

Fire Damage on Extensively vs. Intensively Managed Forest Stands Within the North Fork Fire, 1988¹

Abstract

The Greater Yellowstone fires of 1988 provide an opportunity to study important distinctions between lands managed for preservation versus multiple uses. We surveyed fuel loadings, fire severity, and fire damage in extensively managed, mature forests and in intensively managed, clearcut reproduction areas. Unburned, mature forests support higher fuel loadings in the large and small woody fuel size classes. Fifty percent of the 50 fire severity estimates in mature forest plots were given the highest ratings possible for flame length and ground char. Fire damage was rated highest on 89% of the 55 mature forest plots, based primarily on crown scorch indicators. By contrast, highest fire damage ratings were associated with only 20% of the 45 regeneration sites surveyed. Fire severity and damage were moderated in intensively managed areas. Intensively managed forest areas improve fire management options in the Greater Yellowstone Area.

Introduction

The Greater Yellowstone fires of 1988 provide an opportunity to focus on important distinctions between lands managed for preservation versus multiple uses. Historically, within Yellowstone National Park (YNP), the preservation mandate had allowed no active fuels management prior to 1988. By contrast, on the adjacent Targhee National Forest (TNF), fuels have been actively manipulated since 1960 in conjunction with multiple use objectives, primarily timber management.

The North Fork Fire was started by woodcutters on the Moose Creek Plateau of the TNF on 22 July 1988. Fueled by strong SW winds, the fire quickly spread into YNP. Throughout the next 7 weeks (including eventual merger with the Wolf Lake Fire), the North Fork Fire burned over 200,000 ha of national park, national forest, and Idaho state lands. Numerous developments were threatened, including Old Faithful Village, Madison Junction, Norris, Canyon Village, Mammoth Hot Springs, and Tower-Roosevelt. The communities of West Yellowstone and Gardiner also were endangered. On two separate occasions (27 August and 2-3 September), wind shifts blew the fire back onto the TNF, with estimates ranging from approximately 4,500 to 7,000 ha of national forest burned area (Greater Yellowstone Coordinating Committee 1989, Hardin 1988, respectively). The fire was finally declared controlled in early November, 1988, after the area received significant moisture from snowfall.

This paper presents a survey comparison of fuels, fire severity, and fire damage in forested stands on national park and national forest lands. For purposes of this paper, we define mature forest sites on national park and national forest lands as *extensively managed*; we designated sites on the TNF with reproduction after clearcutting as *intensively managed*. Based on these distinctions, we draw comparisons between fire severity and damage in extensively and intensively managed forest lands within the vicinity of the Moose Creek Plateau. We conclude with inferences about fire potential on lands managed for preservation and the importance of intensive management at the boundary.

Study Area and Objectives

The Targhee National Forest borders the southwestern boundary of Yellowstone National Park in Idaho (Figure 1). The 57,000 ha Moose Creek Plateau abuts the national park in Idaho, south of the Montana state line. Aside from timber harvesting, other uses identified in the TNF Plan (USDA Forest Service 1985) include roaded recreation, wildlife (elk and grizzly habitat), and grazing. Elevations in the study area range from 2,000 m on the plateau to 2,500 m along the YNP boundary. The dense lodgepole pine (*Pinus contorta*) stands in the area have been salvage-logged in response to mortality from mountain pine beetle (*Dendroctonus ponderosae*) infestations since 1960. The widespread infestation also affected trees on adjacent national park lands.

We restricted our investigation to the point of origin (about 50 m from the YNP boundary), the initial area burned on national forest and national

