NOTES

FIRE HISTORY OF THE AIKEN CANYON GRASSLAND-WOODLAND ECOTONE IN THE SOUTHERN FOOTHILLS OF THE COLORADO FRONT RANGE

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ABSTRACT—A fire history for the Aiken Canyon Nature Conservancy preserve in Colorado is presented. Eighteen cross-sections cut from ponderosa pine recorded 20 fire events for the period spanning 1602 to 1999. An unusually small median fire interval (MFI) of 7.5 years was obtained for the period 1753 to 1935. A significant association was found between El Nino weather patterns and the fires at Aiken Canyon. A shorter MFI was observed in the grasslands, which are at lower elevations. Fires from railroads or cattle ranching might have caused the shorter MFI in the grasslands between 1872 and 1935. After 1935, fire suppression became common.

RESUMEN—Se presenta la historia de fuegos en la reserva de la Aiken Canyon Nature Conservancy en Colorado. Dieciocho secciones cortadas de *Pinus ponderosa* registraron 20 acontecimientos de fuego en el período de 1602 a 1999. Un medio excepcionalmente pequeño del intervalo de fuego (MIF) de 7.5 años se obtuvo por el período de 1753 a 1935. Se encontró una asociación significativa entre patrones de tiempo de El Niño y fuegos en el Aiken Canyon. Un MIF más corto se observó en los prados que están en elevaciones más bajas. Fuegos de los ferrocarriles o de ranchos de ganado pudieron haber causado el MIF corto en los prados entre 1872 y 1935. Después de 1935, la supresión del fuego llegó a ser común.

The Nature Conservancy dedicated the Aiken Canyon Preserve in 1994 and soon became concerned about the loss of grassland to woodland within this ecotone. Disturbances such as fire alter landscapes, encouraging species diversity and spatial heterogeneity. Baker (1992) recommended managing nature preserves based on landscape-scale processes rather than for individual species or particular communities, noting that ecotones are worth preserving in their own right. The Nature Conservancy considered controlled burns as a restoration method at Aiken Canyon, but such management requires knowledge of past fire disturbance patterns in terms of their timing, severity, and spatial distribution. Consequently, we conducted this study during the summer of 1999 to examine the historic and climatic factors influencing the grassland-woodland fires at Aiken Canyon and to support management decisions.

Numerous fire histories have been created using ponderosa pine (*Pinus ponderosa*) fire scars in Arizona and New Mexico (Swetnam and Dieterich, 1985; Baisan and Swetnam, 1990; Danzer et al., 1996; Fuli et al., 1997) and in northern and central Colorado (Laven et al., 1980; Brown et al., 1999; Veblen et al., 2000; Donnegan et al., 2001). The nearest comparable sites to our study area are those of Brown and Shepperd (2001): Wet Mountain site, 90 km southwest (elevation 2,680 m), with 10 trees; and Manitou Demonstration Plot, 50 km north (2,400 m), with 26 trees. They observed median fire-free intervals of 10 and 7.5 years covering periods from 1514 to 1908 and 1521 to 1865, respectively. Only a few published fire histories have examined the margins of the Great Plains (Brown and Sieg, 1999), but none exist for the grassland-woodland ecotone along the southeast-facing slopes of the Front Range of Colorado.

