Great Basin Naturalist

Volume 48 | Number 1 Article 9

1-31-1988

Fire history of Paunsaugunt Plateau in southern Utah

Steven J. Stein
University of Colorado, Boulder

FIRE HISTORY OF THE PAUNSAUGUNT PLATEAU IN SOUTHERN UTAH

Steven J. Stein[1]

ABSTRACT.—A fire history of the Paunsaugunt Plateau in southern Utah was developed using dendrochronological methods. Fire frequencies of individual ponderosa pine trees from three sites on the plateau varied from 19.5 to 47 years. Composite fire intervals for the three sites ranged from 15.2 to 18.4 years. The last recorded fires in these study areas occurred in 1892, 1902, and 1911, corresponding to the initiation of fire suppression policies in the West. The absence of fire since 1911 may be contributing to a recently documented decrease in ponderosa pine regeneration within the high-elevation, mixed-coniferous forests of the Paunsaugunt Plateau.

Fossil charcoal in both Tertiary and Carboniferous coal deposits testifies to natural fires from over 400 million years ago to the present (Komarek 1973). Before humans, lightning was the primary cause of fires. McCann (1942) has estimated that each year about 16 million thunderstorms occur on the earth, causing an average of 50 lightning strikes per second or a total of 2 billion strikes a year. Even though only a small percentage of these strikes ignites forest fuels, lightning causes about 50,000 wildland fires per year worldwide (Taylor 1974).

Historical evidence indicates that fires have always been an ecological and evolutionary force in ponderosa pine (*Pinus ponderosa* Laws.) forests (Cooper 1960, Weaver 1951). Fire in primeval ponderosa pine forest typically involved frequent surface fires spreading slowly through the forest (Biswell 1973, Wagener 1961). These fires had a significant effect on community structure and composition by reducing understory vegetation and thereby decreasing competition for water and nutrients, accelerating biogeochemical cycling, and controlling the encroachment of less fire-resistant tree species (Wright 1978, Weaver 1967b, Williams 1959). Fire enhanced ponderosa pine regeneration by creating small openings and by thinning the dense sapling thickets that developed (Wright 1978).

Ponderosa pine has characteristics that allow it to withstand frequent ground fires. These include thick bark, rapid juvenile growth, a moderately high and open crown, deep rooting habit, and open stand structure (Brown and Davis 1973). Mutch (1970) hypothesized that some fire-dependent plants might possess characteristics to enhance the spread of fire. The highly flammable, resinous needles that are dropped in great quantities each year by ponderosa pines may be a characteristic that supports Mutch's contention.

Dense thickets of crowded, spindly ponderosa pine and understories that have become invaded with more shade-tolerant species are now common in post-fire suppression forests (Weaver 1974, Biswell 1973). This leads to speculation that ponderosa pine would likely have a more restricted distribution were it not for frequent fires in the past (Wellner 1970).

In this study the fire history of an isolated plateau in southern Utah is quantified. Results are compared to other studies in the western United States.

STUDY AREA

The study was conducted on the Paunsaugunt Plateau, located within the Powell Ranger District of the Dixie National Forest and Bryce Canyon National Park. The Paunsaugunt Plateau is approximately 49 × 16 km (78,400 ha), occupying a position midway between 37 and 38 degrees North latitude, 16 km west of the 112th meridian. It slopes upward from about 2,100 m in the north to 2,870 m in the south. Ponderosa pine can be found in pure stands from 2,200 to 2,600 m. It begins

[1]EPO Biology Department, University of Colorado, Boulder, Colorado 80309. Present address: Department of Biological Sciences, Northern Arizona University, Flagstaff, Arizona 86011.

to mix with Douglas-fir (*Pseudotsuga menziesii* Franco) at about 2,200 m on north- and east-facing slopes. Most of the higher elevations are covered with mixed coniferous forests including Douglas-fir, blue spruce (*Picea pungens* Engelm.), white fir (*Abies concolor* Lindl.), Engelmann spruce (*Picea engelmannii* Parre.), limber pine (*Pinus flexilis* James), subalpine fir (*Abies lasiocarpa* Nutt.), and quaking aspen (*Populus tremuloides* Michx.). Old individuals of ponderosa pine grow among the spruce and fir trees on the southern end of the Paunsaugunt Plateau, though very little regeneration occurs.

