 30.96 percent of the total Cultural HVRA relative importance. The share of HVRA importance is based on relative importance per unit area and mapped extent

Table 20. Response functions for Archeological areas with Low Fire Sensitivity HVRA.

Sub-HVRA	% of HVRA	Acres	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6
Archeological Districts	66.48%	27,094	30	10	-30	-100	-100	-100
High Fire Sensitivity	2.56%	627	-100	-100	-100	-100	-100	-100
Low Fire Sensitivity	30.96%	37,856	0	-30	-70	-100	-100	-100

[1] Within-HVRA relative importance.

3.4.6 *Limited Habitat*

3.4.6.1 Bighorn Sheep Winter Concentration

Bighorn sheep winter concentration areas are mapped across portions of the San Juan NF. The habitat data layer was obtained from the National Forest, clipped to the analysis area boundary and converted to a 30-m raster (Figure 22).

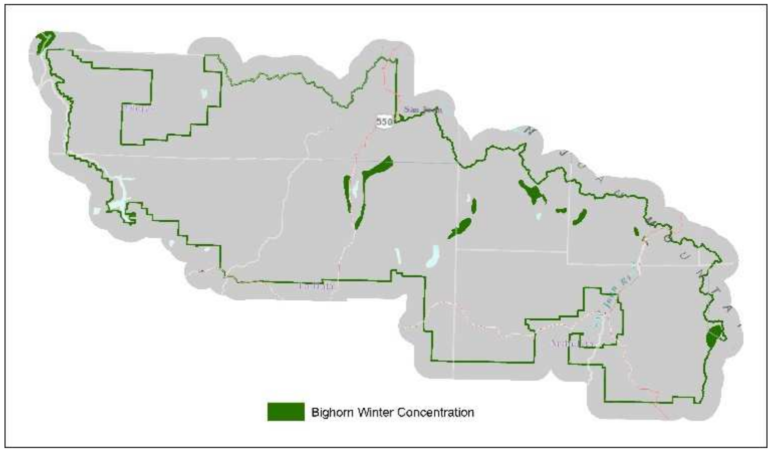

Figure 22. Map of Bighorn Sheep Winter Concentration HVRA within the R2SJ analysis area.

Response functions indicate bighorn sheep, in winter concentration areas, benefit from lower intensity fires (FIL1, FIL2), showing a neutral response at FIL3 and with increasingly negative responses starting at FIL4 (Table 21).

The bighorn sheep winter concentration HVRA received 2.66 percent of the total Limited Habitat HVRA relative importance. The share of HVRA importance is based on relative importance per unit area and mapped extent.

Table 21. Response functions for Bighorn Sheep Winter Concentration HVRA

Sub-HVRA	% of HVRA	Acres	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6
Bighorn sheep winter concentration	2.66%	33,552	20	10	0	-20	-50	-100
Mule deer severe winter range	10.92%	137,939	20	10	0	-20	-50	-100
Mule deer winter concentration	17.91%	271,338	20	10	0	-20	-50	-100
Elk severe winter range	25.07%	316,602	50	40	20	-20	-60	-80
Elk winter concentration	43.44%	658,246	50	40	20	-20	-60	-80

[1] Within-HVRA relative importance.

3.4.6.2 Mule Deer Severe Winter Concentration

Severe winter concentration habitat for mule deer are mapped across large northwestern and southeastern portions of the San Juan NF. The habitat data layer was obtained from the National Forest, clipped to the analysis area boundary and converted to a 30-m raster (Figure 23).

