Historical Perspective on the Yellowstone Fires of 1988

A reconstruction of prehistoric fire history reveals that comparable fires occurred in the early 1700s

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Maintaining an ecosystem shaped primarily by natural geological and ecological processes is a primary goal in Yellowstone National Park (YNP) (Houston 1971). Thus, one important question about the fires of 1988 is whether they were really natural: Did they behave as they would have if Europeans had never entered the area? The park had a policy of complete fire suppression from 1872 to 1972, so past fire control may have led to abnormal fuel conditions and therefore to abnormal fire spread and behavior in 1988 (Dodge 1972, Kilgore and Taylor 1979). In this article, we compare the fires of 1988 with fires during the previous 350 years. We use both information contained in park files and results of our tree-ring research on the prehistoric fire history.

The extensive fires of 1988 should not be viewed as an abnormal event

Fire History

We reconstructed the history of fires in a 129,600-hectare study area located on the subalpine plateaus in south-central YNP (Figure 1). This area, comprising approximately 15% of the park, lies at an elevation of 2400 m and contains dry, infertile habitats on rhyolite substrates as well as more mesic and fertile habitats on andesite and lake-bottom substrates (Despain in press).

From color, low-level aerial photographs we constructed a map of forest patches. We then located in the field each patch that was more than 5 ha, and we collected increment cores (small, nondestructive samples of tree rings from which tree age can be estimated) from 5 to 10 dominant lodgepole pine trees, as well as from cross sections from any fire-scarred trees. Large patches (more than 100 ha) were sampled in at least two areas.

In the lab, we determined the dates of past fires from the fire-scarred sections using dendrochronological methods (Arno and Sneck 1977). Many patches contained no fire-scarred trees; in these patches we determined the date of the last fire from the ages of the dominant lodgepole pine trees.

Finally, we used our map generated from the aerial photographs to determine the areas burned (Arno and Sneck 1977, Heinselman 1973). Because rings are extremely narrow in most fire-scarred trees and fire-scarred trees were not present in many areas, we consider our estimated dates of fires during the last 300 years to be reliable only within one to three years. Therefore, we present the amount of area burned in 10-year intervals.

We also reconstructed the forest mosaics that probably covered our study area at various times during the last 250 years. First we classified the stages of postfire succession after canopy fires on the Yellowstone Plateau by sampling a sequence of stands burned at various times during the last 400 years (Figure 2, bottom). We then drew a map showing the stand age (number of years since the last stand-replacing fire) and successional stage in 1985 of each forest patch. For each patch, we calculated its stand age in 1735 and estimated its successional stage by using the ob-

Figure 1. Subalpine study area in south-central Yellowstone National Park.

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served relationship between age and stage. With this approach, we reconstructed mosaics of stand age and probable successional stage for our study area at 20-year intervals from 1735 to 1985. This work was an extension of an earlier study (Romme 1982, Romme and Knight 1982).

The 1988 fires burned more area than was burned in any previous 10-year period within our study area (Figure 2, bottom). The large extent of burn probably was due to weather conditions in 1988; the structure of the forest mosaic in 1988, which was a product of successional events during the last 250–300 years; and the effects of fire suppression in the twentieth century.

The summer of 1988 was the driest since recordkeeping began in YNP in 1886. April and May had been wetter than average, but precipitation in June, July, and August was 20%, 79%, and 10% of normal, respectively (NPS 1988). By late July, the moisture content was as low as 2–3% in dry herbs and dead twigs and 7% in larger dead woody fuels. These dry fuels, combined with high temperatures and extraordinary winds produced by a series of dry high-pressure systems, created some of the most severe burning conditions observed in this century (NPS 1988).[1]

The forest mosaic provided a fuels complex in which fires could burn intensely over large areas under these weather conditions. Our reconstructions indicate that it may have been nearly 300 years since the Yellowstone landscape had been composed of such a flammable mix of forest stands. Figure 2 (top) shows the percent of our study area covered by different forest successional stages (Figure 3) at various times during the last 250 years.

