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Comparing Resource Values at Risk from Wildfires with Forest Service Fire Suppression Expenditures: Examples from 2003 Western Montana Wildfire Season

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Abstract—Determining the economic effectiveness of wildfire suppression activities is complicated by difficulties in identifying the area that would have burned and the associated resource value changes had suppression resources not been employed. We developed a case study using break-even analysis for two large wildfires from the 2003 fire season in western Montana—the Black Mountain and Crazy Horse Fires. We used GIS to identify the location and taxable value of private residences within perimeters expanding in a likely direction of fire spread for both fires. We identified the size of an expanded perimeter where the market values of private property equaled the amount of money spent suppressing a fire (the break even point). This analysis showed that suppression expenditures on the Black Mountain Fire were economically justified if these efforts reduced the potential fire perimeter a modest amount. However, the potential fire perimeter for the Crazy Horse Fire would have had to be considerably larger than the actual fire perimeter to economically justify the associated suppression expenditures. We also demonstrated the ability to use this methodology to examine nonmarket resource values at risk on the Crazy Horse Fire.

Keywords: wildfire suppression costs, break-even analysis, cost containment, cadastral data

Introduction

New wildfire performance measures compel land managers and researchers to address the complicated problem of determining the economic efficiency of wildfire suppression activities. The USDA Forest Service Strategic Plan (USDA Forest Service 2004) calls for an increase in the percentage of large fires where the value of resources protected exceeds the cost of suppression. Ideally, the cost of suppression expenditures on an individual fire would be evaluated against the change in resource values, both positive and negative, in areas that would have burned had suppression efforts not occurred (a cost-benefit analysis). However, quantifying the resource value change between what actually burned and what would have burned with no suppression effort is extremely difficult and beyond current capabilities for the following reasons:

- The effectiveness of suppression efforts in changing fire behavior and size is poorly understood, particularly during the severe fire weather events that cause most of the damage. Recreating how fires would have burned without suppression would be a highly subjective modeling exercise.
- The effects of fire on many important resource values are difficult to measure, and often the direct and indirect effects are not fully understood. Even when the effects are well understood, it can be difficult to quantify the resource value change in monetary terms. Furthermore, some resource value changes may be considered negative at a small geographic scale or in the short term. However, examining the effects of these changes at a larger geographic scale or over a longer period may indicate that the changes are beneficial.

Nonetheless, understanding the types and values of resources at risk due to wildfires can help managers develop strategic suppression strategies, determine when it may be appropriate to use less aggressive suppression efforts, and prioritize suppression resources between multiple, simultaneous fires. We can use past fires to examine resource values at risk adjacent to actual final fire perimeters and compare these values with Forest Service fire suppression expenditures. If values at risk are high relative to expenditures, it is more likely that suppression efforts were economically warranted than if the values at risk are low relative to expenditures.

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Approach

We provide two examples from the 2003 fire season in western Montana—the Black Mountain and the Crazy Horse Fires (fig. 1). The Black Mountain Fire in the Lolo National Forest burned 7,062 acres in August 2003. The Forest Service spent $19.7 million in suppression expenditures fighting the fire ($2,789 per acre). The fire burned in the urban interface southwest of the city of Missoula and threatened a number of densely populated neighborhoods. Three homes were burned. Of the area in the final burn perimeter, 83 percent was Forest Service nonwilderness, 16 percent private nonindustrial land, and less than 1 percent Plum Creek timberland.

The Crazy Horse Fire on the Flathead National Forest, final area 11,132 acres, occurred in a more rural setting, putting substantial acreage of industrial timberland at risk but threatening few residential structures. The Forest Service spent $10.0 million on suppression ($898 per acre). The fire began in a Forest Service wilderness area and burned into Forest Service nonwilderness and Plum Creek timberland. Of the area within the final burn perimeter, 45 percent was Forest Service wilderness, 32 percent Forest Service nonwilderness, and 23 percent Plum Creek timberland. The taxable land value of the Plum Creek timberland was $1.78 million. No structures were burned.