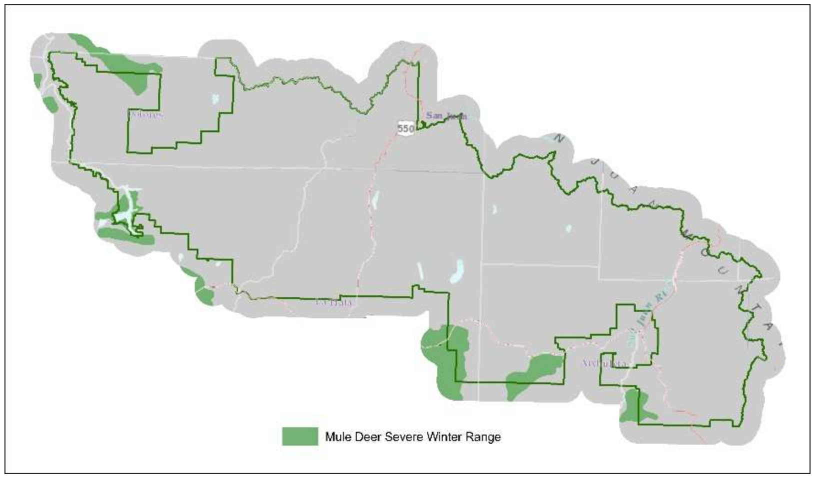

Figure 23. Map of Mule Deer Severe Winter Concentration HVRA within the R2SJ analysis area.

Response functions indicate mule deer, in severe winter concentration areas, benefit from lower intensity fires (FIL1, FIL2), showing a neutral response at FIL3 and starting an increasingly negative response at FIL4 (Table 22)

The mule deer severe winter concentration received 10.92 percent of the total Limited Habitat HVRA relative importance. The share of HVRA importance is based on relative importance per unit area and mapped extent.

Table 22. Response functions for Mule Deer Severe Winter Concentration HVRA

Sub-HVRA	% of HVRA	Acres	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6
Bighorn sheep winter concentration	2.66%	33,552	20	10	0	-20	-50	-100
Mule deer severe winter range	10.92%	137,939	20	10	0	-20	-50	-100
Mule deer winter concentration	17.91%	271,338	20	10	0	-20	-50	-100
Elk severe winter range	25.07%	316,602	50	40	20	-20	-60	-80
Elk winter concentration	43.44%	658,246	50	40	20	-20	-60	-80

[1] Within-HVRA relative importance.

3.4.6.3 Mule Deer Winter Concentration

Mule deer winter concentration areas are mapped across large northwestern and southeastern portions of the San Juan NF. The habitat data layer was obtained from the National Forest, clipped to the analysis area boundary and converted to a 30-m raster (Figure 24).

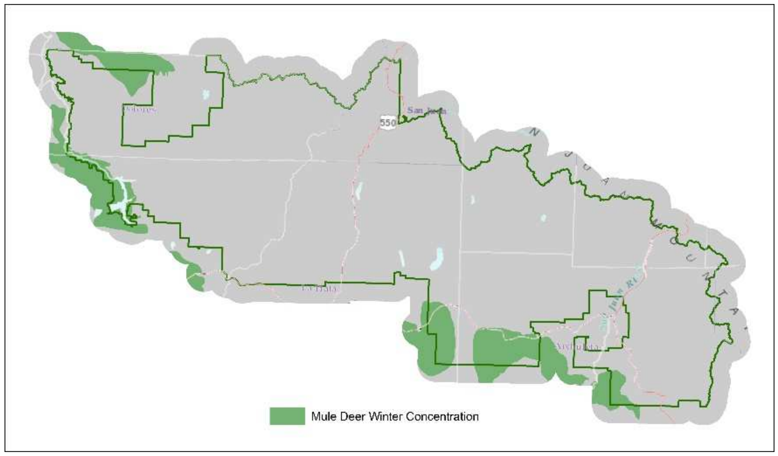

Figure 24. Map of Mule Deer Winter Concentration HVRA within the R2SJ analysis area.

Response functions indicate mule deer, in winter concentration areas benefit from lower intensity fires (FIL1, FIL2), showing a neutral response at FIL3 and starting an increasingly negative response at FIL4 (Table 23)

The mule deer winter concentration received 17.91 percent of the total Limited Habitat HVRA relative importance. The share of HVRA importance is based on relative importance per unit area and mapped extent.