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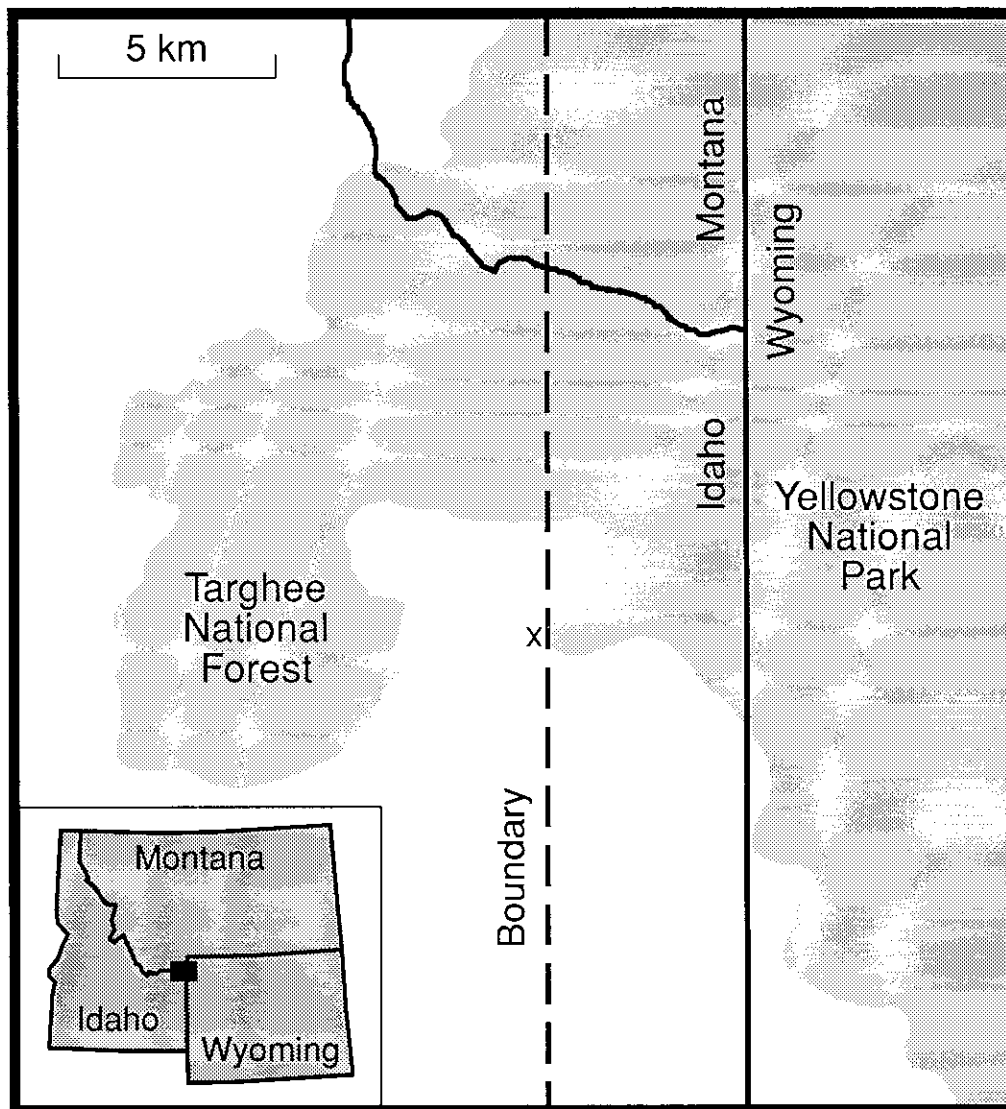


Figure 1. Silhouette of portions of the 1988 North Fork Fire and study area. The fire originated on the Targhee National Forest in Idaho (x = point of origin), on 22 July 1988, and spread quickly into Yellowstone National Park. Shifting winds blew the fire back onto national forest land over one month later, north of the point of origin.

park land (8 ha and 140 ha respectively), and the two subsequent wind-driven burns onto the national forest. Based on initial examination of fire documents and maps, we decided to focus on distinctions between extensively managed versus intensively managed forest stands in the vicinity of the Moose Creek Plateau.

Approximately 54 percent of lands within the North Fork burn on the Moose Creek Plateau were mature (Hardin 1988). These consisted of stand-

ing timber between alternate clearcut strips, and areas yet to be entered for timber harvest. By contrast, 100 percent of national park lands were mature, due to the National Park Service (NPS) preservation philosophy.

Our objectives were:

1. to compare fuels in mature, extensively managed forests versus intensively managed areas (naturally regenerated following cutting);
2. to estimate fire severity (defined below) in extensively managed areas;

3. to assess fire damage (defined below) in extensively versus intensively managed areas.

