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Fire history of the northeastern portion of Crater Lake National Park, Oregon

Abstract:

A fire history chronology extending for 480 years (1501-1981) was developed from tree ring studies of fire-scarred ponderosa and lodgepole pines growing in a 640 ha (1600 ac) study area in the northeastern portion of Crater Lake National Park. Fire control records were examined to compile a total of 25 lightning fires which burned and were suppressed in or near the study area during a 54-year period (1931-1984). Prescribed fire was introduced to the northern portion of the study area in the autumn of 1978 and to the southern portion in the late spring of 1980. Although fire-free intervals (MFIs) range from 1 to 41 years, short intervals are more frequent. Significant differences ($p < .05$) were found between MFIs for the pre-settlement period, prior to 1850 (MFI=4.4 years), the settlement period, 1851-1939 (MFI=2.0 years), and the effective suppression period, since 1940 (MFI=17.3 years). As evidenced by a historic photograph (circa 1920), an open forest existed near the study area during the early part of this century, with few understory shrubs and small trees. No extensive fires have occurred since the early 1900s, however, resulting in the accumulation of high loadings of live and dead fuels for a minimum of 60 years. Future lightning fires may be contained or suppressed by park management rather than being managed as prescribed natural fires.

Introduction:

The establishment of Crater Lake National Park (CLNP) in 1902 took place during the settlement period of the northwestern United States. The forest landscape mosaic included large historic burns which were noted and mapped during the early U.S. Geological Surveys of the forest reserves (Leiberg 1900). Although the actual dates for these fires are unknown, they probably occurred during the late 19th century and include the following sites within CLNP: Grayback Ridge burn above Upper Sun Creek, Upper East Fork of Annie Creek burn, and West Entrance Road burn. Forest fires in the mountains were common at the turn of the century and burned under a wide range of fire weather conditions until contained by fuel discontinuities or precipitation. By the 1920s, fire suppression activities were underway in CLNP. These activities included construction of two lookouts in the Park: Mount Scott Lookout, overlooking the east side of CLNP and adjacent national forest lands, was in place in 1924. The Watchman Lookout, scanning the forested watershed of the upper Rogue River, was completed in 1932. Organized fire suppression activities within park boundaries began in the 1930s. Perhaps of even greater significance were the early fire suppression activities on the adjacent national forests: Rogue River (formerly Crater), Winema, and Umpqua. These activities greatly reduced the probability that national forest fires would enter park forests. Today, fire policies of wildland-managing agencies of the federal government acknowledge the potential favorable ecological effects of fire. Prescribed fire as a management tool and fire as a natural process can both enhance resource values and management objectives (Kilgore 1973).

Investigation of fire's ecological role in ponderosa pine forests was pioneered during the 1950s (Weaver 1951, Biswell 1959). Within the National Park System, investigations of the role of fire were conducted in the 1960s in giant sequoia-mixed conifer forests in Sequoia-Kings Canyon National Parks (Hartesveldt 1964, Harvey et al. 1975).

In 1976, the first CLNP Fire Management Plan was approved. This plan included a prescription for natural fire which allows lightning-ignited fires to burn within remote areas surrounding the caldera rim of Crater Lake. Because the focus of the plan is on natural fire as a process and the long-term goal is to restore the natural role of fire, a need exists to understand fire history. A natural fire (Kilgore 1983) is a fire that, first, burns within the range of fire frequencies, intensities, seasons, distributions, and sizes found in that ecosystem prior to arrival of Euroamericans. Secondly, natural fire yields the range of fire effects and results found in that ecosystem prior to the arrival of Euroamericans. Information on historical fire behavior and effects is valuable toward understanding present-day vegetation and fuel load mosaics. In a forest dependent on fire disturbance for renewal, fire history is disclosed through the current age-class distribution. The distribution of fire intervals can be estimated using the negative exponential distribution of the age classes in the stand (Van Wagner 1978). Each area can be classified by its fire regime, which is characterized by historical fire frequency, intensity, size, and ignition sources.