Lodgepole pine (*Pinus contorta*) is the most common tree in YNP, and Despain (in press) has characterized stands there by their age and state of development. Recently burned forests, until the time of canopy closure (approximately 40 years), are classified as LP0. In these forests, large logs do not burn easily and live fuels are usually too green, and small dead fuels too sparse, to carry fire readily. Stands dominated by densely clustered, young, even-aged lodgepole pines are classified as LP1. Fuels on the forest floor are generally sparse, although some large, rotten logs remain from previously fire-killed trees. Crown fires propagate only in extremely windy conditions. This successional stage lasts from approximately 40 to 150 years postfire.

Even-aged closed canopies of lodgepole pines with a developing understory of Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) are classified as LP2. This stage lasts from approximately 150 to 300 years after a fire. Fuels on the forest floor are sparse to moderate, and flammability begins to increase in the later portions of this stage. Finally, LP3 stands have pine, fir, and spruce of all ages. This stage persists until the next stand-replacing fire. Young spruce, fir, and dead fuels are dense enough to propagate crown fires under dry conditions even without wind.

The earliest successional stages, (LP0, LP1, and the initial period of LP2) which are comparatively less flammable than the older stages (Despain in press, Despain and Sellers 1977), were the most common successional stages in our study area from the mid 1700s through the 1800s. The more flammable older stages have dominated since the early 1900s.

Several extensive fires occurred in our study area between 1690 and 1710 and again between 1730 and 1750 (Figure 2, bottom). Although more recently some fires have occurred in every decade, there were no very large fires, comparable to those of the early 1700s, until 1988. Note that during most of this period there were no Europeans in the region to influence the fire regime. Native Americans had a significant influence on fire frequency in many parts of North America (Barrett 1980, Pyne 1982), but, although their role in high-elevation forests of the Yellowstone region is not well understood, they probably had only a minor influence there. Existing data (Taylor 1964) suggest that Native Americans used the warmer and more productive landscapes at lower elevations more extensively than the high plateaus. Moreover, even if Indians were numerous in our subalpine study area, their major effect on fire history probably was in igniting fires, and ignition sources appear to be far less important than weather and fuel conditions

[1]R. Rothermel, 1989, personal communication. Intermountain Research Station, USDA Forest Service, Missoula, MT.

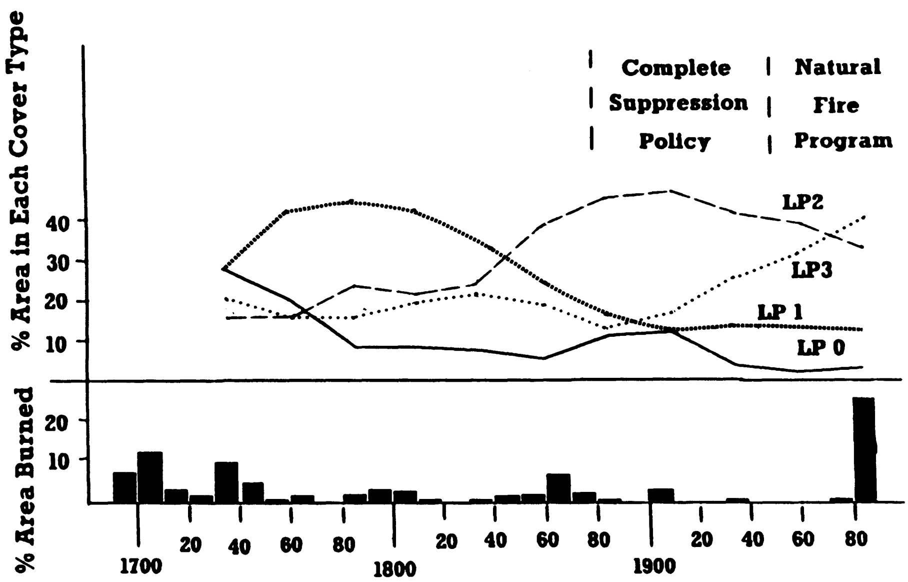

Figure 2. Top: Percent of the study area burned by stand-replacing fires in each decade from 1690 to 1988. **Bottom:** Percent of the 129,600-hectare subalpine study area covered by each successional stage from 1735 to 1985. The area covered by meadows, water, and other constant features of the landscape are not included in the figure (Romme 1982). The reconstructions extend back only to 1735 because extensive fires around 1700 destroyed the evidence necessary to reconstruct earlier landscape mosaics.

in determining fire-return interval in this ecosystem.