Methods

We delineated two vegetative condition classes of primary interest for our study, based on preliminary discussions with TNF personnel (pers. comm. with Mr. Don Black, district fire management officer, 1988). Stands were delineated as either extensively managed (on national park and national forest land) or intensively managed, as follows:

- *Extensively managed stands:* Mature to over-mature, dominated by lodgepole pine overstory, associated with various tree species, depending on elevation. At lower elevations, associated species include scattered mature Douglas-fir (*Pseudotsuga menziesii*) and small aspen clones (*Populus tremuloides*). At higher elevations, associates include subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), limber pine (*Pinus flexilis*), and whitebark pine (*Pinus albicaulis*). Principal understory shrubs include grouse whortleberry (*Vaccinium scoparium*) and blue huckleberry (*V. globulare*). Pre-fire mortality from the pine beetle ranged to as high as 70% in many stands.

- *Intensively managed stands:* Clearcut national forest areas, mostly regenerated naturally following timber harvest and slash disposal, consisting of lodgepole pine seedlings and saplings (<20 years old). Scattered individual Douglas-fir, subalpine fir, and aspen occur. Stocking densities are as high as 15,000 trees/ha in the older reproduction, with tree heights from 0.9-5.0 m. Younger lodgepole pine reproduction (<8 years old) areas consist of smaller trees (0.3-0.9 m height) and lower stocking density (2,000-7,500 trees/ha). On harsher sites, pinegrass (*Calamagrostis rubescens*) and elk sedge (*Carex geyeri*) occur frequently.

Detailed information on the structure of burned and unburned stands was not collected. Two primary habitat types (Steele *et al.* 1983) are descriptive of the burned area. Ninety percent of the area is occupied by the *Abies lasiocarpa/Vaccinium scoparium* (ABLA/VASC) habitat type; *Abies lasiocarpa/Vaccinium globulare* (ABLA/VAGL) occupies the remainder (Hardin 1988).

We surveyed the North Fork burn area on national forest and national park land during July, 1989. We restricted our focus to burned and un-

burned plots as defined above. On national forest land, we had difficulty locating unburned mature stands within the burn area; in fact, less than 4% TNF burned area consisted of mature, extensively managed stands (Hardin 1988). Eventually, ten unburned mature forest stands were located outside the burn perimeter and in unburned islands within the fire perimeter (five each on either side of the TNF-YNP boundary).

Our intent was to distinguish between fuels, fire severity (Ryan and Noste 1985), and fire damage in extensively vs. intensively managed forest stands within the study area. Fuel inventory transects (after Brown 1974, and Burgan and Rothermel 1984) were randomly located in each of the ten unburned mature forest stands. Each unburned stand was assumed representative of the fuel profile which existed prior to the fire. In the adjacent burned stand we completed a fire severity transect (randomly located), consisting of five 30x60 cm subplots at 3 m intervals. Independent estimates were recorded for fire intensity (which relates to heat pulse received by above-ground vegetation, in the subplot vicinity) and depth of char (heat pulse directed to the duff and soil within the subplot), for a total of 50 fire severity estimates (10 transects times 5 estimates per transect). Instead of averaging all intensity and depth of char estimates per transect (after Ryan and Noste 1985), we decided to present the raw data to depict the variability in fire severity within the burned area.

Also, we developed ocular estimates for fire damage in each burned stand, using the following criteria:

- Unburned:* Fire did not enter the stand;
- Light:* Surface burn without crown scorch;
- Spotty:* Irregular crown scorch;
- Moderate:* Intense burn with complete crown scorch;
- Severe:* High intensity canopy burn, with crowns totally consumed.

These criteria represent a synthesis of standards (see Wells *et al.* 1979, Ryan and Noste 1985, Weatherspoon and Skinner 1989, and the burned area map in: Greater Yellowstone Coordinating Committee 1989), adapted to suit our specific needs. We applied these same criteria for assessing damage to an additional 45 intensively managed sites and adjacent mature stands on national forest lands. (No intensively managed sites exist

on national park land due to NPS policy). A total of 55 different stands was included in our survey.

Results

Fuel Loading

Fuel loadings in mature, extensively managed stands (national park and national forest) are summarized and compared against intensively managed, regenerated areas in Table 1. Generally, the mature forest plots support higher loadings than areas clearcut and cleared, for the large, small, and litter fuel categories. In the large fuel category, loadings for rotten, decaying fuels were significantly higher in mature forests (12.0 vs. 2.9 metric tons/ha). Higher loadings were observed for large sound fuels and duff in mature forests, but differences were not significant due to the high variability in these estimates. Also, fuelbed depth (slash plus litter) was significantly higher in the mature forest plots (7.0 cm versus 2.5 cm).