Fire history is inseparable from human history (Pyne 1982, 1984). Presence of aboriginal man in the Crater Lake region is known to predate the climactic eruption of Mount Mazama 6840 years BP (Cressman 1981) or ca. 7700 years calibrated radiocarbon scale. American Indian and Euroamerican fires augmented those set by lightning. Thus, anthropogenic fire is a fundamental component of the fire regime (Franklin and Dyrness 1973, Pyne 1984). However, the actual influence of Indian-caused fires on vegetation remains unknown. Euroamerican settlement was preceded by early explorations. Both the 1826 Peter Ogden party and the 1843 Col. John Fremont party passed near Crater Lake. A later survey left this general account of the forest openness east of CLNP (Langville et al. 1903):

> **"In the yellow pine region bordering the timberless area of eastern Oregon the forest floor is often as clean as if it had been cleared, and one may ride or even drive without hindrance."**

Old photos (circa 1920) of CLNP forest vegetation also reveal an open forest floor devoid of shrubs and carpeted with needle litter. This openness indicates frequent understory burning.

Study Area:

Crater Lake National Park lies in the southern Cascade Mountains in south-central Oregon. The park's most spectacular feature is the deep blue lake, nearly 610 m (2000 ft) deep, located in the 1220-m (3000-ft) deep caldera formed by eruption and collapse of the composite volcanic mountain, Mount Mazama, 6840 years BP (Bacon 1983). The study area is in the northeastern corner of CLNP and is approximately 640 ha (1600 ac) in size. Elevations of the study site range from 1555 m (5100 ft) to 1677 m (5500 ft), and slopes vary from level to about 20 percent. The study area received a major dacite pumice deposit from ancient Mount Mazama. The soil series resembles the Lapine loamy coarse sand described bordering the study area (Dyrness and Youngberg 1966). Also in the study area, a Steiger soil type occurs where slope gradients are below 40 percent and elevations below 1829 m (6000 ft). These series are Regosols which have developed on aeolian pumice deposits. Both are dark brown coarse sand with a loamy, gravelly component (United States Department of Agriculture Soil Conservation Service 1973). Although the park's complex geologic history has been studied (Williams 1942, Bacon 1983), soil surveys have not been conducted within the park. The Mazama tephra deposit is characterized by an abrupt particle size discontinuity. The transition between the coarser upper layer which overlies finer pumice occurs within a 2 cm interval.

A weather station at Chemult, Oregon, approximately 30.4 km (19 mi) northeast of the study area receives average annual precipitation of 67.1 cm (26.4 in), including 406.4 cm (160 in) of snowfall. Chemult is at an elevation of 1451 m (4760 ft) in a zone of cold air drainage. Mean annual precipitation at the study area is estimated to be about 75 cm (29.5 in).

Forest vegetation of the study area is characteristic of the ponderosa pine/antelope bitterbrush habitat type (*Pinus ponderosa/Purshia tridentata* h.t.) (Volland 1976). A stagnated understory of ponderosa pine 2-3 m (6-10 ft) in height and 35-60 years old occurs within canopy gap areas. Aggregations of white fir (*Abies concolor* (Gord. and Glend.) Lindl.) occur on gentle slopes facing northeast or east. Occasional young stands of lodgepole pine (*Pinus contorta* ssp. *murrayana* (Balf.) Critchfield) are also established in the understory. Dead and down woody fuel loadings on this site range from 70 to 100 tons/ha (28-40 tons/ac). Several shrubs occur with the shorter but more widespread bitterbrush, including snowbrush (*Ceanothus velutinus* Dougl.) and greenleaf manzanita (*Arctostaphylos patula* Greene). Associated herbaceous species include long-stolon sedge (*Carex pensylvanica* Lam.), Ross sedge, (*C. rossii* Boott), bottlebrush squirreltail (*Sitanion hystrix* (Nutt.) Smith), western needlegrass (*Stipa occidentalis* Thurb.), and kelloggia (*Kelloggia galioides* Torr.).

Methods:

To determine the frequency of lightning fires in CLNP, fire suppression records and older fire reports were examined for the period May through October, 1931-1984.

