Response of Highly Valued Resources and Assets to Wildfire within Grand Teton National Park and the Bridger-Teton National Forest

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for:

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Project Background

Grand Teton National Park (GTNP) and the Bridger-Teton National Forest (BTNF) cover approximately 3.7 million acres within the Greater Yellowstone Ecosystem. The majority of this land base is fairly remote, much of it either designated Wilderness or roadless, and composed of fire-adapted ecosystems. To add complexity to the fire environment, this fire dependent landscape is adjacent to high profile investments like communities and oil and gas fields as well as home to candidate wildlife species whose habitat may be negatively impacted by fire.

In this challenging context, both units' fire programs use the full range of fire management options – planned and unplanned ignitions, as well as mechanical treatments – to meet resource objectives. In light of the landscape's accessibility, historic dependence on fire, and the potential values impacted by fire, the units' fire management groups must be strategic in placing fuels treatments and in taking advantage of every opportunity to allow fire to play its natural role in the ecosystem. Optimizing the use of these tools requires first identifying the actual wildfire hazard across the landscape, then pinpointing the threats and benefits of fire.

To get a full picture of where the fire hazard is and how that hazard could be expected to interact with the resources and assets in GTNP and on the BTNF, the two units turned to the fire response assessment. Fire, resource, and line managers wanted to know:

- What areas have the highest likelihood of burning in a given year
- What areas could be expected to burn at the highest intensities? At the lowest intensities?
- How will critical natural resources and infrastructure be affected by fire at different intensities? Will they be uniformly damaged or improved by fire at different intensity levels?
- How could fire hazard combine with resource/infrastructure response to fire to indicate what areas on the landscape could expect to see a benefit from fire? What areas would expect a negative impact from fire? What areas would expect both positive and negative outcomes?

Answering these questions will help guide decisions on where to place fuels treatment most effectively, where managers may expect resource benefits from managing unplanned ignitions and where managers may expect negative resource impacts.

Crafting valid fuels projects and successfully managing unplanned ignitions requires input from both resource and fire managers. Particularly in the case of managing unplanned ignitions, the more input that can be gathered prior to an actual fire start, the more thoroughly all the resource concerns may be addressed. One of the many positive outcomes of this project is engaging fire and resource managers as well as line officers to determine which resources are of particular interest, how they respond to fire at different intensities, and how much weight they should be given in driving decisions.

This wildfire response assessment was conducted for both GTNP and the BTNF. Wildfire hazard was assessed across agency boundaries to capitalize on efficiencies in modeling. Both agencies conducted separate, but parallel, efforts to determine which highly valued resources or assets (HVRAs) to assess, determine their response, and rank their relative importance. This phase was done separately for each agency to acknowledge their respective management priorities and missions.

Analysis Overview

Three main components are required to assess the response of HVRAs to wildfire:

1) Wildfire hazard: geospatial data of burn probability and wildfire intensity generated from simulations

2) HVRA characterization: geospatially identified HVRAs

3) Wildfire response: response functions that describe the effects of fire to each HVRA

Pairing components 1 and 2 alone provides important information regarding where on the landscape HVRAs will likely interact with fire, and under what fire behavior conditions (also known as exposure analysis). The addition of component 3 further characterizes the effects to various HVRAs from this interaction with fire, which is very useful to inform planning efforts aimed at minimizing wildfire-related losses and maximizing wildfire-related benefits. That is, risk assessment. The following sections discuss the methods used to compile each of these components.

Fire Modeling Landscape

Geospatial data characterizing vegetation, fuels, and topography make up the fire behavior modeling landscape required to simulate the first of the three components listed above — wildfire hazard. Vegetation characteristics include forest canopy cover and forest canopy height. Fuel characteristics include surface fire behavior fuel model, forest canopy base height, and forest canopy bulk density. Topography characteristics include slope steepness, aspect, and elevation. The vegetation and fuel characteristics are derived from additional geospatial data characterizing existing vegetation and biophysical setting. We downloaded LANDFIRE[1] version 1.0.5 (Refresh 2001) of these data for an extent which is a minimum of ten miles from GTNP or BTNF administrative boundaries. This buffer allows for the simulation of wildfire spread on to GTNP and BTNF land from adjacent land without introducing an artificial "edge effect."

In November 2009, BTNF and GTNP fire managers and fuels specialists conducted a workshop to critique and update the LANDFIRE version 1.0.0 (National) data for use in their interagency fire management program. The critique focused on ensuring fuel models were mapped appropriately while the update accounted for wildfires that occurred between 2000 and 2008. As part of this critique and update process adjustments were made to surface fire behavior fuel model mapping rules using the LANDFIRE Total Fuel Change Tool (LFTFC, see www.niftt.gov). Because there are significant differences between the version 1.0.0 and 1.0.5 data in existing vegetation characteristics and surface fire behavior fuel model mapping rules are sensitive to thresholds of these characteristics, the original workshop adjustments to the mapping rules were invalid. We cross-walked the workshop-adjusted rules and updated the LFTFC database as part of this project.

[1] LANDFIRE (www.landfire.gov) is a national interagency mapping program that produces a comprehensive suite of geospatial data for the United States to support land management analysis and planning.

In addition to updating the LFTFC database surface fire behavior fuel model mapping rules we also updated the fire modeling landscape for wildfire disturbance for the time period of 2009 through 2010 and insect induced tree mortality for the time period of 2000 to 2008 (Goetz et al. 2009). The end result is the most up to date fire modeling landscape available for use in this assessment.

Wildfire Hazard

Wildfire hazard refers to the likelihood and potential intensity of wildfire across a landscape. Specifically, wildfire hazard is quantified as annual burn probability (*BP*), mean fireline intensity (*MFI*), and the distribution of wildfire intensity given that one does occur (conditional probability by flame-length class).

For this analysis we used the large fire simulator (FSim) to quantify wildfire hazard across the landscape at a 90 m spatial resolution (2 acres per pixel). FSim is a comprehensive fire occurrence, growth, behavior, and suppression simulation system that uses fuel, weather, topography, and historical fire occurrence information to estimate the spatial BP, MFI, and expected distribution of flame length at each point across a landscape (Finney et al. 2011).

FSim requires information regarding historic weather. We identified the weather stations across the landscape that have consistent hourly wind and daily fire weather observations. From these we selected the Raspberry Remote Automated Weather Station (RAWS) to use for the analysis because of its central location and exposure to winds from all directions. FSim results are sensitive to wind speed and direction, so adequate representation of winds is more important than other variables, such as fuel moisture. At other RAWS locations, particularly those in valley-bottom locations, wind direction was influenced by nearby mountain ranges. Weather data for this RAWS was used to produce monthly distributions of wind speed and direction, season-long trends of mean and standard deviation of Energy Release Component (ERC) for fire danger fuel model G, and percentile values of dead fuel moisture content.

FSim also requires information regarding the historic occurrence of fire in the analysis area, specifically large fires—those that escape initial attack and require extended suppression response. For this analysis we defined a large fire as one greater than 100 acres in final fire size. We gathered fire occurrence data for all jurisdictions in the analysis area for the period of 1990-2009[2]. During this period, 209 large fires ignited in the fire modeling area; at least one large fire started on 183 days (some days had multiple fire starts). We used FireFamilyPlus to construct a logistic regression model of the probability of a large-fire day within the 14.4 million acre fire modeling area. A large-fire day is a day on which one or more fires start (or is discovered) and eventually burns more than 100 acres. The logistic regression model for this assessment's fire modeling area is:

P(Large-fire day) = 1 / (1 + exp(-1 * -5.1242 + (-1 * 0.0444) * ERC))

For reference, the 95th percentile ERC is 64, and the 90th percentile ERC is 56. The probability of a large-fire day is less than 0.067 percent—about 1 in 1,500—on 90 percent of days of the year.

We determined the distribution of number of fires started on each of the 183 large-fire days. During the last 20 years on the fire modeling area, only one large fire started 91 percent of the

[2] This time period was used because the ignition density grid used for input to FSim was constructed from fire occurrence data for this time period. The addition of data from the 2010 and 2011 fire seasons would not be expected to significantly influence the results of the analysis.

large-fire days, two large fires started on 8 percent of the large-fire days. The remaining large-fire days had 3, 4 or 8 large-fire starts (one observation of each).

During the historic period, an average of 30,001 acres per year burned in fires ignited within the landscape, corresponding to a landscape-mean burn probability of 0.002.

Historic fire occurrence was not uniform across the fire modeling area. To account for that non-uniformity, FSim uses a geospatial layer indicating relative ignition density across the landscape, and will randomly locate fires according to this density grid during simulation. We used logistic regression to create a probability density grid representing the historic spatial pattern of ignitions across the landscape (Figure 1). This ignition grid was used by FSim to determine where ignitions were placed for each simulated fire.

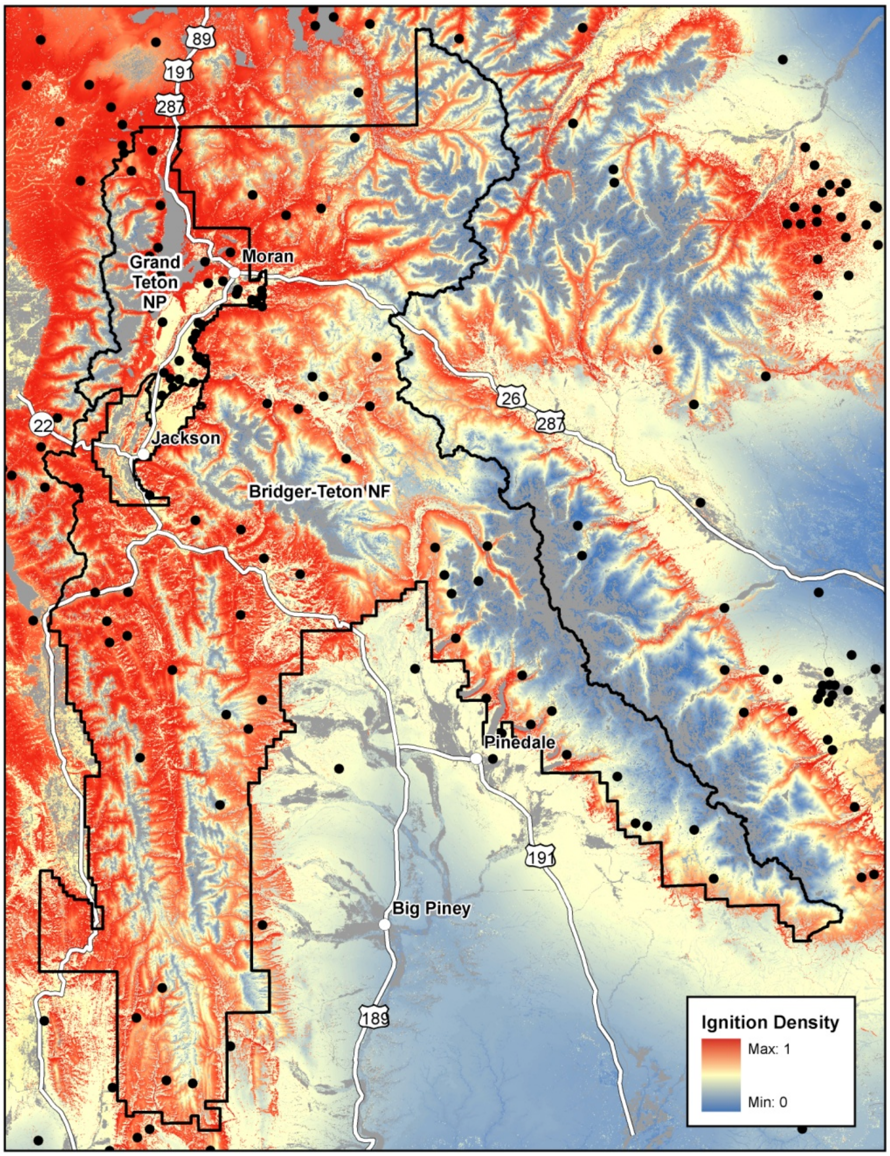

Figure 1: Relative ignition density. Dark red areas have highest ignition density; dark blue have the lowest ignition density. Grey indicates zero. Black points represent the location of ignitions that exceeded 100 acres in final fire size.

The final FSim wildfire hazard simulation used a rate of spread (ROS) adjustment factor of 0.7 on the low load, dry climate grass (GR2); moderate load, dry climate grass (GR4); and moderate load, dry climate grass-shrub (GS2) fuel models. ROS adjustment factors were left at 1.0 for all other fuel models. These adjustments were necessary to balance the fire growth rates in the open grasslands versus the forested areas.

The maximum simulated fire size was set to 250,000 acres. The Scott and Reinhardt (2001) crown fire method was used for the simulation. Simulations were set to begin on May 15; the first simulated fires started at the end of May. Results from the wildfire hazard assessment start on page 28 of this document.

HVRA Characterization

Prior to determining the response of HVRAs to spatially explicit estimates of wildfire hazard, the HVRAs need to be characterized and mapped. Resources and assets were deemed ‘highly valued’ for the purposes of this assessment based on their utility in driving fire management decision making. For example, infrastructure was determined to be an HVRA because depicting the potential for loss of infrastructure helps identify considerations for managing a natural ignition. Similarly, aspen stands determined to be a high priority for restoration by fire were also identified as an HVRA. Capturing the potential for benefit to these stands may help identify prescribed fire treatments or craft objectives for a managed wildfire.

The lists of HVRAs to assess were generated separately for GTNP and the BTNF but using similar processes. For both units, resource specialists and fire managers gathered together to discuss this project and brainstorm initial HVRA lists. Wyoming Game and Fish habitat biologists joined the BTNF group. The same groups then reconvened to confirm the lists, identify items that could be combined, and remove any items that would were determined to be captured elsewhere or serve better as reporting units for summarizing the results.

Recognizing both units’ basic land management direction to steward the fire-adapted ecosystems present on their landscapes and the desire to have vegetation in its historic mix of structure and composition, both GTNP and the BTNF determined that they needed an HVRA that would characterize the ‘diverse and resilient vegetation’ of fire-adapted ecosystems. The two units approached characterizing this HVRA in different ways. GTNP’s approach is captured in this document and the BTNF’s is captured in a separate document (Helmbrecht and others [in prep.]).

The list of individual HVRAs identified for an assessment can be quite long, suggesting a two-level hierarchical structure to organize HVRAs (Thompson and others 2012). The primary HVRA represents a group of similar HVRAs. The individual HVRAs within a primary HVRA are called sub-HVRAs. In some cases, an additional variable—here called a covariate—may have been identified as an important HVRA characteristic affecting the HVRA's response to wildfire. HVRAs and sub-HVRAs are can be assigned different response functions and different relative importance values; a covariate results in a different response function, but the relative importance is the same as the HVRA or sub-HVRA to which it belongs. GTNP identified four primary HVRAs to be analyzed in this assessment and the BTNF identified seven. Table 1 summarizes all the HVRAs identified by both units.

Table 1: HVRAs, sub-HVRAs, and covariates identified by GTNP and the BTNF.

Unit	HVRA	Sub-HVRA	Covariates
GTNP	Investments	Developments Utilities Repeaters/communication sites Patrol cabins, backcountry and frontcountry campsites, vault toilets, utility sheds Whitebark pine plus trees	
	Diverse and Resilient Vegetation	Fire dependent vegetation types from the GTNP existing vegetation map	Vegetation classes corresponding to successional stages, from the GTNP veg map
	Invasive Plants	High potential for spread post fire Moderate potential for spread post fire	
	Habitat	Northern leatherside chub habitat	
BTNF	Investments	Wyoming Game and Fish feed grounds Special use permit areas Trailheads/boating sites Campgrounds/picnic areas Cabins/guard stations/lookouts Oil and gas development areas Communication sites Power lines White bark pine plus trees	
	Wildland-Urban Interface (WUI)	WUI defense Protection FMU outside WUI defense	
	Critical Fish and Wildlife Habitat	Lynx (unmapped)	Lynx key areas LAUs with over 30% in a stand initiation phase LAUs with over 20% in a stand initiation phase
		Migration routes	Pronghorn antelope
			Bighorn sheep
		Moose thermal cover	
		Sage-grouse	Core areas
			Sagebrush within 2 miles of occupied leks
		Cutthroat trout and Northern leatherside chub streams	
	Priority Vegetation	Whitebark pine stands classified as A-D based on canopy damage	
		Sensitive plants	Positive response to fire
			Negative response to fire

		Aspen	High priority for treatment
			Aspen stands adjacent to Wyoming Game and Fish elk feedgrounds
	Municipal Watersheds		
	Diverse and Resilient Vegetation	Five biophysical settings (BpS) that cover the majority of the BTNF	Each BpS has a covariate for under-represented, similar, and overrepresented successional classes, relative to a reference condition
	Timber Base	Desired Future Condition 1B (Substantial commodity resource development with moderate accommodation of other resources) Desired Future Condition 10 (Simultaneous development of resources, opportunities for human experiences, and support for big-game and a wide variety of wildlife species)	

The following sections give a general overview of the rationale for selecting each HVRA and how each was characterized and mapped.

Grand Teton National Park

Investments

The GTNP investments HVRA represents infrastructure or other assets within Grand Teton National Park. This HVRA was developed in order to assess the wildfire risk to these investments.

The HVRA is split into the following seven sub-HVRAs:

- WUI areas
- Powerlines
- Historic buildings
- Repeaters and communication sites
- Recreation infrastructure
- Restoration sites
- Whitebark pine plus trees

The recreation infrastructure sub-HVRA is further split into the following four covariates:

- Patrol cabins
- Backcountry campsites
- Frontcountry campsites
- Vault toilets, utility buildings

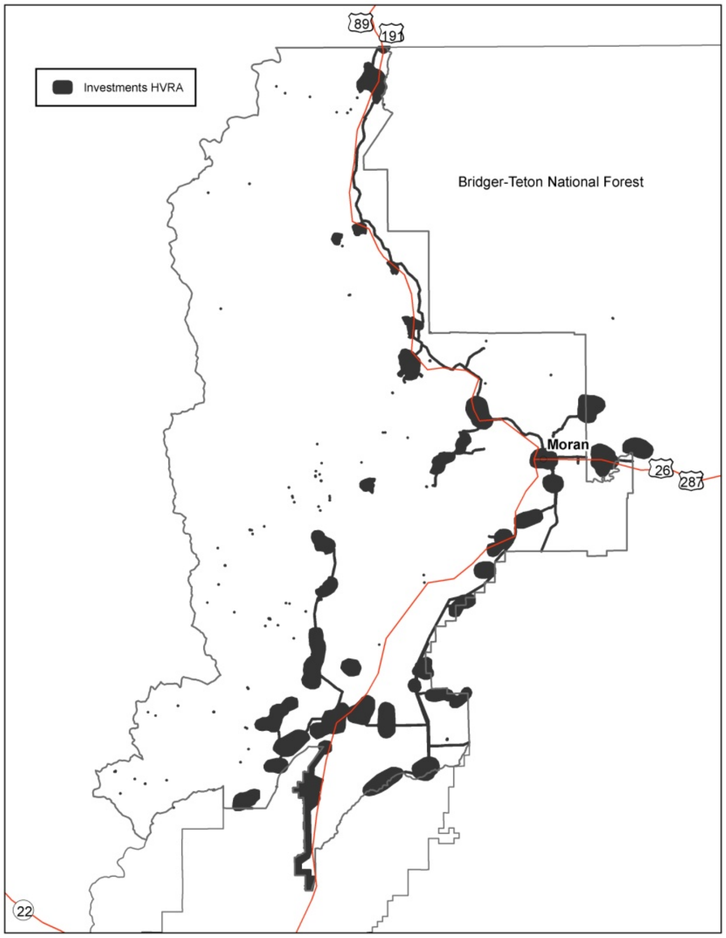

Figure 2: Geospatial distribution of GTNP Investments HVRA.

The sub-HVRAs and covariates were derived from existing NPS geospatial data.

Diverse and Resilient Vegetation

The GTNP diverse and resilient vegetation HVRA represents the successional stages present within the GTNP vegetation communities. This study assumes that the reference condition distribution of successional states present in all the fire-adapted vegetation communities equates to diverse and resilient vegetation communities. GTNP wanted to capture diverse and resilient vegetation as an HVRA in order to capture its importance as the cornerstone of successful land management, a proxy for fire's role in fire-adapted ecosystems, and a proxy for habitat of the wildlife species endemic to the area.

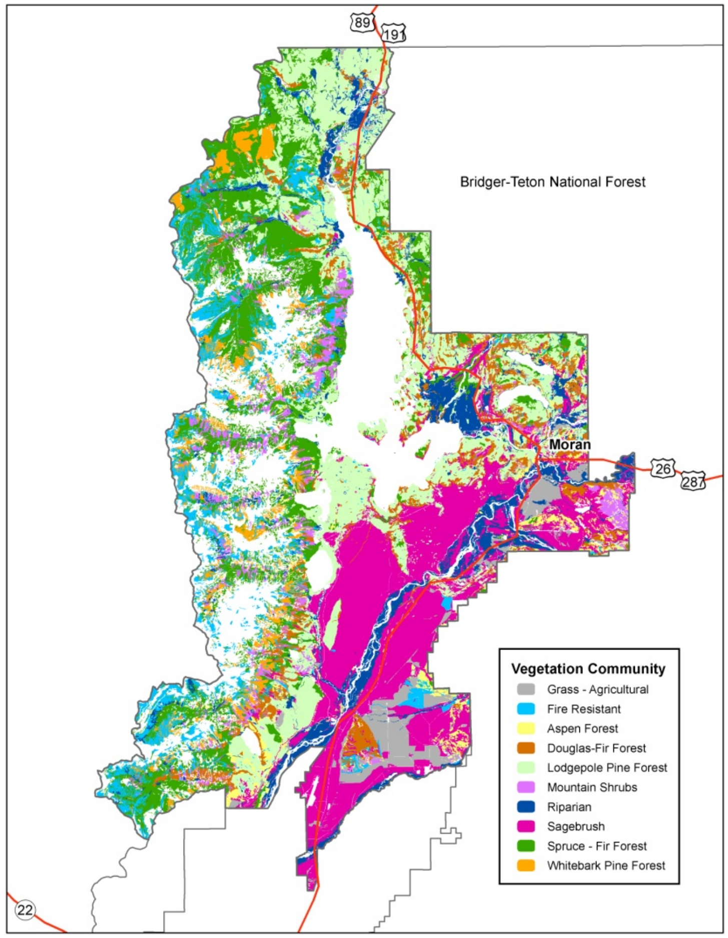

Figure 3: Geospatial distribution of GTNP Diverse and Resilient Vegetation HVRA.