TABLE 1. Inventoried fuel loadings (metric tons/hectare) for duff, litter, small woody fuel (< 7.6 cm diameter), large woody fuel (> 7.6 cm diameter), dead grasses and shrubs, and live fuels in unburned, extensively managed (mature) stands, versus unburned, intensively managed (regeneration areas), in the vicinity of the Moose Creek Plateau (standard errors parenthesized).

Fuel Component	Extensively Managed Stands (n = 10)	Intensively Managed Areas (n = 10)
Duff ^a	27.7 (7.7)	15.2 (3.9)
Litter ^b	3.1 (0.5)	1.6 (0.2)*
Small Woody ^c	5.1 (1.0)	4.3 (0.7)*
Large Woody ^c	28.8 (8.6)	8.1 (2.0)*
Dead Grasses & Shrubs ^b	0.03 (0.02)	0.02 (0.01)
Live Grasses & Shrubs ^b	0.10 (0.05)	0.07 (0.03)
Live Small Trees ^d	--	21.1

*Mature forest loading significantly higher than regenerated areas ($p < .10$)

^aAfter Brown et al. (1982).

^bAfter Burgan and Rothermel (1984).

^cAfter Brown (1974).

^dPoint estimate from Brown et al. (1982), based on weights for trees of average height and stocking densities (trees/ha) for plantations in the area. Small trees were an insignificant component of mature stands and were not inventoried.

Fire Severity in Mature Forests

Fifty percent of the 50 fire severity estimates in mature forest plots were given the highest ratings

possible for flame length and ground char (Figure 2). Of these 25 highest ratings, 15 occurred on national park and 10 on national forest plots. In these plots, overstory trees were killed. Litter and duff were completely consumed over much of the area, along with most twigs and small surface fuels. Evidence for soil discoloration due to soil heat pulse was difficult to detect, given the time (1 year) between the fire and our survey.

On the remainder of mature forest plots (25), fire severity ratings varied from light to moderate (Figure 2). In general, on these plots varying degrees of litter and duff were consumed, but surface twigs and branchwood remained.

Overall, as shown in Figure 2, the entire range of ground char classes was observed in our fire severity estimates. By contrast, flame length classes were either low (classes 1 and 2) or very high (class 5).

Fire Damage in Extensively Managed vs. Intensively Managed Stands

Fire damage ratings in mature, extensive forests versus regeneration areas are compared in Figure 3. Nearly 89% of the 55 extensively managed sites received the highest fire damage ratings (moderate and severe), whereas less than 20% of the 45 intensively managed sites received the same ratings. Over 80% of the intensively managed sites received ratings of "unburned," "light," or "spotty" fire damage.

In each of the 45 regeneration sites surveyed within the burn, we also rated fire damage to the adjacent mature stands (Figure 4). There were 7 cases in which "moderate" or "severe" regeneration damage was accompanied by "severe" damage to the adjacent mature stand. However, in 38 regeneration sites damage was rated "unburned," "light," or "spotty," while damage to the adjacent mature stand was primarily "moderate" or "severe." Thus high fire damage in adjacent extensively managed stands was more often associated with lower levels of fire damage in intensively managed stands (38 of 45 cases).

Discussion

Most of the mature, extensively managed stands within the North Fork burn area had moderate or severe fire damage. By contrast, most of the intensively managed regeneration areas had light or no damage. Although these findings are based on

