Fire History and the Possible Role of Apache-Set Fires in the Chiricahua Mountains of Southeastern Arizona

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Abstract.—Fire history was reconstructed for the Rustler Park area of the Chiricahua Mountains and compared with the historical and documentary record of Apache presence to interpret possible associations between the Apaches and fire occurrence. Dendrochronological techniques were used to crossdate and analyze samples from 63 fire-scarred trees, resulting in a tree-ring reconstruction of fire history that extended from 1644 to 1995. The fire chronology exhibited unusually high fire frequency relative to most other Southwestern fire chronologies (approximately one fire every three years between 1700 and 1900). A greater proportion of dormant season scars (late winter or spring fires) than observed elsewhere in the Southwest may indicate a greater occurrence of human-set fires. Specific key events in borderlands history were also concurrent with temporal changes in the Chiricahua fire chronology. For example, fire occurrence increased between 1760 and 1786 when Apaches waged an aggressive war against the Spanish, but decreased following 1786 when peace was established. While the hypothesis of important Apache alteration of fire regimes in the Rustler Park area was supported by concurrence with the documentary record and temporal patterns of fire occurrence, we could not conclusively distinguish the Apache influence from other factors regulating fire regimes, especially climate.

INTRODUCTION

During recent decades fire has assumed a more prominent role in land management, and is now acknowledged to be an essential ecological process in grassland and forest ecosystems. An understanding of the frequency, extent, seasonality, and severity of past wildfires is therefore required to help develop sound fire management policy. Developing knowledge of past fire regimes, however, is complicated by recent (post-1880) anthropogenic disturbances, such as logging, livestock grazing, mining, urban development, and fire suppression (Bahre 1991, 1995), that have disrupted fire as an ecological process. The application of dendrochronological (i.e., tree-ring dating) techniques to fire history studies allows researchers to evaluate the historical patterns of fires across both time and space prior to Euro-American disturbances (Swetnam and Baisan, in press). Such information identifies the historical range of variability of past fire regimes, providing a perspective on how ecosystems operated in the past, and the extent to which they have changed during the 20th century. Knowledge and understanding of these historical patterns provide fundamental evidence for development of ecologically informed land management plans (Allen 1994, Kaufmann et al. 1994, Swetnam and Baisan, this volume).

In southeastern Arizona, the Chiricahua Apaches were the dominant force in shaping local history from the approximate time of their arrival into southeastern Arizona (perhaps as late as the 1600s), until the final surrender of Geronimo in 1886 (Opler 1983, Worcester 1979). The Apache economy was based heavily on raiding and warfare supplemented by hunting and gathering, making it difficult for both Spanish and American forces to secure the South-

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west for settlement and exploitation. In 1748, war officially was declared against the Apaches by the Spanish; however, a state of war had been in effect for many previous decades with Apache raids throughout southern Arizona, New Mexico, and northern Sonora (Wilson 1995). Between 1760 and 1886, the Apaches were the only Native American group that challenged Spanish, Mexican, and American control of southeastern Arizona, traveling to and from northern Sonora via the San Pedro, Sulphur Spring, and San Simon Valleys to plunder rancherias throughout the borderlands area.

Native Americans of the Southwest allegedly used fire for various reasons: for driving game, to increase forage for livestock and large game, for direct and indirect warfare tactics, and for creating travel corridors (Dobyns 1981, Pyne 1982). Because the nomadic Apaches lived and traveled extensively throughout southeastern Arizona, it is possible that fire regimes were altered by their use of fire in some areas during certain periods. Newspaper reports from the late 1800s contain several allegations of Apaches setting fires in the mountains around Tucson, Arizona (Bahre 1985). However, early accounts of wildfires set by Apaches should be interpreted cautiously because:

1. Only a few eye-witness accounts of Apaches actually setting fires are known,
2. Most fires attributed to Apaches occurred during the time of year when lightning fires were most common, and
3. Early Euro-American settlers expressed considerable anti-Apache sentiment, and may have been prone to attribute any fire to the Apaches (Baisan 1990).

Swetnam and Baisan (in press) have argued that, while Native Americans probably altered fire regimes during certain periods and in certain places in the Southwest, lightning patterns, fuel moisture, and fuel production largely controlled fire regimes in most Southwestern locations. Thus, the debate is not whether Native Americans intentionally burned landscapes or not, but rather where and when human-set fires influenced Southwestern fire regimes.