Ten sub-HVRAs are characterized as the vegetation communities shown in Figure 3. Each sub-HVRA is further split into covariates that represent different successional states or physical characteristics of the community (Table 3). The sub-HVRAs and covariates were derived from existing NPS geospatial data based on expert opinion from the Teton Interagency Fire Ecologist, the GTNP Assistant Fire Management Officer and the GTNP Ecologist (Abendroth 2012).

Invasive Plants

The GTNP invasive plants HVRA represents areas within GTNP that are susceptible to post-fire invasive plant infestation. The HVRA is split into two sub-HVRAs representing high and moderate potential for post-fire colonization. The sub-HVRAs were derived from existing NPS geospatial data and the expert opinion of the GTNP Vegetation Biologist.

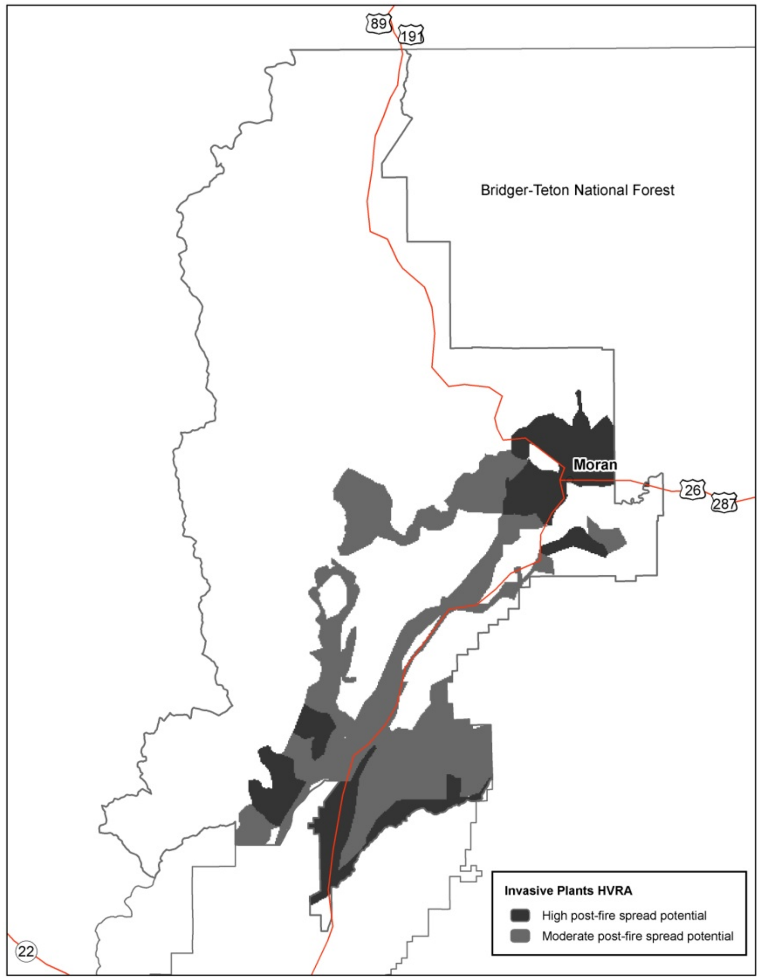

Figure 4: Geospatial distribution of GTNP Invasive Plants HVRA.

Critical Fish and Wildlife Habitat

The GTNP critical fish and wildlife habitat HVRA represents northern leatherside chub habitat, a proposed candidate for listing as threatened or endangered. This was the only species' habitat specifically identified because it was determined that the Diverse and Resilient Vegetation HVRA captured the terrestrial species' habitat needs. This HVRA is characterized as 6th level hydrologic unit code (HUC) sub-watersheds within which stream reaches are occupied by northern leatherside chub. The 6th level HUC was used because only fire over the entire watershed would impact the fish's habitat.

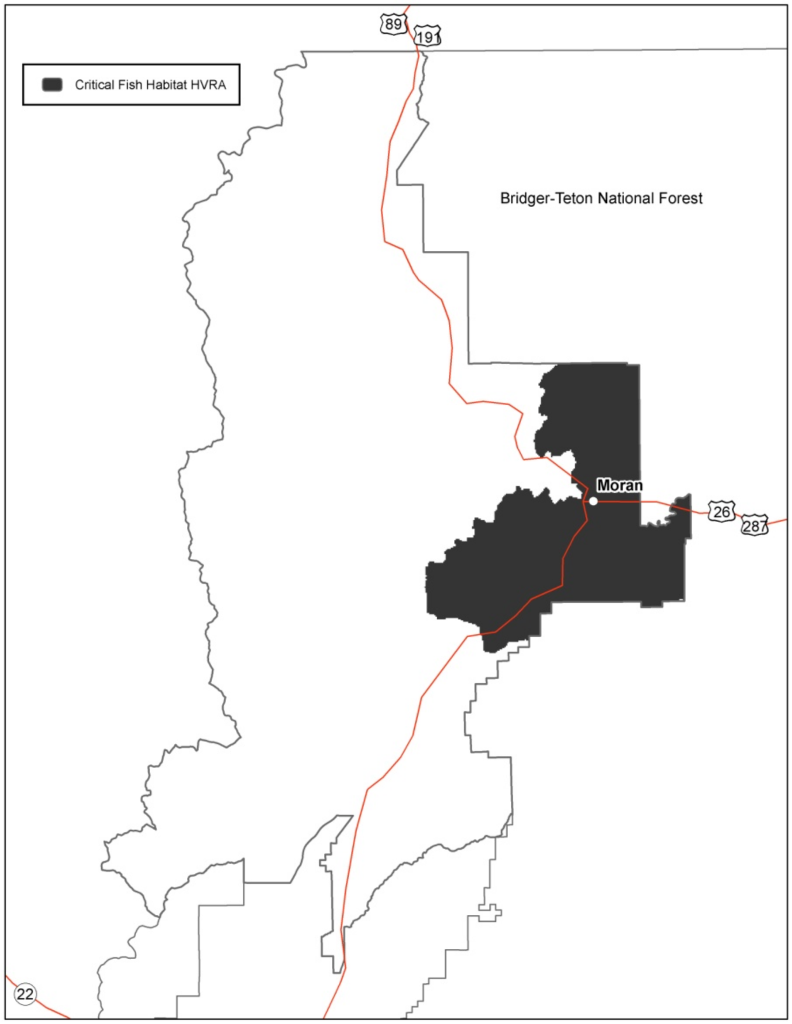

Figure 5: Geospatial distribution of GTNP Critical Fish Habitat HVRA.

Bridger-Teton National Forest

Investments

The BTNF investments HVRA represents infrastructure both within and adjacent to the Bridger-Teton National Forest. This HVRA includes investments made by the Forest Service as well as those made by special use permit holders and cooperating agencies. This HVRA was developed in order to assess the wildfire risk to these investments.

The HVRA is split into the following nine sub-HVRAs:

- Wyoming Game and Fish feed grounds
- Special use permit areas
- Trailheads/boating sites
- Campgrounds/picnic areas
- Cabins/guard stations/lookouts
- Oil and gas development areas
- Communication sites
- Power lines
- White bark pine plus trees

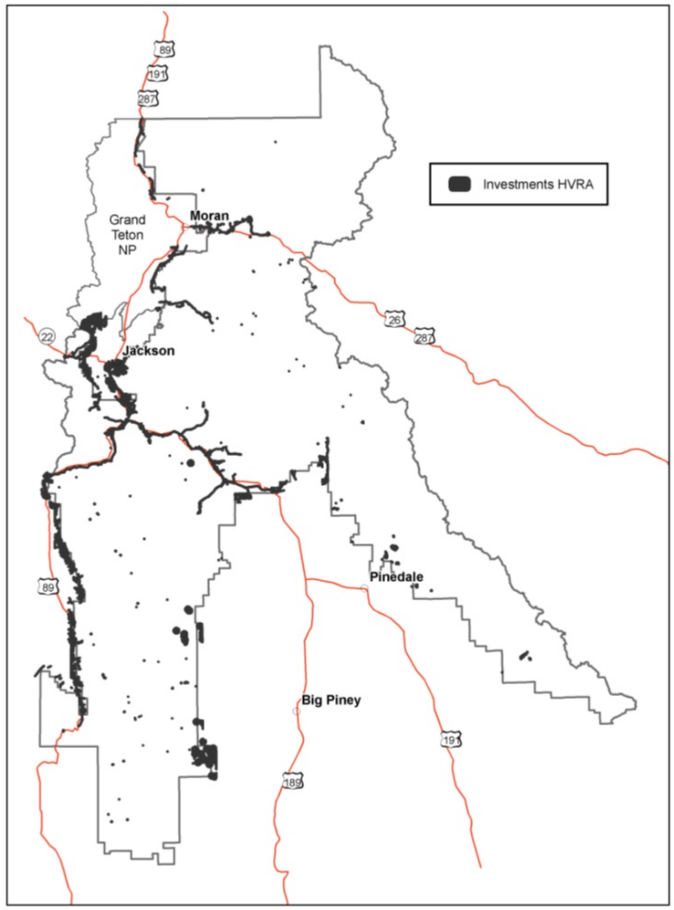

Figure 6: Geospatial distribution of BTNF Investments HVRA.

All sub-HVRAs were mapped on and within one mile of the Forest boundary. Data on the Wyoming Game and Fish elk feed grounds were provided by the Wyoming Game and Fish Department. Oil and gas development area data were provided by the Wyoming Oil and Gas Commission. Power line data were provided by Lower Valley Energy. Remaining sub-HVRA data were derived from the BTNF corporate geospatial data set.

Wildland-Urban Interface

The BTNF wildland urban interface (WUI) HVRA represents areas on the Forest closest to private land. The HVRA has two components, represented by sub-HVRAs: the WUI defense zone and the Protection Fire Management Unit (FMU) outside the WUI defense zone. The WUI defense zone is characterized as NFS land within a 0.25 mile buffer of private land. This sub-HVRA represents the area of highest interest for fuel reduction projects. The Protection FMU outside the WUI defense zone captures the balance of the BTNF lands that receive a predominantly suppression response to wildfires due to their proximity to values at risk.

The Protection FMU is characterized in the BTNF Fire Management Plan (USDA Forest Service, 2012). The sub-HVRAs were derived from the BTNF corporate geospatial dataset

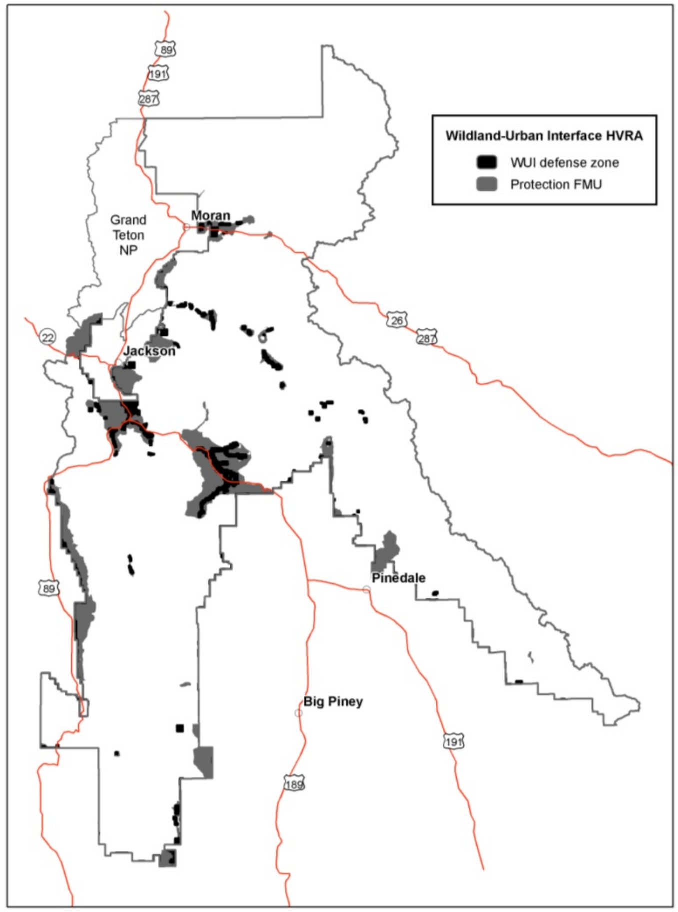

Figure 7: Geospatial distribution of BTNF Wildland Urban Interface HVRA

Critical Fish and Wildlife Habitat

The BTNF critical fish and wildlife habitat HVRA represents habitat components of five wildlife and three fish species. Lynx are a federally-listed threatened species and sage-grouse are a candidate species. Pronghorn antelope, bighorn sheep, and moose are all species whose habitat needs are of concern to the Wyoming Game and Fish Department.

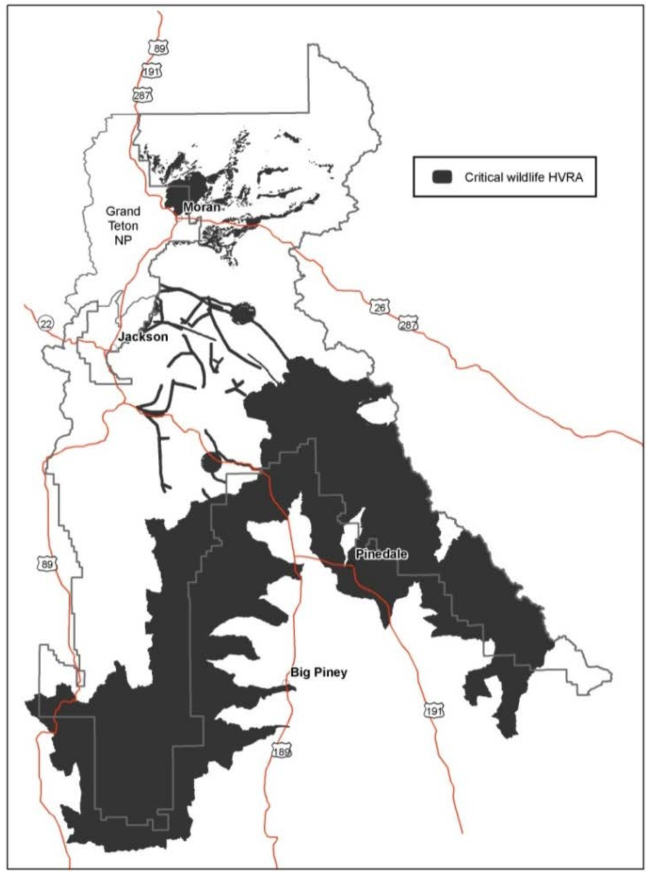

Figure 8: Geospatial distribution of BTNF Critical Fish and Wildlife Habitat HVRA.

The three fish species are all proposed candidates for listing. This sub-HVRA was mapped as occupied 6th level HUC. The 6th level HUC was used because only fire over the entire watershed would impact the fishes' habitat.

The HVRA is split into the following nine sub-HVRAs:

- Lynx key areas (vegetation associations that meet lynx habitat requirements
- Lynx Analysis Units (geographic areas delineated by the Lynx Conservation Assessment and Strategy (USFWS 2000) for managing lynx habitat) with over 30% vegetation in stand initiation phase
- Lynx Analysis Units with 20-30% vegetation in stand initiation phase
- Pronghorn antelope migration routes
- Bighorn sheep migration routes
- Moose thermal cover in Teton Wilderness
- Sage-grouse core areas
- Sagebrush within two miles of occupied sage-grouse leks
- Bonneville and Colorado River cutthroat trout and Northern leatherside chub (proposed candidate species)

Lynx key areas and the Lynx Analysis Units' vegetation in the stand initiation phase thresholds were identified as HVRAs but were not mapped accurately enough to include in the geospatial fire response assessment. However, these sub-HVRAs' responses to fire were determined during the response function workshop.

Lynx key areas are further split into foraging and non-foraging covariates. Pronghorn antelope migration routes are split into conifer and non-conifer covariates. Geospatial data for all sub-HVRAs with the exception of fisheries were obtained from the Wyoming Game and Fish Department. The fisheries sub-HVRA was derived from existing USFS data.

Priority Vegetation

The BTNF priority vegetation HVRA represents Threatened, Endangered, Sensitive and Proposed Candidate vegetation on the BTNF that is sensitive to wildfire (positive or negative). The priority vegetation HVRA also represents aspen stands that are particularly sensitive to wildfire (positive or negative). Aspen was identified as a species of particular interest given its decline throughout the region and its critical role as wildlife habitat.

The HVRA is split into the following seven sub-HVRAs:

- Whitebark pine stands A-D (Candidate for listing as Threatened or Endangered)
- Sensitive plants
- Aspen stands adjacent to elk feed grounds
- Aspen with high priority for restoration treatment

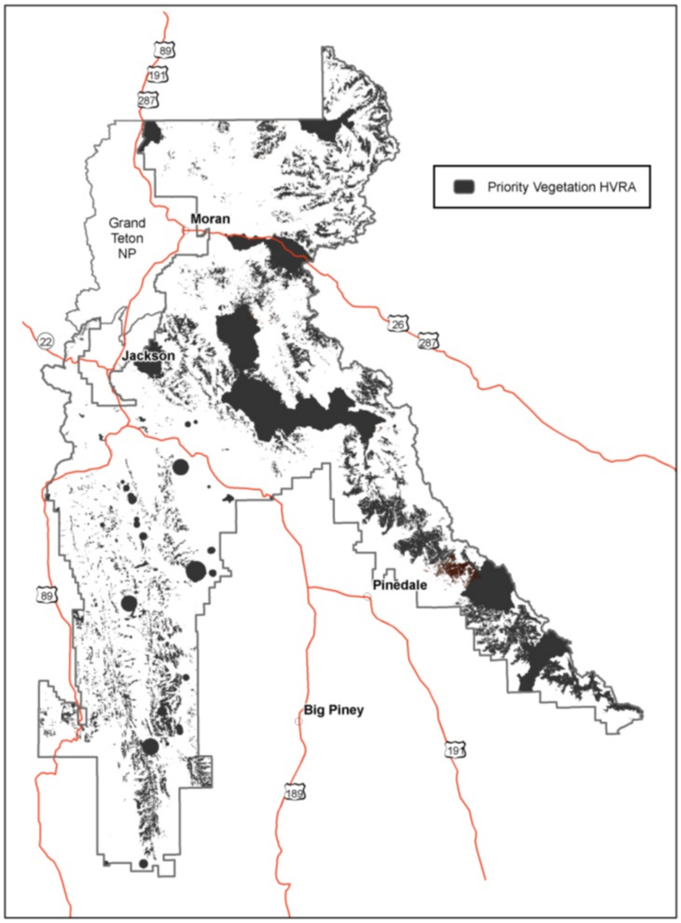

Figure 9: Geospatial distribution of BTNF Priority Vegetation HVRA.

Whitebark pine data were obtained from Greater Yellowstone Coordinating Committee (GYCC) Whitebark sub-committee. The whitebark pine stands were then split into four sub-HVRAs (A-D) based on the extent of canopy damage and anticipated fire effects. This characterization was provided by the GYCC Whitebark sub-committee co-chair.

The sensitive plants sub-HVRA is further split into two covariates representing those species that have a positive response to fire and those that have a negative response. Data for these plants were provided by the BTNF botanist, based on the Wyoming Natural Diversity Database.

Aspen adjacent to elk feed grounds may be damaged post-fire due to intensive herbivory by elk. These aspen stands at risk were identified by the Wyoming Game and Fish department, based on the 2007 BTNF vegetation map (USDA Forest Service 2007).

The high restoration priority aspen is based on the Campbell and Bartos aspen risk key used in the Grey's River Aspen Assessment (Loosen et al. 2009). These high restoration priority aspen stands are limited to those identified during the Greys River Aspen Assessment.

Municipal Watersheds

The BTNF municipal watersheds HVRA represents areas identified by the Desired Future Condition (DFC) of the same name in the BTNF Forest Plan (USDA Forest Service 1990).

Data for the municipal watersheds HVRA were obtained from the BTNF corporate geospatial dataset.

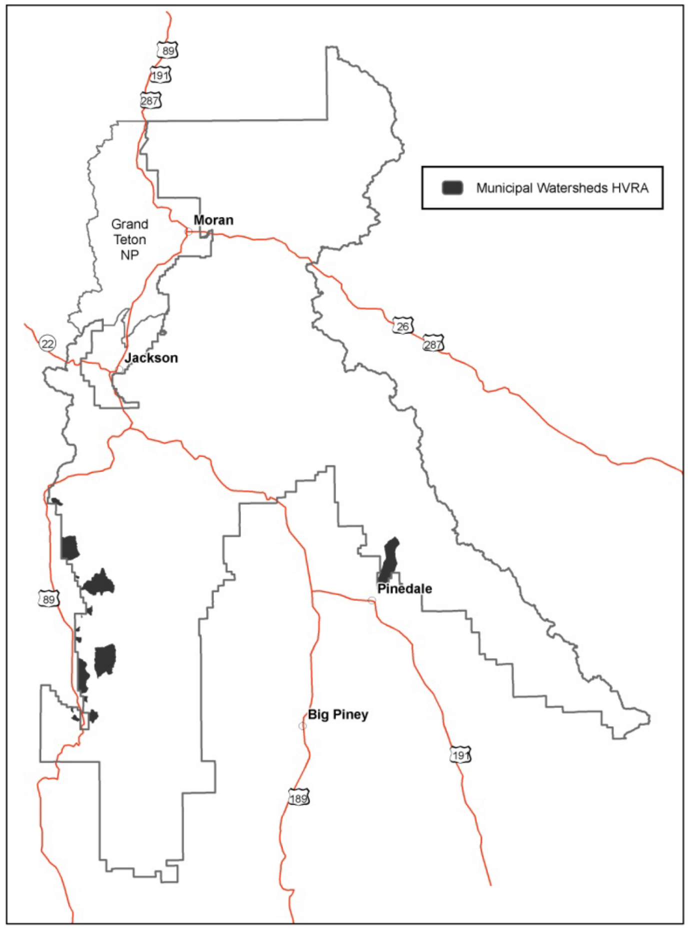

Figure 10: Geospatial distribution of BTNF Municipal Watersheds HVRA.