Table 23. Response functions for Mule Deer Winter Concentration HVRA

Sub-HVRA	% of HVRA	Acres	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6
Bighorn sheep winter concentration	2.66%	33,552	20	10	0	-20	-50	-100
Mule deer severe winter range	10.92%	137,939	20	10	0	-20	-50	-100
Mule deer winter concentration	17.91%	271,338	20	10	0	-20	-50	-100
Elk severe winter range	25.07%	316,602	50	40	20	-20	-60	-80
Elk winter concentration	43.44%	658,246	50	40	20	-20	-60	-80

[1] Within-HVRA relative importance.

3.4.6.4 Elk Severe Winter Range

Severe winter concentration habitat for elk are mapped across portions of the San Juan NF. The habitat data layer was obtained from the National Forest, clipped to the analysis area boundary and converted to a 30-m raster (Figure 25).

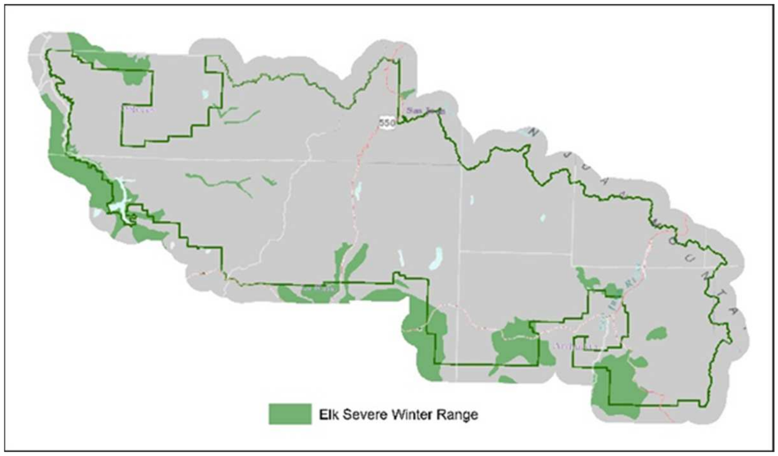

Figure 25. Map of Elk Severe Winter Severe Winter Range HVRA within the R2SJ analysis area.

Response functions indicate elk, in severe winter concentration areas, have a relatively high benefit from lower intensity fires (FIL1 thru FIL3), showing increasingly negative responses starting at FIL4 (Table 24).

Elk severe winter concentration locations received 25.07 percent of the total Limited Habitat HVRA relative importance. The share of HVRA importance is based on relative importance per unit area and mapped extent

Table 24. Response functions for Elk Severe Winter Range HVRA

Sub-HVRA	% of HVRA	Acres	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6
Bighorn sheep winter concentration	2.66%	33,552	20	10	0	-20	-50	-100
Mule deer severe winter range	10.92%	137,939	20	10	0	-20	-50	-100
Mule deer winter concentration	17.91%	271,338	20	10	0	-20	-50	-100
Elk severe winter range	25.07%	316,602	50	40	20	-20	-60	-80
Elk winter concentration	43.44%	658,246	50	40	20	-20	-60	-80

[1] Within-HVRA relative importance.

3.4.6.5 Elk Winter Concentration

Winter concentration habitat for elk are mapped across large portions of southern and western edges of the San Juan NF. The habitat data layer was obtained from the National Forest, clipped to the analysis area boundary and converted to a 30-m raster (Figure 26).

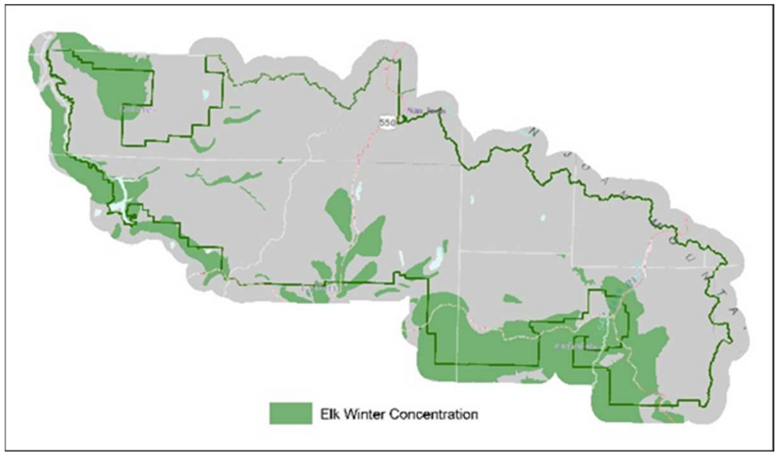

Figure 26. Map of Elk Winter Concentration HVRA within the R2SJ analysis area.