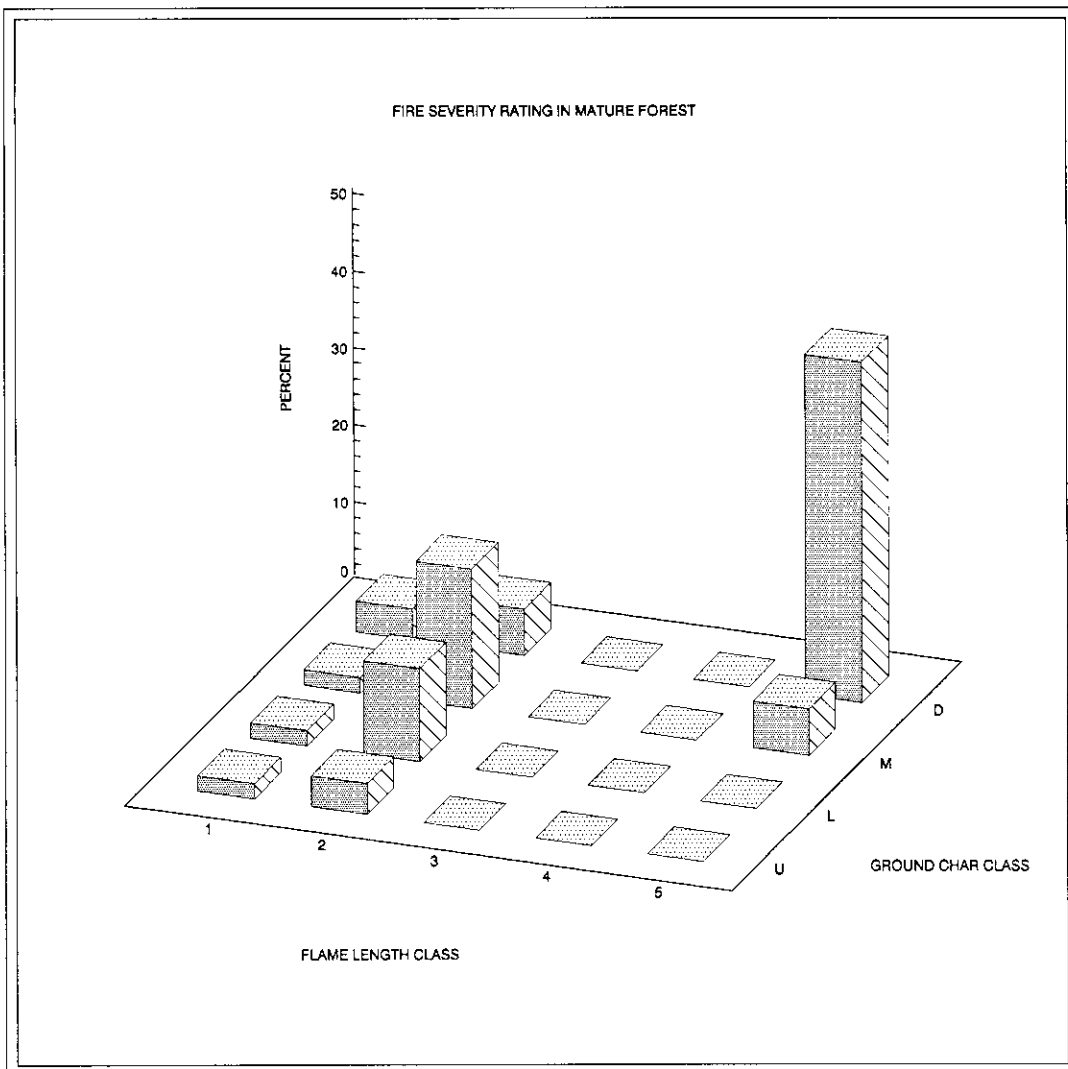


Figure 2. Distribution of 50 fire severity ratings (after Ryan and Noste 1985) recorded in 10 extensively managed, mature forest stands, near the North Fork Fire's origin (Fig. 1). Fifty percent of the estimates were assigned the highest flame length class, 44% with the deepest ground char and 6% with moderate ground char.

a limited field survey, we feel that our results are indicative of significant differences between fire characteristics in extensively versus intensively managed stands. Further, our results are in general agreement with Hardin's (1988) photo survey, which reported that 7% of sawtimber stands and 34% of regenerated stands in the North Fork burn "had escaped fire damage." Reasons for this contrast between mature forest and regenerated stands can be understood in terms of the fuel inventory distinctions.

The higher flammability of extensively managed, mature stands in the study area can, in part, be explained by the higher litter, small fuel loadings (< 7.6 cm), greater large fuel loadings (> 7.6 cm), and higher fuelbed depth as compared to intensively managed areas. Fuelbed and stand differences between mature and immature stands also provide insights into comparative fire effects on lands managed for preservation vs. multiple uses in the Greater Yellowstone Area (GYA).