Diverse and Resilient Vegetation

The BTNF diverse and resilient vegetation HVRA represents the combination of vegetation communities and their distribution of successional states. This study assumes that the reference condition distribution of successional states present in fire-adapted vegetation communities equates to diverse and resilient vegetation communities. The BTNF wanted to capture diverse and resilient vegetation as an HVRA in order to capture both its importance as the cornerstone of successful land management and a proxy for fire's role in fire-adapted ecosystems.

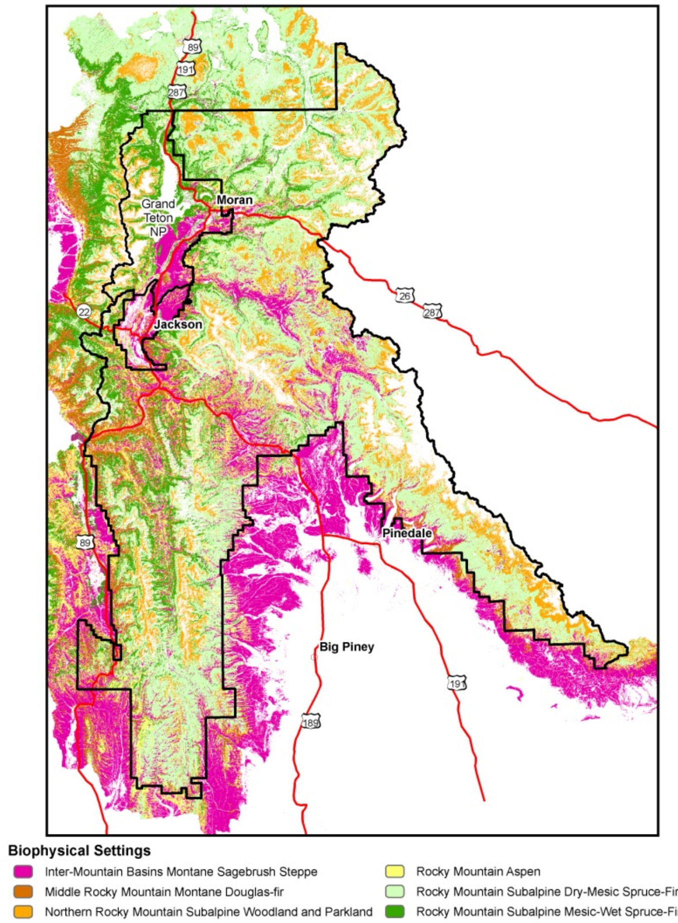

Figure 11: Geospatial distribution of biophysical settings used to derive the BTNF Diverse and Resilient Vegetation HVRA.

Seven sub-HVRAs are characterized as the biophysical settings (BpSs) shown in Figure 11. Each sub-HVRA is further split into covariates that represent whether the current percentage of the individual S-Classes are in deficit, similar, or in surplus when compared to the mean percentage under the historic range of variation[3] (Table 4). The sub-HVRAs and covariates were derived from LANDFIRE geospatial data using the Fire Regime Condition Class mapping tool (Helmbrecht and others [in prep.]).

[3] Reference conditions were acquired from LANDFIRE vegetation dynamics models.

Timber Base

The BTNF timber base HVRA represents two DFC areas identified in the 1990 BTNF Forest Plan (USDA Forest Service 1990) where commercial timber harvest activities may take place. DFC 1B refers to areas of substantial commodity resource development and DFC 10 refers to areas of simultaneous development of resources and other opportunities.

The sub-HVRAs were derived from the BTNF corporate geospatial dataset.

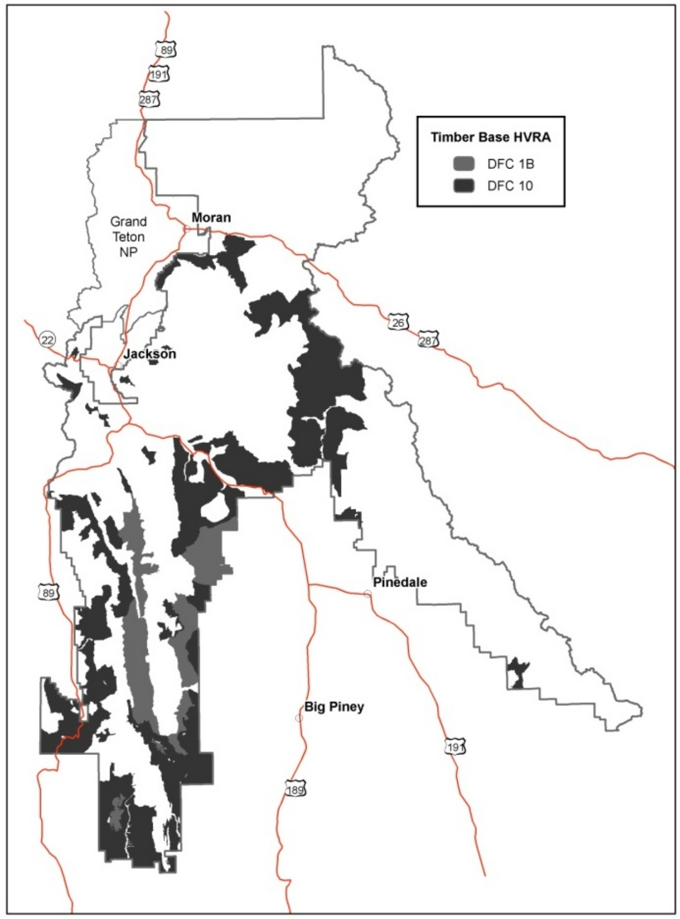

Figure 12: Geospatial distribution of BTNF Timber Base HVRA.

Wildfire Response

The analysis quantifies wildfire response as the expected value of net response (Finney 2005). This approach has previously been applied to a nationwide assessment (Calkin and others 2010) and to two Forest-level assessments (Scott and Helmbrecht 2010, Helmbrecht and others 2012) of wildfire response. The analysis relies on local 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 fire intensity levels (FILs), represented as 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 increase in value). Table 2, below, describes the different fire intensity levels.

Table 2: Fire intensity level descriptions.

FIL	Flame length	Description
1	0-2	Scorch height 5-20'; typically low severity; backing/flanking fire, low fuel load or mild conditions
2	2-4	Scorch height 10-40'; typically low-to-moderate severity; heading/flanking fire, moderate fuel load or moderate conditions
3	4-6	Scorch height 20-60'; typically moderate severity; heading/flanking fire in moderate fuel and moderate-to-severe conditions
4	6-8	Scorch height 30-80'; typically moderate-to-high severity; heading fire in moderate-to-heavy fuel and moderate-to-severe conditions
5	8-12	Scorch height 50-100'; typically high severity; heading fire in moderate-to-heavy fuel load and moderate-to-severe conditions
6	12+	Scorch height exceeds tree height; high severity; head fire in heavy fuel in moderate-to-severe conditions

In order to integrate HVRAs with differing units of measure (for example, habitat vs. homes), relative importance (*RI*) values were assigned to each HVRA by Park and Forest line officers. Relative importance values were developed by first ranking the HVRAs then assigning an *RI* value to each. The most important HVRA was assigned *RI* = 100. Each remaining HVRA was then assigned an *RI* value indicating its importance relative to that most-important HVRA.

The *RI* values apply to the overall HVRA on the Forest or Park as a whole. The calculations need to take into account 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 on the forest. Here, relative extent refers to the number of 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; an HVRA with a great many pixels has a low importance per pixel.

The *RF*, *RI* and *RE* values were combined with estimates the annual burn probability (*BP*) in each of the six FILs. Weighted net wildfire response for each HVRA (WNR_j), whether threat or benefit, was quantified as the expected value of net wildfire response at each pixel on the landscape. This was calculated as the sum-product of burn probability (*BP*) and response function value (*RF*) over all the six FILs, with weighting factor adjustments for the relative importance and relative extent of each HVRA, as follows:

Table 3: Response functions for the Grand Teton National Park HVRAs.

HVRA Name	HVRA RI	Sub-HVRA Name	Sub-HVRA RI	Covariate	FIL 1	FIL 2	FIL 3	FIL 4	FIL 5	FIL 6
Investments	100	WUI areas	100		-40	-60	-80	-100	-100	-100
		Power lines	20		-10	-20	-40	-60	-100	-100
		Historic buildings	100		-40	-60	-80	-100	-100	-100
		Repeaters/communication sites	60		-10	-20	-60	-100	-100	-100
		Recreation infrastructure	10	Patrol cabins	-40	-60	-80	-100	-100	-100
				Backcountry campsites	0	-20	-30	-60	-80	-80
				Front country campsites	0	-20	-30	-60	-80	-80
				Vault toilets, utility buildings	0	-20	-40	-60	-80	-100
		Restoration sites	50		-100	-100	-100	-100	-100	-100
		Whitebark pine plus trees	30		-40	-60	-80	-100	-100	-100
Diverse and Resilient Vegetation	90	Grass- Agricultural	10		20	10	0	0	-10	-40
		Fire resistant	5	Alpine	0	0	-5	-10	-10	-20
				Tall forb	0	0	0	0	-10	-10
				Dry sparse forbs	0	-10	-20	-30	-40	-50
		Aspen forest	80	Aspen forest	10	20	50	60	50	40
				Aspen conifer mix	0	60	90	100	90	80
				Aspen regeneration	0	-20	-20	-20	-30	-50
		Douglas-fir forest	40	Douglas-fir forest	90	95	60	60	50	40
				Mixed conifer forest – Douglas-fir dominant	80	60	40	40	40	30

HVRA Name	HVRA RI	Sub-HVRA Name	Sub-HVRA RI	Covariate	FIL 1	FIL 2	FIL 3	FIL 4	FIL 5	FIL 6
		Lodgepole pine forest	70	lodgepole pine forest	80	70	50	40	40	30
				Mixed conifer forest – lodgepole pine dominant	50	20	0	-40	-50	-50
				Lodgepole pine regeneration	30	30	30	30	30	30
				Recently burned	0	0	0	0	0	0
		Mountain shrubs	15	Mountain shrubs	30	30	30	30	-20	-20
				Ceanothus shrubland	0	0	0	0	0	0
				Steep slope shrubs	0	0	0	0	-20	-20
		Riparian	15	Wet meadow	0	0	0	0	0	0
				Forested river channels	0	0	0	0	0	0
				Willow shrubland	20	10	0	-40	-50	-60
		Sagebrush	100	Sagebrush	-10	-30	-60	-60	-60	-60
				Mesic sagebrush	0	0	0	0	0	0
				Sagebrush - bitterbrush	-70	-90	-90	-90	-90	-90
				Dwarf sagebrush	10	0	0	0	0	0
		Spruce-fir forest	100	Subalpine fir-Engelmann spruce forest	60	60	50	30	20	10
				Mixed conifer forest – spruce - fir dominant	60	60	50	30	20	10
				Mixed conifer regeneration	0	0	0	0	0	0

HVRA Name	HVRA RI	Sub-HVRA Name	Sub-HVRA RI	Covariate	FIL 1	FIL 2	FIL 3	FIL 4	FIL 5	FIL 6
				Krumholz	0	0	-5	-10	-10	-20
		Whitebark pine forest	90	Whitebark pine forest	-80	-100	-100	-100	-100	-100
				Mixed conifer – whitebark pine dominant	-80	-100	-100	-100	-100	-100
Invasive Plants	50	High potential for post-fire spread	100		-30	-60	-90	-100	-100	-100
		Moderate potential for post-fire spread	50		-10	-30	-60	-90	-100	-100
Critical Fish and Wildlife Habitat	5	Northern leatherside chub	100		50	25	0	-40	-80	-90

Table 4: Response functions for the Bridger-Teton National Forest HVRAs.

HVRA Name	HVRA RI	Sub-HVRA Name	Sub-HVRA RI	Covariate	FIL 1	FIL 2	FIL 3	FIL 4	FIL 5	FIL 6
Investments	100	Wyoming Game and Fish feedgrounds	60		-50	-70	-90	-100	-100	-100
		Special use permit areas	100		-50	-70	-90	-100	-100	-100
		Trailheads/boating sites	85		0	-10	-20	-30	-40	-50
		Campgrounds/picnic areas	85		0	-10	-20	-55	-75	-75
		Cabins/guard stations/lookouts	100		-50	-70	-90	-100	-100	-100
		Oil and gas development areas	100		-10	-20	-40	-80	-100	-100
		Communication sites	100		0	-30	-60	-80	-100	-100
		Power lines	100		-10	-20	-40	-80	-100	-100
		Whitebark pine plus trees	60		-10	-70	-100	-100	-100	-100
Wildland Urban Interface (WUI)	100	WUI defense zone	100		0	-50	-75	-100	-100	-100
		Protection fire management unit	70		10	0	-25	-50	-50	-50
Critical Fish and Wildlife Habitat	75	Lynx key areas	12.5	Foraging	-20	-75	-100	-100	-100	-100
				Non-foraging	100	100	100	100	100	100
		Lynx Analysis Units with over 30% vegetation in stand initiation phase	15		50	25	-90	-100	-100	-100
		Lynx Analysis Units with 20-30% vegetation in stand initiation phase	10		50	25	-30	-50	-70	-100
		Pronghorn antelope migration routes	30	Non-conifer	50	35	15	0	-30	-70
				Conifer	100	100	100	100	100	100
		Bighorn sheep migration routes	60		100	100	100	100	100	100
		Moose thermal cover in Teton Wilderness	70		50	0	-30	-70	-90	-100
		Sage-grouse core areas	100		-50	-100	-100	-100	-100	-100
		Sagebrush within two miles of	80		20	-20	-100	-100	-100	-100

HVRA Name	HVRA RI	Sub-HVRA Name	Sub-HVRA RI	Covariate	FIL 1	FIL 2	FIL 3	FIL 4	FIL 5	FIL 6
		occupied sage-grouse leks								
		Cutthroat trout and leatherside chub streams	50		50	25	0	-40	-80	-90
Priority Vegetation	75	Whitebark pine - A	100		0	-50	-100	-100	-100	-100
		Whitebark pine - B	20		0	-50	-100	-100	-100	-100
		Whitebark pine - C	80		0	-50	-100	-100	-100	-100
		Whitebark pine - D	0		0	-50	-100	-100	-100	-100
		Sensitive plants	30	Positive response	20	20	20	50	50	20
				Negative response	0	0	-10	-20	-25	-30
		Aspen in close proximity to elk feedgrounds	17		0	0	-20	-40	-50	-60
		Aspen with high priority for restoration treatment	85		20	30	50	75	100	100
Municipal Watersheds	70		100		20	0	-20	-50	-75	-100
Diverse and Resilient Vegetation	50	Rocky Mountain subalpine dry-mesic spruce-fir forest and woodland	30	SclassA-Surplus	40	40	-20	-30	-30	-30
				SclassB-Deficit	30	15	-10	-50	-70	-80
				SclassC-Similar	30	30	15	0	-60	-70
				SclassC-Deficit	50	50	15	0	-70	-80
				SclassD-Surplus	10	20	40	40	20	10
				SclassU	30	30	15	0	-60	-70
		Inter-mountain basins montane sagebrush steppe	100	SClassA-Deficit	-30	-40	-50	-50	-50	-50
				SclassB-Surplus	50	50	60	60	50	40
				SclassB-Similar	40	40	50	50	40	30
				SclassC-Deficit	0	20	40	40	30	20

HVRA Name	HVRA RI	Sub-HVRA Name	Sub-HVRA RI	Covariate	FIL 1	FIL 2	FIL 3	FIL 4	FIL 5	FIL 6
				SclassU	-30	-40	-50	-50	-50	-50
		Northern Rocky Mountain subalpine woodland and parkland	70	SclassA-surplus	30	30	-10	-20	-20	-20
				SclassA-similar	30	30	-10	-20	-20	-20
				SclassB-Deficit	30	40	0	-70	-80	-80
				SclassC-Similar	20	30	0	-60	-70	-70
				SclassC-deficit	30	40	0	-70	-80	-80
				SclassD-Surplus	10	20	40	60	20	0
				SclassE-similar	30	20	0	-60	-90	-90
				SclassE-deficit	40	30	-10	-70	-100	-100
				SclassU	30	30	-10	-20	-20	-20
		Rocky Mountain subalpine mesic-wet spruce-fir forest and woodland	20	SclassA-Surplus	30	30	-20	-30	-30	-30
				SclassA-similar	30	30	-20	-30	-30	-30
				sclassC-deficit	30	40	0	-70	-80	-80
				SclassD-Surplus	10	20	40	60	20	0
				SclassE-deficit	40	30	-10	-70	-100	-100
		Rocky Mountain aspen forest and woodland	100	sclassA-similar	0	0	-10	-30	-50	-70
				SClassA-Deficit	0	0	-20	-40	-60	-80
				SClassB-deficit	-10	-10	-20	-40	-60	-80
				Sclass-C-similar	20	20	0	-20	-40	-60
				SclassC-Deficit	10	10	-10	-30	-50	-70
				SclassD-Surplus	10	20	40	100	100	100
				SclassE-similar	10	10	10	10	10	10
				SclassE-deficit	0	0	0	0	0	0
				SclassU	-10	-10	-20	-40	-60	-80

HVRA Name	HVRA RI	Sub-HVRA Name	Sub-HVRA RI	Covariate	FIL 1	FIL 2	FIL 3	FIL 4	FIL 5	FIL 6
		Middle Rocky Mountain montane Douglas-fir forest and woodland	50	SclassA-Surplus	30	30	-20	-30	-30	-30
				SclassA-similar	30	30	-20	-30	-30	-30
				SclassB-Deficit	40	40	20	-50	-50	-50
				SclassC-Similar	50	60	60	0	-50	-50
				SclassC-Deficit	60	70	70	0	-60	-60
				SclassD-similar	50	60	60	20	-40	-50
				SclassD-deficit	60	70	70	30	-50	-60
				SclassE-surplus	0	20	70	70	-40	-50
				SclassE-similar	70	70	70	70	-40	-50
				SclassU	60	70	70	0	-60	-60
Timber Base	15	Desired future condition 1B areas	100		20	-20	-50	-80	-100	-100
		Desired future condition 10 areas	70		50	25	10	0	-25	-50

Analysis Results

The basic wildfire hazard results—burn probability and mean fireline intensity—are presented for the entire fire modeling area in the following sub-section. Geospatial data regarding additional wildfire hazard results are included in the data package (Appendix C). Those datasets include burn probability by flame-length class, Torching Index and Crowning Index.

Basic wildfire response results are presented after the wildfire hazard sub-section. Those results are presented separately for the Forest and Park. Results are presented for each HVRA separately as well as the sum across all HVRAs.

Wildfire Hazard

The wildfire hazard simulations resulted in a mean of 5.9 fires per year exceeding 250 acres, with a mean size of 6,108 acres. This corresponds to a mean annual area burned of 36,508 acres/year compared to the historic 20-year mean of 30,001 acres/year. More importantly, FSim also estimates how those acres-burned are distributed across the landscape as burn probability (Figure 13).

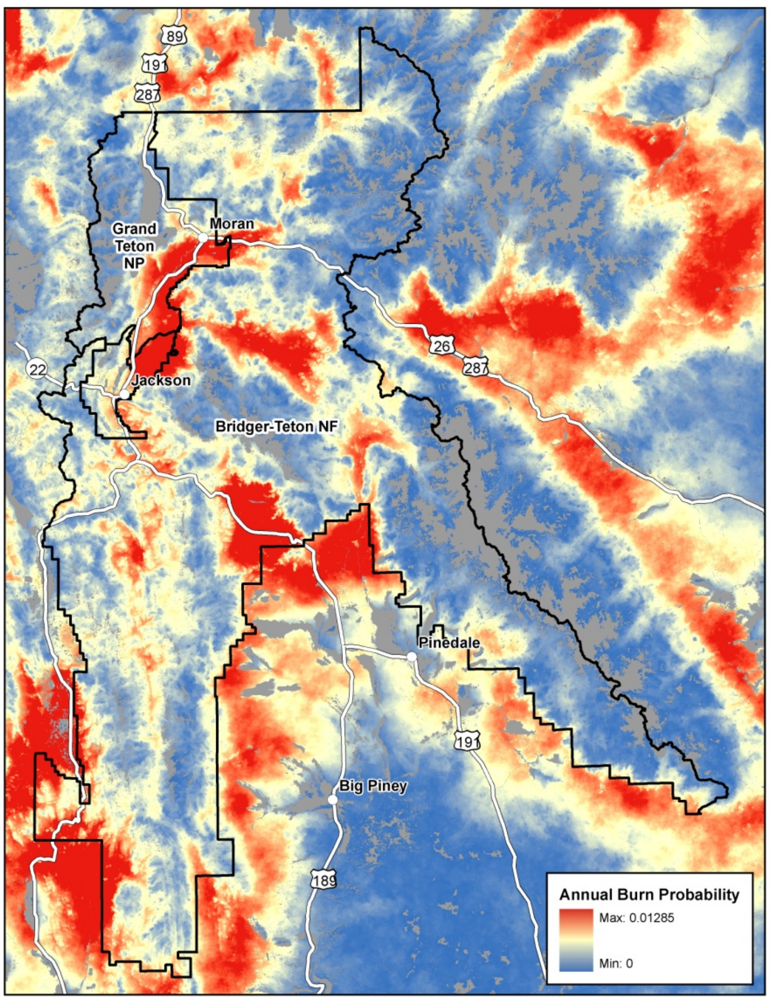

Figure 13: Annual burn probability across the fire modeling landscape. Areas in red have the highest burn probabilities; areas in blue the lowest. Yellow is intermediate burn probability. Grey indicates zero.

Simulated annual *BP* is a function of ignition density (see Figure 1 above) and spread rate potential within an area of the landscape. The south-central portion of the landscape has both low ignition potential and low spread rate potential (fuel is predominantly sparse grass), so that region has some of the lowest burn probabilities. The highest *BP* values occur in the moderate grass and grass-shrub fuelbeds (fuel models GR2, GR4 and GS2) because these fuel models exhibit relatively high spread rates.