Response functions indicate elk, in winter concentration areas, have a relatively high benefit from lower intensity fires (FIL1 thru FIL3), showing increasingly negative responses starting at FIL4 (Table 25).

Elk winter concentration locations received 43.44 percent of the total Limited Habitat HVRA relative importance. The share of HVRA importance is based on relative importance per unit area and mapped extent.

Table 25. Response functions for Elk Winter Concentration HVRA

Sub-HVRA	% of HVRA	Acres	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6
Bighorn sheep winter concentration	2.66%	33,552	20	10	0	-20	-50	-100
Mule deer severe winter range	10.92%	137,939	20	10	0	-20	-50	-100
Mule deer winter concentration	17.91%	271,338	20	10	0	-20	-50	-100
Elk severe winter range	25.07%	316,602	50	40	20	-20	-60	-80
Elk winter concentration	43.44%	658,246	50	40	20	-20	-60	-80

[1] Within-HVRA relative importance.

3.4.7 *Timber*

3.4.7.1 Plantations: Tree

The Timber Plantation HVRA (Figure 27) includes areas designated as plantations in San Juan NF. The data layer was provided by San Juan NF. For use in the analysis, the dataset was clipped to the analysis area and converted to a 30-m raster.

Plantations demonstrate extremely negative responses to fire for all FILs because it is land managed for timber production.

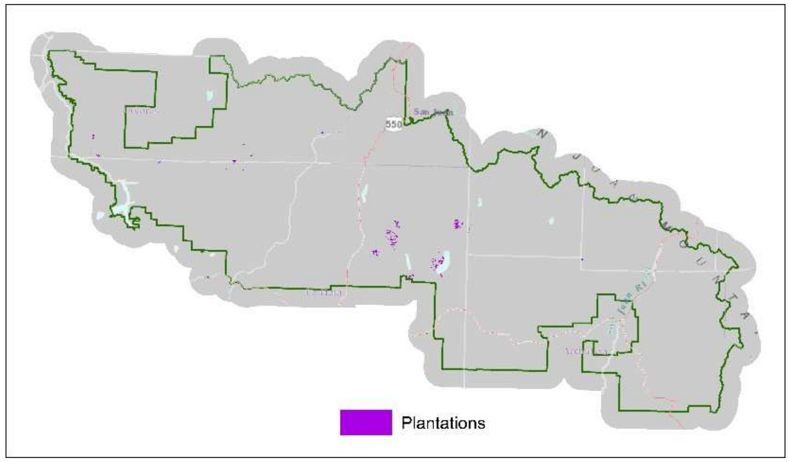

Figure 27. Map of Timber Plantations in the R2SJ analysis area

In total, the area mapped as plantations received 3.17 percent of the total Timber HVRA importance (Table 26) because there are so few acres mapped relative to the other Timber HVRA. The share of HVRA importance is based on relative importance per unit area and mapped extent.

Table 26. Response functions for the Timber-Plantations HVRA

Sub-HVRA	% of HVRA	Acres	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6
Tree Plantations	3.17%	3,063	-100	-100	-100	-100	-100	-100
Lands Suitable for Timber Production	96.83%	311,896	20	0	-20	-50	-80	-100

[1] Within-HVRA relative importance.

3.4.7.2 Suitable Timber

The suitable timber HVRA (Figure 28) provided by San Juan NF includes multiple sub-variables including timber size, timber type, timber density, species, species/cover-mix, etc. The San Juan NF provided the dataset with value attribute assignments. Leveraging the provided attribute assignments, the dataset was converted to a 30-m raster.