The mean monthly precipitation recorded at Bryce Canyon National Park Headquarters ranges from 1.5 cm in June to 5.6 cm in August with an annual mean of 40.9 cm. The mean maximum temperature is 2 C in January and 27 C in July. The mean minimum temperature is −12 C in January and 8 C in July.

The three study areas selected were Whiteman Spring, Seiler Mill, and Straight Canyon. Because the first two areas contained recent timber sales, cross sections could be easily obtained from stumps.

Materials and Methods

Cross sections were collected from 14 fire-scarred ponderosa pine trees. Each cross section was surfaced with progressively finer sandpaper (40–500 grit) until individual cells were readily visible with the aid of a dissecting microscope. Annual rings were dated using the skeleton plot technique (Stokes and Smiley 1968). These plots then were cross-dated with a master skeleton plot developed from cores of 20 trees growing in the same area as the fire-scarred trees. A master tree ring chronology developed in Bryce Canyon National Park and vicinity was also used (Tree Ring Laboratory, University of Arizona). Fire scars were identified from the 14 cross sections on the basis of the following criteria (Stokes 1980): (1) the presence of a break or gap within or along a tree ring boundary, (2) the presence of charred wood within the break or gap, (3) subsequent overlapping curvilinear growth over the break.

Fire scars were dated by determining the ring in which the fire scar appeared. When the scar occurred between the latewood of one ring and the earlywood of the next ring, the scar was dated to the year of the latewood growth.

Individual fire frequencies (mean fire intervals) were determined for each of the 14 fire-scarred ponderosa pines. This represents the mean interval between fires from the first to the last fire scar. A composite fire interval (mean interval for an area) was then constructed for each of the three study areas, which expresses the historical fire frequency for a particular area (Dieterich 1980).

Results and Discussion

Fire frequency and intensity vary among species. Fire patterns for any one species also vary over its geographic range. Prior to fire suppression, the average fire frequency of ponderosa pine forests in Arizona and New Mexico was between 4 and 12 years (Dieterich 1980, Weaver 1951). In Washington and Oregon, Weaver (1967a, 1959) showed that fire frequency varied from 6 to 47 years in a wide range of ponderosa pine communities. Arno (1980) reported an average fire frequency of between 6 and 12 years in the northwestern Rockies. Ponderosa pines have an average fire frequency of between 39 and 46 years in the Colorado Rocky Mountains (Laven et al. 1980, Rowdabaugh 1978), and between 8 and 14 years in California (McBride and Jacobs 1980, Warner 1980, Wagener 1961).