FSim also produces an estimate of mean fireline intensity (*MFI*) across the landscape (Figure 14). MFI is calculated as the arithmetic mean fireline intensity (kW/m) of the simulation iterations that burned each pixel and inherently incorporates the effects of relative spread direction (heading, flanking, and backing) and variability in wind speed, wind direction, and fuel moisture. Forested areas of the landscape experience very high fire intensity during crowning when the wind is strong and aligned with the slope, but burn with low fire intensity at low wind speeds or on the flanking and backing portions of the perimeter. As a result, the MFI in these areas is often low to moderate, because the low underburn intensities are averaged with the high crown fire intensities. By contrast, grass and grass-shrub fuelbeds burn at moderate to high fire intensities under a broad range of conditions, so the MFI in these areas is typically higher than in the forested areas.

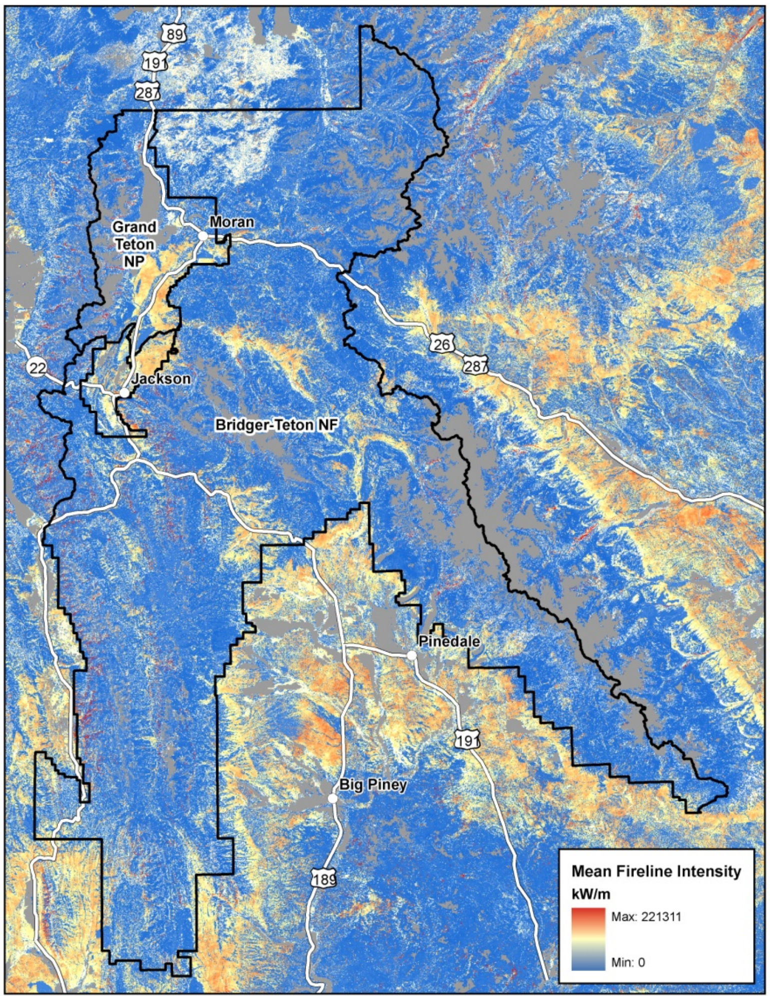

Figure 14: Mean fireline intensity (kW/m) across the fire modeling landscape. Areas in blue have the lowest MFI; areas in red the highest. Grey indicates zero.

Wildfire Response

Grand Teton National Park

This section describes the assessment results for all HVRAs across Grand Teton National Park. Subsections for each of the four main HVRAs follow.

The number of overlapping HVRAs at a point is a very general indicator of potential wildfire response. The more overlapping HVRAs present at a given location, the greater the potential for effects, whether positive or negative. This assessment includes diverse and resilient vegetation (DRV) as an HVRA. Because DRV covers so much of the Park, only 22 percent of the landscape is not covered by any HVRA (Figure 15).

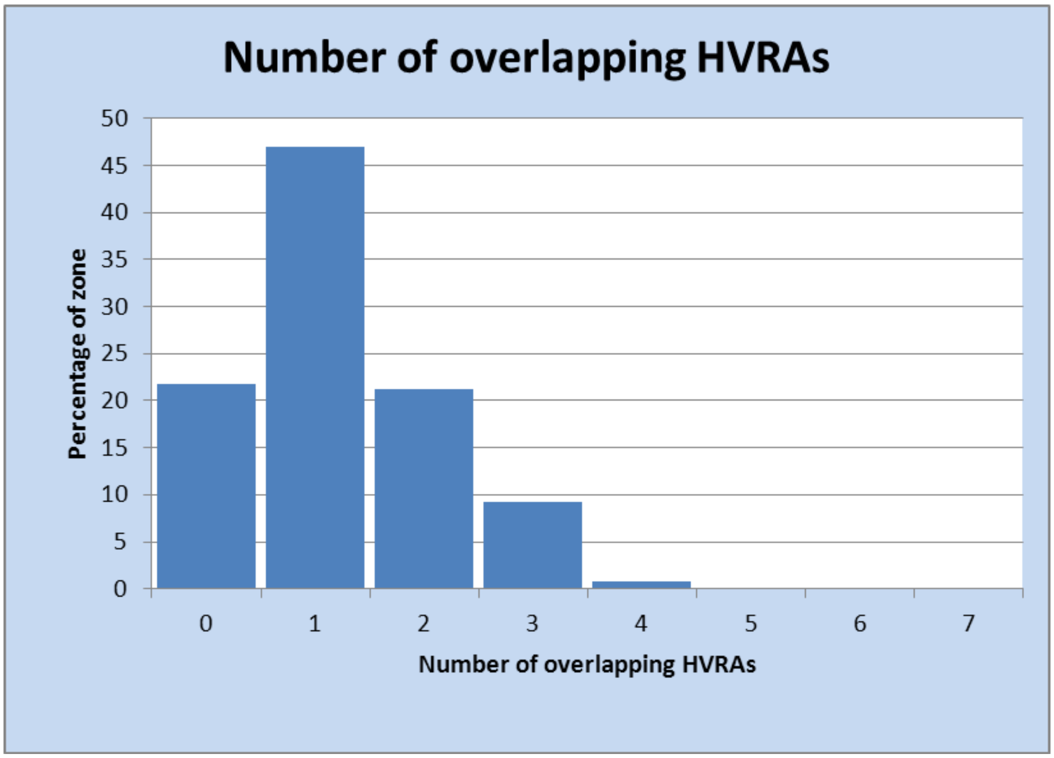

Figure 15: Distribution of the number of overlapping HVRAs across GTNP.

Sixty-eight percent of the landscape is covered by just one or two HVRAs; three HVRAs overlap on nine percent of the Park.

Each HVRA and sub-HVRA was assigned a value of Relative Importance in order to permit weighting the HVRAs together. In GTNP, the Investments HVRA, which includes WUI, was assigned a relative importance of 100, the highest possible value (Figure 16).

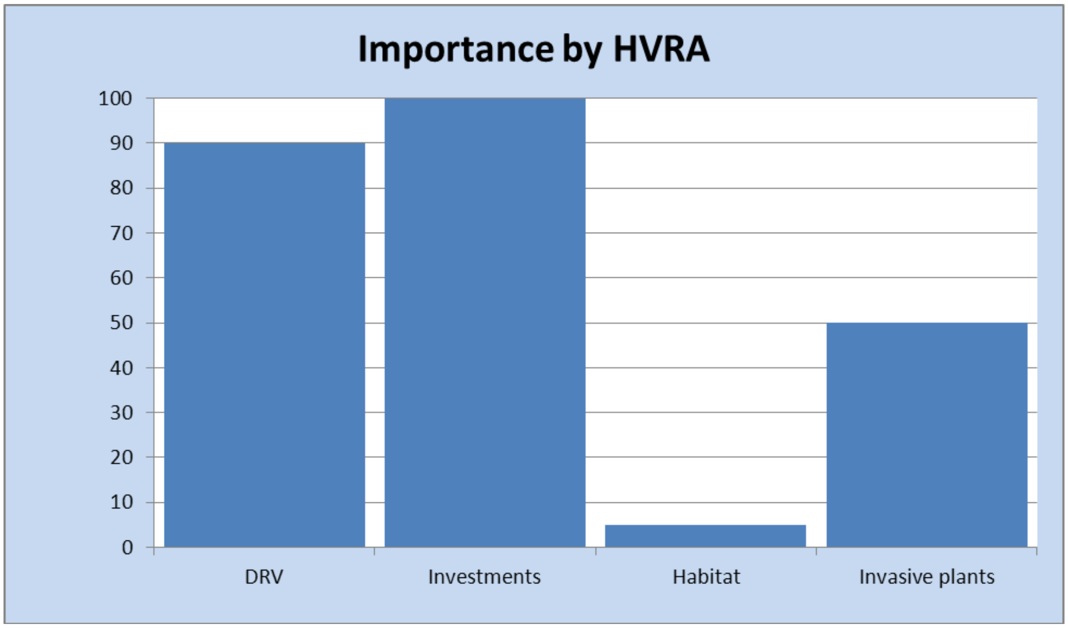

Figure 16: Relative importance of each primary HVRA across GTNP.

DRV was only slightly less important overall, at 90% of Investments. The Invasive Plants HVRA was assigned 50 percent of the maximum importance, and Critical Fish and Wildlife Habitat—limited to the northern leatherside chub in this assessment—just 5 percent. These RI values are divided by the extent of each HVRA, in terms of the number of pixels, to produce the final weighting factor for each HVRA—relative importance per unit relative extent.

Weighted net wildfire response in GTNP was calculated as described in the Analysis Overview section above. The results are spatially displayed on a logarithmic scale ($\log_{10}$) in Figure 17.

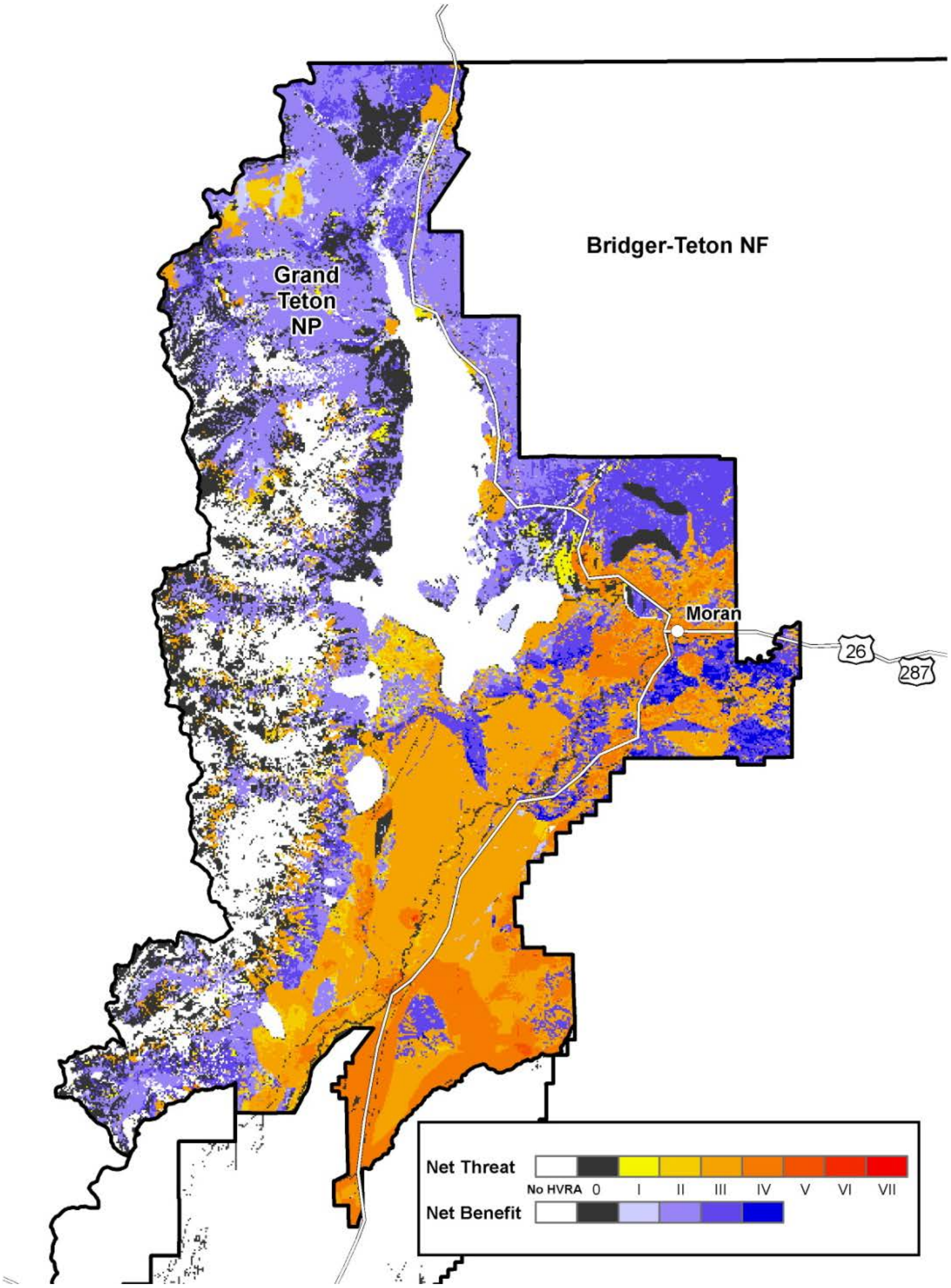

Figure 17: Weighted net response to wildfire across all HVRAs within GTNP. Values are displayed on a logarithmic scale ($\log_{10}$). Each category is an order of magnitude (10 times) greater than the previous.

Weighted net wildfire response combines information about wildfire hazard (burn probability by flame-length class) with information about the location, susceptibility, importance and extent of HVRAs. Positive values indicate that wildfire is expected to have a net positive effect; negative values indicate that wildfire is expected to have a net negative effect. The magnitude of the response values indicates the strength of the effect, whether positive or negative.

Summary wildfire hazard and response characteristics within each of the GTNP fire management units (FMUs) are presented in Table 5 below. HVRA area is the land area covered by at least one HVRA; a pixel with overlapping HVRAs is counted only once. Expected annual area burned is the land area covered by at least one HVRA that is expected to burn annually; it is calculated as the product of HVRA area and mean BP. Mean BP is the arithmetic mean BP of the pixels covered by at least one HVRA. Finally, the last three columns in this table represent the cumulative weighted wildfire response results. The 'Benefit' column is the cumulative positive response of wildfire among the FMUs, without considering any offsetting negative effects (*WBO*). The 'threat' column is the cumulative negative response, without considering any offsetting positive effects (*WTO*). The values in these two columns are scaled such that the FMU with the greatest positive or negative effect is scaled to 100 or -100, respectively. The final column, net response, is the sum of WNR_T across all pixels in an FMU.

Table 5: Wildfire hazard and cumulative weighted wildfire response across all HVRAs in GTNP.

GTNP fire management unit (FMU)	HVRA area (ac)	Expected annual area burned (ac)	Mean burn prob. (fraction)	Benefit	threat	Net
Conditional	181,631	1,098	0.00605	19	-100	-81
Fire Use	158,293	239	0.00151	9	-14	-5
Protection	59,111	200	0.00338	2	-36	-34

These three basic measures—benefit, threat and net response—can be summarized in various ways to illustrate how the overall response is distributed among HVRAs and FMUs. First, the net response results for each HVRA (and sub-HVRA) are sorted by decreasing threat and displayed on a bar chart (Figure 18). Negative response is shown as a red bar; positive response is shown as a blue bar. The net response of each HVRA is indicated in parentheses as a percentage of greatest net response. In GTNP, the invasive plants with high-potential for post-fire spread invasives sub-HVRA exhibits the greatest weighted net threat, so it is given a value of -100. The next most-threatened sub-HVRA is restoration sites, with roughly half of the maximum threat, followed closely by WUI areas, historic buildings and invasive plants with moderate potential for post-fire spread. Sagebrush is the most threatened sub-HVRA under the DRV HVRA, followed by whitebark pine forest, which has roughly one-quarter the overall threat as sagebrush. The fire resistant, riparian, and grass-agriculture sub-HVRAs are all neutral in response to wildfire. The remaining DRV sub-HVRAs all exhibit a slight net benefit.

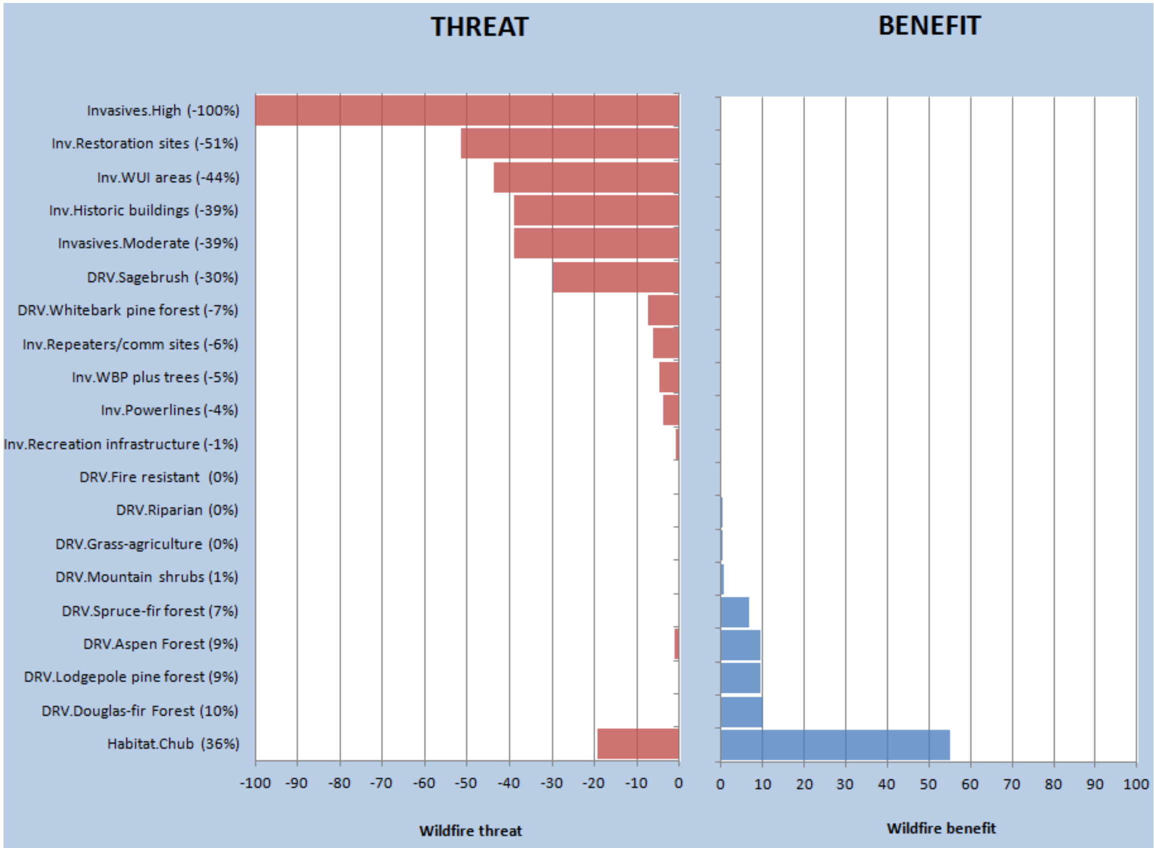

Figure 18: Weighted net wildfire threat and benefit results over all highly valued resources and assets (HVRAs) in GTNP. HVRAs are listed in order from greatest expected net threat at the top to greatest net benefit at the bottom. Percentages in parentheses indicate fraction of greatest net response.

Note that most HVRAs in GTNP have an exclusively positive or exclusively negative response. Only the aspen sub-HVRA and Critical Fish and Wildlife Habitat (northern leatherside chub) balance offsetting positive and negative effects. In both cases, the positive effects outweigh the negative, so the resulting net response is beneficial.

A graphical presentation of the last column of Table 5 is shown in Figure 19. Here, as in Table 5, the wildfire response is cumulative, so that an FMU with greater land area can accumulate more threat or benefit even if it does not have the greatest average threat or benefit.

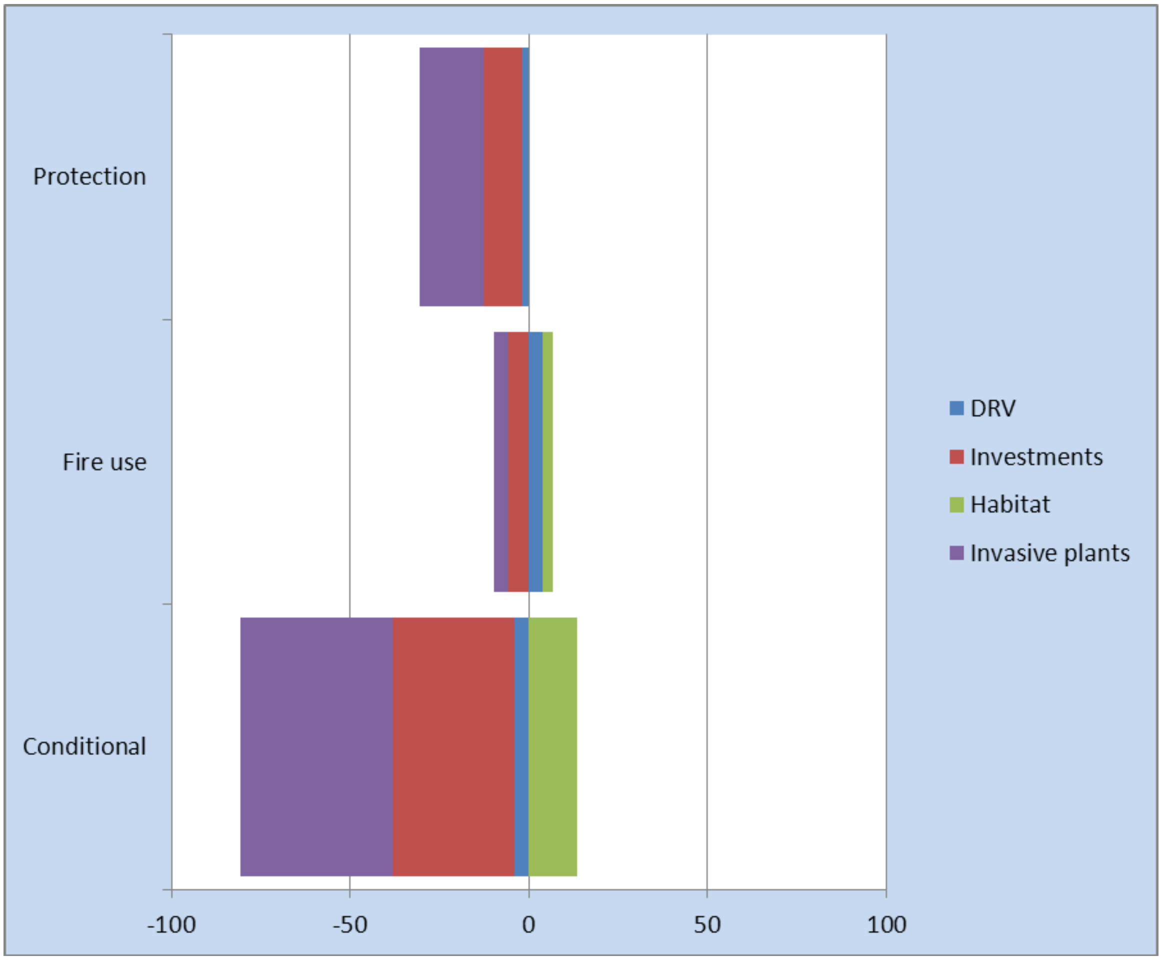

Figure 19: Cumulative weighted net wildfire response by HVRAs as distributed among fire management units (FMUs) in GTNP. Larger FMUs have the opportunity to accumulate more threat or benefit than smaller FMUs. Negative values indicate a net threat; positive values indicate a net benefit.