We conducted GIS-based spatial analysis using multiple data sets to evaluate both market and nonmarket resources proximate to the perimeters of the Black Mountain and Crazy Horse Fires. All analytic procedures used standard program features; no custom programming was necessary. All data are publicly available (specific information regarding software, data sources, and procedures used in this pilot are available upon request). In general, buffers in 0.5 km increments were generated into unburned lands to a distance of 10 km from the fire perimeter. For this preliminary exercise, an Area of Concern (AOC) was defined extending through the buffered region to the east (fire spread in western Montana typically occurs to the east due to prevailing west winds). However, any polygon defining an AOC may be used. It may be generated by fire behavior software or hand-digitized based on expert opinion or political concerns.

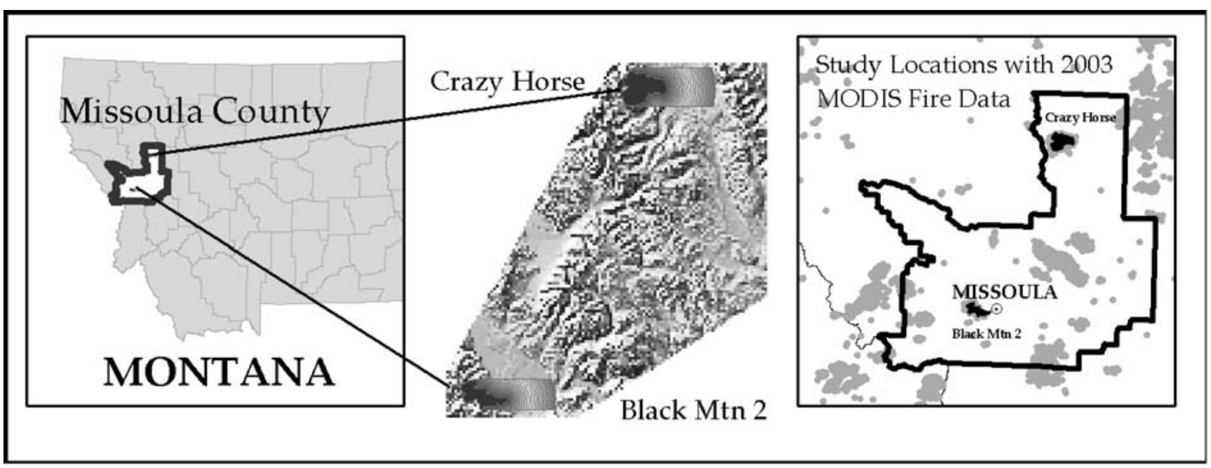

Figure 1—Location within Montana of fires analyzed in this study.

Once these zoned buffers were defined (see fig. 2), we identified selected resource values that were threatened by the fire within these expanded perimeter zones. Break-even analysis—the point where project costs equal the marketable benefits—was employed to identify the expanded fire perimeter area where the amount spent on suppressing the fire (the costs) equaled the resources protected for which we can assign a monetary value (the benefits). If it is likely that the fire would have spread beyond this break-even point had no suppression effort occurred, the expenditures on suppression resources were economically justified. However, if it is unlikely that the fire would have reached this break-even point, nonmarket resource values at risk may still justify an aggressive suppression response. If it does not appear that fire suppression