Following fire history methodologies developed for analyzing tree-ring patterns to date fire scars (Arno and Sneck 1977, Stokes 1980, Madany, et al. 1982, McBride 1983), wedges bearing fire scars were selected from 33 live ponderosa and lodgepole pine trees within CLNP. The wedge-shaped sections were removed by sawing from a basal wound. In all cases, fire scars were distinguished from similar basal wounds by (1) the presence of charcoal, and (2) the pattern of overlapping scars and healing growth. Fire scars in selected lodgepole pines showed charcoal and thus were not the direct result of mountain pine beetle wounding, which may mimic fire scars (Stuart 1983). Each section was air dried, polished with sandpaper, and examined under magnification (10X) to count annual growth rings. Fire scars were dated, and mean fire intervals (MFIs) were computed for the presettlement, European settlement, and fire exclusion periods. The MFI was defined here as the number of years between two successive fire occurrences for the specified study area. Mean fire intervals for the pre-settlement and settlement periods were compared using the Student's t-test (a statistical test for significant difference between means). An attempt was made to dendrochronologically cross-date ring patterns, but the ring patterns were too complacent (not sufficiently sensitive or variable) to complete this procedure (Stokes and Smiley 1968).

***Results*:**

The CLNP Fire Atlas 54-year record of lightning fires shows that July and August are the most probable times for lightning fires (Fig. 1). It also reveals that during the past 54 years, 25 lightning fires were suppressed in or near the study area. (Not included in this figure are lightning fires suppressed on adjacent national forest lands. Some of these would probably have entered the study area if they had been allowed to burn.)

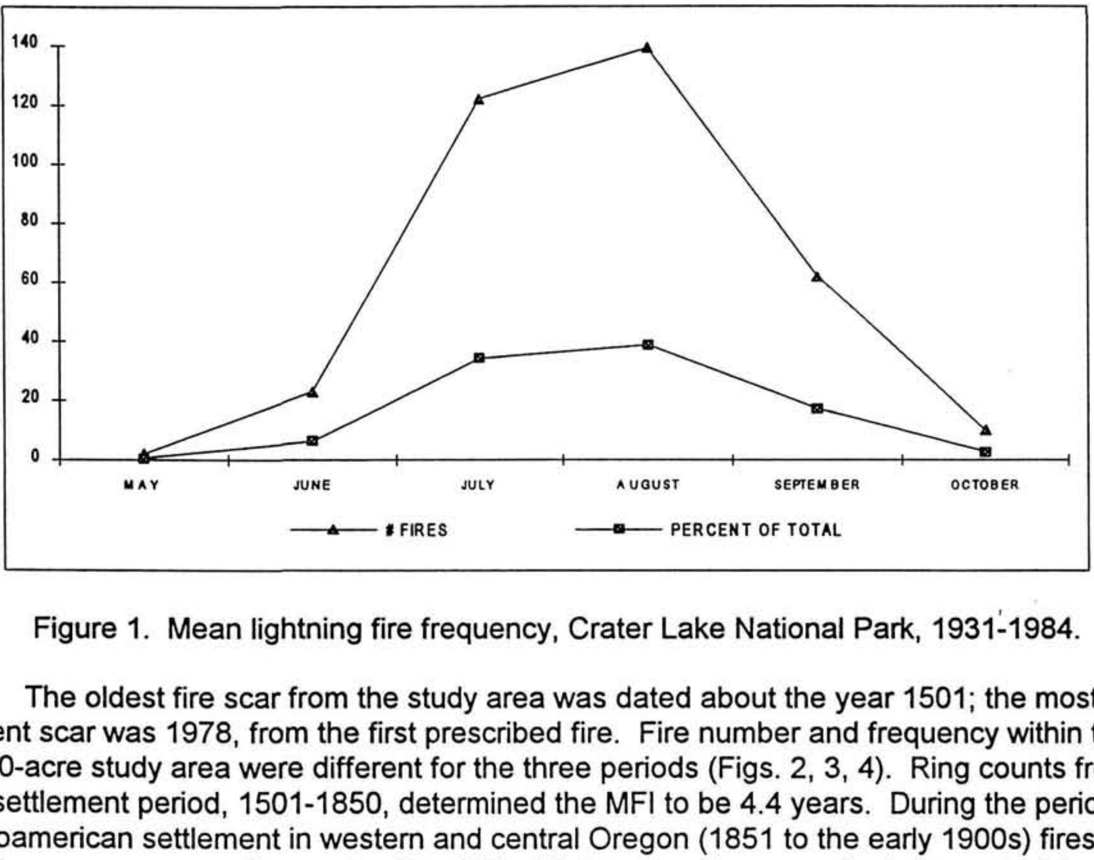

Figure 1. Mean lightning fire frequency, Crater Lake National Park, 1931-1984.