The greatest expected negative effects occur in the Conditional FMU, primarily in the Invasive Plants and Investments HVRAs. Critical Fish and Wildlife Habitat in this FMU has a slightly beneficial overall response to wildfire.

Similarly, the cumulative net response over each of the four main HVRAs is shown in Figure 20.

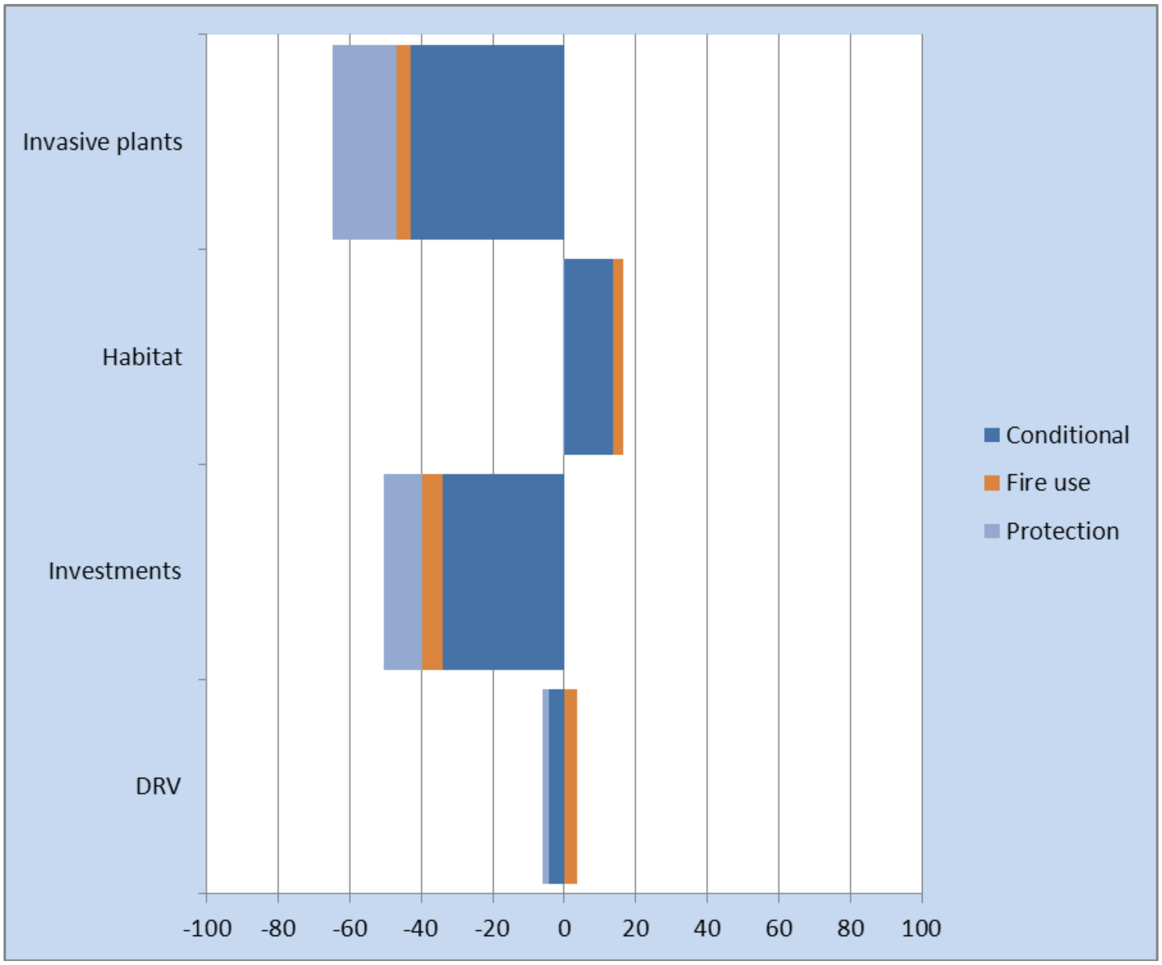

Figure 20: Cumulative net wildfire response by ranger districts as distributed among HVRAs in GTNP. Negative values indicate a net threat; positive values indicate a net benefit.

The two Invasive Plants sub-HVRAs accumulate the greatest overall negative effects in GTNP, even larger than the threat to Investments.

In the following sections we present more detailed results for each HVRA and FMU in Grand Teton National Park.

Investments

The response functions for the Investments HVRA indicate only negative or neutral responses to wildfire, resulting in uniformly negative net response. The majority of the cumulative threat occurs in the Conditional FMU. The greatest cumulative net threat occurs at the restoration sites sub-HVRA. More than half of the cumulative net threat occurs in the WUI and historic buildings sub-HVRAs. Threat to power lines, communication sites and recreation infrastructure combined for just 10 percent of the cumulative threat to investments.

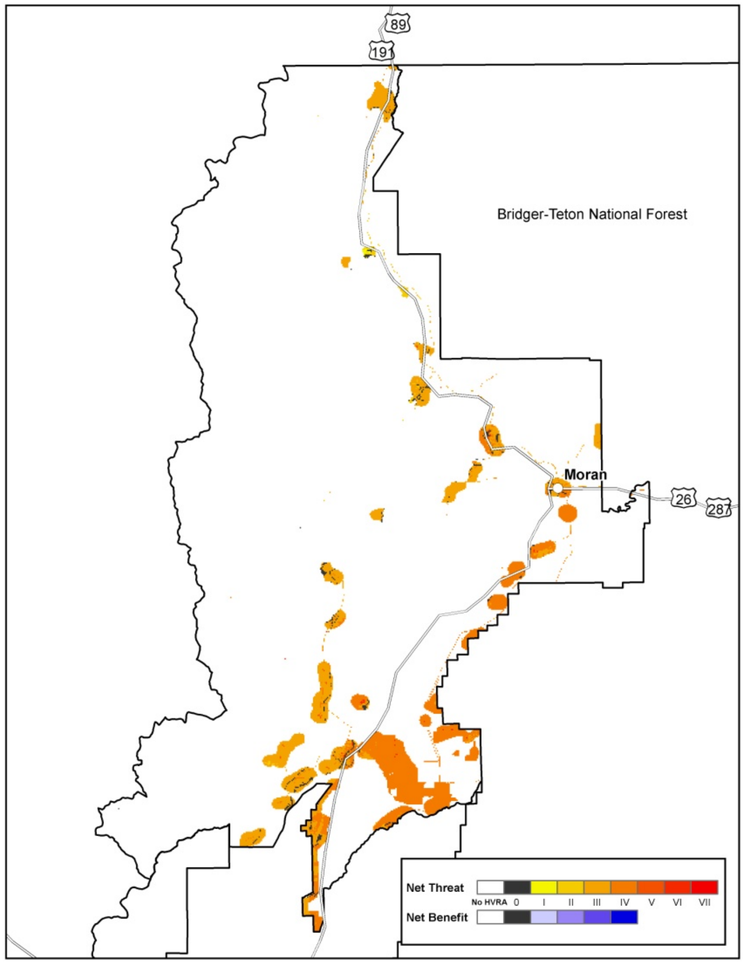

Figure 21: Geospatial distribution of weighted net response to wildfire of the Investments HVRA in GTNP. Values are displayed on a logarithmic scale (log_{10}). Each category is an order of magnitude (10 times) greater than the previous.

Diverse Resilient Vegetation

The net response of the Diverse Resilient Vegetation HVRA to wildfire spans a wide range. Only the sagebrush and whitebark pine sub-HVRAs exhibit a negative net response. However, the sagebrush net response is strong, overwhelming the positive effects in other vegetation types in the Conditional FMU where it occurs. The geospatial mix of vegetation types (sub-HVRAs) is such that cumulative net response is most positive in the Fire Use FMU. The magnitude of the cumulative net benefit in the Fire Use FMU is approximately equal to the cumulative net threat in the Conditional FMU.

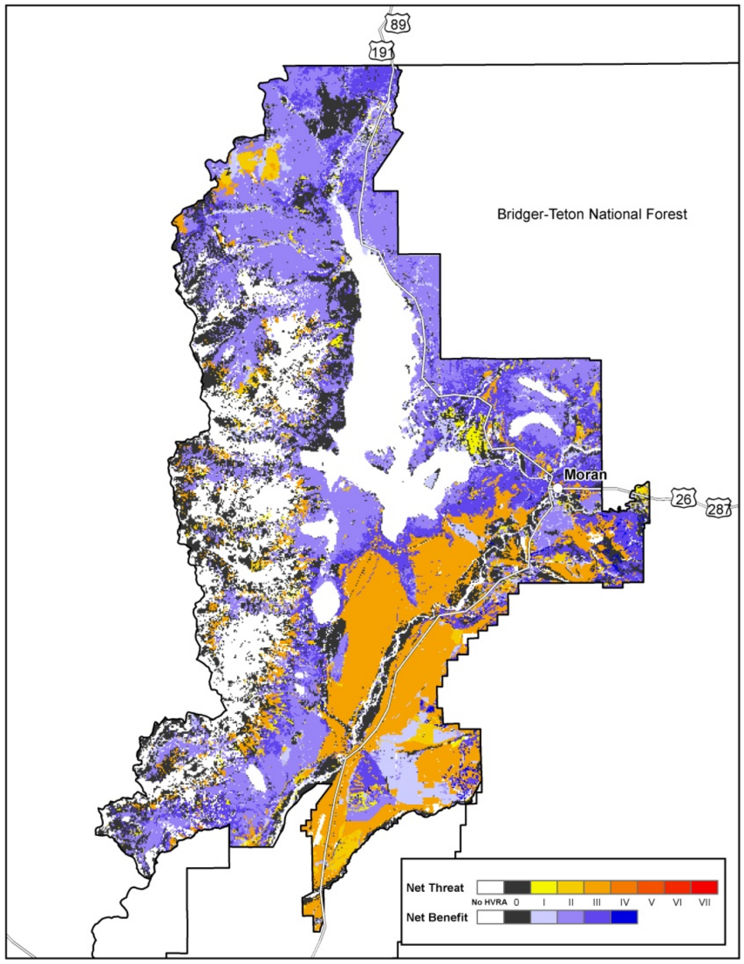

Figure 22: Geospatial distribution of weighted net response to wildfire of the Diverse Resilient Vegetation HVRA in GTNP. Values are displayed on a logarithmic scale ($\log_{10}$). Each category is an order of magnitude (10 times) greater than the previous.

Invasive Plants

The Invasive Plants HVRA experiences a uniformly negative net response. The greatest cumulative net threat occurs in the Conditional FMU, followed by the Protection FMU, due to the prevalence of this HVRA in those units. The invasive plants with high potential for post-fire spread sub-HVRA accounts for 72% of the total net threat despite covering just 34% of the area due to its more strongly negative response function and greater relative importance (Table 3).

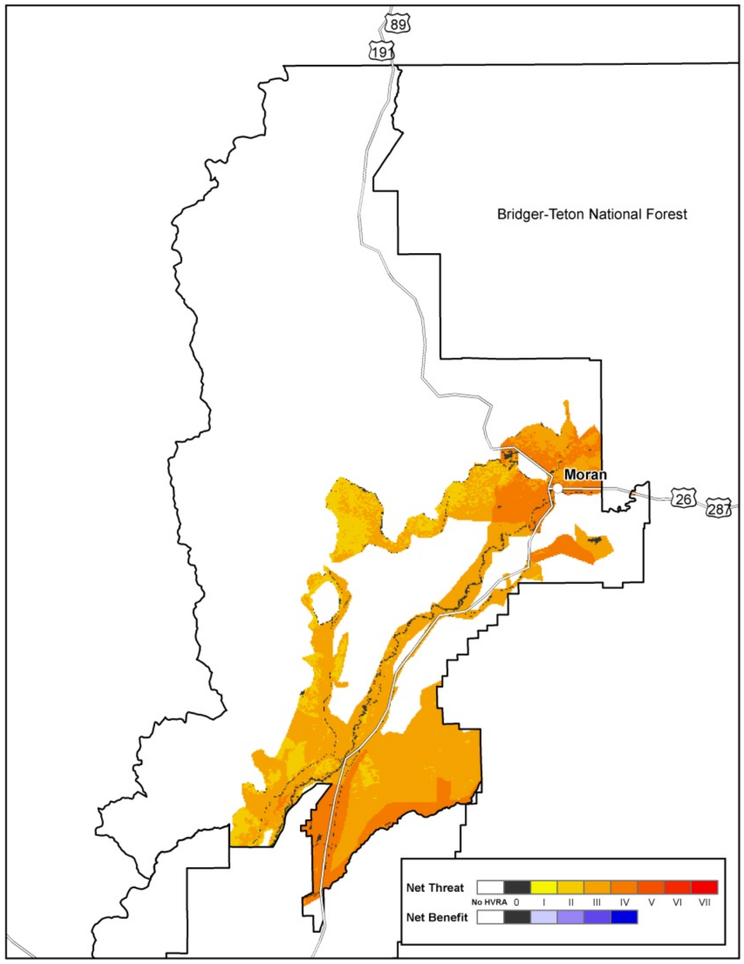

Figure 23: Geospatial distribution of weighted net response to wildfire of the Invasives HVRA in GTNP. Values are displayed on a logarithmic scale (log_{10}). Each category is an order of magnitude (10 times) greater than the previous.

Critical Fish and Wildlife Habitat

The Critical Fish and Wildlife Habitat HVRA experiences both positive and negative expected net responses to wildfire. However, the cumulative net response in all FMUs is positive, meaning that the expected benefits outweigh the threats within each FMU. Nonetheless, large contiguous areas where the net response is negative still exist on the landscape.

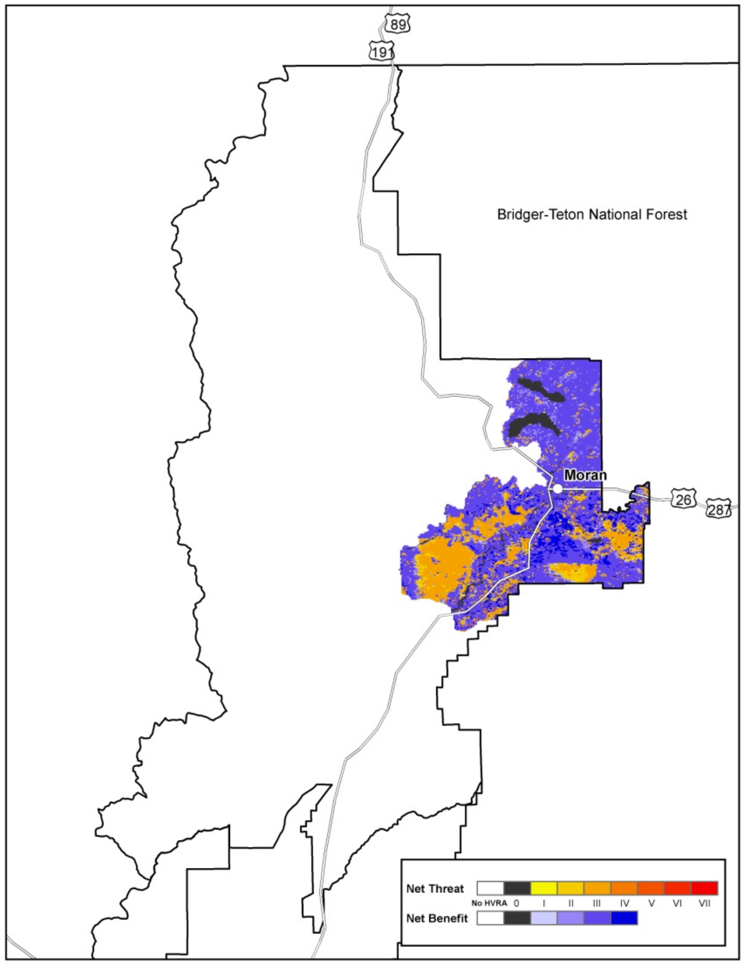

Figure 24: Geospatial distribution of weighted net response to wildfire of the Habitat HVRA in GTNP. Values are displayed on a logarithmic scale (log_{10}). Each category is an order of magnitude (10 times) greater than the previous.

Bridger-Teton National Forest

This section describes the assessment results across the whole BTNF and integrates the results for all HVRAs. Subsections for each HVRA follow. All HVRAs were clipped to the Forest boundary except investments, which were clipped to one mile of the Forest boundary. Results for the investments HVRA that occur outside the Forest boundary are labeled "non-Forest" in the ranger district summaries.

The number of overlapping HVRAs at a point is a very general indicator of potential wildfire response. The more overlapping HVRAs present at a given location, the greater the potential for effects, whether positive or negative. This assessment includes diverse and resilient vegetation (DRV) as an HVRA. Because DRV covers nearly all of the landscape (only a few biophysical settings were not assessed), only 8 percent of the landscape is not covered by any HVRA (Figure 25).

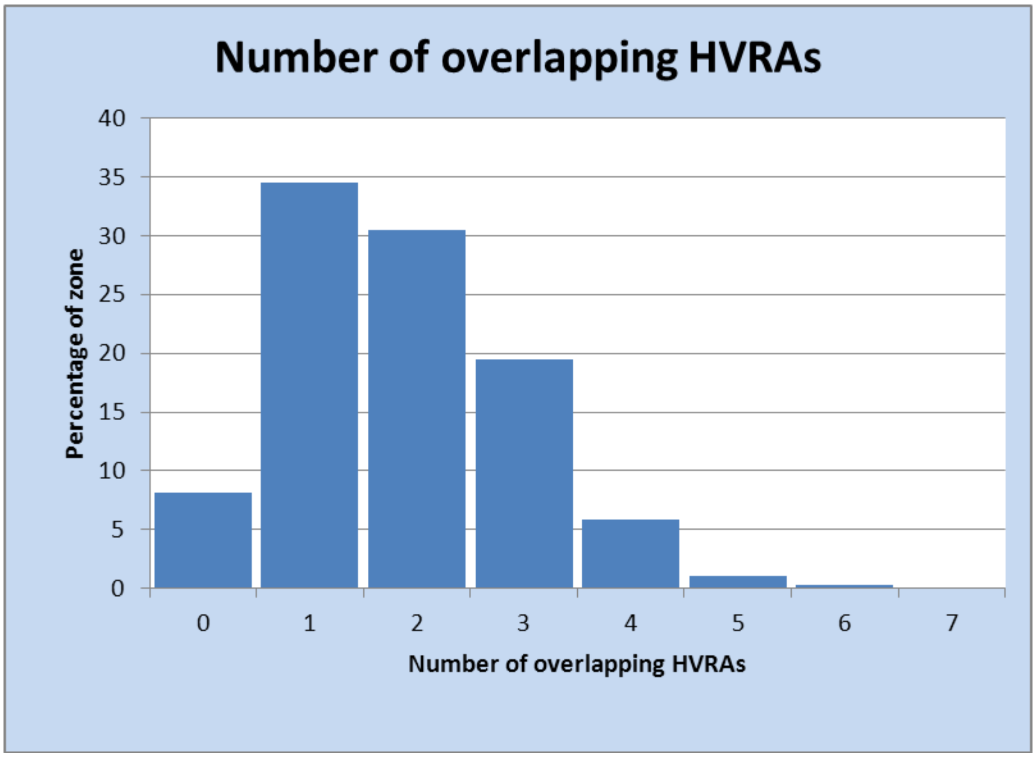

Figure 25: Distribution of the number of overlapping HVRAs across the BTNF.

Sixty-five percent of the landscape is covered by just one or two HVRAs; four or more HVRAs overlap on seven percent of the landscape.

Each HVRA and sub-HVRA was assigned a value of Relative Importance in order to permit weighting the HVRAs together. On the BTNF, the WUI and Investments HVRAs were assigned a relative importance of 100, the highest possible value (Figure 26).