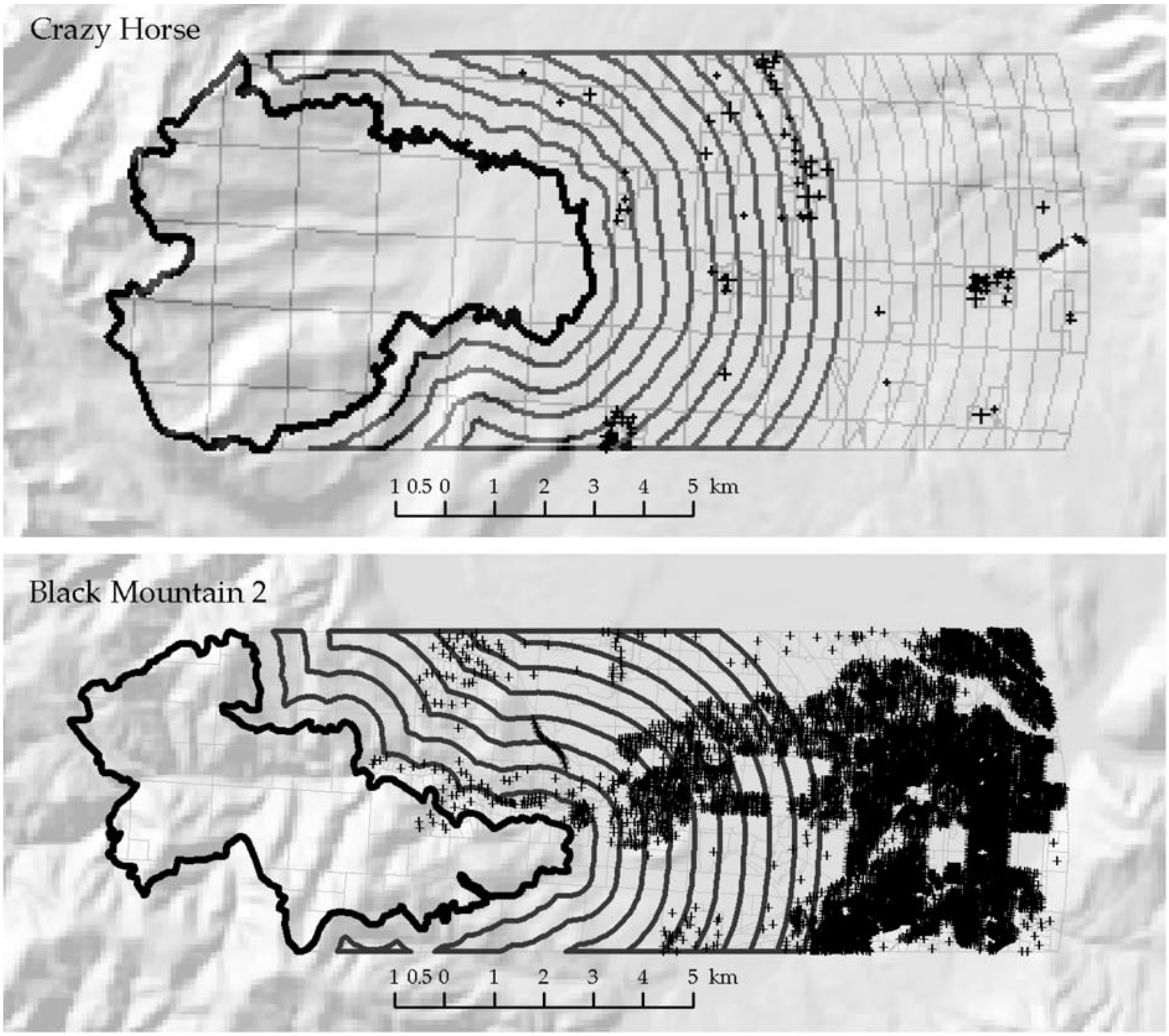

Figure 2—Buffer zones extending from fire perimeters with building centroids (+).

was justified from a values-at-risk standpoint (both market and nonmarket resources), a discussion can be initiated of some of the policy drivers that encourage aggressive suppression tactics by the Forest Service.

To demonstrate the utility of our approach, we focused initially on assessed taxable private land and structure value from the Montana cadastral data layer (MT NRIS 2003). We did not quantify the likelihood that a given structure would burn had the fire expanded into the perimeter that includes the structure. We simply quantified private land value for the expanded fire perimeters assuming 100 percent of the structure value and 25 percent of the land value. The assumption of 25 percent loss of land value is a coarse assumption that will be improved in future work by identifying land value change of burned properties through public assessors' records. Additionally, we categorized forestland by type (low elevation species, high elevation species, and other), relative size (young and mature), and ownership and designation (Forest Service Wilderness, Forest Service Nonwilderness, State, Tribal, and Private). We did not assign a value change to these areas had the fire burned, we simply quantified the area in each class for each expanded fire perimeter zone and listed the Plum Creek Timber assessed taxable land value. Additionally we considered noneconomic, ecosystem attributes for the Crazy Horse Fire; fire regime and condition class for fire areas and wildlife habitat (CST 2002). Fire regime and condition class may be used to assess potential ecological effects of fire. Analysis of sensitive wildlife habitat included bull trout spawning and rearing habitat.