The oldest fire scar from the study area was dated about the year 1501; the most recent scar was 1978, from the first prescribed fire. Fire number and frequency within the 1600-acre study area were different for the three periods (Figs. 2, 3, 4). Ring counts from the presettlement period, 1501-1850, determined the MFI to be 4.4 years. During the period of Euroamerican settlement in western and central Oregon (1851 to the early 1900s) fires in the study area were more frequent, with a MFI of 2.0 years. However, the latter part of the presettlement period exhibited a fire frequency similar to that of the settlement period (Fig. 4). As expected, the suppression period showed the longest fire interval, 17.3 years (Fig. 3). The distribution of fire intervals is skewed to the right (Figs. 3, 4). Differences between MFIs for the three periods were statistically significant ($p < .05$).

***Discussion*:**

Historic fires in CLNP probably burned for weeks in forest fuels, under a variety of fire weather conditions. Certainly, each historic fire may not be significant ecologically, in the sense that substantial change results in the ecosystem. The amount and direction of change are greatly influenced by the timing of fires within the season and their intensity. Ignitions from lightning are most probable during July and August (Fig. 3). Fires ignited early in the season burn under changing weather conditions and display a range of fire behavior and fire effects. If drought prevails, where heavy fuel loads exist more intense fires would occur and may persist through the autumn.

