Reconstructing Fire History of Lodgepole Pine on Chagoopa Plateau, Sequoia National Park, California[1]

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Abstract

Information on fire's role in pre-twentieth-century lodgepole pine forests of the southern Sierra Nevada is limited. It has generally been assumed that fire plays only a minor role in lodgepole's dynamics unlike in other portions of its range. This assertion was examined by sampling fire-scarred trees and reconstructing fire history in monospecific stands of lodgepole pine (*Pinus contorta* var. *murrayana* [Grev. & Balf.] Engelm.) on Chagoopa Plateau in the Kern River drainage of Sequoia National Park. Using dendrochronological methods 17 fire events were dated between A.D. 1385 and 2000. Prior to 1860 and Euro-American settlement, fire event dates showed mixed degrees of synchronization among sites with a number of widespread fires of the plateau. Mean fire return interval among sites was 45.4 yr, ranging from 31 to 74 yr by site. The frequency of past fire occurrence on the plateau indicates fire had a strong influence on this ecosystem, which continues through the present. These findings differ significantly from the generally held notion that fire does not play an important role in lodgepole ecosystems in the Sierra Nevada. Also of interest was a cluster of 1880s fire dates at sites near Sky Parlor Meadow suggesting burning around meadows by Euro-American shepherds.

Introduction

Prior to Euro-American settlement, fire occurred frequently in the Sierra Nevada and influenced the dynamics of most Sierra Nevada ecosystems (Kilgore and Taylor 1979, Skinner and Chang 1996). Fire histories derived from tree rings have shown variable fire-return intervals prior to Euro-American settlement (Kilgore and Taylor 1979, Swetnam 1993, Caprio and Swetnam 1995, Stephens 2001) but nearly all these results are from lower- and mid-elevation conifer forests. Change in this important ecological process, beginning with Euro-American settlement, has resulted in widespread impacts to Sierran ecosystems (Kilgore 1973, Parsons and DeBenedetti 1979).

Within the range of lodgepole pine, fire has been recognized as an important ecological process in the "interior" Rocky Mountain variety (*P.c.* var. *latifolia* Engelm. ex S. Wats.), with stand replacing fires occurring at 100-to-400 year intervals (Brown 1975, Arno 1980). This contrasts to the Sierra Nevada where fire has generally not been recognized as having had a significant ecological influence on monospecific stands of this species (Parker 1986, 1988; Rundel and others 1988, Rourke 1988, Lotan and Critchfield 1990, Skinner and Chang 1996). However, lodgepole in the Sierra Nevada has not been well studied and no fire history sampling has been conducted to examine past fire occurrence (Skinner and Chang 1996).

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The goal of this study was to document past fire occurrence patterns in monospecific lodgepole pine forests in the upper Kern River drainage of the Sierra Nevada. This information will improve our understanding of current and past vegetation composition and processes in this community. This paper will primarily review fire frequency patterns. Spatial patterns and climate relationships of fire occurrence were also examined but will not be addressed here due to space limitations.

Study Area

Chagoopa Plateau (4,379 ha) is located in the upper Kern River drainage in the southern Sierra Nevada (*fig. 1*). The plateau is bounded on the east by the Kern River Trench and to the west and south by the Big Arroyo drainage, both deeply incised by glacial activity. Vegetation on the plateau is dominated by lodgepole pine which grades into foxtail pine (*P. balfouriana* ssp. *balfouriana* Grev. & Balf.) on higher elevation sites and xeric conifer at lower elevations. Several meadow complexes also occur with Sky Parlor being the largest.