If Native American groups altered past fire regimes, then distinct patterns of fire occurrence indicating such use may be apparent in certain fire chronologies as:

1. Periods of increased fire frequency above the frequency expected from lightning fires alone,
2. Temporal changes in fire regimes that correspond with documented events in Apache history, or
3. Some other change in the historical fire regime pattern (e.g., a shift in the seasonality of past fires that is not explained by concurrent changes in climate).

The purpose of this study was to examine the relationship between wildfires and Apaches by developing a tree-ring based fire history for the Rustler Park area of the Chiricahua Mountains, and comparing this fire chronology to the historic record of Apache presence to determine their possible influence on fire occurrence in the Chiricahua Mountains.

SITE DESCRIPTION

The study site was located in the high-elevation mixed-conifer forests along the crest of the Chiricahua Mountains (Fig. 1) in and around the Rustler Park area. This area was selected because the high-elevation meadows of Rustler Park are in close proximity to travel routes over the mountains, and to areas used by the Chiricahua Apaches, and therefore might reasonably be expected to contain a record of their influence on fire regimes. The most common habitat type is *Pseudotsuga menziesii-Pinus strobiformis/*

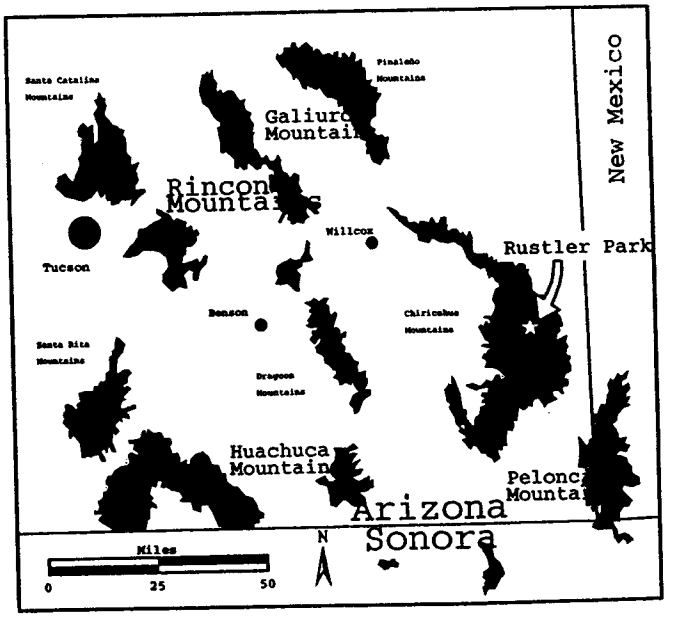

Figure 1. Location of the study site in the Chiricahua Mountains. Shaded areas are major forested and woodland areas of southeastern Arizona.

Muhlenbergia virescens (Moir and Ludwig 1979), dominated by Douglas-fir (*Pseudotsuga menziesii*) and southwestern white pine (*Pinus strobiformis*). Common associates include ponderosa (or Arizona) pine (*Pinus ponderosa*), white fir (*Abies concolor*), and quaking aspen (*Populus tremuloides*). Common understory plants include screwleaf muhly (*Muhlenbergia virescens*), creeping barberry (*Berberis repens*), western bracken fern (*Pteridium aquilinum*), false lupine (*Thermopsis pinetorum*), and Pringle's needle grass (*Stipa pringlei*) (Moir and Ludwig 1979, Sawyer and Kinraide 1980). Extensive and "abusive" logging occurred in these high elevation forests beginning in the 1870s (Bahre 1995), but subsided with the establishment of the Crook National Forest (later incorporated into the Coronado National Forest) in 1908. Livestock grazing, a major industry in the nearby Sulphur Spring Valley beginning in the late 1870s (Bailey 1994), occurred throughout the mountain range (Bahre 1995), and may have considerably impacted the high elevation forests as well.