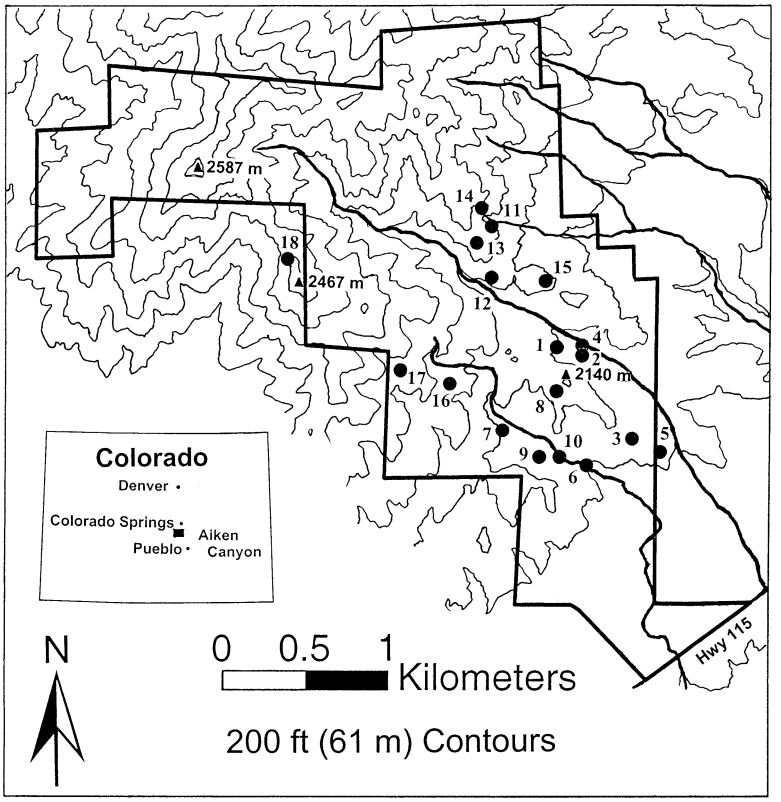

FIG. 1—Map of The Nature Conservancy Aiken Canyon Preserve, Colorado (625 ha). Fire-scarred tree samples are indicated by dots.

Ecotones composed of intermingled grasslands and piñon-juniper woodlands (*Pinus edulis* and *Juniperus monosperma*), as at Aiken Canyon, will have scarred trees, but difficulties in dating piñon and juniper render these fire-history studies unreliable. Instead, researchers favor working with nearby ponderosa pine stands, extrapolating onto adjacent plant communities (Kaib et al., 1996; Brown and Sieg, 1999).

Several studies exist connecting fire frequency to variations in climate at the seasonal, annual, and decadal level for New Mexico and Colorado (Swetnam and Betancourt, 1990; Diaz and Markgraf, 1992; Swetnam and Betancourt, 1998; Grissino-Mayer and Swetnam, 2000; Donnegan et al., 2001). For Aiken Canyon, such connections are of special interest because it lies on the edge of an area where Cole and Cook (1998) found strong correlations between El Niño southern oscillations and local drought area indices.

The historical context should also be reported when developing fire histories. In 1842, the city of Pueblo, Colorado was founded and mail service along the Front Range was initiated. Railroads reached the area in 1872, and rangeland was sometimes burned to improve fodder for cattle (Chapman, 1924). Unlike much of Colorado, Aiken Canyon was never logged (Colorado Natural Areas Program, 2002). Fire suppression became a policy of the Forest Service by 1910, but enforcement would have been impractical until a Conservation Corps was formed nearby in 1935 (Colorado State Archives, 2002).

Aiken Canyon is 20 km southwest of Colorado Springs (38°38′N, 104°53′W) on the eastern slope of the Rampart Range, a smaller range within the foothills of the Front Range (Fig. 1). Higher elevations to the west (Rampart Range) and north (Monument Hill/Palmer Divide) of Aiken Canyon create a barrier that supports a grassland-woodland ecotone.

