

AN ANALYSIS OF FOREST FIRE HISTORY ON THE  
LITTLE FIREHOLE RIVER WATERSHED, YELLOWSTONE  
NATIONAL PARK

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Objectives

Fire is now recognized as a major process in Rocky Mountain coniferous forests, with many ecosystem patterns and processes being affected as much by fire as by climate and soil. For this reason there is a move toward reinstating fire as a natural process within our National Parks and Wilderness Areas, a move which is proceeding cautiously, however, because there is still much that we do not know about fire's natural role in ecosystems. In Yellowstone National Park, where a fire management plan is now in effect, an important question is: What is the natural frequency and size of wildfires in different Park ecosystems? An understanding of natural fire frequency and size is important not only in formulating and evaluating fire management plans, but also in evaluating long-term effects of fire on wildlife habitat, productivity, nutrient cycling, and other ecosystem processes.

The purpose of the present study is to determine the historical frequency and areal extent of large fires in the lodgepole pine forest zone of Yellowstone National Park. Specifically we are working on the following objectives:

1. To construct a map of forest stand age on the watershed of the Little Firehole River.
2. To determine the incidence of major fires on the watershed during the last 3 or 4 centuries, and the average area or proportion of the watershed burned during any specified time interval.
3. To estimate fire frequency, i.e., the time interval between successive fires on any particular site.
4. To measure changes in stand structure and fuel accumulation following a destructive fire.

Procedures

Location of study area: The Little Firehole River watershed covers an area of about 150 km<sup>2</sup> on the Madison Plateau just west of the Upper Geyser Basin (USGS "Old Faithful" and "Madison Junction" quadrangle maps). Elevation ranges from 2210 m to 2680 m, with most of the area lying between about 2425 m and 2500 m. Geologic substrate is rhyolite, with soils developing on unmodified bedrock, glacial till, or alluvium (U. S. Geological Survey 1972). Vegetation is primarily lodgepole pine forest,

with small patches of spruce-fir forest at higher elevations and sub-alpine meadows on some alluvial sites.

Sample sites were selected in the field to delineate borders between stands of different ages, and to sample forest structure and fuel accumulation in stands representing a broad range of age and site characteristics.

Sampling: Stand age was estimated by aging several dominant, un-suppressed canopy trees with an increment corer. Cores were taken from at least 5 trees whenever possible, although in many older stands most of the dominant trees have rotten centers and fewer than 5 suitable cores could be obtained. In even-aged stands the age of the oldest tree sampled was considered to be the approximate age of the stand. In non-even-aged stands, other stand characteristics were used in addition to tree age to estimate stand history and age. These characteristics included stand structure and species composition, fuel accumulation, fire sign, and tree ring growth patterns (Romme 1977). Where available, living fire-scarred trees were sampled by drilling an increment corer into the dead wood of the scar and emerging through the living bark on the opposite side of the tree. The date of the fire was calculated by subtracting the number of rings on either side of the center. (This method gave the same results as wedge-shaped sections taken from the tree, however, the increment core method is less work and less damaging aesthetically. Where 2 or more stands appeared to lie within the same even-aged forest (i.e., they originated following the same destructive fire), their tree age and fire scar data were pooled to arrive at a more precise estimate of the fire date.

Fuels were sampled with the planar intersect method (Brown 1974). Density and basal area of living and dead trees of each species in a stand were estimated by tallying all stems in a single circular plot placed in a representative portion of the stand (Habeck 1974). Occurrence of bark beetle and mistletoe was also tallied in the plot. Site productivity was estimated by calculating site index (Alexander 1966, 1967) and/or habitat type (Steele et al. 1977).

### Results

Data analysis is not yet complete, and more data collection next year is needed to cover the entire watershed. However, some preliminary results are the following:

At least 14 major fires have burned on the watershed during the last 450 years. We have evidence of burns in ca. 1525, ca. 1650, ca. 1660, ca. 1695, ca. 1730, ca. 1739, 1752, ca. 1760, 1764, 1794, 1810, 1837, 1853, and 1949. The boundaries of these fires will be determined with additional field work and the study of low altitude aerial photographs provided by the National Park Service. Most of the area sampled thus far has burned during the last 450 years, although one relatively large patch of spruce-fir forest on a sheltered northeast-facing slope has not burned for at least 500 years. Fire incidence apparently has not been uniform during the last 450 years. Between 1525 and 1695 the average

fire interval is 57 years; between 1695 and 1853 the average interval is 17.5 years; and between 1853 and 1949, 96 years.

Preliminary fuel data indicate a correlation between stand age and fuel accumulation. More data are needed to clarify which age-related stand characteristics account for the changes in fuels with time, and any other factors (e.g. site factors) that also influence fuel accumulation and decomposition.

### Discussion

The burns located thus far represent only major destructive fires which covered a relatively large area. Certainly many more very small fires have occurred during the last 500 years, but they have left little or no evidence of their occurrence. Current research by the National Park Service on 36 natural fires in Yellowstone Park between 1972 and 1976 indicates that only a small percentage of lightning fires ever burn more than a few hectares (Despain and Sellers 1977). However, from a watershed perspective the infrequent large burns may be the most important; they are the events which trigger cyclic changes in wildlife habitat and ecosystem processes (productivity, nutrient cycling) over a large area.

Fire frequency on a particular site is much more difficult to determine than fire incidence on a watershed. Large fires in the lodgepole pine and spruce-fir forest zones usually completely destroy an existing forest, and living relic trees within an even-aged stand of fire-origin are uncommon. Trees with basal fire scars are more common, but not all of these scars represent a significant fire event in the history of the stand. Where a fire-scar date coincided with the date of origin of an even-aged stand, we concluded that the fire which scarred the tree had also destroyed most of the surrounding stand and initiated a new cycle of forest regrowth. However, several fire scar dates bore no relationship to the age of the other trees in the stand. These scars probably represent isolated lightning strikes or fire brands which never affected more than a few trees in a very small area. A few useful fire scars and relic trees have been found which provide preliminary data for estimating fire frequency on a site. Field work next year will emphasize further fire scar and relic tree analysis.

Lightning strikes probably occur more or less at random throughout the Little Firehole River watershed. An important factor determining whether or not a particular lightning strike results in a major fire is the nature and abundance of potential fuel. Fire may not be able to spread in young lodgepole pine forests because they have not yet accumulated enough fuels to carry a fire, whereas older forests typically have fuel conditions conducive to a major fire (Despain and Sellers 1977). Preliminary fuel data from the Little Firehole River watershed support the thesis that fuel increases significantly with stand age. Additional fuel data will be collected next year to clarify the relationships between stand age or stage of development and accumulation of fuels of different size classes.

### Conclusions

Preliminary conclusions thus far are: (1) The Little Firehole River watershed is covered by a complex mosaic of forest stands of different ages, most of which originated following major fires during the last 450 years. Most stands are even-aged, with all of the trees dating from the last destructive fire. (2) Major fires have occurred on the watershed at intervals of from 4 to 125 years, with fires apparently having been more frequent during the eighteenth and early nineteenth centuries. (3) Total fuel accumulation increases with stand age.

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