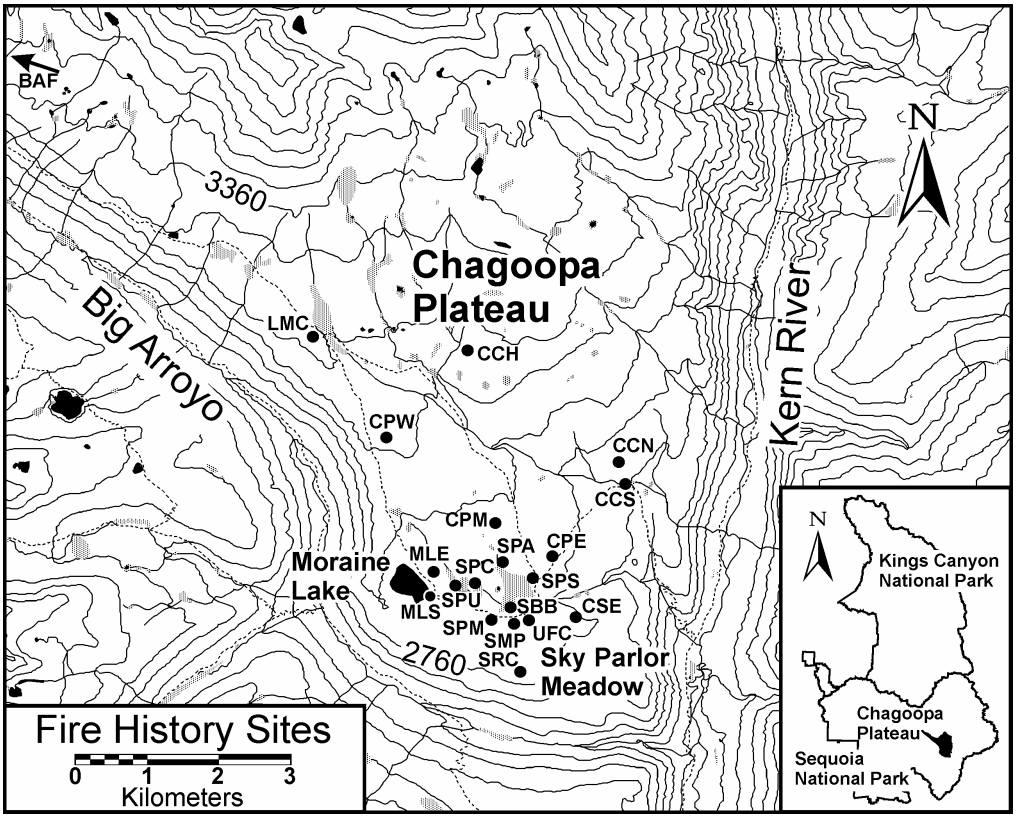

Figure 1—Map of Chagoopa Plateau (120 m contour intervals) showing location of fire history collection sites (black circles) and relative location of plateau within Sequoia National Park (inset). Lakes are shown as irregular black polygons, meadows as shaded areas, and trails as dotted lines. Site BAF is off the map to the west.

Climate of the area is Mediterranean with moist winters and dry summers. Total annual precipitation averaged 580 mm at the Crabtree Meadow weather station. Precipitation in the upper Kern is strongly influenced by the high ridges and peaks of

the Great Western Divide that create a strong rain-shadow effect on storm tracks moving west-to-east. Sporadic thunderstorms can produce a limited amount of summer moisture. Temperatures on the plateau are cool during the winter (January mean -6.7ºC) and moderately warm in the summer (mean 9.8ºC during August).

Methods

Samples were obtained from 20 sites on the plateau that were predominantly monospecific stands of lodgepole pine. Area encompassed by each site ranged from about 0.25 to 1 ha. Sites were selected to reduce possible effects of the size of area sampled or within site variations on fire frequency estimates (Arno and Peterson 1983). Sites were homogeneous with similar vegetation, topography, soils, and aspect. No obvious fire spread barriers were present within sites.

Samples were collected from multiple trees at each site since it is uncommon to find all fire events recorded by a single tree (Agee 1993). Potential samples were examined in the field for evidence of fire other than the catface scar to assist in determining whether scars were fire caused. Number of samples obtained at a site was determined by the amount and quality of available material. Samples were collected as either cores using methods described by Sheppard and others (1988) or as partial sections (Arno and Sneck 1977).

Samples were surfaced and crossdated using standard dendrochronological techniques (Stokes and Smiley 1968) allowing fire scars to be assigned to the calendar year of occurrence. Mean fire return intervals (MFRI) were determined for each site (a site was considered a replicate and individual trees sampled as subsamples) based on the number of times the site (considered a point on the landscape) had burned over a specific time period.

Results and Discussion

Nineteen sites were sampled (18 on the plateau and one in Big Arroyo) with samples collected from 93 trees. An additional set of samples from the Funston Cabin (cores from seven logs) also provided evidence of past fire from growth suppressions apparent in the tree-ring series. Sample size varied from three to fourteen fire-scarred trees per site (with one exception at site MLS where only one tree was sampled). Cross dating was successful on 81 (87 percent) of the scar samples.

Fire scar dates spanned the period from 1455 to 1996 (tree-ring series from samples spanned the period from A.D. 1385 to 2000). However, prior to 1751 only a single recorder tree was sampled and fire history and frequency estimates become less reliable. A total of 186 fire indicators (scars or other fire related markers such as growth suppressions) were found on the 88 trees crossdated and these indicators recorded 17 fire event dates. Six of these event dates were widespread and found at multiple sites while 11 were found at single sites. Pre-Euro-American settlement MFRI by site ranged from 31 to 97.8 yr (average for plateau was 50.1 yr) for the full period of record prior to 1860 and 31 to 74 yr (average for the plateau was 45.4 yr) for the period from 1744 to 1860 (*table 1*). For the latter period, during which there were many replicate samples, individual fire return intervals ranged from 9 yr (one site recorded both the 1806 and 1815 fire events) to 74 yr.