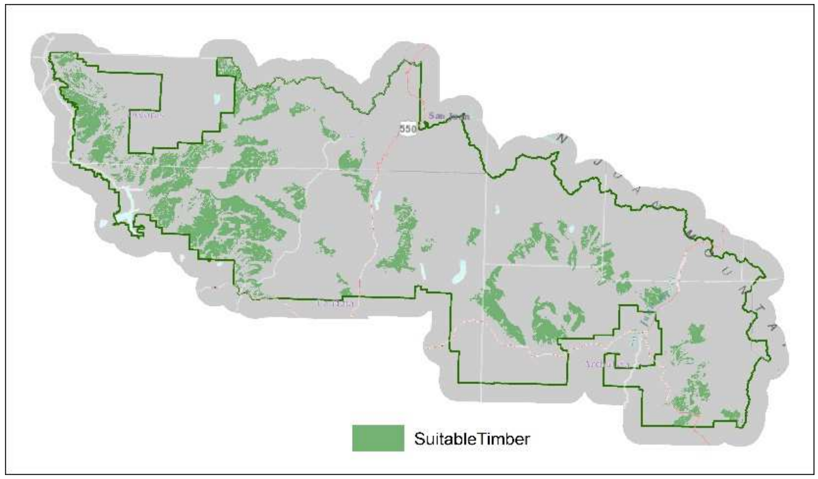

Figure 28. Map of Suitable Timber in the R2SJ analysis area

The suitable timber HVRA demonstrates an initial positive response at FIL1, transitions to a neutral response for FIL2, and has an increasingly negative response to fire for FIL4 thru FIL6 (Table 27).

In total, the area mapped as suitable timber received 96.83 percent of the total Timber HVRA importance due to the large number of acres mapped relative to the other Timber HVRA. The share of HVRA importance is based on relative importance per unit area and mapped extent.

Table 27. Response functions for the Suitable Timber HVRA

Sub-HVRA	% of HVRA	Acres	FIL1	FIL2	FIL3	FIL4	FIL5	FIL6
Tree Plantations	3.17%	3,063	-100	-100	-100	-100	-100	-100
Lands Suitable for Timber Production	96.83%	311,896	20	0	-20	-50	-80	-100

[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 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 29) with a net positive eNVC for Limited Habitat, a relatively minimal net negative eNVC for Drinking Water Collection, Watershed Condition and Timber. Threatened & Endangered Species Habitat, Cultural, and WUI show a more strongly negative overall eNVC, with Infrastructure showing the most negative net eNVC result. Figure 30 shows cNVC results by percentile 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) focuses the map to the areas with both the greatest wildfire likelihood and the greatest consequence as seen in the eNVC map in Figure 31.

