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Fire History Reconstructions in the Mogollon Province Ponderosa Pine Forests of the Tonto National Forest Central Arizona

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Abstract— Four montane-conifer forest sites were selected for fire reconstruction studies in central Arizona within the Mogollon Biotic Province. The sites include Webber Creek (West of the Dude Fire), Mount Ord, the Pinal Mountains, and the Sierra Anchas. Fire history was reconstructed from fire-scarred pine samples using tree-ring-dating methods (dendrochronology) and analyzed in the context of land-use history. Presettlement fire regimes were reconstructed and the relative extent of past fires inferred.

Fire regimes declined precipitously at all sites with Anglo-American settlement, livestock grazing, and logging beginning in the early 1880s (Fig. 1). Presettlement fire frequencies were relatively high and extremely variable at all sites. A fire-regime shift to fewer finer-scale with more frequent medium- and broader- scale fire events was recorded for the century after 1780 at Webber Creek and Mount Ord. Large numbers of fine-scale fire events were recorded at MFIs ranging between one to two years. These fires roughly ranged from one-hundredth to one hundred hectares.

Presettlement fire history reconstructions indicate that ponderosa pine and mixed-conifer forest stands below the Mogollon Rim experienced fine-, medium-, or broad- scale fire events at least every other year. The high frequency and spatial variability of fire regimes at these sites indicate the profound role that fires had in the past in shaping the landscape patterns throughout this province.

Introduction

Fires have been an important ecological process for hundreds and thousands of years in the pine forests of central Arizona (Weaver 1964, 1968; Wright and Bailey 1982; Dieterich 1983a; Anderson 1993). Fire history studies in the Mogollon Biotic Province have been conducted in western New Mexico (Swetnam 1983; Dieterich and Swetnam 1995; Abolt 1997), northeast of these study areas (Dieterich 1980b; Dieterich and Hibbert 1988), and to the southeast (Grissino-Mayer et al. 1995). The most relevant fire history research has been recently completed in the montane-conifer forests of the San Carlos Apache Tribe to the east (Kaib 2001).

Tonto National Forest Land-Use and Fire History

The Tonto Apache inhabited and farmed the upper Webber Creek study area around the late 1800s (Northern Gila County Historical Society 1984; Redman 1993). Substantial land-use changes began in this region with the Apache settlement on reservations (Johnson 1970; Sheridan 1995). In the 1880s settlement period, Pine

Arizona became a Mormon colony and ranching homesteads increased rapidly. The early communities subsisted primarily on livestock ranching supplemented with hunting, trapping, logging, and farming (Gosney 1899; Croxen 1926; Forrest 1936; Ellison 1968). There were several sawmills established around the 1880s in Pine, Payson, and Christopher Creek (Northern Gila County Historical Society 1984). The settlement period between 1880 and 1890 marks the beginning of tremendous land-use and vegetation changes throughout the Southwest U.S., and the Mogollon Province was no exception (Hastings and Turner 1965; Bahre 1991; Sowards 1997).

Historical records illustrate early settlement land uses and vegetation changes. William Craig settled the Spade Ranch within the study site area on Webber Creek in 1883. He recounts the forest character in the vicinity.

> "Pine bunch grass in the pine timber under the rim was three feet high and stood in great bunches. The cattle and horses that grazed it ate only the heads (Croxen 1926: 3)."

The Haught family settled and developed some large ranch herds in this area.

> "Sam Jr. [Haught] came to the upper Webber Creek in 1882 and brought a fine herd of cattle with him… The herd grew to near 10,000 head and Sam Jr. had nearly 1,000 horses [by ca. 1898] (Nellie Gene Connolly; Northern Gila County Historical Society 1984: 118)."

A surveyor for the General Lands Office describes the forest changes in central Arizona that had occurred by the turn of the century.