Why fire activity had been low

We suggest that one important reason for the low level of fire activity during the last 250 years was that the forest mosaic was composed largely of early to middle successional stages, so it had relatively low flammability. Lightning probably ignited fires every summer, but, due to unfavorable fuels complexes, fires were unable to spread over large areas. It is also possible that there simply were no years from 1735 to 1987 with weather conditions as dry and windy as 1988. We cannot tell, because tree rings indicate moisture and temperature conditions, but not wind.

Fires as extensive as those of 1988 probably could have been supported by the vegetation in any year after approximately 1930 (Figure 2, top). We suggest that they did not occur until 1988 because of summer weather conditions and human fire control efforts.

How important was suppression? Park records reveal that lightning ignitions have occurred every summer. Even without suppression, most of these ignitions fail to spread. They occur either in a fuels complex that cannot support fire spread or during a period of wet weather. From 1972 through 1987, 235 lightning-caused fires (an average of 15 per year) were allowed to burn without interference in Yellowstone National Park.[2] All but 15 of these fires (94%) burned less than 40 ha and only 8 (3.4%) were larger than 400 ha. Moreover, only in 5 of these 16 years did the total area burned in the park equal more than 40 ha, and in only 2 years did it exceed 4000 ha.

Organized fire suppression efforts in YNP began in 1886. These early efforts probably were fairly effective along roads and major trails, but they probably had little effect in remote areas on the high plateaus until after World War II, when new fire-fighting methods and technologies became widely available. Written accounts in park records from before the 1940s suggest that often by the time a crew hiked into an inaccessible area, the fire either had gone out or had grown to such a size that it could not be extinguished with the hand tools available.

By the mid-1970s, Yellowstone, Grand Teton National Park, and several of the adjacent National Forest Wilderness Areas had new fire management policies that permitted some lightning-caused fires to burn without interference in backcountry areas (Despain and Sellers 1977). Therefore, the period of consistent fire exclusion in most of Yellowstone National Park, from the mid 1940s until the mid-1970s, spanned approximately 30 years. Even during the