METHODS

We used a chain saw to cut cross-sections from 63 fire-scarred southwestern white pine and ponderosa pine logs, snags, stumps, and remnant pieces of wood along a two-mile north-south gradient, beginning at the trail head to Buena Vista Peak, through Rustler Park, and culminating in the Long Park area. Smaller cross-sections were cut from living trees to obtain a record of 20th century fires (Arno and Sneck 1977). In the laboratory, all tree-ring samples were sanded, then crossdated using skeleton plots developed from nearby tree-ring chronologies in the Chiricahua Mountains (Pinery Canyon and Flys Peak). The seasonal timing of past fires was inferred from the position of the fire scars within the annual rings (Baisan and Swetnam 1990). All information was entered in a computer database, then statistically and graphically analyzed using FHX2, software designed specifically for analyzing fire history from tree rings (Grissino-Mayer and others 1994, Grissino-Mayer 1995). Statistical analyses incorporated the Weibull distribution fit to the fire interval data to provide more robust statistical measures of fire regime characteristics (Grissino-Mayer 1995). Finally, we compared the composite fire chronology to documentary evidence of Apache presence in southeastern Arizona to identify coincidences (or lack thereof) in Apache historical events that would, by inference, suggest the possible influence of Apache-set fires in altering fire regimes in the study area.

RESULTS

The master fire chronology revealed that wildfires occurred frequently in the Chiricahua Mountains prior to 1892 (Fig. 2). Between 1700 and 1892, the period when sample depth was considered adequate for statistical analyses (i.e., a minimum of five trees recorded fires), fires occurred approximately once every three years based on the mean, median, and Weibull median probability fire intervals (Table 1). The shortest interval between fire years was one year, which occurred several times during the 200 year period (e.g. 1759-1760, 1765-1766, and 1862-1863). The most remarkable sequence of one year intervals occurred during the years 1770 (recorded

Table 1—Descriptive statistics for fire intervals, Chiricahua Mountains, 1700 - 1900. All values are in years.

	Statistic
Mean Fire Interval	2.91
Median Fire Interval:	3.00
Weibull Median Probability Interval[a]:	2.71
Fire Frequency Probability per Year[b]:	0.37
Standard Deviation:	2.09
Coefficient of Variation:	0.72
Weibull Shape Parameterc:	2.30
Skewness:	3.88
Kurtosis:	21.45
Minimum Fire Interval:	1.00
Maximum Fire Interval:	16.00
95% Exceedance Intervald:	0.87
5% Exceedance Intervale:	5.12
Maximum Hazard Intervalf:	4.00

[a] Median interval based on fitting a Weibull distribution to the fire interval data.

[b] Inverse of the WMPI.

[c] Shape parameter estimated for the Weibull distribution fit to the actual data.

[d] Interval exceeded by 95% of all other intervals based on the Weibull distribution.

[e] Interval exceeded by 5% of all other intervals.

[f] Maximum interval at the 100% hazard rate based on the Weibull distribution.