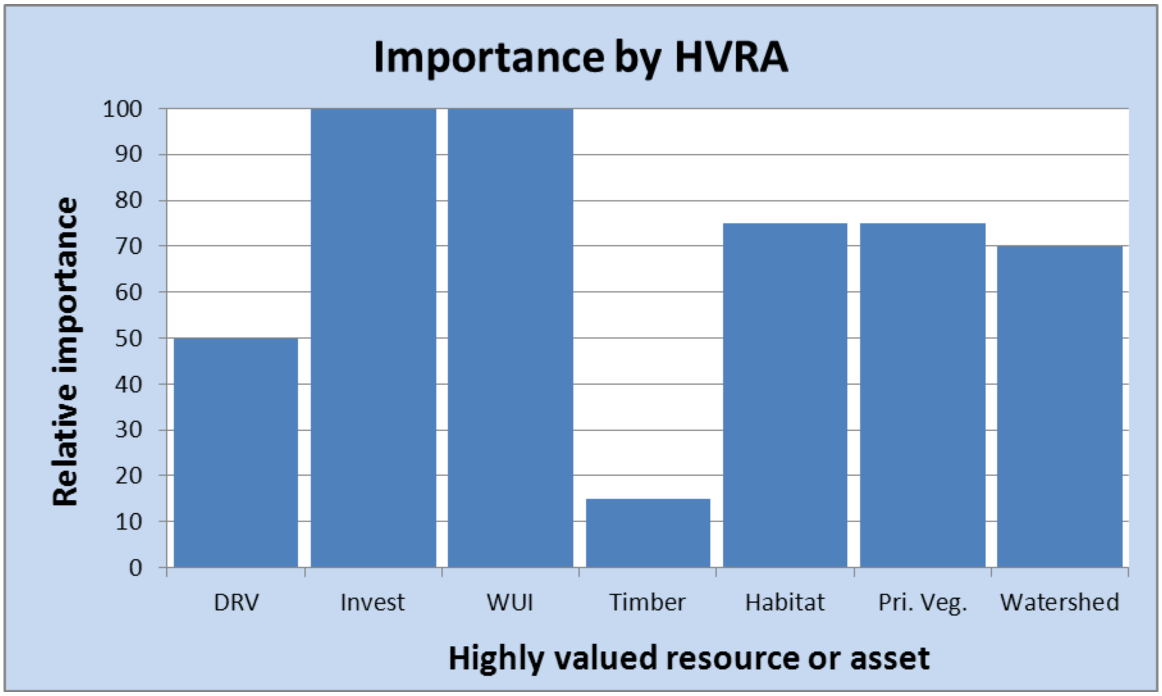

Figure 26: Relative importance of each HVRA across the BTNF.

Habitat, Priority Vegetation, and Municipal Watersheds were assigned 70 to 75 percent of the maximum importance. DRV was given 50 percent, and the timber resource just 15 percent of maximum importance. These *RI* values are divided by the extent of each HVRA, in terms of the number of pixels, to produce the final weighting factor for each HVRA—relative importance per unit relative extent.

Weighted net response to wildfire on the BTNF was calculated as described above and summed across all HVRAs. The results are spatially displayed on a logarithmic scale ($\log_{10}$) in Figure 27. Each category is an order of magnitude (10 times) greater than the previous.

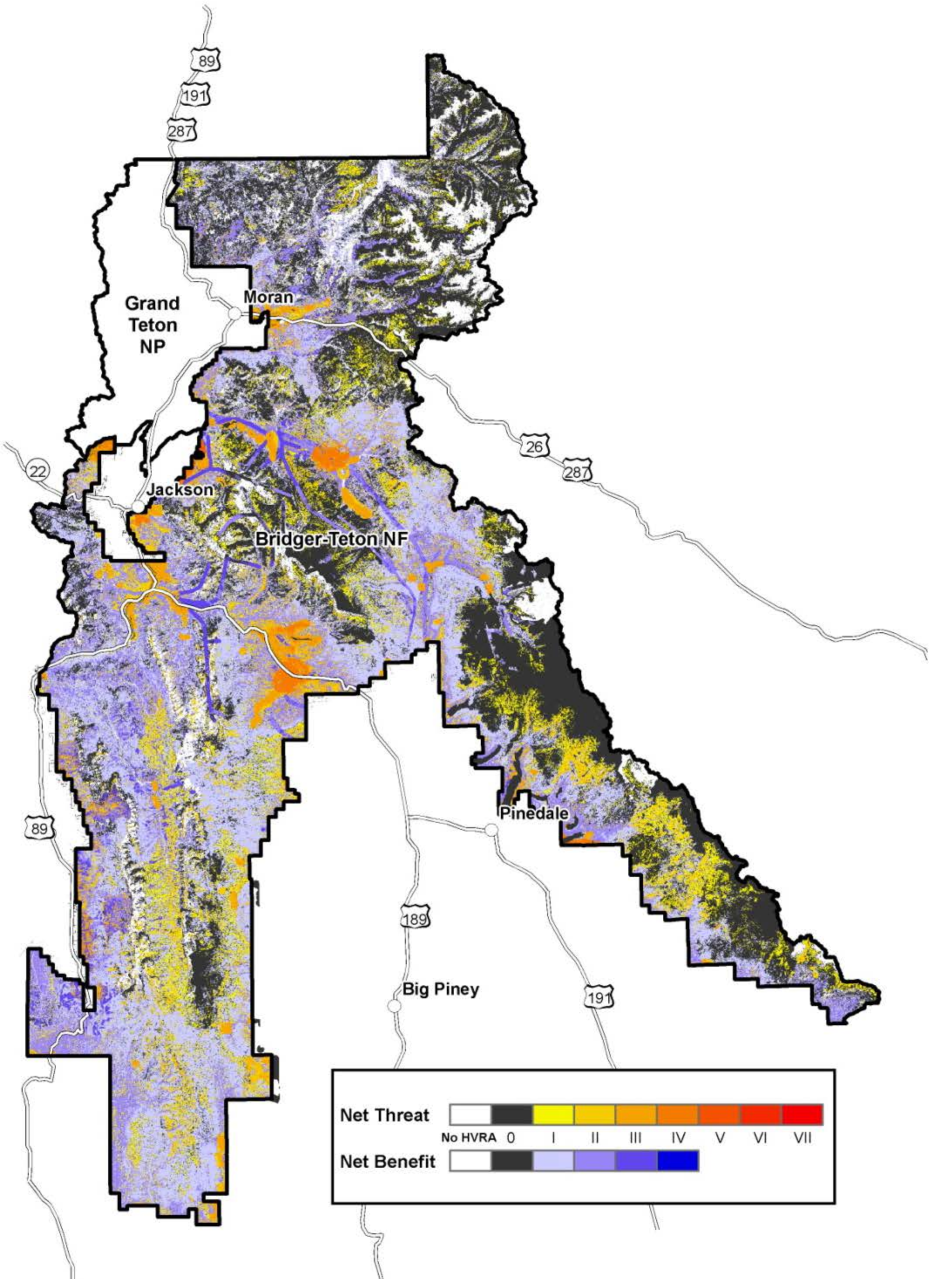

Figure 27: Weighted net response to wildfire across all HVRAs on the BTNF. Values are displayed on a logarithmic scale ($\log_{10}$). Each category is an order of magnitude (10 times) greater than the previous.

Weighted net response combines information about wildfire hazard (burn probability by flame-length class) with information about the susceptibility, importance and extent of HVRAs. Positive values indicate that wildfire is expected to have a net positive effect; negative values indicate that wildfire is expected to have a net negative effect. The magnitude of the response values indicates the strength of the effect, whether positive or negative.

Summary wildfire hazard and response characteristics within each BTNF ranger district are presented in Table 6 below. HVRA area is the land area covered by at least one HVRA; a pixel with overlapping HVRAs is counted only once. Expected annual area burned is the land area covered by at least one HVRA that is expected to burn annually; it is calculated as the product of HVRA area and mean BP. Mean BP is the arithmetic mean BP of the pixels covered by at least one HVRA. Finally, the last three columns in this table represent the cumulative weighted wildfire response results. The 'Benefit' column is the cumulative positive response of wildfire among the ranger districts, without considering any offsetting negative effects (*WBO*). The 'threat' column is the cumulative negative response, without considering any offsetting positive effects (*WTO*). The values in these two columns are scaled such that the ranger district with the greatest positive or negative effect is scaled to 100 or -100, respectively. The final column, net response, is the sum of WNR_T across all pixels in a district.

Table 6: Wildfire hazard and cumulative weighted wildfire response across all HVRAs by BTNF ranger district.

BTNF Ranger District	HVRA area (ac)	Expected annual area burned (ac)	Mean burn prob. (fraction)	Benefit	threat	Net
Big Piney RD	1,046,123	3,547	0.0034	9	-78	-69
Buffalo RD	827,256	1,589	0.0019	5	-12	-7
Greys River RD	814,366	2,574	0.0032	20	-21	-1
Jackson RD	1,044,940	3,495	0.0033	24	-100	-76
Kemmerer RD	784,894	3,059	0.0039	5	-12	-6
Pinedale RD	1,871,350	3,303	0.0018	8	-33	-26
non-Forest	10,444	37	0.0035	0	-11	-11

These three basic measures—benefit, threat and net response—can be summarized in various ways to illustrate how the overall response is distributed among HVRAs and ranger districts. First, the net response results for each HVRA (and sub-HVRA) are sorted by decreasing threat and displayed on a bar chart (Figure 28). Negative response is shown as a red bar; positive response is shown as a blue bar. The net response of each HVRA is indicated in parentheses as a percentage of greatest net response. On the BTNF, the WUI defense zone is the HVRA with the greatest weighted net threat, so it is given a value of -100. The next most-threatened HVRAs are Sage grouse core areas and sage grouse habitat near leks, which exhibit 55% and 38% of the threat represented by the WUI defense zone.

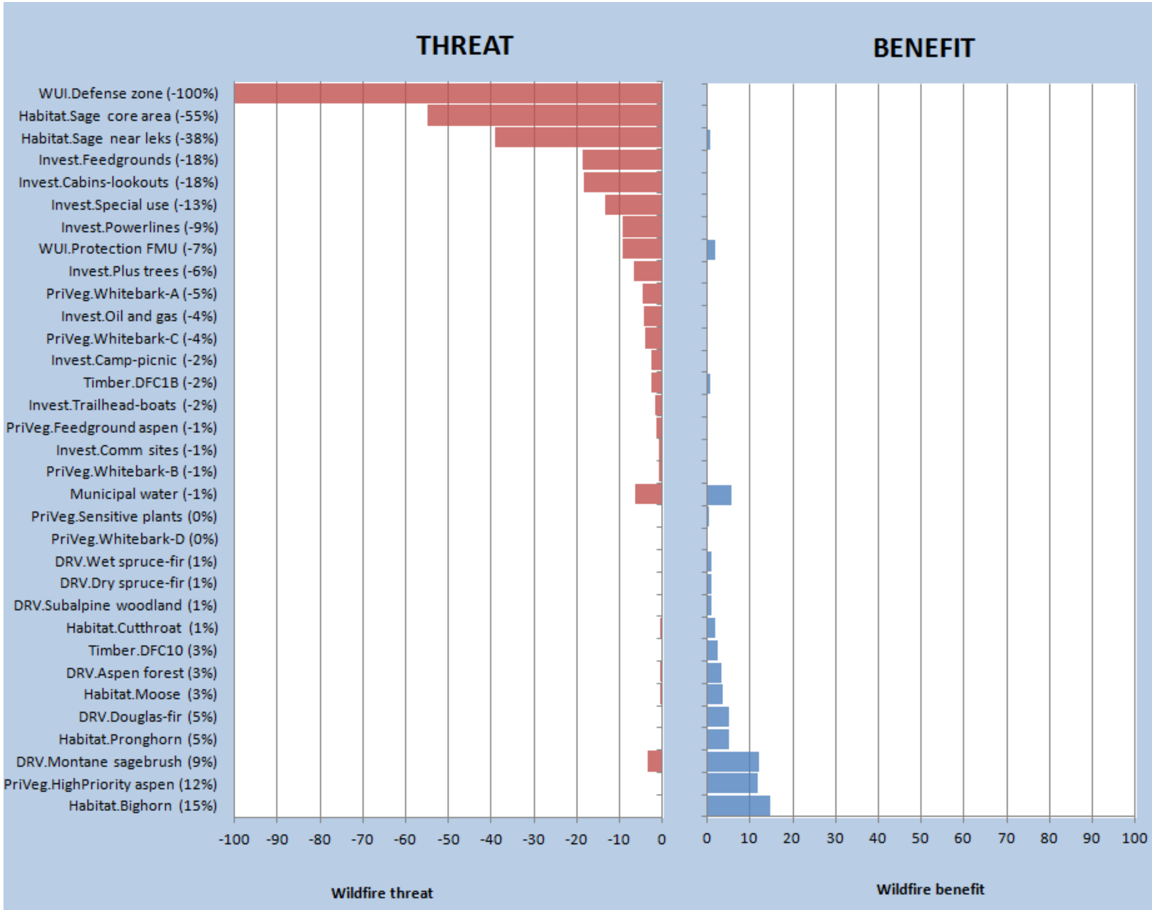

Figure 28: Weighted net response over all highly valued resources and assets (HVRAs) on the BTNF. HVRAs are listed in order from greatest expected negative net response at the top to greatest net benefit at the bottom. Percentages in parentheses indicate fraction of greatest net response.

As an example of the effect of offsetting threats and benefits, note that power lines and the WUI protection zone have equal threat values (as represented on the x-axis), but the WUI protection zone has a different net response value (7% vs. 9% as represented in parentheses on the y-axis). This is because the response function for the protection zone indicates a small benefit of burning at low flame lengths, indicated by the small blue bar.

The municipal watershed HVRA exhibits both positive and negative effects (at different flame lengths), but these effects are almost completely offsetting. Twelve of the 22 HVRAs exhibit a net positive response to wildfire, including all of the biophysical settings in the diverse and resilient vegetation HVRA. Note that the overall net positive effects are generally smaller in magnitude than the negative effects.

A graphical presentation of the last column of Table 6 is shown in Figure 29. Here, as in Table 6, the wildfire response is cumulative, so that a ranger district with greater land area can accumulate more threat or benefit even if it does not have the greatest average threat or benefit.

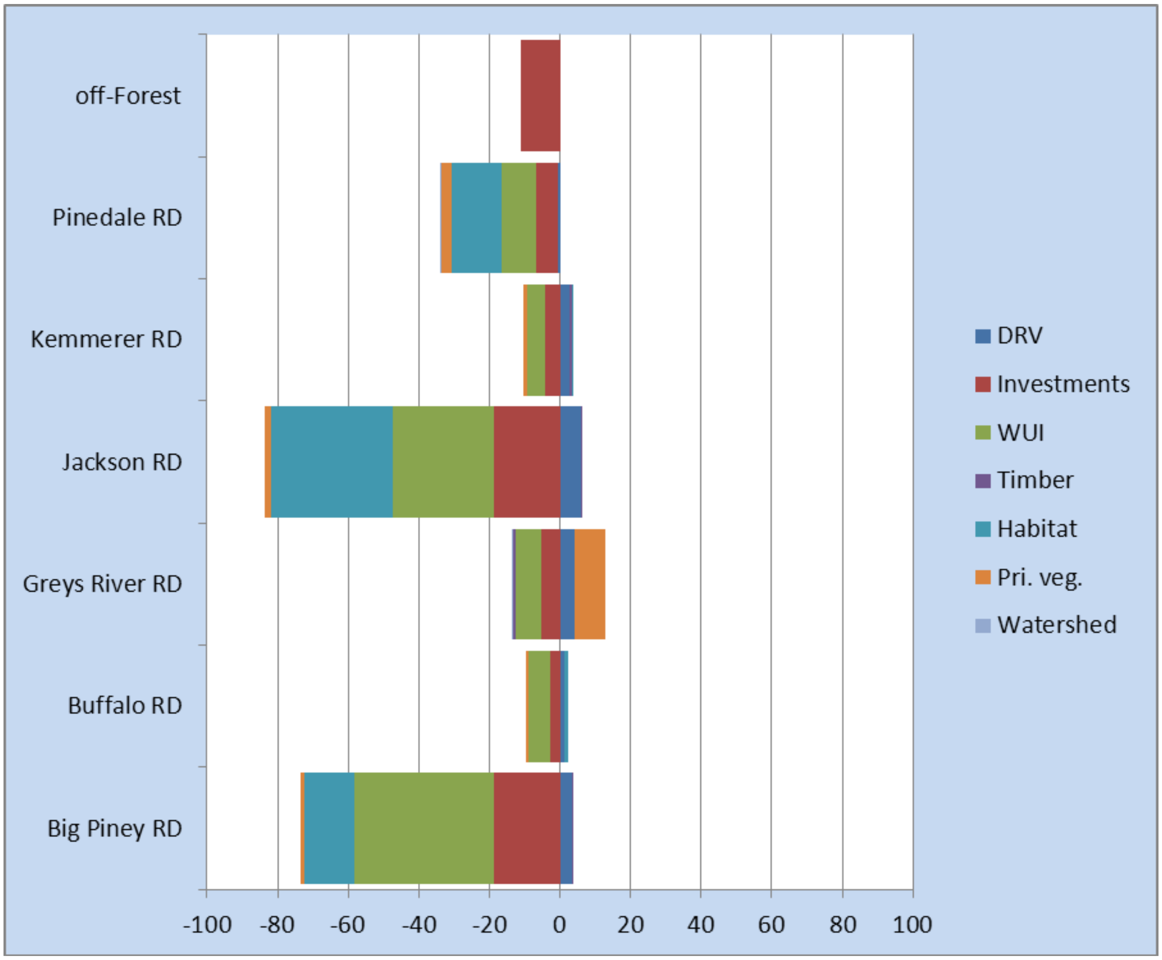

Figure 29: Cumulative weighted net wildfire response by HVRAs as distributed among ranger districts on the BTNF. Larger ranger districts have the opportunity to accumulate more threat or benefit than smaller ranger districts. Negative values indicate a net threat; positive values indicate a net benefit.

The greatest expected negative effects occur on the Jackson and Big Piney ranger districts, primarily in the Investments, WUI and wildlife habitat HVRAs.

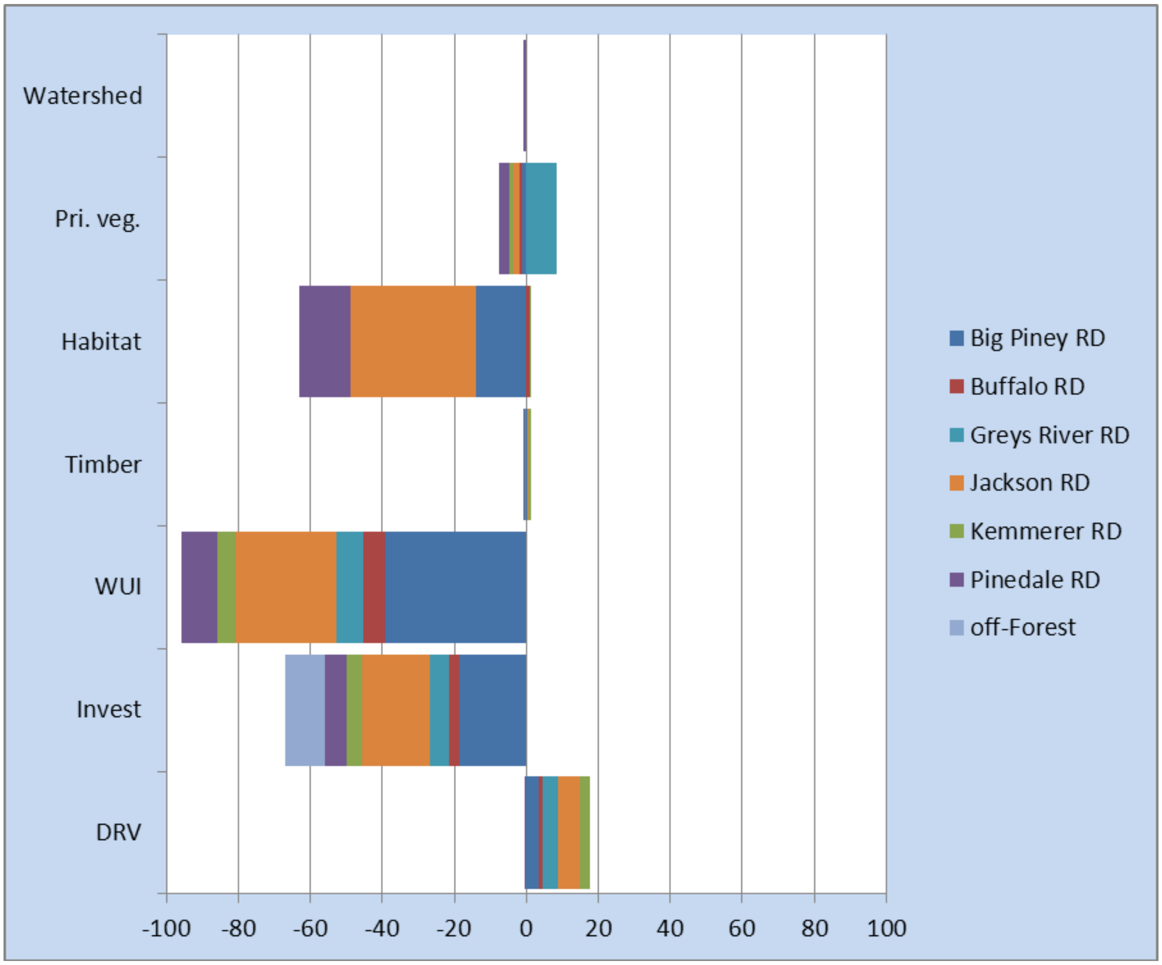

Figure 30: Cumulative net wildfire response by ranger districts as distributed among HVRAs on the BTNF. Negative values indicate a net threat; positive values indicate a net benefit.

The greatest threat on the BTNF is found in the Wildland Urban Interface HVRA, followed by Investments within the Forest (plus oil and gas developments within one mile of the Forest boundary). Wildlife Habitat is the next most-threatened HVRA, primarily due to sage-grouse core areas and sage-grouse habitat near leks. The diverse and resilient vegetation HVRA is expected to have a net benefit on all ranger districts. Priority Vegetation is threatened on all ranger districts except Greys River, where there is a net benefit.

In the following sections we present more detailed results for each HVRA and ranger district on the BTNF.

Investments

The Investments HVRA has only a net threat from wildfire; there are no offsetting benefits at any FIL.

The majority of the threat to investments is found on the Jackson and Big Piney Ranger Districts. The special use permit areas contribute to threat on the Jackson Ranger District, while the feedgrounds and cabins/guard stations/lookouts sub-HVRAs contribute to threat on the Big Piney Ranger District. Many of the Investments sub-HRVAs occur as isolated pixels or groups of pixels, so they may not be visible on this map.

Note: residential structures are included in a separate HVRA below (WUI).