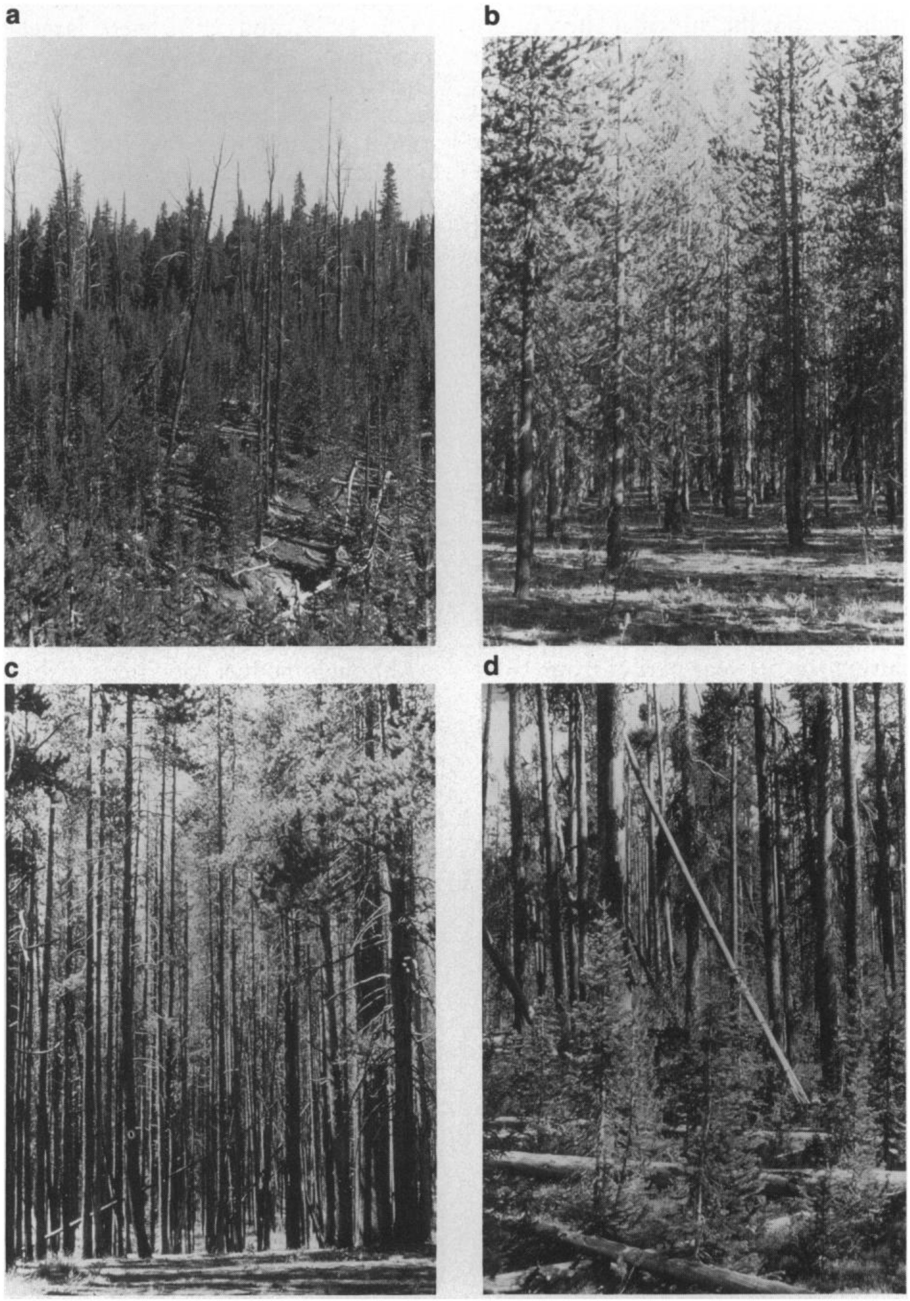

Figure 3. Forest successional stages in Yellowstone National Park (Despain 1989). See Taylor (1969) for additional discussion on flammability. **a.** LP0: recently burned stands up to the time of canopy closure (0–40 years postfire). **b.** LP1: stands dominated by dense, young, even-aged lodgepole pine (*Pinus contorta* var. *latifolia*) (40–150 years postfire). **c.** LP2: even-aged, closed canopy of lodgepole pine stands with a developing understory of lodgepole pine, subalpine fir (*Abies lasiocarpa*), and Engelmann spruce (*Picea engelmannii*) (150–300 years postfire). **d.** LP3: all-aged stands of pine, fir, and spruce, which persist until the next stand-replacing fire.

[2]Unpublished fire records on file at Yellowstone National Park, WY.

effective suppression period, fires burned hundreds of hectares in some years—1946, 1949, 1953, 1960, 1961, and 1966 (Taylor 1973).

The effect of fire suppression

How then did these 30 or so years of attempted fire exclusion influence fire behavior in 1988? Our data (Figure 2) indicate that the principal effect of fire suppression was to delay the onset of a major fire event, which probably was inevitable given the nature of the fuels complex that had developed since the last extensive fires in the 1700s. Large fires might have burned during the six dry summers from 1946 to 1966 had all lightning-ignited fires not been suppressed. However, these fires probably would not have been as extensive as the fires of 1988 because the weather conditions were less severe. If some of the area that burned in 1988 had burned in those previous years, the 1988 fires might have been smaller.

From this perspective, the fires of the late twentieth century were comparable, in total area burned, to the fires of the late seventeenth and early eighteenth centuries. Stand-replacing fires burned 34% of our study area during the 50-year period from 1690 to 1739, and 26% of our study area during the 49-year period from 1940 to 1988 (Figure 4).

An important difference is that nearly all of the area burned in the most recent half-century was burned in one year rather than being spread out over a few major fire years. What may be the ecological effects? Increased landscape homogeneity could result if a large, single burn was uniform (Turner 1988). However, in many areas, the 1988 burns were quite patchy due to spotting behavior and variation in fuel conditions and topography. This patchiness, combined with differential rates of succession, will maintain a considerable level of heterogeneity in most of our study area.

Were the 1988 fires abnormal?