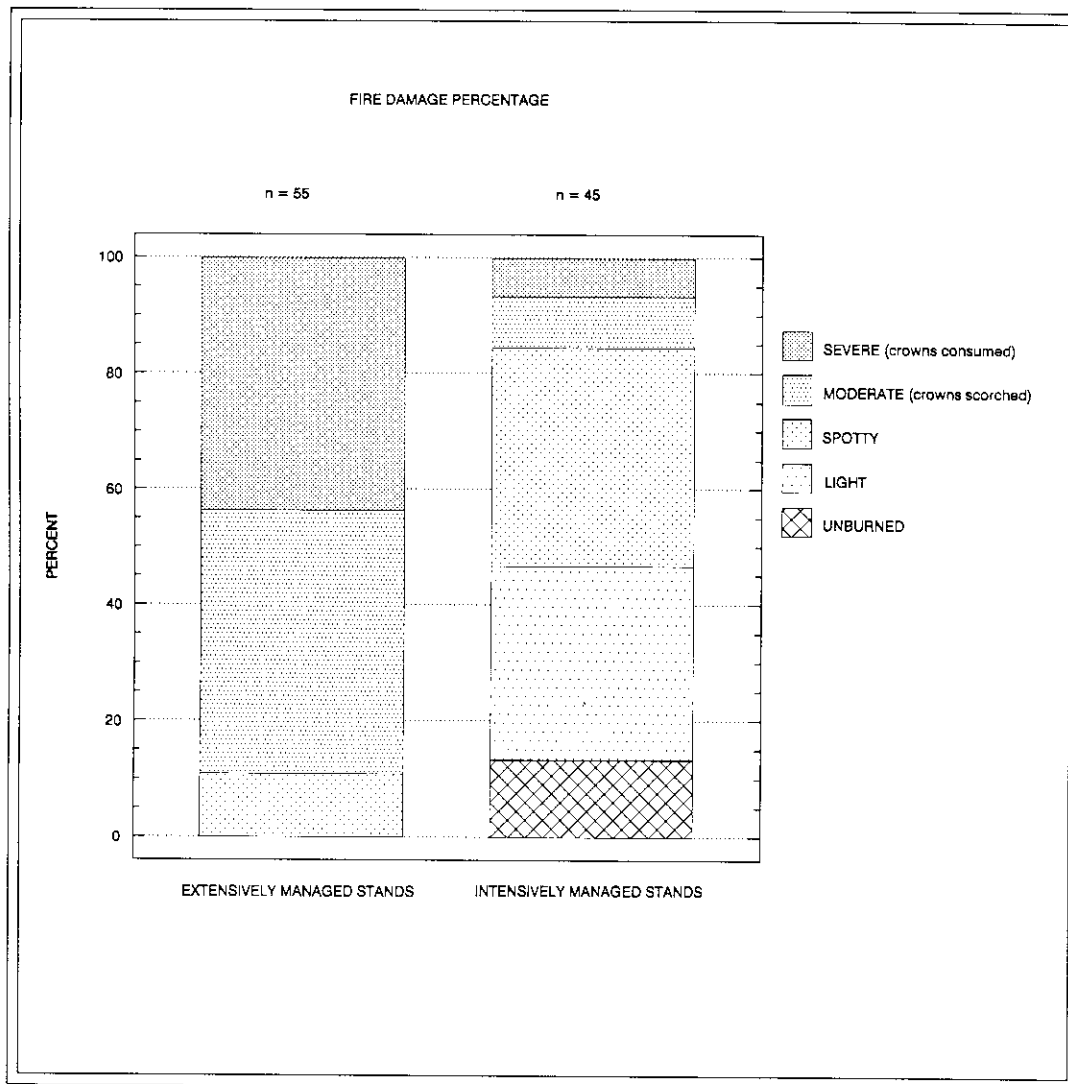


Figure 3. Distribution of fire damage ratings on 55 plots located in extensively managed, mature forest areas (by %), versus ratings on the 45 intensively managed, regeneration sites. Plots were located within the North Fork Fire perimeter, near the point of origin and subsequent burn areas (Fig. 1).

The higher loadings of small fuels and greater fuelbed depths may contribute to higher fire intensities in the mature forests. The higher levels of large fuels also provide a larger heat pulse after flaming, contributing to higher levels of fuel consumption, and greater severity and damage in the mature forest. Usually, large fuels do not contribute greatly to rate of spread and flaming characteristics (Burgan and Rothermel 1984). However, during the extended drought of summer, 1988, lower fuel moistures in large sound and rotten fuels may have

increased both fire intensity and depth of charring in the mature forest. Consequently, the mature forest endured greater fire damage than reproduction, even though fire severity was not uniform in extensively managed stands.