> "Briefly, the history of the forests of Arizona, which my opportunities have enabled me to gather from many of the oldest reliable pioneers, is that when first invaded by the white man the forests were open, devoid of undergrowth, and consisted in the main of matured trees, with practically no forest cover. Instead of forest undergrowth, the ground was well set with perennial grasses and other herbage… Where hundreds of tons of hay were cut under the actual spread of the forest trees… there is not now enough grass on a thousand acres to keep in condition a family cow. Where were then running streams are now dry arroyos, and where were then living springs are now beds of silt and sand (Holsinger 1902: 22-23)."

Fred Croxen (1926) estimated that there were 15 to 20 times more cattle in 1900 compared to 1926. It was approximated from his and other USFS records that in the year 1900 about one and a half to two million cattle were grazing in the Tonto N.F., compared to the 26,400 cattle permits that existed in 1993 (Alford 1993). The effects of intense grazing in the decades between 1880 and 1910 were also compounded by repeated droughts (Bahre 1991). The influence of early settlement grazing and logging on fire suppression has been well documented early on and at most fire history sites throughout the Southwest U.S. (Leopold 1924; Marshall 1963; Swetnam and Baisan 1996a, 1996b).

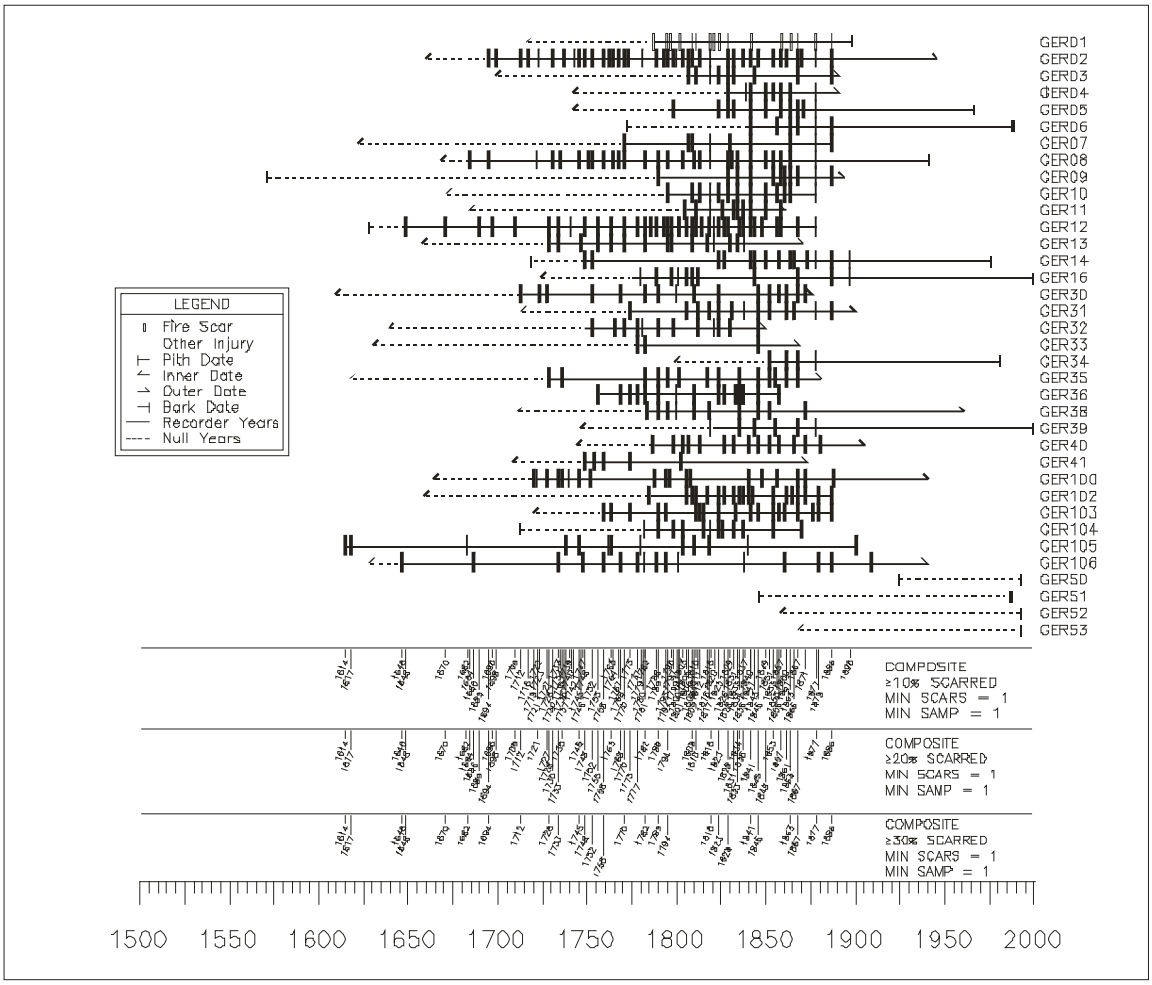

Figure 1. Fire history chronology chart showing crossdated fire-scarred trees (horizontal lines) with dated fire events (vertical hatchmarks), and fire composites below showing fire events recorded by increasing numbers of trees (≤10% fire-scarred trees, ≥10% fire-scarred trees, ≥30% fire-scarred trees), that indicate increasing relatively-larger fire events. Note severe decline in frequent fire regime in late 1800s.

Lightning and Fires

The role and importance of lightning as a source of fire was greatly underestimated in this region until the establishment of USFS fire guards and lookouts (Plummer 1912; Barrows 1978; Swetnam and Baisan 1996a; Allen 2000). This historical bias taints earlier historical accounts of human-set fires that were not witnessed firsthand. The Mogollon region was demarcated in 1912 as a lightning "hotspot" based on surveys of lightning-scarred trees (Plummer 1912). U.S. Forest Service records over 14 years show that 81 percent of the fires recorded in the Southwest Region (New Mexico and Arizona) were attributed to lightning (Barrows 1978). In this Region between 1940 and 1975, an average of 1,770 lightning fires occurred annually. Furthermore, forest fuel and fire conditions were probably very different in presettlement times compared to current high densities of living, dead, heavy, and fine fuels (Cooper 1960; Weaver 1951; Fule et al. 1997). The greater grass cover and more open forests where fuels could dry out more quickly may have facilitated even higher rates of lightning ignition and fire spread in the past.