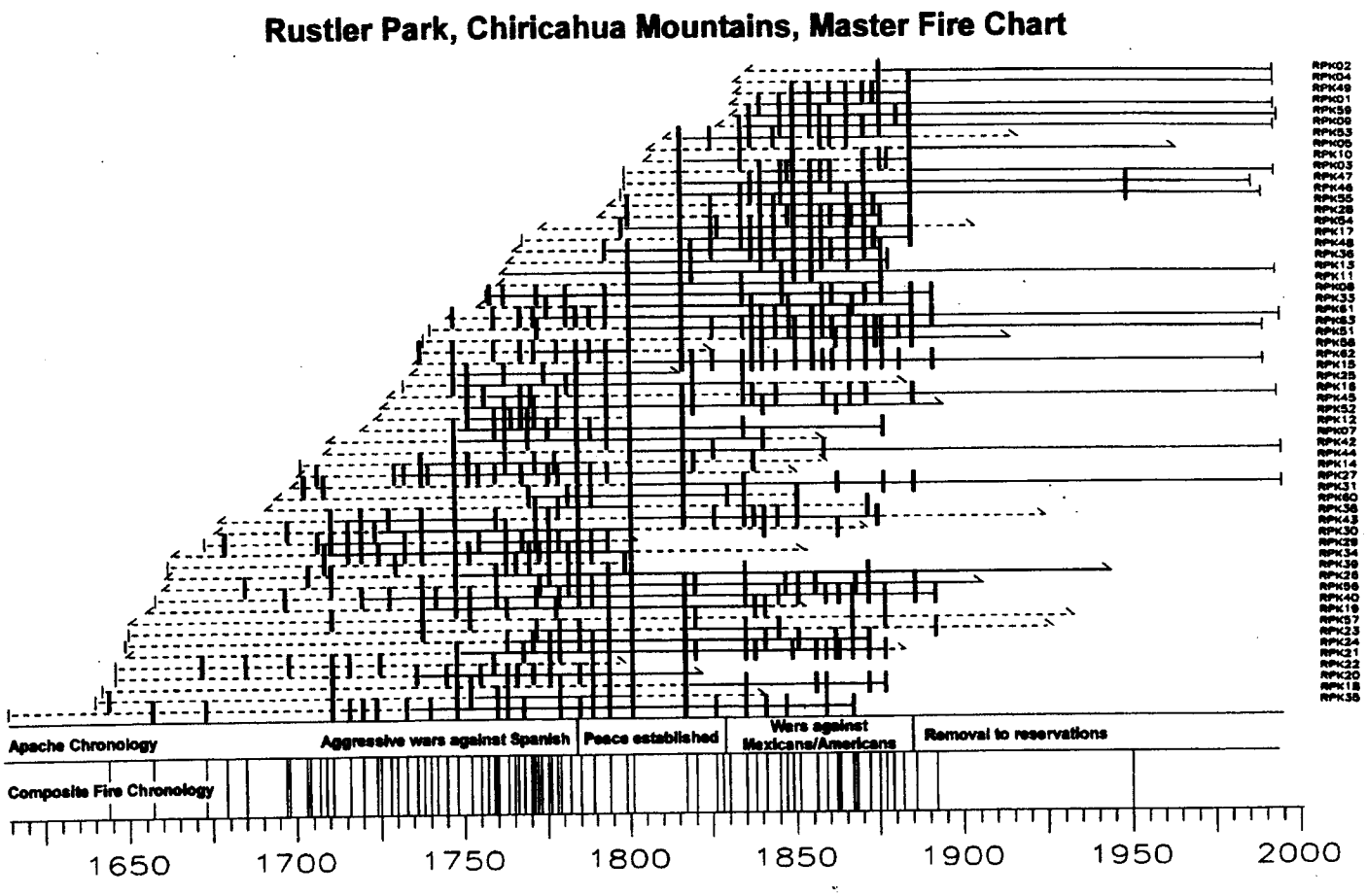

Figure 2. Master fire chronology for the study site. Each horizontal line represents information from one tree, while small vertical bars represent dated fire events (i.e. fire scars or other fire related injuries). Note the long fire-free interval between 1801 and 1817, and the near absence of fires after 1890.

by five trees), 1771 (three trees), 1772 (10 trees), and 1773 (four trees). Such long runs of consecutive-year fires have only been reconstructed in southern Arizona and New Mexico at one other location - the Organ Mountains of south-central New Mexico where Apache-set fires were also hypothesized to have been especially important (Morino 1996).

After the fire in 1892, however, widespread fires virtually ceased, a common feature of nearly all fire-scar chronologies so far developed for the Southwest (Swetnam and Baisan, in press). This rather sudden decrease in fire frequency is attributed primarily to two human-related disturbances:

- Grazing by livestock (Allen 1994, Grissino-Mayer and others 1994, Savage and Swetnam 1990, Touchan and others 1995) which became a major industry of southeastern Arizona beginning in the 1880s (Allen 1989, Bahre 1991, Bailey 1994, Wilson 1995), and
- Fire suppression, the effects of which are most pronounced after World War II (Grissino-Mayer 1995, Pyne 1982, van Wagtendonk 1991), although some suppression efforts may have begun as early as the 1910s.

Many fires were widespread along the entire two mile gradient (e.g., the fires in 1748, 1801, 1817, 1851, and 1886). Synchroneity with past fires in Chiricahua National Monument 8.5 miles to the north (Swetnam and others 1989) and with fires in other lower-elevation locations in the Chiricahuas (Kaib and others, this volume) indicates that some widespread fires prior to 1890 were perhaps equal to or greater than the size of the Rattlesnake Fire of 1994 in the Chiricahua Mountains (ca. 27,500 acres).

The longest interval between fires was 16 years between 1801 and 1817 (Fig. 2). This long fire-free period was concurrent with similar unusually long fire-free periods in many other mountain areas of the

Southwest (Swetnam and Baisan, in press and this volume). Critical intervals, denoting unusually long fire-free periods, are provided by the 5% exceedance interval and the maximum hazard interval (Grissino-Mayer 1995), which indicate that fire-free periods of four to five years approached the maximum length the forests of the Chiricahua Mountains sustained in the presettlement era before burning was highly probable. Therefore, the unusual 16 year fire-free period far exceeded the maximum length expected based on the fire interval distribution.