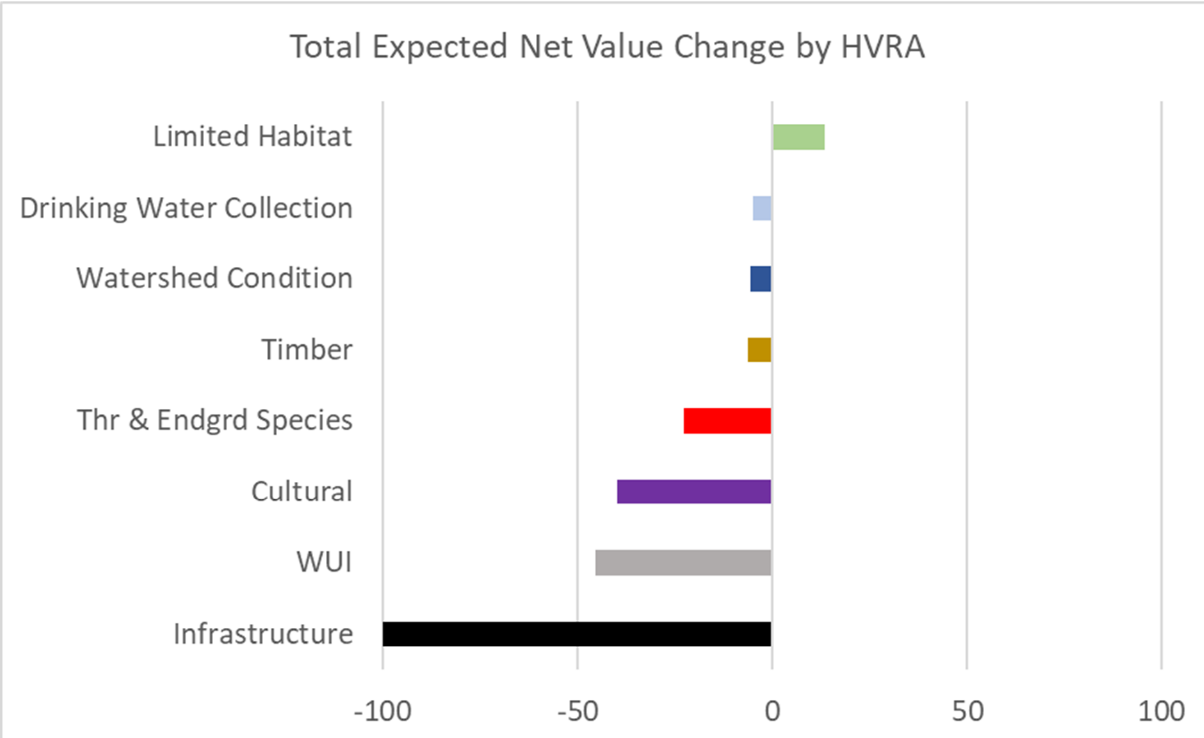

Figure 29: Weighted net response over all highly valued resources and assets (HVRAs) in the assessment. HVRAs are listed in order from greatest expected positive net value change (response) at the top, to greatest negative net value change at the bottom.