Results

Taxable residential value was very high adjacent to the Black Mountain Fire and quickly became extremely large as the fire perimeter was expanded into densely developed neighborhoods on the outskirts of Missoula. Figure 3 presents a graph of private land and structure values as a function of the increased fire size (potential timber value loss due to fire is not included in this figure). If the fire had progressed 1 km to the east (an increase of 55 percent from the final fire size), the residential value within the expansion area equaled approximately $22.5 million, while if the fire had progressed 5 km (188 percent increase in fire size) residential value increased to $227.5 million. The amount the Forest Service spent on suppression efforts ($19.79 million) was equivalent to the residential value in an expanded perimeter of between 32 and 55 percent of the final fire size (between 0.5 and 1 km eastern buffer zones). These expanded perimeters included significant private land (39 percent private land in the 1 km perimeter and 69 percent in the 5 km perimeter). Additionally, we looked at the distribution of residential values in these expanded perimeters. Suppression strategy for protecting one second home valued at $2 million may vary from protecting 20 year-round residences valued at $100,000 each because of social equity. Total market value at risk is the same, but the social impact of the loss would likely be much greater for the fulltime residents. Figure 4 presents the distribution of residential values within a 5 km perimeter. A majority of the structures in this expanded area are valued at under $200,000. However, there are a number of structures valued above $400,000 with one structure exceeding $1 million.

The Crazy Horse Fire presents a far different situation. If the fire had progressed 1 km to the east (an increase of 42 percent from the final fire size), residential value within the expansion area equaled only $0.42 million, while if the fire had progressed 5 km (136 percent increase in fire size) residential value increased to $9.39 million (see fig. 5). The amount the Forest Service spent on suppression efforts ($9.97 million) was equivalent to the residential value in an expanded perimeter of between 182 and 191 percent of the final fire size (between the 7.5 and 8 km eastern buffers). Land ownership in these expanded perimeters was mixed, with 55 percent Forest Service nonwilderness, 5 percent Forest Service Wilderness, 37 percent Plum Creek Timber, and 3 percent private nonindustrial land in the 1 km perimeter, and 42 percent Forest Service nonwilderness, 2 percent Forest Service Wilderness, 29 percent Plum Creek

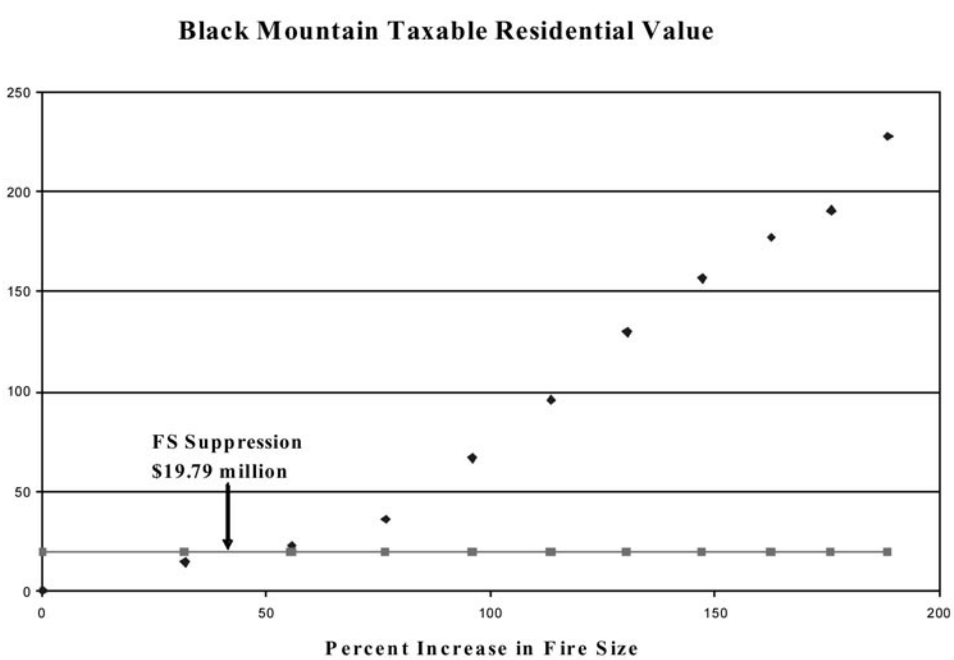

Figure 3—Increase of taxable value (million $) with increasing fire size for Black Mountain II Fire.