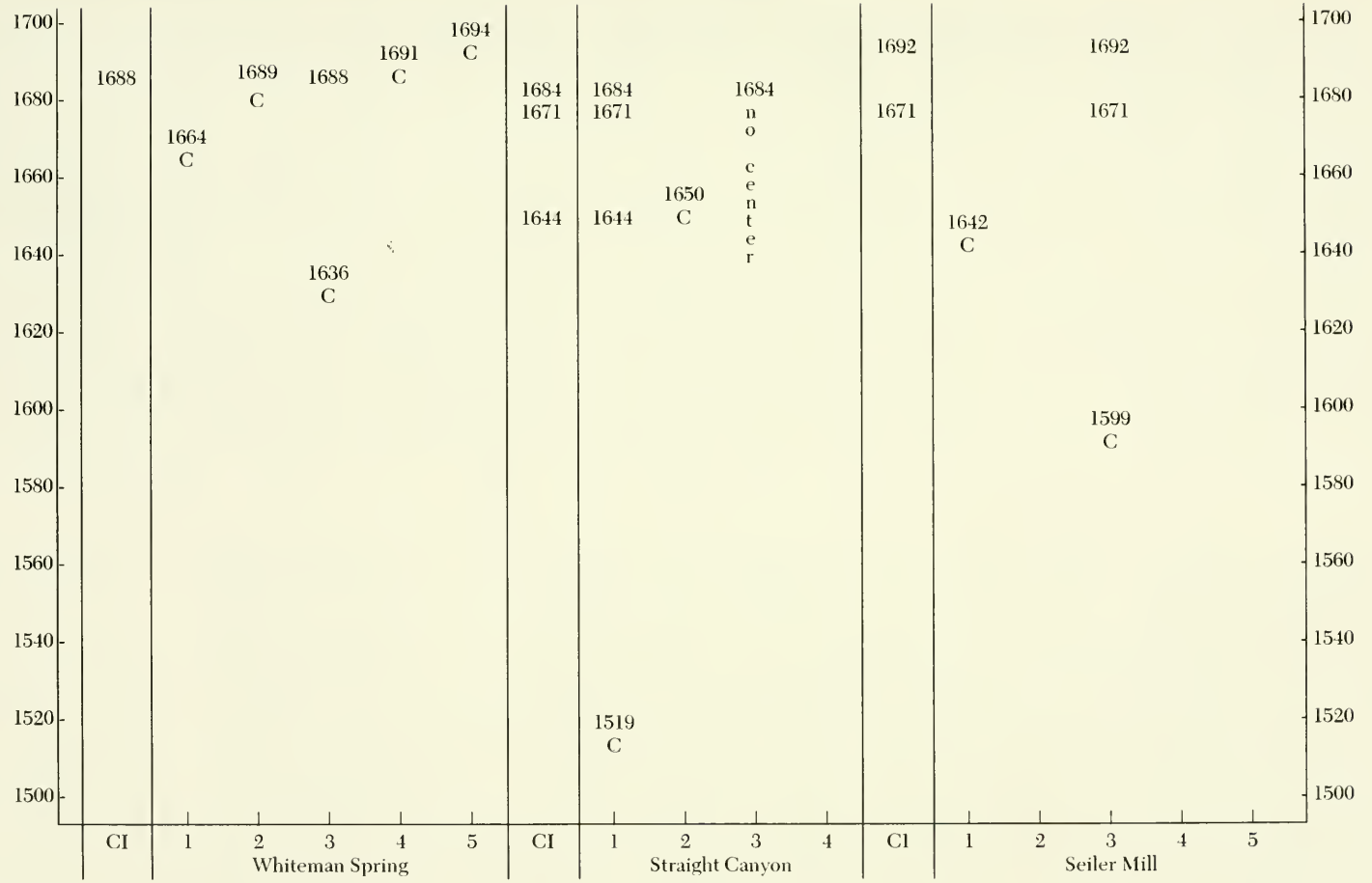
The fire history of the Paunsaugunt Plateau is presented in Figure 1. Fire frequencies of individual trees varied from 19.5 to 47 years. Composite fire intervals from the three study areas ranged from 15.2 to 18.4 years.

Though these observed fire frequencies are greater than those reported from the central Rocky Mountains, they are less than other reports in ponderosa pine stands. On the Paunsaugunt Plateau, understory growth and buildup of litter are slow due to the cool, dry climate, nutrient-poor soils, and short growing season (Stein 1983). Generally, fires are of small areal extent because of cool temperatures and the shortage of fuels. This pattern of fires is reflected by the rarity of fires that affected all trees sampled at a particular site (Fig. 1). Consequently, the composite interval for each area is much less than the fire intervals of the individual trees.

The last recorded fires in the three study areas occurred in 1892, 1902, and 1911 (Fig.