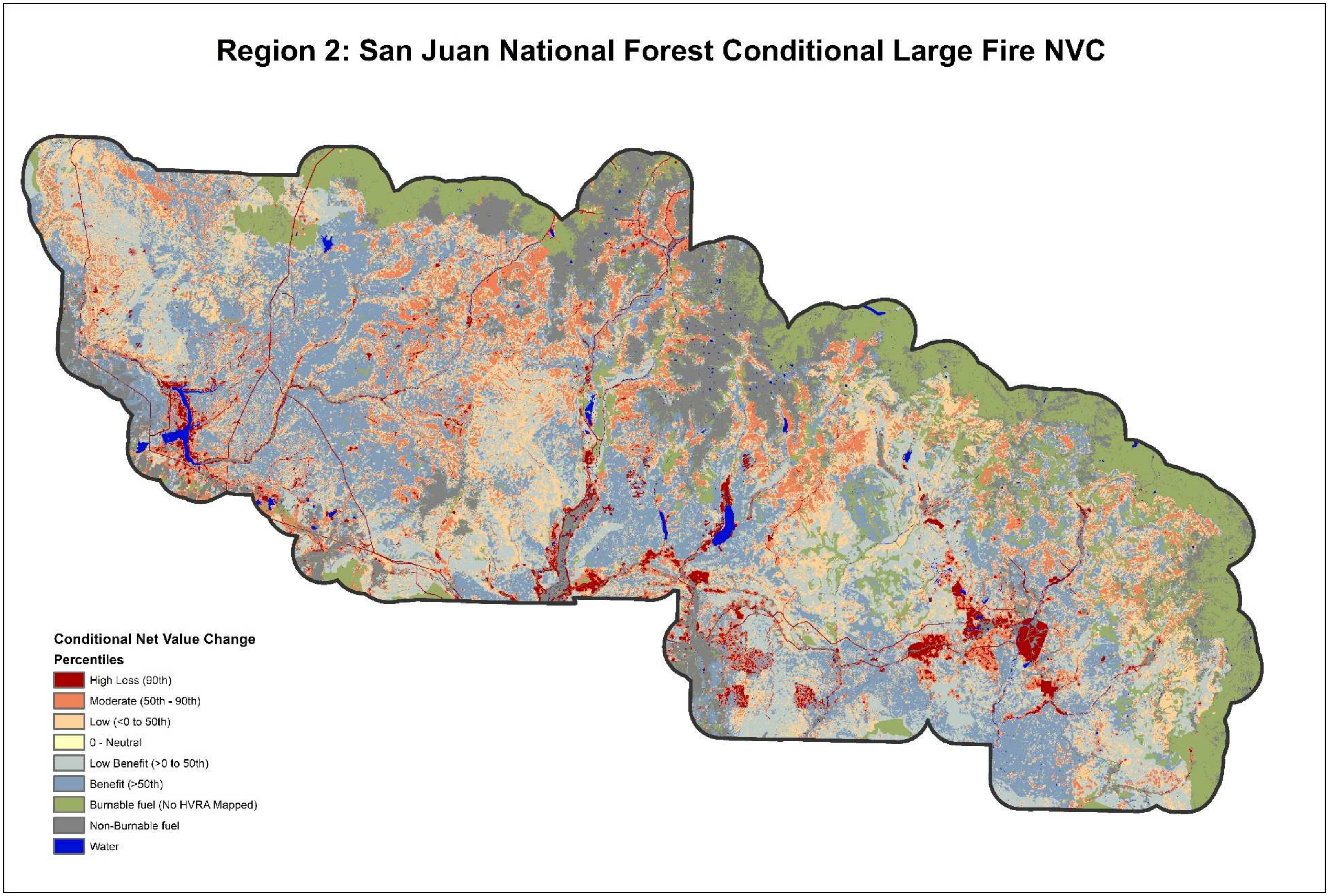

Figure 30: Map of Conditional Net Value Change (cNVC) for the R2SJ analysis area.