The seasonality of past fires was strongly bimodal (Fig. 3), with peaks occurring in both the dormant season (i.e. in spring, prior to the onset of tree growth) and the middle portion of the growing season (i.e. late May to early June). This seasonal pattern is unlike that found for most other fire histories in the borderlands, which typically showed that fires occurred predominantly during the early and middle portions of the growing season prior to the onset of summer monsoonal rainfall (Swetnam and Baisan, this volume). For example, in the nearby Pinaleño Mountains to the north, over 70% of all fire scars were positioned in the early and middle portions of the tree rings (Grissino-Mayer and others 1994). Analyses on temporal patterns of seasonality (Swetnam 1992; Grissino-Mayer 1995) for the Rustler Park fire chronology showed no period was dominated by one scar position over another. The distribution of scar positions within individual fire years (Baisan and Swetnam 1990) revealed presettlement fires may have burned throughout most of the growing season during some fire years. For example, the major fire year of 1817 at Rustler Park showed 25% of all scars were classified as dormant season, 18% as early growing season, 46% as middle growing season, and 11% as late growing season (n=28). Few fire years were dominated by only one scar position.

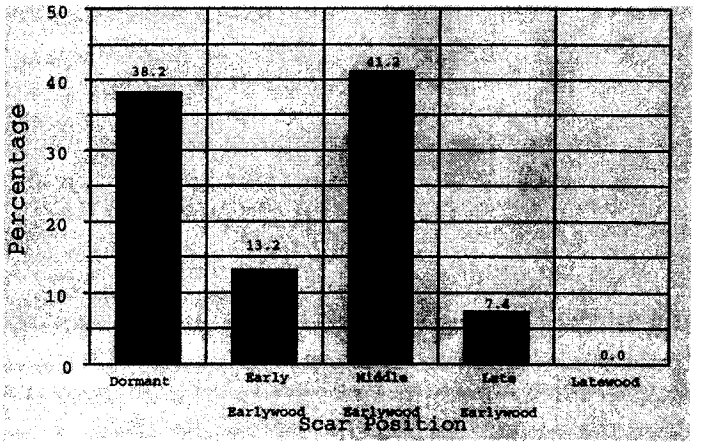

Figure 3. The seasonality of past fires in the Chiricahua Mountains based on the positions of fire scars within the annual rings. The distribution is strongly bimodal. Approximate periods associated with these seasons: Dormant—prior to mid-May; Early Earlywood—mid-May to early June; Middle Earlywood—late May to early July; Late Earlywood—mid-June to late July; Latewood—after July. Overlaps in these seasonal designations occur due to differential growth associated with year-to-year climate variations.

DISCUSSION

To investigate whether Apaches may have altered past fire regimes in the Chiricahua Mountains, we compared specific historical events in Apache history with the Chiricahua fire chronology (Table 2). Certain key periods in Apache history coincided well with specific changes in the fire chronology. For example, fire occurrence increased in the latter decades of the 17th century, a period when the Apaches resided in and around the Chiricahua Mountains, and made repeated raids into northern Mexico (Wilson 1995, Worcester 1979). However, the low fire frequency prior to 1690 may be an artifact of low sample depth rather than specific changes in Apache behavior. The first major widespread recorded fire occurred in 1748, the year in which the Spanish officially declared war on the Apaches. However, fires occurred in numerous mountain ranges throughout the Southwest during this extreme drought year (Swetnam 1990, Swetnam and Baisan, in press), indicating that regional climatic patterns were largely responsible for the widespread fires in this year.

Fire occurrence increased between 1760 and 1780 (Fig. 2), a period when the Apaches aggressively fought the Spanish (Wilson 1995). This period was also characterized by an unusual number of one-year fire intervals, lending support to the hypothesis for Apache alteration of fire regimes, because one-year intervals are uncommon in most Southwestern fire chronologies. Fire may have been used extensively by the Apaches as a means for warfare (e.g., intentional burning of vegetation to deter the enemy, to drive the enemy to prearranged areas, to deprive

Table 2—Chronology comparing major events in Apachean history (adapted from Wilson 1995) with major features of the fire history developed for this study.