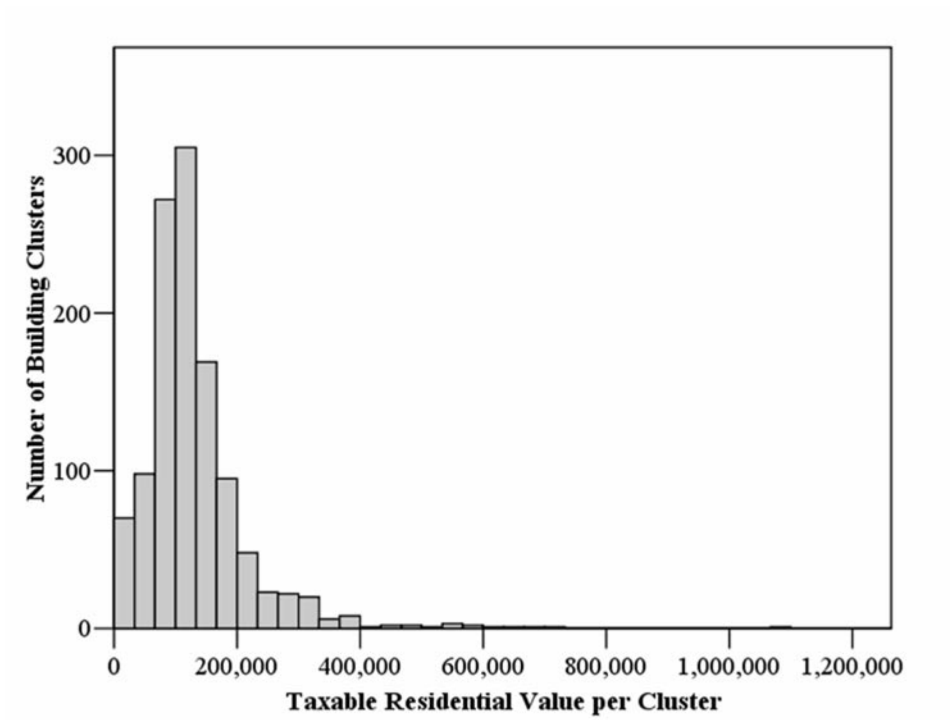

Figure 4—Distribution of taxable residential value within 5 km of final Black Mountain II Fire perimeter.