Settlement land uses and particularly grazing fragmented these landscapes and reduced the grasses and forbs thereby preventing normal fire ignitions and spread (See Fig. 1). The last widespread presettlement-like fire was recorded at Webber Creek in 1886, even though seven fire-scarred tree samples extended well beyond the 1950s. The last widespread fire at Mount Ord was recorded in 1881, suggesting an even earlier influence from grazing. The last widespread presettlement-like fire in the Pinals was recorded in 1889 and the last widespread fire in the Sierra Anchas was recorded in 1890. All these sites had tree samples that extended into the current decade; however widespread-fire events were not recorded over the last century (See Fig. 1).

Fire, Fuels, and Climate Changes

Although there were probably some fires that went unrecorded by the trees sampled at these sites over the last 100 years, the frequency and size of fires have been severely reduced (Bahre 1991; Thiel 1993; Sowards 1997). USFS Region-3 fire records in Arizona and New Mexico also show that major changes in fire regimes have occurred over the last century (Fig 2; Grissino-Mayer and Swetnam 2000). These records indicate that on average less than 500,000 hectares burned annually in Region-3 between 1910 and 1970, and there was a steady increase in the annual area burned after 1970 that peaked at over 2.5 million hectares in 1994 (See Figure 2; Grissino-Mayer and Swetnam 2000).

In northern Arizona, Fule and others (1997) found ponderosa pine forest densities in 1883 had 65 trees per hectare with a mean diameter of 42 centimeters,

compared to 720 trees in 1994 with a mean diameter of 23 centimeters. These and other authors have concluded that an ecological shift from low-intensity surface fires to anomalous stand-replacing fires is partly due to a century or more of fire suppression and accumulated forest biomass (Swetnam 1990; Fule et al. 1997). The Southwest U.S. warming-drying trend that began in the 1990s likely has exacerbated this shift to stand-replacing fires. The majority of firefighters and incident managers on the Dude Fire had not in their careers witnessed Southwest ponderosa-pine stand-replacing fires of this magnitude before this event.