There are three indications that fire behavior, in terms of heat release, flame height, and rate of spread, was similar in 1988 and in the 1700s. First, we identified even-aged lodgepole pine forests, covering thousands of hectares, that originated after past fires (e.g., in 1703); such stands apparently develop only after severe fires that kill all aboveground biomass and consume much of the organic matter of the forest floor, as occurred in 1988. Second, the differences in fire behavior in 1988 and in uncontrolled lightning-caused fires in 1976, 1979, and 1981 were largely quantitative rather than qualitative. These earlier, uncontrolled fires were as intense or nearly so and spread almost as rapidly as the 1988 fires, but they maintained high intensities and rates of spread for much shorter times. Third, 30 years of fire exclusion does not appear to be long enough to create abnormal fuel conditions in these forests characterized by centuries-long intervals between fires. The accumulations of dead woody fuels observed before the 1988 fires are typical of late successional lodgepole pine stands (Brown 1975). Indeed, early explorers in Yellowstone described dense tangles of dead and fallen trees (e.g., Strong 1875, Langford 1905), long before fire suppression could have produced abnormal changes in fuels.

Although the fuel conditions within any individual stand probably were not abnormal, the extent and continuity of flammable old-growth stands may have been greater in 1988 than they would have been with no previous fire suppression. Because earlier large fires would have created patches of less flammable early successional stages, the more continuous landscape in turn may have allowed the fires in 1988 to burn a larger total area than if fires had burned without interference during the effective suppression period. The actual effectiveness of such hypothetical fire barriers is difficult to assess, however, because in August and September 1988 the fires were jumping over and burning through areas up to 1600 ha that had burned just 10–50 years earlier. Finally, our landscape reconstructions (Figure 2, top) do not show an abrupt change in the landscape mosaic corresponding to the onset of fire suppression; rather they show a continuation of successional dynamics that were initiated almost 300 years earlier.

We conclude, therefore, that the fires of 1988 should not be viewed as an abnormal event. Some of the fires were unnatural in terms of ignition source (three of the eight major fire complexes were caused by people, and these fires were responsible for roughly half of the total area burned). However, numerous lightning ignitions occurred in the vicinity of the human-caused fires in late July and August of 1988. If the human-caused fires had been eliminated and these lightning fires had been allowed to burn without interference, they might have burned a comparable area, although the spatial distribution would have been different.

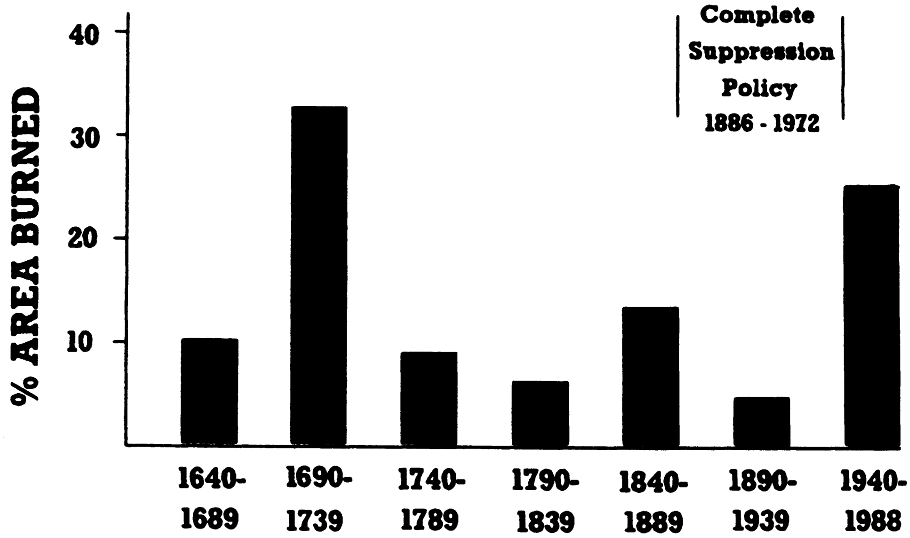

Figure 4. Percent of the area within the study area that burned during each half-century interval from 1640 to 1988.

In terms of total area burned and fire severity, the 1988 fires evidently were similar to those around 1700. Past human actions, mainly fire suppression, had some influence on the size and behavior of the fires in 1988, but these large fires were the result primarily of drought and wind conditions, as well as of normal successional dynamics following the last major fires approximately 280 years ago.

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