Outside ring		1980	1980	1980	1980	1980		1932	1968	1906	1968		1948	1980	1980	1980	1980	
Number of fires	15	9	3	8	8	5	17	10	5	7	3	12	5	2	4	5	3	
Mean fire interval	15.9	22.8	19.5	28.5	23.6	20.3	15.2	26.0	27.3	36.3	28.5	18.4	33.8	23.0	47.0	27.3	29.0	
1920																		1920
	1911	1911				1911												
							1902			1902								
1900												1892				1892		1900
	1888	1888		1888	1888	1888												
							1885		1885			1883		1883				
1880																		1880
							1878	1878										
	1874					1874	1876	1876	1876	1876	1876							
												1871					1871	
1860												1860	1860	1860		1860	1860	1860
	1847	1847	1847	1847	1847	1847	1848				1848							
							1841		1841									
1840																		1840
	1830					1830												
	1824	1824		1824	1824		1825		1825									
1820	1820		1820				1819	1819			1819							1820
							1817			1817		1814	1814					
												1813			1813	1813	1813	
1800	1808	1808	1808		1808									1807 C				1800
	1796	1796			1796		1795	1795	1795	1795		1794	1794					
												1789				1789		
1780	1777	1777		1777	1777													1780
							1774	1774				1773	1773		1773	1773		
							1766			1766								
	1763	1763		1763														
1760																		1760
	1749			1749	1749													
1740																		1740
	1729	1729		1729														
	1723				1723		1723	1723		1723		1725	1725			1728 C	1728 C	
1720																		1720
							1711	1711			1713 C							

YEAR YEAR



CI = composite interval
C = tree center

Fig. 1. Paunsaugunt Plateau fire chronology based on dendrochronological analysis of fourteen fire-scarred *Pinus ponderosa* trees from the three study areas. The dates in each column represent the years fire scars were present for individual trees. The left-hand column for each study area displays the composite fire interval for that area.

1). These dates correspond to the initiation of fire suppression policies in the West around 1900, and the establishment of Dixie National Forest in 1905. The exclusion of forest fires on the Paunsaugunt Plateau by the Dixie National Forest and Bryce Canyon National Park has been effective since 1911. Before 1911, periodic ground fires were common. These fires may have created conditions that helped to establish fire-dependent ponderosa pines at higher elevations, where only scattered individuals remain today (Stein 1988).

Many inventories show a marked decrease in land dominated by ponderosa pine (Gruell et al. 1982, Eyre 1980, Barrett 1979, Schubert 1974, Weaver 1961, Cooper 1960). These and other authors have observed an anomalous size-class distribution of ponderosa pine in many stands, due to a lack of individuals in smaller size-classes. Both these changes have been documented on the higher elevations of the Paunsaugunt Plateau (Stein 1988). Fire suppression policies have probably made ponderosa pine regeneration difficult at higher elevations throughout its range, favoring the more competitive, shade-tolerant spruce and fir. This is somewhat ironic since ponderosa pine is the favored timber tree throughout much of the interior West. However, the Forest Service continues its policy of eliminating forest fires despite the major ecological and evolutionary role that fire has played in the establishment and persistence of ponderosa pine forests.

ACKNOWLEDGMENTS

I would like to thank J. H. Bock, C. E. Bock, and Y. B. Linhart for their help and encouragement during this project. I also thank J. A. MacMahon for reviewing the manuscript. Financial assistance was provided by the Francis Ramaley Fund for Botanical Research and the Kathy Lichty Fund for Ecological Research.

LITERATURE CITED

ARNO, S. F. 1980. Forest fire history in the northern Rockies. J. For. 78: 460–465.

BARRETT, J. W. 1979. Silviculture of ponderosa pine in the Pacific Northwest: the state of our knowledge. USDA For. Serv. Rept. PNW-97.

BISWELL, H. 1973. Fire ecology in ponderosa pine-grassland. Proc. Tall Timbers Fire Ecol. Conf. 12: 69–96.

BROWN, A. A. AND R. P. DAVIS. 1973. Forest fire control and use. 2d. ed. McGraw-Hill Book Co., New York. 686 pp.

COOPER, C. F. 1960. Changes in vegetation, structure and growth of southwestern forests since white settlement. Ecol. Monogr. 39: 129–164.

DIETERICH, J. H. 1980. Chimney Spring forest fire history. USDA For. Serv. Res. Pap. RM-220. 8 pp.

EYRE, F. H. 1980. Forest cover types of the United States and Canada. Society of American Foresters. 148 pp.

GRUELL, G. E., W. C. SCHMIDT, S. F. ARNO, AND W. J. REICH. 1982. Seventy years of vegetal change in a managed ponderosa pine forest in western Montana—implications for resource management. Gen. Tech. Rept. INT-130. 42 pp.