Year	Events in Apachean History	Rustler Park Fire Chronology
1682	Apaches made first reported raid into Mexico.	Fire chronology shows increased numbers of fires beginning late 1600s.
1690s	Apaches are known to reside in the Chiricahua mountains.	
1748	Spanish viceroy approves a declaration of war against the Apaches.	First major widespread fire. Over 85% of trees scarred in study area.
1760	Apaches begin aggressive challenge of Spanish control of southeastern Arizona.	Fire frequency dramatically increases between 1760 and 1780.
1768	Apaches launch major offensive into Sonora.	
1786	Peace established with Apaches.	Wildfires decrease dramatically.
1831	Apaches resume raiding.	Wildfires resume in 1817, but long gap until next major fire in 1835.
1843	Apaches force abandonment of last Mexican ranches in northern Sonora.	
1861	War breaks out between the Apaches and the United States army.	Wildfires continue at short, fairly regular intervals.
1872	Cochise agrees to go onto a reservation, and the Apaches are now peaceful.	
1873	Heavy ranching develops in the Sulphur Springs Valley.	Wildfires continue at short, fairly regular intervals.
1878	Commercial lumbering and the earliest sawmill in the Chiricahua Mountains.	
1886	Geronimo surrenders; Indian wars over.	Last major wildfire in Chiricahuas.

forage for stock owned by their enemies, or to cover trails left by the Apaches, see Pyne 1982), thereby increasing the number of fire occurrences above that expected from lightning fires alone. After peace was established in 1786, fire occurrence dropped considerably, with no fires recorded between 1801 and 1817. However, peace with the Apaches continued until 1831 (Wilson 1995), but a widespread fire occurred in 1817, followed by other smaller fires in 1820, 1826, 1828, and 1830. Nonetheless, the decrease in fire occurrences between 1786 and 1831 is visually obvious (Fig. 2), was concurrent with the Apache peace, and was indeed followed by an increase in fire frequency after 1835.

However, fire occurrence after 1831 was not as common as fire occurrence prior to 1786. The mean fire interval during the period 1831-1900 (3.00 yrs, n=19) was significantly longer ($p < .05$) than the mean fire interval for the period 1700-1786 (2.28 yrs, n=36). Although this is a relatively small change, it is both graphically (Fig. 2) and statistically discernible. During the peace period between 1786 and 1831, the Spanish supplied rations to the Apaches, and Apache raids were less likely. Therefore, intentionally-set fires (perhaps for hunting and warfare practices) would have decreased. However, after the peace was broken and the Apaches once again turned to raiding and warfare, fire occurrences should have increased to pre-peace levels if the hypothesis of Apache-set fires is correct. It is possible that the long fire-free period between 1801 and 1817 may have caused fuels to become more homogeneous across the landscape, causing fewer, but perhaps more widespread fires. Similar temporal changes in fire regimes (from the late 1700s to early 1800s) have been observed in other locations in the Southwest, arguing in favor for a regional factor, such as climate. Grissino-Mayer (1995) attributed changes in fire regimes at El Malpais National Monument, New Mexico, to changes in long-term precipitation, especially in the summer monsoonal component. Morino (1996), however, attributed similar temporal changes in fire regimes for the Organ Mountains of southern New Mexico to Apache-set fires, but could not rule out changes in climate as a possible factor.

Fire occurrence terminated abruptly after the major fire in 1886, and another smaller fire in 1892. Interestingly, war between American forces and the Chiricahua Apaches also formally terminated in 1886 with the surrender of Geronimo. Throughout the Southwest, the period between 1870 and 1900 saw most Apachean groups deported and/or placed on reservations, concurrent with the decrease in fire occurrences throughout the Southwest. It is unlikely, however, that the post-1880 fire decline was directly due to the removal of Native Americans. For example, in the Sierra de los Ajos in northern Sonora, fire occurrence continued uninterrupted into the 20th century (Baisan and Swetnam 1995, and this volume), suggesting Apaches were not the cause of

wildfires. The post-1880 influx of Euro-Americans greatly disturbed the Southwestern landscape through livestock grazing, logging, mining, fuelwood gathering, urban development, and fire exclusion. These factors, particularly intensive livestock grazing, are widely cited as being primary causes for fire decline (Cooper 1961, Leopold 1924, Savage and Swetnam 1990, Swetnam 1990). In addition, a shift to wetter conditions around the turn of the century (Fritts 1991, Grissino-Mayer 1995) may also have contributed to a decrease in fire occurrences, although the shift occurred ca. 1910-1920, after the changes in fire frequency. Hence, the decline in surface fires in the Southwest may have been due to many factors, among them the physical removal of the Apaches from the Southwestern landscape.