Table 1—*Summary of fire history information by site prior to 1860 with mean fire return intervals (MFRI), number of intervals, and range in years of individual intervals between fires.*

Site	Mean fire return interval		
	Interval (no.)		Range (yr)
Meadow sites (6)	47.5	(2)	31–64
SMP	31.7	(3)	9–55
SPU	49	(2)	34–64
MLS	-	(0)	-
MLE	64	(1)	-
CPE	40	(1)	-
CPM	31	(1)	-
CSE	97.8	(4)	40–155
SRC	48.0	(2)	41–55
CCS	74	(1)	-
CCN	-	(0)	-
CPW	31	(1)	-
CCH	40	(1)	-
LMC	-	(0)	-
BAF	-	(0)	-

Widespread fires burned across large portions of the plateau in 1751, 1806, 1815, 1846, and 1996. These five fire event dates, found at multiple sites, indicate fire spread over variable and moderate-to-large areas of the plateau. This suggests fuel loads were sufficient to carry a fire and/or that extreme burning conditions existed. The eight sites recording the 1751 fire were confined to the southwest portion of plateau. Early in the nineteenth century, two mutually exclusive fires occurred within nine years of one another. Sites recording the 1806 fire (six sites) were located on the eastern portion of the plateau and those recording the 1815 date (eight sites) on the western portion. The 1846 fire event was recorded at 14 sites located across the eastern and northern portion of plateau. The fire in 1996, recorded at 13 of 15 sites within the burn perimeter, was lightning caused and burned 1,115 ha on the plateau.

Six single-site event dates were recorded prior to 1860. Dates prior to 1751 (1455±, 1610, and 1744) were from a single recorder tree at CSE. Prior to the 1880s other single year dates were found in 1772, 1847, and 1849. These events may have been: 1) small fires, 2) fires that burned adjacent to the plateau and only burned a small area on the plateau, 3) larger fires where the record was lost or 4) large fires that were missed by the current site localities. Post-1860 fires at single sites were recorded in 1867 and 1989.

Also of interest was a cluster of fires during the 1880s (1882, 1885, 1887, 1889) at sites around Sky Parlor Meadow. All 10 sites recording these events were within 500 m of Sky Parlor or an associated meadow. The number of fires recorded during this 7 yr period, coupled with reports of the utilization by shepherds, strongly suggests the fires were human-caused and probably related to grazing. Many reports from the period allude to shepherds burning areas in the fall as they left the mountains to improve grazing conditions (Barrett 1935 in Vankat 1977).

It is currently unknown whether fire return interval patterns found in the lodgepole community on Chagoopa Plateau are representative of lodgepole throughout the southern Sierra Nevada. The FRI values for lodgepole forest on

Chagoopa Plateau are intermediate between those reported for closely associated red fir forest (MFRI 15 to 30 yr) and xeric conifer forest (MFRI 30 to 60 yr), and generally higher elevation subalpine conifer forest (MFRI 187 to 374 yr) found in the parks (Caprio and Graber 2000).

The frequency of pre-Euro-American fires on Chagoopa Plateau was unexpected. Assumptions about fire regimes in this community have usually suggested that fire was rare or that fires were small and not important (Lotan 1975, 1976; Rundel and others 1988) or that frequencies were long–in the order of every 100 to 200 years (Vankat 1977, Caprio and Graber 2000, van Wagtendonk and others 2002). In Yosemite National Park, Parker (1986, 1988) found little evidence of fire in lodgepole pine stands that were studied. This contrasts markedly with the results from the present fire history analysis. The importance of fire in lodgepole in the southern Sierra was also suggested by Keifer (1991), who examined age structure of lodgepole near Rock Creek, immediately east of Chagoopa Plateau. This study found pulses of regeneration closely linked to specific fire dates. Overall, these regional differences suggest there may be geographical variation in the importance of fire in Sierran lodgepole pine communities and that these may vary over fairly short distances.

A question that cannot be answered by the current results is what past patterns of fire severity occurred across the landscape. The many trees with multiple fire scars indicate that fires were often not stand replacing. Observations of the sampled stands indicate a mixed severity regime. The stand age patterns found by Keifer (1991) in Rock Creek also indicated a mixed fire severity pattern with pulsed recruitment and even-aged patches. Severity patterns might also be inferred from contemporary fires such as the 1996 Big Arroyo Fire. Descriptions of this fire by National Park Service fire monitors (Monica Buhler personal communication) indicate fire behavior varied between low intensity surface fire that would flare into a high intensity stand replacing canopy fire when conditions warmed and moderate to high winds occurred.

Conclusions

It has generally been assumed that fire was not common in monospecific lodgepole pine forests of the Sierra Nevada and thus played an insignificant ecological role. However, results from this fire history study contrast with this view. It suggests fire's role in lodgepole pine, in at least some areas of its range in the Sierra Nevada, may be quite different than expected and that it may have a significant ecological influence. The geographic differences that exist may relate to local variations in site productivity and the frequency and scale of disturbance.

The results also have important management implications. First, they begin to establish reference conditions for fire and its natural range of variability in this forest type in the southern Sierra Nevada. They show that widespread fires can occur in lodgepole pine-dominated forest types in this region. Lastly, they reflect how variable pre-Euro-American fire regimes and their relationships to vegetation dynamics can be. Even within nearby portions of the Sierra Nevada, care needs to be taken when extrapolating fire history results away from the local area sampled. This variability is a result of complex climatic, topographic, historic, and biotic interactions that can vary over fairly short distances. As of yet, we do not have sufficient baseline information to allow us to fully understand how these components interact to produce a specific fire regime.

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