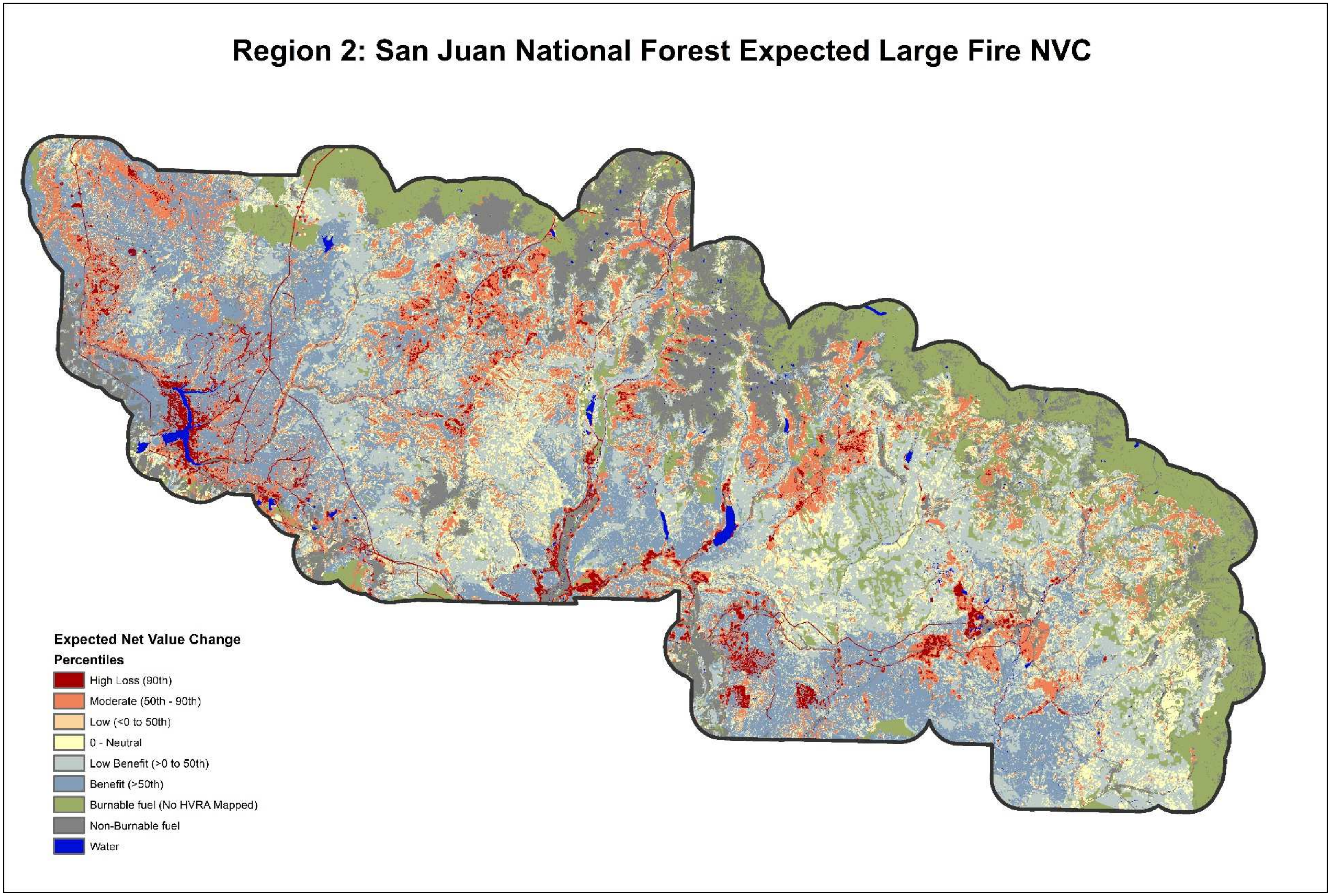

Figure 31: Map of Expected Net Value Change (eNVC) for the R2SJ analysis area.

5 Analysis Summary

The Region 2, San Juan National Forest QWRA provides foundational information about wildfire risk to highly valued resources and assets across the Forest. 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 Forest Fire/Fuels Staff and Leadership, 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

1. **SJ_RiskResults_20190916.gdb –** This geodatabase contains 64 rasters representing HVRA for San Juan National Forest and their associated Expected Net Value Change (eNVC), Conditional Net Value Change (cNVC) and totals.
    a. All datasets within the geodatabase are 30-m cell size representation of wildfire risk to one or more Highly Valued Resource or Asset (HVRA) selected for inclusion in the R2SJ Quantitative Wildfire Risk Assessment. This data layer is part of a set of wildfire risk results developed for the Region 2: San Juan National Forest Wildfire Risk Assessment (R2SJ). Please reference the R2SJ project report for information on data sources and reference the "SJF_RF-RI_08.26.19.xlsx" spreadsheet for raster value interpretation along with wildfire response functions and relative importance used in these calculations. The results use 30-m FSim wildfire behavior results. For information on downscaling methods, please see the metadata associated with the SWCO_FSim_120_d1_30.gdb results.
2. **SJ_RiskResults_Prelim_20180917_UnWeighted.gdb**
    a. All These products are UNWEIGHTED among HVRA categories. To use, decide the appropriate proportion of relative importance for each HVRA. To generate a new "Total" eNVC or cNVC, we recommend using the ArcGIS Weighted Sum Tool in the Spatial Analyst Toolbox to assign new importance weights. If new values are not assigned, HVRA importance is equally allocated among HVRA groups.
3. **SWCO_FSim_120_d1_30.gdb** – This geodatabase contains 13 rasters representing mosaic data results from the FSim simulations in the 5 FOAs within the R2SJ project area:
    a. **FLEP_GT2 –**

        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_GT4** – see FLEP_2 description above
    c. **FLEP_GT6** – see FLEP_2 description above
    d. **FLEP_GT8** – see FLEP_2 description above
    e. iBP_30 –

        This dataset is a 30-m cell size (downscaled from 120-m) 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 30-m cell size (downscaled from 120-m) 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_30 –**

This dataset is a 30-m cell size (downscaled from 120-m) 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_30** – see iFLP_FIL1 description above
i. **iFLP_FIL3_30** – see iFLP_FIL1 description above
j. **iFLP_FIL4_30** – see iFLP_FIL1 description above
k. **iFLP_FIL5_30** – see iFLP_FIL1 description above
l. iFLP_FIL6_30 – see iFLP_FIL1 description above
m. iMFI_30 –

This dataset is a 30-m cell size (downscaled from 120-m) 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.

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