The seasonality of past fires in the Chiricahua Mountains lends some support for the hypothesis of Apache-set fires. The high proportion of dormant season scars is unusual relative to fire histories developed for nearby sites, such as Rhyolite Canyon in Chiricahua National Monument (Swetnam and others 1989), the Camp Point and Peter's Flat sites in the Pinaleño Mountains (Grissino-Mayer and others 1994), and Mica Mountain in the Rincon Mountains (Baisan and Swetnam 1990). The Rustler Park fire scars showed a much higher proportion of dormant season scars than observed in these other sites. This pattern could be due to Apache-set fires during the fall and/or winter seasons, or in spring prior to the start of the growing season. Because most lightning ignitions occur predominantly in May through July and are less frequent in the dormant season, a larger proportion of fire scars in the dormant season argues for anthropogenic fires. Unfortunately, no accurate records of specific seasonal use of fire by the Apaches exists to support this hypothesis.

CONCLUSIONS

In summary, no firm conclusions can be drawn concerning the degree to which the Apaches influenced the fire regimes of the Chiricahua Mountains. It is highly probable that the Apaches exerted some influence, because they traveled the area extensively for 300+ years, and fire may have been a useful tool for specific purposes. Clear associations exist between the fire chronology and specific, major events in Apache history. During the wars with the Spanish, fire occurrence increased (with many one-year intervals), while fires decreased following a peace establishment in 1786. After the peace was broken in 1831, fires resumed, but occurred less frequently. The unusual, bimodal seasonality of past fires also argues for possible Apache influence on fire regimes, as does the termination of fires following the removal of the Apaches to reservations after 1886.

While some scholars believe that all Native American groups used fire extensively for many reasons (Pyne 1982, Sauer 1950), widespread intentional use of fire may have been incompatible with some aspects of the Apache economy, which was largely based on hunting, gathering, raiding, and warfare (Basso 1971, Opler 1983, Worcester 1979). Intentional use of fire would have exposed locations of Apache encampments, which relied heavily on stealth and secrecy, to enemy factions over broad areas. Intentional burning might also have been detrimental to many of the major food plants upon which the Apaches subsisted (e.g. agaves), but may also have increased forage for livestock taken in raids (Kaib and others 1996). In addition, Apache clans in the southern portion of the Southwest were mostly nomadic, occupying the valleys between mountain ranges. Temporary residences may have been established at higher elevations for hunting, gathering, and religious purposes, but long-term use of the higher elevations was not practiced. Finally, separation of Apache camps was needed to make available the limited resources in the semiarid deserts of the Southwest borderlands. Careless use of fire by one group could have been detrimental to adjacent camps (and therefore to relatives).

Additional research is needed to:

- Gather specific information about the extent to which the Apaches used fire, and
- Determine where and when Apache fire practices had significant impacts on fire regimes and, therefore, ecosystems of the borderlands region.

First, a more thorough search for and review of the available literature on the Apaches should be conducted to document traditional use of fire, including specific periods of use, locations, intent, and seasonal use of fire. This information should be compared with previous citations of use of fire by the Apaches. Second, reconstructions of fire history from fire-scar records should be obtained from specific areas fre-

quently used by the Apaches (e.g., known travel routes in southeastern and east-central Arizona) and compared to fire chronologies developed for areas unlikely to have been frequently used (e.g., see Barrett and Arno 1982). Support for the Apache-set fire hypothesis would be gained if the fire-scar records consistently showed different fire regimes in areas of frequent Apache use. Third, more detailed analyses concerning the wildfire-climate relationship should be conducted. Because climate and fire occurrence are coupled across both time and space, specific periods showing a weak or non-existent relationship would argue in favor of Apache alteration of fire regimes. For example, Swetnam and others (1990) showed no relationship existed between fire and climate during the period 1800 to 1900 in the lower portion of Rhyolite Canyon in Chiricahua National Monument, and hypothesized that Apache-set fires could have disrupted the fire-climate relationship.

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