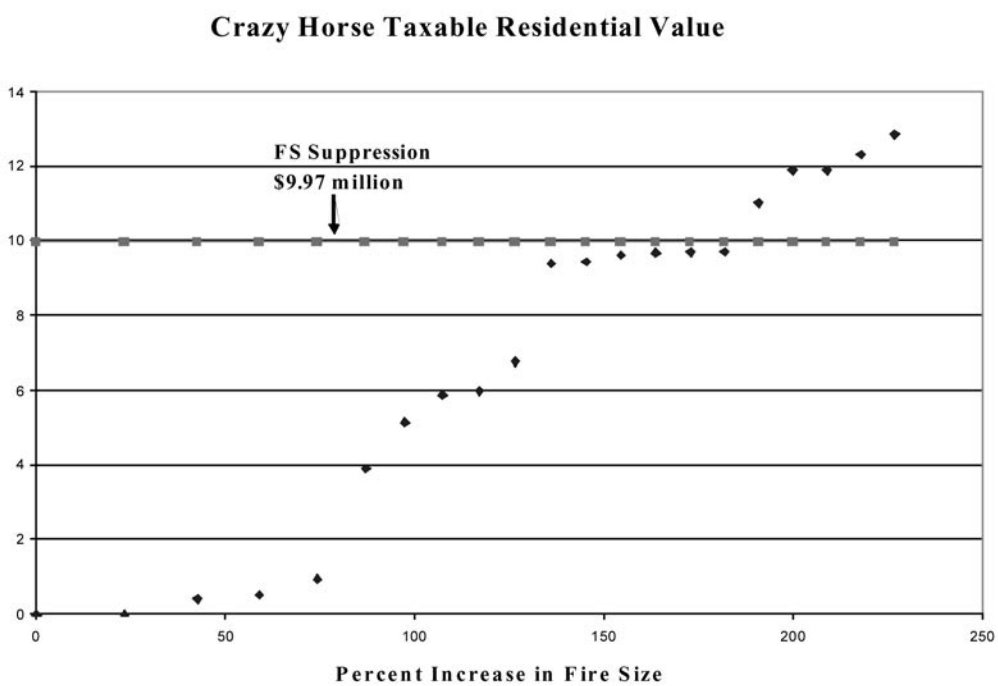

Figure 5—Increase of taxable value (million $) with increasing fire size for Crazy Horse Fire.

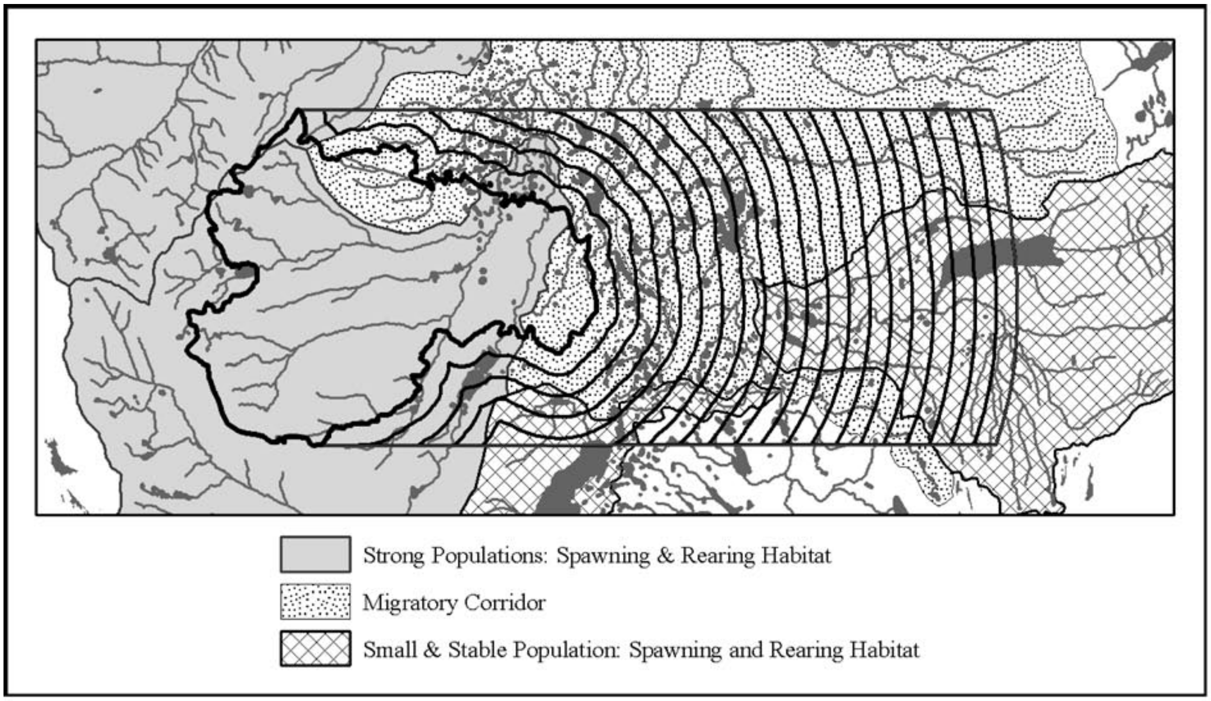

Figure 6—Bull trout habitat status, Crazy Horse Fire.

Timber, and 28 percent private nonindustrial land in the 5 km perimeter. The Plum Creek timberland in the 1 km expanded perimeter has a taxable value of $1.31 million, while the taxable value of Plum Creek lands within the 5 km buffer is $2.51 million.

Future studies will include estimates of the effect of wildfire on timber values, and these value changes may be incorporated into figures 3 and 5 to more fully represent market values at risk.