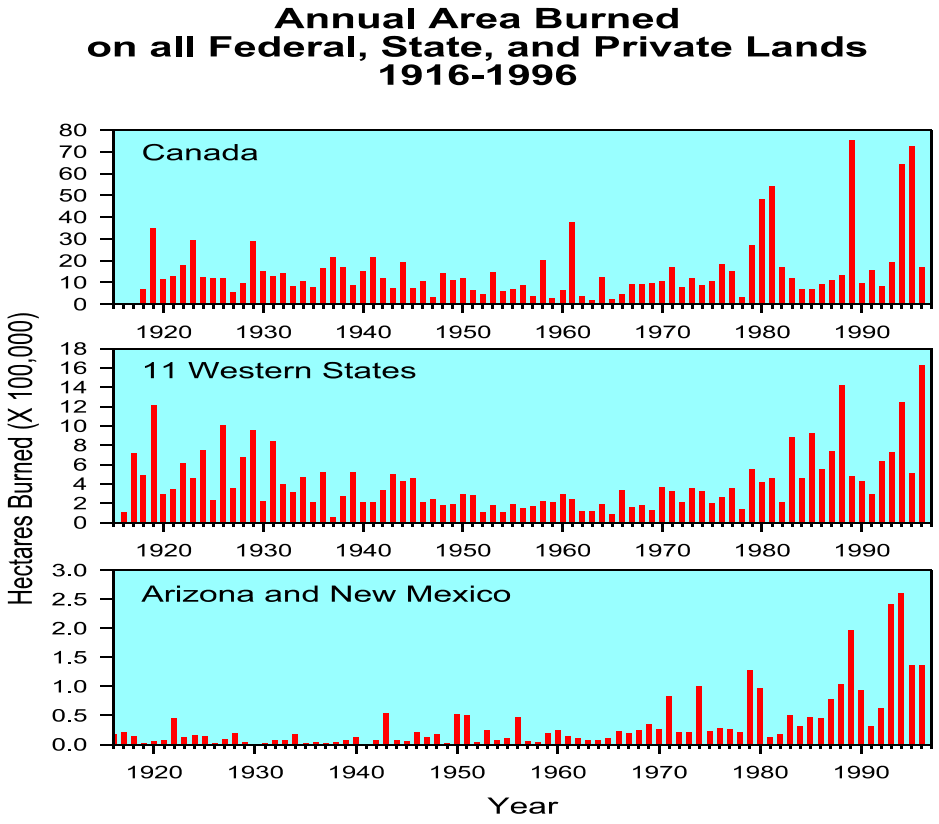

Figure 2. Annual Area burned on Federal, State and Private lands, 1919-1996. Note increase in hectares burned in Southwest U.S. beginning in the 1970s (Swetnam et al. 2001).

Management Implications

The severe reduction in the numbers and extent of fires over the last 120 years has resulted in much denser forest stands and fuel conditions, and increased the likelihood for anomalous stand-replacement type fires (Cooper 1960; Weaver 1964; Fule et al. 1997). The unprecedented Dude Creek, Four Peaks, and the Coon Creek fires have recently demonstrated these types of anomalous fire intensities on the Tonto N.F..

There have been hundreds of thousands of acres consumed by anomalous stand-replacing fires in ponderosa pine forests of the southwest since the Dude Fire (e.g., Rattlesnake, Aspen, Cerro Grande, Rodeo Chediski, etc…).

The high frequency and spatial variability of fire regimes at these sites indicate the fundamental role that fires had in the past in shaping the landscape patterns throughout this province. This natural range of variability may ironically facilitate the future use of fire in ecosystem management by providing greater flexibility to the application of fire in the ponderosa pine and mixed-conifer forests of the Southwest US.