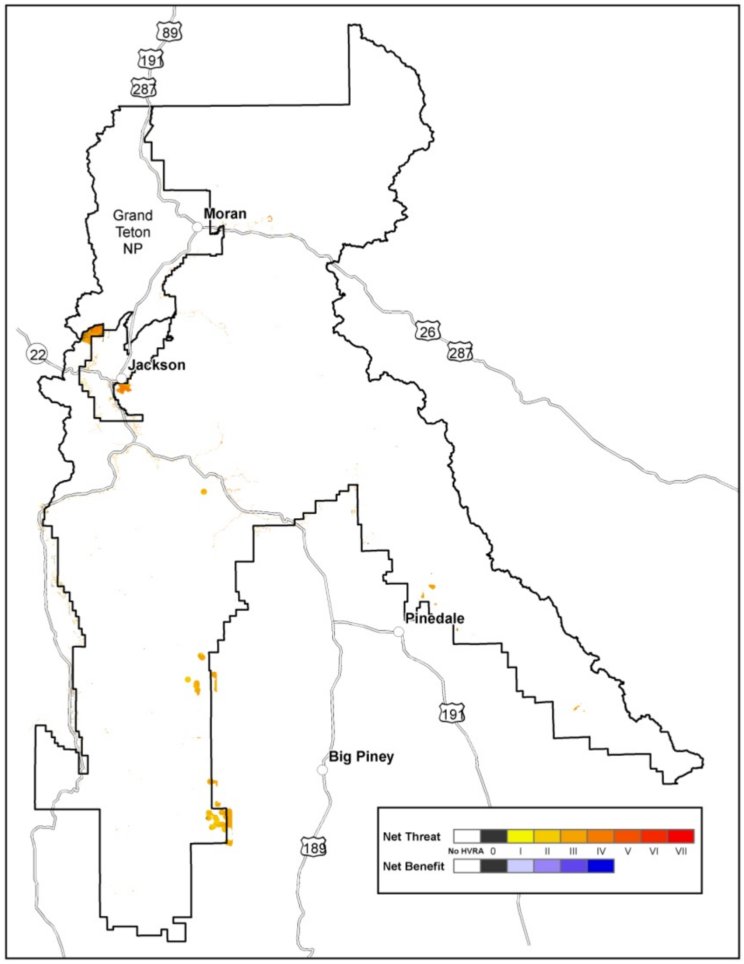

Figure 31: Geospatial distribution of weighted net response to wildfire of the Investments HVRA on the BTNF. Values are displayed on a logarithmic scale (log_{10}). Each category is an order of magnitude (10 times) greater than the previous.

Wildland-Urban Interface

The WUI HRVA is split into two sub-HVRAs: the WUI defense zone and the protection fire management unit (FMU). The defense zone accounts for more than 90% of the total WUI threat across the whole Forest. This result is due to the more strongly negative response function for the defense zone, as well as its greater relative importance (Table 4). Again, the Jackson and Big Piney Ranger Districts comprise most of the WUI threat across the forest. The response of WUI to wildfire is almost uniformly negative. The protection FMU response function indicates a small benefit of burning at very low flame lengths, so some ranger districts have a small offset of the threat.

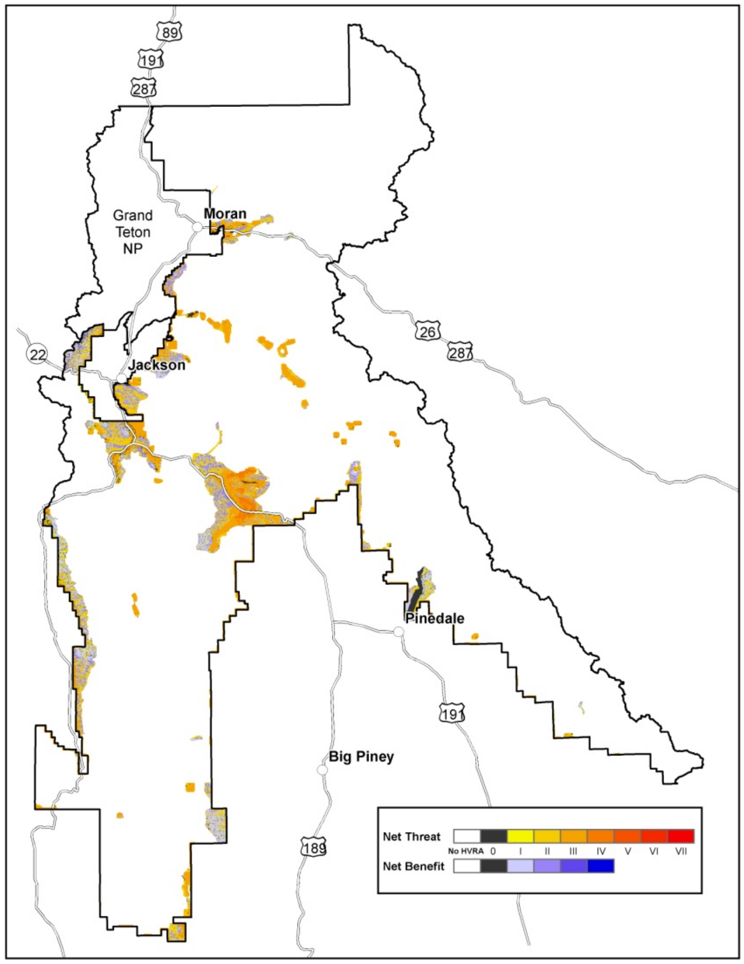

Figure 32: Geospatial distribution of weighted net response to wildfire of the Wildland-Urban Interface HVRA on the BTNF. Values are displayed on a logarithmic scale (log_{10}). Each category is an order of magnitude (10 times) greater than the previous.

Wildlife Habitat

Both positive and negative net responses to wildfire exist for the Wildlife Habitat HVRA, but overall, a net threat exists, due almost entirely to sage-grouse habitat. Also, the threat to sage-grouse core areas is slightly greater overall than the threat to sage-grouse habitat near leks. This threat is concentrated in the Jackson Ranger District, with smaller amounts in the Big Piney and Pinedale districts. Except in the concentrated areas of sage-grouse habitat, the majority of the wildlife habitat HVRA has a slight benefit or only a slightly negative net response to wildfire.

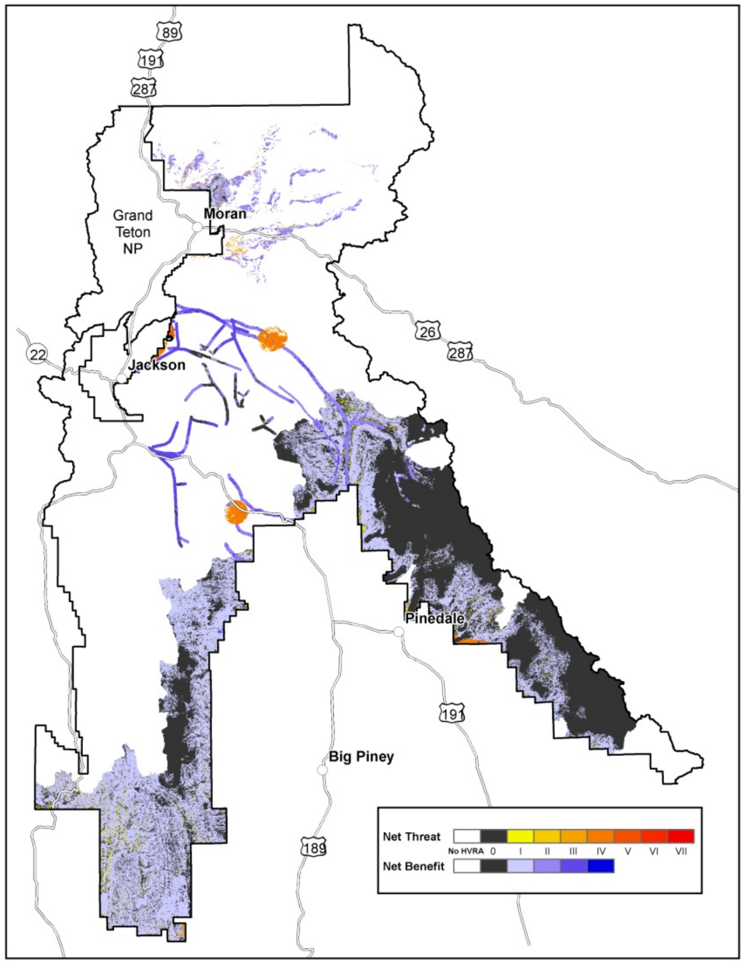

Figure 33: Geospatial distribution of weighted net response to wildfire of the wildlife habitat HVRA on the BTNF. Values are displayed on a logarithmic scale (log_{10}). Each category is an order of magnitude (10 times) greater than the previous.

Priority Vegetation

Net response to wildfire of the Priority Vegetation HVRA exhibits both a strong positive response and mild negative response. Overall, the greatest cumulative response is a net benefit on the Greys River Ranger District, due to the "aspen with high priority for restoration treatment" sub-HVRA found there. The high priority areas have a positive response function and moderate relative importance (Table 4). Elsewhere on the forest, cumulative response is slightly negative because the response functions for the remaining sub-HVRAs are mostly negative.

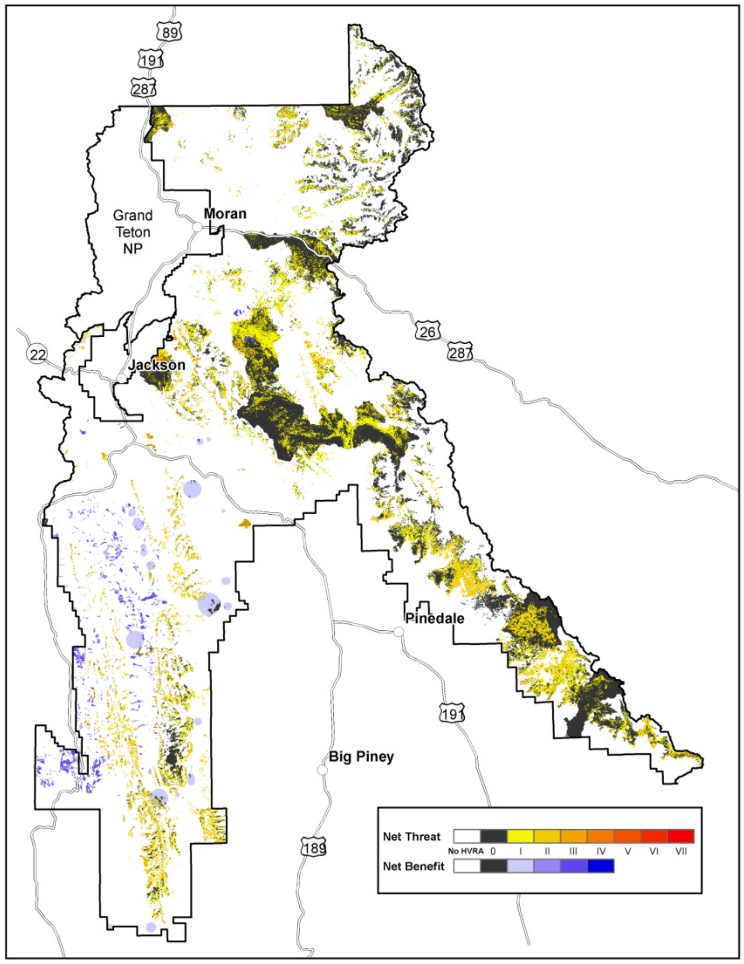

Figure 34: Geospatial distribution of weighted net response to wildfire of the Priority Vegetation HVRA on the BTNF. Values are displayed on a logarithmic scale (log_{10}). Each category is an order of magnitude (10 times) greater than the previous.

Municipal Watersheds

The response function for the municipal watersheds HVRA indicates a mild benefit at low flame lengths and increasingly negative response at higher flame lengths (Table 4). Overall, the two effects nearly cancel out, but the negative effects are slightly stronger. These municipal watersheds occur only on the Pinedale and Grays River districts.

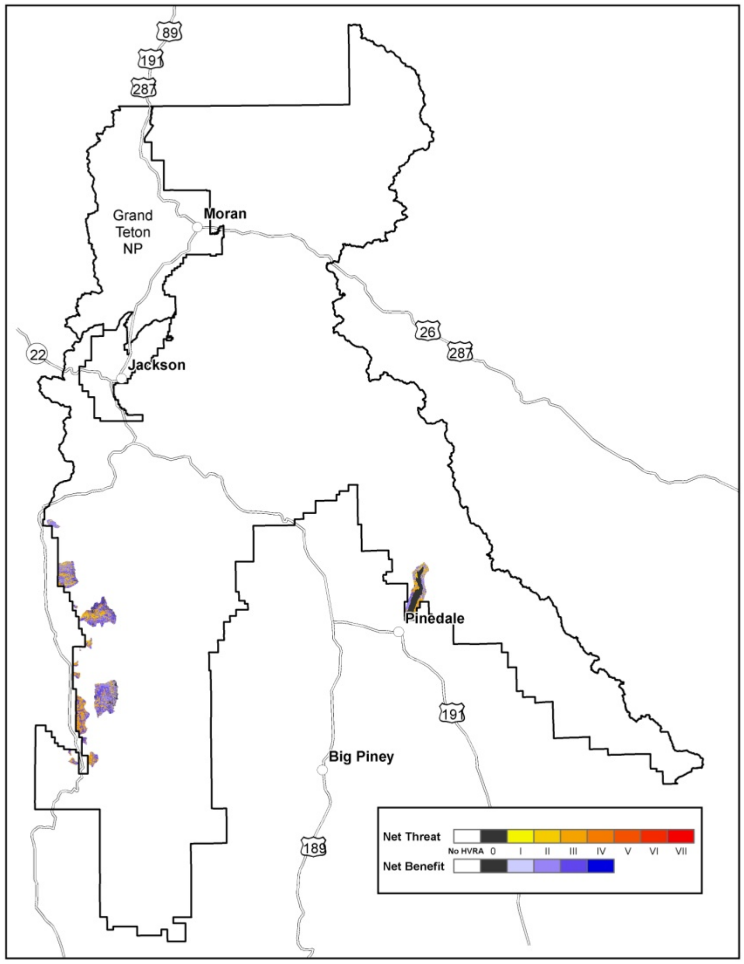

Figure 35: Geospatial distribution of weighted net response to wildfire of the Municipal Watersheds HVRA on the BTNF. Values are displayed on a logarithmic scale (log_{10}). Each category is an order of magnitude (10 times) greater than the previous.

Diverse and Resilient Vegetation

The Diverse and Resilient Vegetation HVRA on the BTNF covers nearly all of the Forest. Overall, wildfire is expected to have a mildly beneficial net effect on restoring vegetation structure to the reference condition across the entire Forest. Very little land area within this HVRA is expected to have a negative net response. Those areas which do respond negatively to fire are characterized by early-seral sagebrush and early-seral aspen.

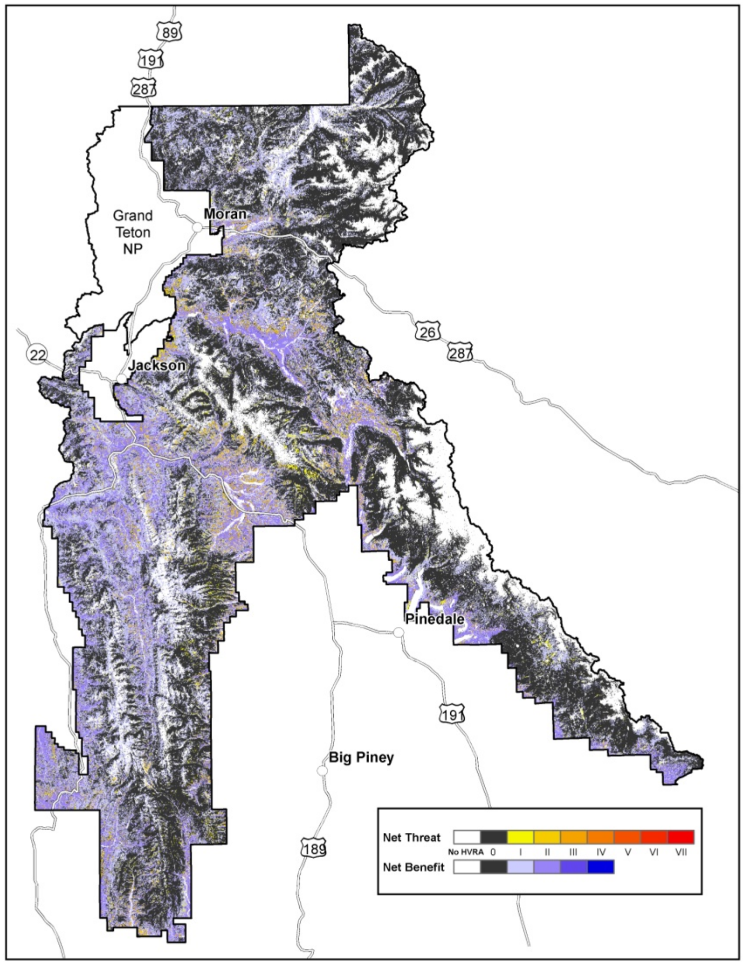

Figure 36: Geospatial distribution of weighted net response to wildfire of the diverse resilient vegetation HVRA on the BTNF. Values are displayed on a logarithmic scale ($\log_{10}$). Each category is an order of magnitude (10 times) greater than the previous.

Timber

Net wildfire response for the Timber HVRA is mildly positive in the DFC10 sub-HVRA and mildly negative in the DFC1B sub-HVRA. In the Greys River ranger district the negative response outweighs the positive, due to the presence of a large amount of DFC1B there. Elsewhere on the Forest, the positive effects of burning at low fire intensity result in a positive net response.

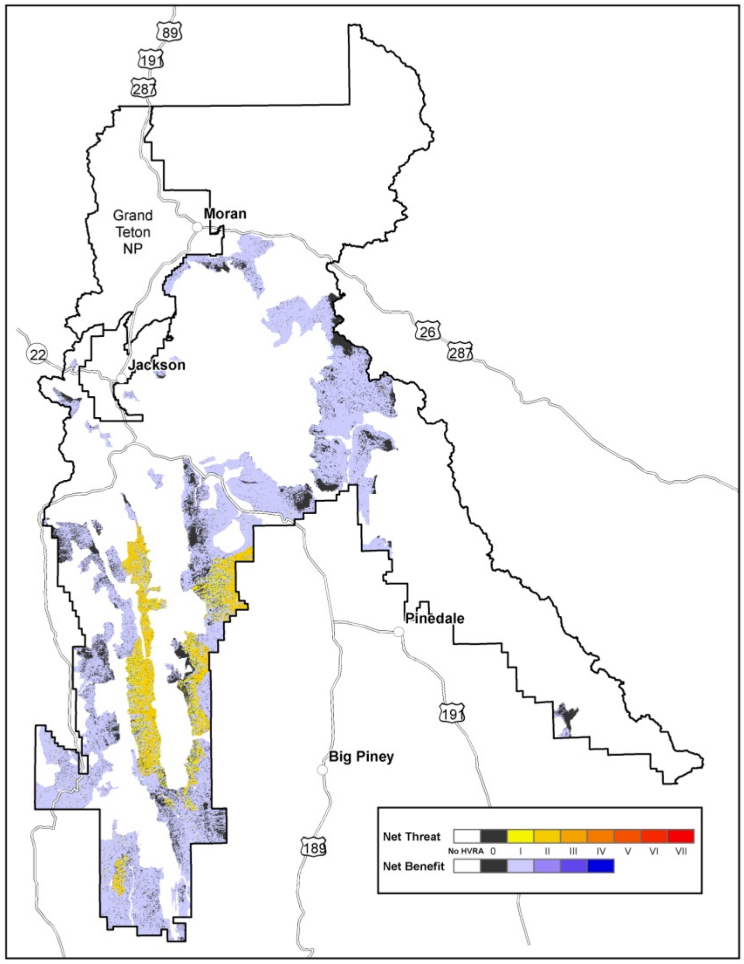

Figure 37: Geospatial distribution of weighted net response to wildfire of the Timber HVRA on the BTNF. Values are displayed on a logarithmic scale ($\log_{10}$). Each category is an order of magnitude (10 times) greater than the previous.

Summary

In this assessment we used the stochastic wildfire simulation model FSim to quantify the likelihood of wildfire impacting HVRAs at different intensity levels. GTNP and BTNF resource specialists identified, characterized and mapped HVRAs for their respective jurisdictions and further characterized the susceptibility of the HVRAs to wildfire induced loss or benefit using an expert judgment approach. GTNP and BTNF line officers assigned relative importance values to individual HVRAs. Relative importance values were combined with the relative extent of each HVRA to enable integration of results across all.

The 20-year historic mean annual area burned corresponded well with the simulated mean annual area burned, thus suggesting reasonable validity of the burn probability results. In GTNP the highest overall cumulative net threat was in the Conditional FMU, followed by Protection and Fire Use; primarily in the Invasive Plants and Investments HVRAs. The cumulative WNR_T is always negative when summed across any individual FMU. However the Critical Fish and Wildlife Habitat (limited to northern leatherside chub habitat in this assessment) and Diverse and Resilient Vegetation HVRAs show a cumulative net benefit in some FMUs.

On the BTNF, the highest cumulative net threat was on Jackson Ranger District, followed by Big Piney and Pinedale. This threat is found primarily in the WUI, Investments and Critical Fish and Wildlife Habitat HVRAs. As in GTNP, across any individual ranger district, cumulative WNR_T is always negative. However, large portions of each ranger district still exhibit a positive WNR_T, but the negative response is stronger than the positive when summed to the ranger district level. The Diverse and Resilient Vegetation and Priority Vegetation HVRAs show a significant cumulative net benefit in some ranger districts.

Acknowledgements

The National Park Service Intermountain Region’s financial support made this project possible. Participation by both resource and fire management specialists from both Grand Teton National Park and the Bridger-Teton National Forest was critical to this project’s success, as was the participation of the Wyoming Game and Fish Department’s habitat biologists.

References

Abendroth, D., 2012. Diverse and resilient vegetation of Grand Teton National Park information and map packet. Unpublished report. USDI National Park Service. On file at: Grand Teton National Park Headquarters, Moose, WY. 23p.

Calkin, D.E., Ager, A.A., Gilbertson-Day, J., Scott, J.H., Finney, M.A., Schrader-Patton, C., Quigley, T.M., Strittholt, J.R., Kaiden, J.D., 2010. Wildfire risk and hazard: procedures for the first approximation. Gen. Tech. Report RMRS-GTR-235. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Finney, M.A. 2005. The challenge of quantitative risk assessment for wildland fire. For. Ecol. Manage. 211, 97-108.