For this pilot project we limited our vegetation analysis to the area within the Crazy Horse Fire perimeter. Of the vegetation within the burned area, 65 percent was classified as upper elevation species (subalpine fire, grand fir, and lodgepole pine); 55 percent was identified as having stand replacement fires as the historic fire regime; and Fire Regime Condition Class (FRCC) was distributed between 62 percent in FRCC 1 (low departure from historic fire regime), 19 percent in FRCC 2 (moderate departure), and only 16 percent in FRCC 3 (high departure). Prior to containment, the fire was spreading downslope into areas where stand-replacement fires should be expected. The current vegetation was classified predominantly as FRCC 1 or as representing current vegetation conditions with low departure from the historic fire regime.

The entire Crazy Horse burn occurred in bull trout habitat (fig. 6). Over 9,000 acres rated as strong spawning and rearing habitat burned during the fire. A fire perimeter expanded 5 km to the east included over 14,000 additional acres of critical spawning and migration corridor habitat. Bull trout habitat was presented to demonstrate the ability to include analysis of nonmarket resource values. However, the effects of fire on bull trout habitat are currently not fully understood. Short-term effects on trout habitat may be negative due to increased siltation; however, in the long term, habitat may improve due to increased downed wood in streambeds (Rieman and Clayton 1997). Market resource values appear not to provide sufficient justification for aggressive suppression on the Crazy Horse Fire. However, discussion with Region 1 Fire and Aviation Management (Greg Greenhoe, pers. comm. 2004) identified that when a fire that started on lands protected by the Forest Service burns into or threatens non-Federal land (Plum Creek timberland in this case), aggressive suppression is expected by the stakeholders and the jurisdictional agency (Montana Department of Natural Resources and Conservation, in this case).

Discussion

In this analysis, as a first step in comparing values at risk with suppression expenditures, we concentrated on residential land values. Obviously, wildfire affects a number of resource values in addition to residential lands, and wildfire suppression decisions are not based solely on values at risk. Some resource value changes due to wildfire, such as managed timberland value, could be evaluated and assigned a monetary value. Others, such as the value of endangered species habitat, are far more difficult. In many instances the value change to a resource due to wildfire may be positive (for example, low intensity fire in low elevation forest types can reduce hazardous fuel levels and improve forest health). Black and others (2004) suggest that determining if the effects of fire on forestland are positive or negative can be gleaned by comparing the area burned by FRCC with desired future conditions established within existing land management plans. We endorse the premise that "management for wildland fire objectives cannot be isolated from the management of native fishes (and other ecosystem concerns)" (Rieman and others 2003). The challenge before us is to determine how best to incorporate ecosystem considerations into this analytic approach. This requires that we work with resource specialists to build consensus on which resources to analyze and how they are to be analyzed in the context of wildland fire management.

Further analysis is planned to provide a more comprehensive accounting of resource values at risk due to fire including assessing the likelihood that individual structures will burn under different wildfire conditions, quantifying resource value changes that can be assigned a monetary value such as timber value change, and accounting for those resource values that are difficult to assign monetary values (both negative and positive effects). We plan to expand research efforts to examine a wider range of fire sizes and geographic areas, and will incorporate fire spread models such as FARSITE (Finney 1998) and RERAP (USDA Forest Service 2000) to better define areas of concern.

Management Implications

Spatial maps identifying the value and location of important resource values at risk due to fire can improve communications between local land managers and fire managers during strategic wildfire planning. In the spring and summer of 2005, we will work with Fire and Aviation Management personnel in Forest Service Region 1 and the Northern Rockies Coordination Group (NRCG) to provide resource value maps to fire managers in real time at wildfire events in western Montana for the 2005 fire season. Additionally, mapping the values at risk for multiple fires occurring at the same time can help prioritize resource allocation to these fires. For the 2005 fire season we will deploy in a Multi-Agency Coordination (MAC) group to help managers prioritize suppression resources to large wildfires.

The strength of this analysis approach is that it may be applied using any resource, market or nonmarket, for which a GIS-based inventory exists. The primary limitation of this approach is the availability and consistency of the spatial data. Application of this approach to nonmarket resource values should be undertaken with caution. The effects of fire and fire management on many nonmarket resource values are poorly understood, and it is frequently difficult to determine resource value change. Rule sets for quantifying wildfire risks to nonmarket resource values should be developed in the spatial and temporal context of fire management decisions.

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