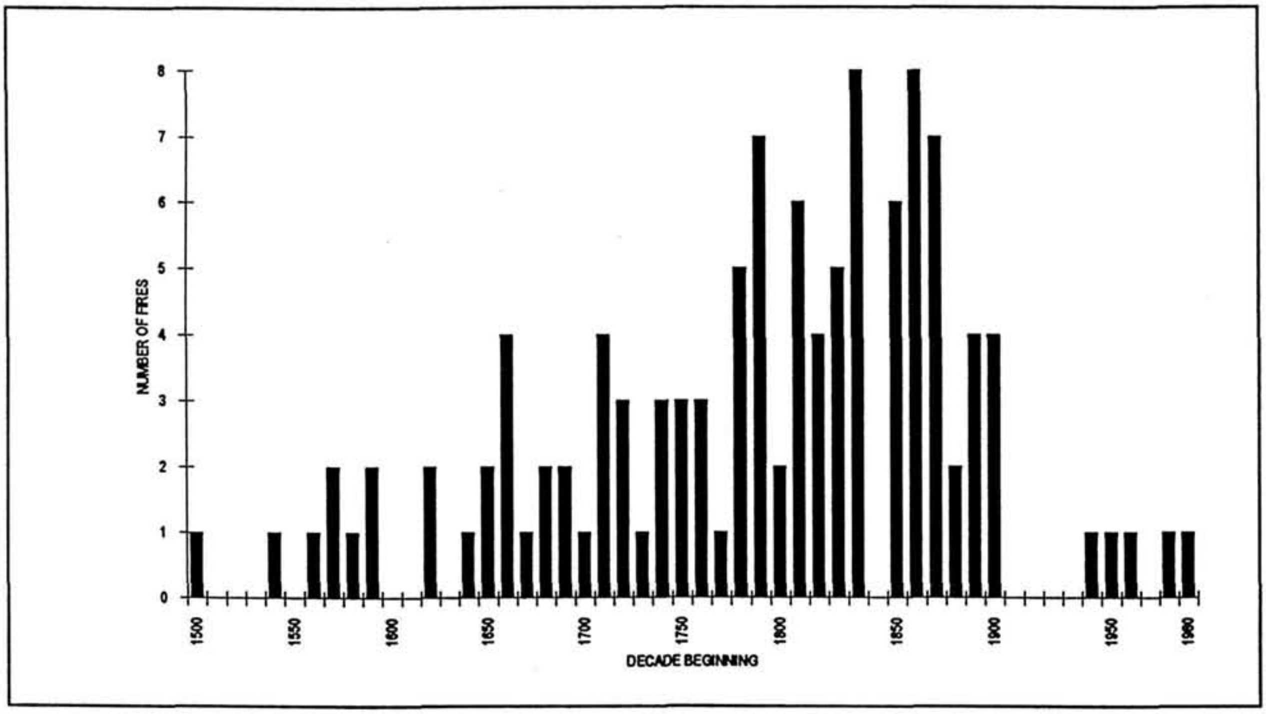

Figure 2. Fire number in old-growth ponderosa pine, NE corner, Crater Lake National Park.

Fire scar formation is the result of several interacting variables including fire behavior and tree sensitivity (Gill 1974). Not every tree will be scarred by each fire event, and portions of older fire scars may be consumed by subsequent burning. Therefore, a fire history based solely on fire scars provides a conservative view of the fire record. Among the limitations of information derived from sampling fire scars is sample size. Mean fire intervals are inversely related to the size of the sample area (Arno and Peterson 1983). Large sample units (stands) tend to yield short intervals whereas small sample units (trees) yield long intervals. Also limiting interpretation of fire-scar data are unknowns such as ignition source, actual area burned, and intensity and season of the fire.

Other sources of historical information are relevant to interpretations of fire scar data. Historic photos (about 1920) of similar forest vegetation one mi south of the study area, within the same habitat type, reveal an open forest floor devoid of shrubs and carpeted with needle litter. This openness indicates frequent understory burning. The widespread occurrence of an all-aged ponderosa pine forest in the study area indicates historically favorable seedling establishment conditions which may have been created through such underburning.

Mean fire intervals in the study area are comparable to those determined in other studies from similar forest types nearby (Soeriaatmadja 1966, McNeil and Zobel 1980). The ratio of lightning to man-caused fires is unknown, but lightning is now the primary ignition source, and it may have been the primary source in the pre-settlement period (Fig. 2). The data for the study area show the longest fire-free intervals early in the record when little information is available and late in the record during fire exclusion (Fig. 4). The 1978 prescribed fire ended at least 60 years of suppression activity. The apparent increase in fires during the settlement period and the accounts of Leiberg and Langville (Langville, et al. 1903) suggest that man-caused fires were very important at that time. The skewing of the distribution of fire intervals to the right in this study suggests man-caused fires and better fire reporting (Figs. 3, 4).