Finney, Mark A.; McHugh, Charles, W.; Grenfell, Isaac, C.; Riley, Karin L.; Short, Karen C. 2011. A simulation of probabilistic wildfire risk components for the continental United States. Stoch Environ Res Risk Assess. DOI 10.1007/s00477-011-0462-z.

Goetz, W.; Maus, P.; Nielsen, E. 2009. Mapping whitebark pine canopy mortality in the Greater Yellowstone area. RSAC-0104-RPT1. Salt Lake City, UT: U.S. Department of Agriculture Forest Service, Remote Sensing Applications Center.18 p.

Helmbrecht, Don; Joe H. Scott; David Keefe. 2012. Little Belts Landscape Assessment: Vegetation Departure and Wildfire Threat Report. 46 p.

Helmbrecht, Don; Martha Williamson, Diane Abendroth. [in prep.]. Bridger-Teton National Forest Vegetation Condition Assessment. Unpublished report. USDA Forest Service. On file at: Bridger-Teton National Forest Supervisor's Office, Jackson, WY.

Loosen, A.S., S. Kilpatrick, M. Graham, and B. Younkin. 2009. Aspen assessment and inventory in the Greys River Ranger District final report. Conservation Research Center of Teton Science Schools. Jackson, Wyoming.

Scott, Joe H. and Helmbrecht, Don. 2010. Wildfire threat to key resources on the Beaverhead-Deerlodge National Forest. Unpublished report to U.S. Department of Agriculture, Beaverhead-Deerlodge National Forest. [December 24, 2010]. 44 p.

Scott, Joe H. and Elizabeth D. Reinhardt. 2001. Assessing crown fire potential by linking models of surface and crown fire behavior. Res. Pap. RMRS-RP-29. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 59 p.

Thompson, M.P., Scott, J., Helmbrecht, D., and D.E. Calkin. 2012. Integrated wildfire risk assessment: Framework development and application on the Lewis and Clark National Forest in Montana, USA. Integrated Environmental Assessment and Management doi: 10.1002/ieam.1365

USDA Forest Service. 1990. Bridger-Teton National Forest Land and Resource Management Plan. U.S. Department of Agriculture, Region 4. Bridger-Teton National Forest, Jackson, Wyoming. 396 pp.

USDA Forest Service. 2007. Existing Vegetation Mapping Summary: Bridger-Teton National Forest. Remote Sensing Applications Center technical report. RSAC-0091-TECH1. 128 pp.

USDA Forest Service. 2012. Bridger-Teton National Forest Fire Management Plan. U.S. Department of Agriculture, Region 4. Bridger-Teton National Forest, Jackson, Wyoming. 113 pp.

USDI Fish and Wildlife Service. 2000. Canada Lynx Conservation Assessment and Strategy. Available online: http://library.fws.gov/Pubs5/Lynx_consassess_2000.pdf. 132pp.

Appendix A – Hazard and Threat Summary Tables

Appendix A consists of a set of tables summarizing wildfire hazard and threat on Grand Teton National Park (GTNP) and the Bridger-Teton National Forest (BTNF). There is one table for each primary HVRA. Each table lists, for individual reporting units within the Park or Forest, the total HVRA area, expected annual HVRA area burned, mean annual burn probability and the relative cumulative wildfire benefit, threat and net response. The benefit (positive numbers) and threat (negative) values have been scaled to indicate to the percentage of the reporting unit with the greatest benefit (100) or threat (-100). Net response is simply the arithmetic combination of benefit and threat. The reporting units in the GTNP tables represent Fire Management Units (FMUs); the reporting units in the BTNF tables represent Ranger Districts.

Grand Teton National Park

Table 7: Wildfire hazard and cumulative weighted wildfire response of the Investments HVRA by GTNP FMU.

GTNP FMU	HVRA area (ac)	Expected annual area burned (ac)	Mean burn prob. (fraction)	Benefit	threat	Net
Conditional	11,837	74	0.00628	0	-100	-100
Fire Use	1,998	5	0.00239	0	-15	-15
Protection	10,986	40	0.00365	0	-40	-40

Table 8: Wildfire hazard and cumulative weighted wildfire response of the Diverse Resilient Vegetation HVRA by GTNP FMU.

GTNP FMU	HVRA area (ac)	Expected annual area burned (ac)	Mean burn prob. (fraction)	Benefit	threat	Net
Conditional	84,123	511	0.00608	66	-100	-34
Fire Use	139,391	199	0.00143	62	-31	31
Protection	27,345	90	0.00331	14	-16	-2

Table 9: Wildfire hazard and cumulative weighted wildfire response of the Invasives HVRA by GTNP FMU.

GTNP FMU	HVRA area (ac)	Expected annual area burned (ac)	Mean burn prob. (fraction)	Benefit	threat	Net
Conditional	48,332	267	0.00552	0	-100	-100
Fire Use	5,654	15	0.00264	0	-9	-9
Protection	20,005	66	0.00330	0	-41	-41

Table 10: Wildfire hazard and cumulative weighted wildfire response of the Wildlife Habitat HVRA by GTNP FMU.

GTNP FMU	HVRA area (ac)	Expected annual area burned (ac)	Mean burn prob. (fraction)	Benefit	threat	Net
Conditional	37,338	246	0.00659	100	-40	60
Fire Use	11,250	20	0.00181	14	-1	13
Protection	775	3	0.00428	2	0	2

Bridger-Teton National Forest

Table 11: Wildfire hazard and cumulative weighted wildfire response of the Investments HVRA by BTNF ranger district.

BTNF Ranger District	HVRA area (ac)	Expected annual area burned (ac)	Mean burn prob. (fraction)	Benefit	threat	Net
Big Piney RD	9,067	25	0.00271	0	-100	-100
Buffalo RD	793	4	0.00484	0	-15	-15
Greys River RD	508	2	0.00320	0	-28	-28
Jackson RD	8,769	28	0.00322	0	-100	-100
Kemmerer RD	64	0	0.00503	0	-23	-23
Pinedale RD	1,261	2	0.00181	0	-32	-32
non-Forest	10,444	37	0.00352	0	-59	-59

Table 12: Wildfire hazard and cumulative weighted wildfire response of the Wildland Urban Interface HVRA by BTNF ranger district.

BTNF Ranger District	HVRA area (ac)	Expected annual area burned (ac)	Mean burn prob. (fraction)	Benefit	threat	Net
Big Piney RD	92,332	612	0.00663	2	-100	-98
Buffalo RD	16,256	94	0.00578	0	-15	-15
Greys River RD	48,246	174	0.00361	1	-19	-18
Jackson RD	114,342	489	0.00428	2	-73	-71
Kemmerer RD	14,707	64	0.00433	0	-12	-12
Pinedale RD	40,749	126	0.00309	0	-25	-25
non-Forest	-	-	-	-	-	-

Table 13: Wildfire hazard and cumulative weighted wildfire response of the Wildlife Habitat HVRA by BTNF ranger district.

BTNF Ranger District	HVRA area (ac)	Expected annual area burned (ac)	Mean burn prob. (fraction)	Benefit	threat	Net
Big Piney RD	241,929	600	0.00248	6	-34	-28
Buffalo RD	52,205	99	0.00189	7	-5	2
Greys River RD	362	1	0.00179	0	0	0
Jackson RD	71,194	313	0.00439	31	-100	-69
Kemmerer RD	286,700	1,119	0.00390	2	-1	1
Pinedale RD	686,982	1,064	0.00155	6	-28	-22
non-Forest	-	-	-	-	-	-

Table 14: Wildfire hazard and cumulative weighted wildfire response of the Priority Vegetation HVRA by BTNF ranger district.

BTNF Ranger District	HVRA area (ac)	Expected annual area burned (ac)	Mean burn prob. (fraction)	Benefit	threat	Net
Big Piney RD	63,240	102	0.00161	1	-13	-12
Buffalo RD	166,023	229	0.00138	0	-7	-7
Greys River RD	62,535	186	0.00298	100	-12	88
Jackson RD	185,756	477	0.00257	10	-28	-18
Kemmerer RD	40,455	89	0.00221	0	-13	-13
Pinedale RD	349,360	426	0.00122	0	-29	-29
non-Forest	-	-	-	-	-	-

Table 15: Wildfire hazard and cumulative weighted wildfire response of the Municipal Watersheds HVRA by BTNF ranger district.

BTNF Ranger District	HVRA area (ac)	Expected annual area burned (ac)	Mean burn prob. (fraction)	Benefit	threat	Net
Big Piney RD	-	-	-	-	-	-
Buffalo RD	-	-	-	-	-	-
Greys River RD	43,099	138	0.00320	96	-100	-4
Jackson RD	-	-	-	-	-	-
Kemmerer RD	-	-	-	-	-	-
Pinedale RD	11,759	10	0.00088	6	-9	-3
non-Forest	-	-	-	-	-	-

Table 16: Wildfire hazard and cumulative weighted wildfire response of the Diverse Resilient Vegetation HVRA by BTNF ranger district.

BTNF Ranger District	HVRA area (ac)	Expected annual area burned (ac)	Mean burn prob. (fraction)	Benefit	threat	Net
Big Piney RD	375,555	1,258	0.00335	65	-16	49
Buffalo RD	560,217	1,075	0.00192	22	-4	18
Greys River RD	427,254	1,345	0.00315	68	-6	62
Jackson RD	594,743	1,926	0.00324	100	-16	84
Kemmerer RD	263,080	1,037	0.00394	47	-6	41
Pinedale RD	605,977	1,152	0.00190	55	-9	45
non-Forest	-	-	-	-	-	-

Table 17: Wildfire hazard and cumulative weighted wildfire response of the Timber HVRA by BTNF ranger district.

BTNF Ranger District	HVRA area (ac)	Expected annual area burned (ac)	Mean burn prob. (fraction)	Benefit	threat	Net
Big Piney RD	264,001	951	0.00360	75	-62	13
Buffalo RD	31,762	88	0.00277	8	0	8
Greys River RD	232,361	729	0.00314	62	-100	-38
Jackson RD	70,137	262	0.00373	21	0	20
Kemmerer RD	179,888	750	0.00417	53	-7	46
Pinedale RD	175,262	524	0.00299	40	-1	39
non-Forest	-	-	-	-	-	-

Appendix B – Conditional Response to Wildfire

The basic results of the assessment indicate the *expected* wildfire response, which includes the influence of annual burn probability. For some fire management planning applications, the expected response is less important than the *conditional* response (that is, the wildfire response given that a wildfire occurs). Planning for the management of wildfires for resource objectives is one such application. It that case, once a wildfire starts the influence of burn probability on expected wildfire response is no longer desired. To "remove" the influence of *BP* in the response calculations, we simply divide the weighted net response by *BP*.

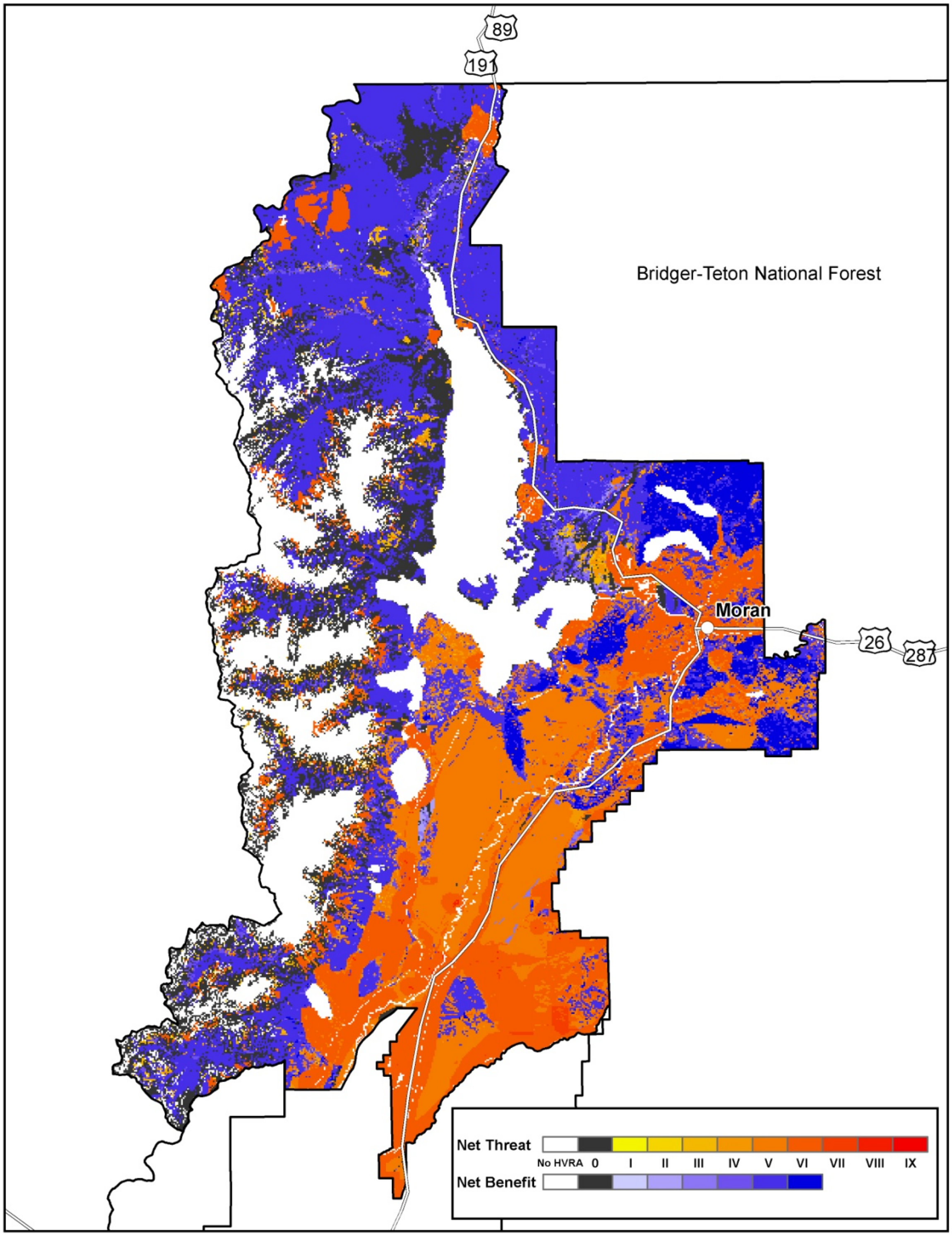

Figure 38: Conditional weighted threat only (red scale) and benefit only (blue scale) in Grand Teton National Park. Threat and benefit classes are logarithmic, so overall response increases 10-fold from one class to the next.

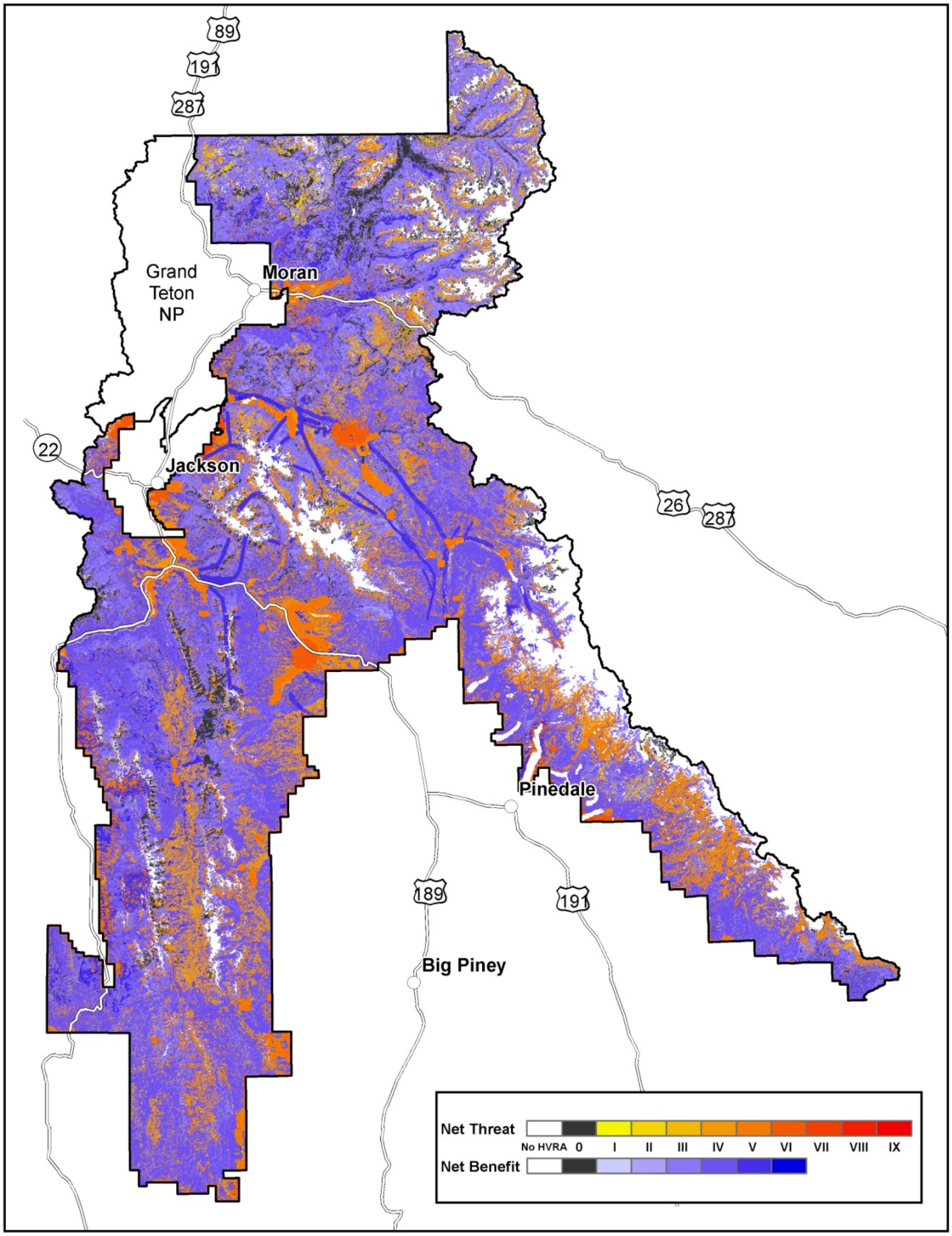

Figure 39: Conditional weighted threat only (red scale) and benefit only (blue scale) on the BTNF. Threat and benefit classes are logarithmic, so overall response increases 10-fold from one class to the next.

Appendix C: – Data Overview

The data compiled during this assessment have application beyond what can be presented in this report. This appendix provides a general description of each of the data products that have been developed and an indication of management applications for the geospatial data. Further application of these data will depend on the analysis objectives.

Directory	Subdirectory/File	Description
FSim	RawResults	Raw FSim results from inputs specified in the RunFiles directory.
	RunFiles	All required input files for FSim simulation (includes executable files).
GeoSpatialData	IntegratedResponse.gdb	Integrated (all HVRAs) response to wildfire. Includes expected and conditional results for threat only, benefit only, and net response.
	HVRA.gdb	Individual HVRA rasters.
	IndividualResponse.gdb	Expected net response by individual HVRA (sum of all sub-HVRAs).
	WildfireHazard.gdb	FSim and NEXUS (torching and crowning indices) results.
lfGrids90m		Updated circa 2011 rasters (in ESRI grid format) used to make a “landscape file” (LCP) for use in FSim. Grids were resampled to 90 meter resolution from 30 meter resolution data in the lfUpdate30m/Output directory described below.
lfUpdate30m	Input	ToFuDelta input rasters (ESRI grid format). Includes existing vegetation type, cover, and height; biophysical setting; and disturbance rasters at 30 meter resolution.
	MU	ToFuDelta management unit rasters. These are created by the ToFuDelta tool.
	Output	Updated 30 meter resolution rasters (ESRI Grid format) required for creating a “landscape file” (.LCP) for use in fire behavior modeling systems. Layers have been updated from LANDFIRE v1.0.5 (Refresh 2001) to circa 2011 conditions for disturbance from wildfire, insects and disease. Updates include adjustments to surface fuel mapping rules in undisturbed areas based on local expert knowledge.
	ToFuDelta.mdb	ToFuDelta beta v0.12 database used to update base LANDFIRE v1.0.5 (Refresh 2001) data. Includes all fuel mapping rules.
ResultsSummaryFiles	XXXX_ThreatSummary_V2.xlsx	Charts summarizing HVRA characteristics and benefit/threat by HVRA and across reporting units for Bridger-Teton National Forest (BTNF) and Grand Teton National Park (GRTE). ‘RF’ worksheet can be used to explore alternative weighting schemes.
	TIARA_RF-RI_Summary(04-25-2012).xlxs	Response functions and relative importance values generated at response function workshop.
	teton_XXX_mask.csv	Risk tool output of weighted benefit only (WBO), net response (WNR), and threat only (WTO).

RiskTool	FRISK Toolbox	Wildfire Risk Analysis ArcGIS toolbox developed by RMRS Human Dimensions Program.
	RunFiles	Files required for running Response Function Analysis script in the Wildfire Risk Analysis ArcGIS toolbox.

Management applications for geospatial data:

WildfireHazard.gdb:

The wildfire hazard data may be used to identify areas that may benefit most immediately from fuels reduction treatments. These data may also be used to describe current conditions in National Environmental Policy Act (NEPA) documents and to support NEPA effects analyses.

HVRA.gdb:

The HVRA data may be used during project development or for assessing risk to resources and assets when managing unplanned ignitions. The data in this geodatabase are the raster version of the vector data in the TIARA_HVRAs geodatabase, available on the Teton Interagency Fire external hard-drives.

IntegratedResponse.gdb:

The data in the integrated response geodatabase may be used to anticipate both the threat and benefit to HVRAs from wildfire. This information may be useful in project planning, NEPA effects analysis, and in developing objectives for managing unplanned ignitions. Areas that can expect to see benefit from wildfire across multiple HVRAs may be targets for prescribed fire treatment. Expected response data for the HVRAs – whether positive or negative, the magnitude of response, as well as the tabular response functions themselves – may be used to inform NEPA effects analyses. The conditional weighted values (described in Appendix B) may be used to estimate the potential effects of a going wildfire. This information is essential to anticipating how a wildfire may actually be managed to meet resource objectives as well as articulating early what the potential negative impacts of such a fire may be.