KOMAREK, E. V. 1973. Ancient fires. Pages 219–240 *in* Proc. of the Tall Timbers Fire Ecol. Conf. 1972.

LAVEN, R. D., P. N. OMI, J. G. WYANT, AND A. S. PINKERTON. 1980. Interpretation of fire scar data from a ponderosa pine ecosystem in the central Rocky Mountains, Colorado. Proc. of the Fire History Workshop, Tucson, Arizona, 1980. USDA For. Serv. Gen. Tech. Rept. RM-81. 142 pp.

MCBRIDE, J. R., AND D. F. JACOBS. 1980. Land use and fire history in the mountains of southern California. Proc. of the Fire History Workshop, Tucson, Arizona, 1980. USDA For. Serv. Gen. Tech. Rept. RM-81. 142 pp.

MCCANN, C. D. 1942. When lightning strikes. Sci. Amer. 49: 23–25.

MUTCH, R. W. 1970. Wildland fires and ecosystems—a hypothesis. Ecology 51: 1046–1051.

ROWDABAUGH, K. M. 1978. The role of fire in the ponderosa pine–mixed conifer ecosystem. Unpublished thesis, Colorado State University, Fort Collins.

SCHUBERT, G. H. 1974. Silviculture of southwestern ponderosa pine: the status of our knowledge. USDA For. Serv. Res. Pap. RM-123. 71 pp.

STEIN, S. J. 1983. Reproductive failure and scattered distribution of aged ponderosa pine within a high elevation mixed coniferous forest of southern Utah. Unpublished thesis, University of Colorado, Boulder.

———. 1988. Explanations of the imbalanced age structure and scattered distribution of ponderosa pine within a high elevation mixed coniferous forest. For. Ecol. and Manage. In press.

STOKES, M. A. 1980. The dendrochronology of fire history. Proc. of the Fire History Workshop, Tucson, Arizona, 1980. USDA For. Serv. Gen. Tech. Rept. RM-81. 142 pp.

STOKES, M. A., AND T. C. SMILEY. 1968. Introduction to tree ring dating. University of Chicago Press, Chicago.

TAYLOR, A. R. 1974. Ecological aspects of lightning. Proc. of the Tall Timbers Fire Ecol. Conf. 1973.

WAGENER, W. W. 1961. Past fire incidence in the Sierra Nevada forests. J. For. 59: 739–747.

WARNER, T. E. 1980. Fire history in the yellow pine forests of Kings Canyon National Park. Proc. of the Fire History Workshop, Tucson, Arizona, 1980. USDA For. Serv. Gen. Tech. Rept. RM-81. 142 pp.

WEAVER, H. A. 1951. Fire as an ecological factor in southwestern ponderosa pine forests. J. For. 49: 93–98.

———. 1959. Ecological changes of the ponderosa pine forest of Warm Springs Indian Reservation in Oregon. J. For. 57: 15–20.

———. 1961. Ecological changes in the ponderosa pine forest of Cedar Valley in southern Washington. Ecology 42: 416–420.

———. 1967a. Fire and its relationship to ponderosa pine. Proc. Tall Timbers Fire Ecol. Conf. 7: 127–149.

———. 1967b. Fire as a continuing ecological factor in perpetuation of ponderosa pine forests in the western United States. Adv. Front. Plant Sci. 18: 137–154.

———. 1974. Effects of fire on temperate forests: western United States. *In:* T. T. Kozlowski and C. E. Ahlgren, eds., Fire and ecosystems. Academic Press, New York.

WELLNER, C. A. 1970. Fire history in the northern Rocky Mountains. *In:* The role of fire in the Intermountain West, Proc. Symp. 1970. Missoula, Montana.

WILLIAMS, H. W., JR. 1959. The effect of understory competition on the growth rate of ponderosa pine in northcentral Oregon. J. For. 57: 852–853.

WRIGHT, H. A. 1978. The effect of fire on vegetation in ponderosa pine forests: a state of the art review. Texas Tech. University Range and Wildlife Series #2, Pub. 9-9-199.