We did not observe the fire behavior during the North Fork Fire so we can only speculate about the differences in fire severity in mature forests vs. regeneration areas. In fact, we do not know for sure if fire spread was predominantly from reproduction into the mature forest, or vice versa. However,

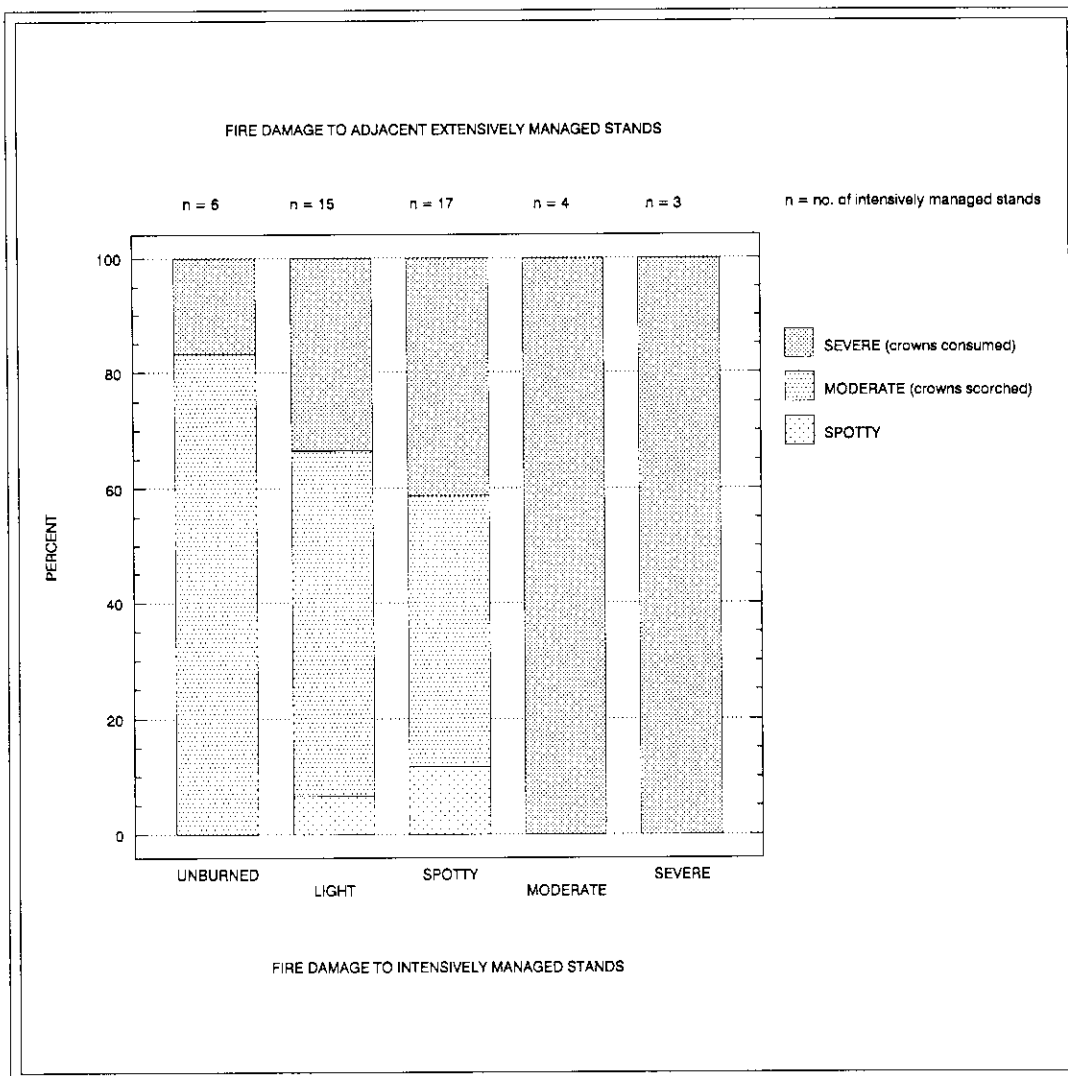


Figure 4. Conditional distribution of fire damage to adjacent extensively managed (mature) forest stands, given damage levels in 45 intensively managed (regenerated) sites. For example, where fire damage to regeneration was light ($n = 15$) or spotty ($n = 17$), 93% and 88% (respectively) of adjacent mature stands received moderate or severe damage.

regeneration areas did seem to abate the intensity, severity, and damage. Like Weatherspoon and Skinner (1989), we observed patchy burns in regeneration areas. Although localized damage did occur in regeneration areas, we likewise did not observe a general increase in severity from the edge inward.