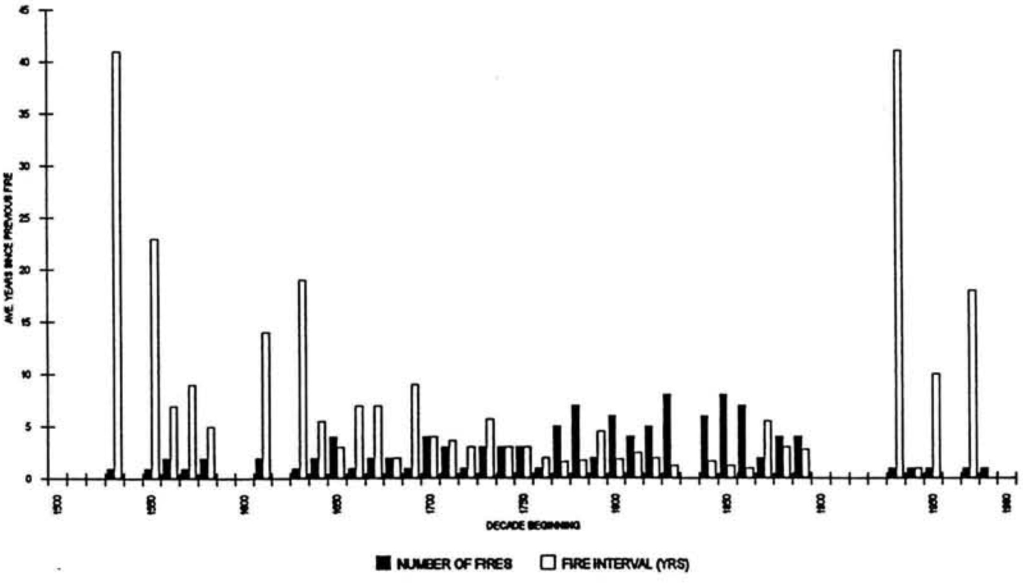

Figure 3. Fire history of old-growth ponderosa pine, NE corner Crater Lake National Park.

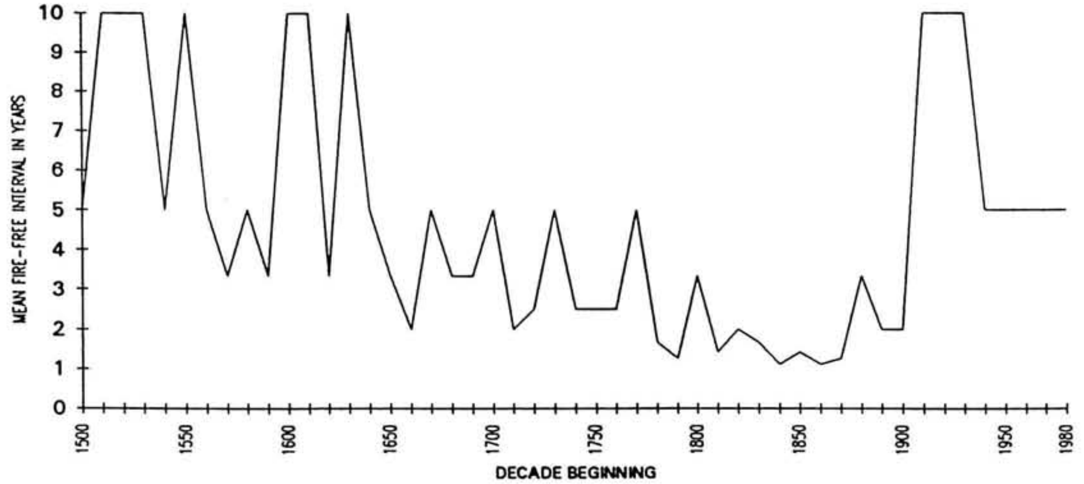

Figure 4. Fire frequency in old-growth ponderosa pine, NE corner Crater Lake National Park.

The fire cycle or natural fire rotation is an expression of the number of years required for all fires in an area to burn an amount of land equivalent to the total space in the area. For an area the size of the study area (540 ha, 1600 ac), the fire cycle is estimated to be a maximum of 50 years.

Conclusions:

A knowledge of fire history allows managers of natural areas to assess needs for fire and fuels management and to predict long-term vegetation changes. Management implications derived from fire history information must be carefully interpreted since the historical fuel/fire scene is complex and not easily reconstructed. Important to maintaining vegetation and fuel mosaics is a balance between allowing some lightning fires to burn and applying prescription fire. Although the MFI is useful for comparisons among study sites of similar size and fuels, it will be necessary for managers to simulate the pre-1850 distribution of fire intervals to achieve a natural mosaic of vegetation. Monitoring of dead and down woody fuel accumulations and vegetation changes is important to determine if management objectives are being achieved during the long-term program. Changes in stand structure and species composition which would have occurred under a natural fire regime are consistent with current policy management objectives for natural areas. A long-term monitoring program will provide the critical baseline information for understanding and evaluating future vegetation changes.

The role of fire exclusion needs to be better understood. Fire may be thought of as one climatic factor affecting vegetation change. Other climatic factors may affect plant population behavior and favor increasing densities of shade-tolerant *Abies* understories within broad ecotonal areas. There is some evidence that broad ecotonal areas (such as Panhandle habitat types) at CLNP would be dominated by *A. concolor* even without fire exclusion. The interpretation that *A. concolor* abundance represents an unnatural condition will require additional paleoecological research and a coherent monitoring program.

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4 graphs

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