We restricted our attention to fuel loading contributions to variations in fire severity and fire damage, although numerous other independent var-

iables might also be important. These include fine fuel continuity (surface and tree crown), elevation, aspect, slope, and crown diameter. In areas subjected to past fuel removal after logging, we also did not have information on time since logging/fuel treatment, fuel treatment method, or intensity of fuel treatment. We also did not account for the higher density of access roads in treated areas, which may have affected fire spread through the area.

Although collection of these data was beyond the scope of our survey investigation, we feel that

the North Fork Fire would have probably burned with greater localized intensity in the absence of fuel management activities. The fuel complex in intensively managed areas is simply less conducive to fire spread than a stand supporting standing and fallen dead trees, killed by the mountain pine beetle. Although natural decomposition would eventually reduce the fire hazard in the infested stand, judicious fuel treatment may be a more attractive alternative, especially in areas where public safety and resource utilization are high priorities.

Conclusions

The 1988 Yellowstone fires illustrated the dramatic contrast between prescribed natural fire strategies on national park and national forest lands. Ironically, high severity wildfires were tolerable under the national park's preservation philosophy; however, high severity fires were considered unacceptable on adjacent national forest lands managed for multiple uses.

Clearly, sound management practices are required if preservation and multiple-use policies are to co-exist in an area. It is not our intent to debate the merits of preservation vs. multiple use management in this paper. However, our data suggest marked distinctions in fuels and flammability between lands managed under these two philosophies. As a result, mature forest stands were more combustible and sustained greater fire damage than adjacent regeneration areas.

The mature forests were more combustible since they consisted of beetle-killed lodgepole pine trees. Timber removal reduced fire damage through disposal of large quantities of standing and fallen dead material. Thus fuels management accomplished through timber removal appeared to reduce fire damage, especially since harvest was followed by removal of residues. Apparently, flammability was lower in intensively managed areas since insufficient time had elapsed since harvest to allow accumulation of surface fuels, or tree mortality by insects and disease. Since environmental conditions (wind and moisture) supported severe fire behavior in adjacent mature stands, the reduction of fuels in intensively managed areas was at least partially responsible for their lower flammability.

While we have focused primarily on fuels and fire characteristics at the Park boundary, our findings could relate to strategies within YNP as well.

Within Park boundaries, fuel manipulation should be considered as an option for both unburned and burned areas. In unburned areas fuel hazards will continue to accumulate over time. Concurrently, the amassing snags and decaying materials may provide important habitat for insects, birds, and other wildlife. However, eventually a fire will break out, perhaps under drought conditions similar to 1988, and threaten life and property.

In burned areas, fire-killed trees will eventually fall over and could contribute to high fuel hazards in the future. Reduction of hazardous fuels should be considered especially near high-value resources or in strategic locations, such as around developed areas and private in-holdings, and adjacent to the Park boundary.

Both inside and outside Park boundaries, opportunities for managing fuels will be limited in the absence of tree removal. Within the Park, logging for fuel hazard reduction may be difficult to justify, especially over a large enough area to improve future large-fire management options. Large-scale prescribed firings alone probably will not represent a cost-efficient alternative. Still, some form of fuels management will be necessary in order to lower the flammability of mature forests. Outside the Park, fuels management through timber removal is more attractive, especially when costs can be covered by higher stumpage prices. Justification may prove difficult during periods of low stumpage prices (e.g., 1988 TNF timber sales were below cost), but the wood harvest is a major driving force in the local economy.

In short, many factors beside fuels and flammability must be considered when contemplating future management options in the GYA. Clearly, the existence of Yellowstone National Park affects management options and practices in adjacent national forests. At the same time, judicious fuel management at the boundary will be essential in order to improve management options within the Park.

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