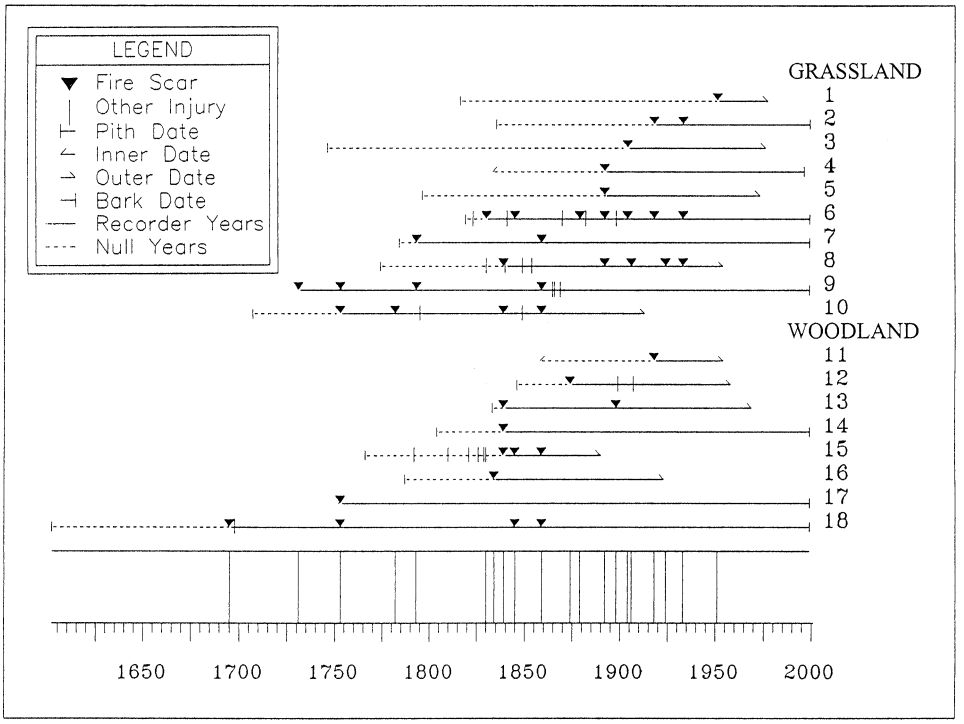

FIG. 2—Fire chronology for Aiken Canyon Preserve, Colorado, with tree sample numbers corresponding to those shown in Fig. 1.

The northern limit of candelabra cactus (*Opuntia imbricata*) and the eastern limit of blue spruce (*Picea pungens*) are located here. From 36 to 51 cm of precipitation are received over the 2,100 to 2,500 m elevation range at this site (United States Department of Agriculture, 1981). The variation in precipitation, soils, and drainage creates a mosaic of tallgrass and midgrass species (e.g., *Andropogon gerardii* and *Bouteloua gracilis*), piñon-juniper woodland, and deciduous shrubland (e.g., *Quercus gambelii*). These grade into coniferous forest (*Abies concolor, Pinus ponderosa,* and *Pseudotsuga menziesii*) growing above 2,200 m, where soils are more acidic compared to the calcic sedimentary soils of the grasslands.

Eighteen samples (all cross-sections or wedges, no cores) were collected and cross-dated visually using skeleton plots (Stokes and Smiley, 1968) for all fire-scarred ponderosa pines that could be located along the grassland-woodland ecotone. Fire-scar dates were assigned after the dendrochronology was completed, and scar dates were subsequently entered into the program FHX2 for data reduction (Grissino-Mayer, 2001).

The complete dendrochronology extends from 1602 to 1999, and the results of the data reduction are summarized in Fig. 2. For the period 1753 to 1935, when at least 4 fire-scarred trees were present, there was a median fire interval of 7.50 years and a Weibull median 50% probability interval (WMPI) of 9.53 years, with a range of intervals from 2 to 37 years. These intervals are at the low end of the results reported by Brown and Shepperd (2001). They are also low compared to most of the sites of Donnegan et al. (2001), although their lowest elevation site (1,996 m) with 12 trees had a WMPI of 5 years for the period 1781 to 1920.

The 65 injuries and scars recorded corresponded to at least 20 fires, with 5 fire years (1753, 1839, 1859, 1892, and 1933) scarring 3 or more trees spaced over multiple hectares. Overall, the fire interval at Aiken Canyon was relatively short compared to most sites in Colorado. Along the northern Front Range, Veblen et al. (2000) found that widespread fire was

more than twice as frequent in the zone below 2,015 m compared to above 2,440 m. In our study, grasslands (<2,140 m) had twice the fire frequency compared to the woodlands (>2,140 m) for the period 1872 to 1935 (Fig. 2).

There was an association ($\chi_c^2 = 5.15$, $P = 0.023$) between the proxy index of El Niño events (Quinn et al., 1987) and fires at Aiken Canyon occurring 1 to 2 years later for the period 1753 to 1935. This association was measured using a 2×2 contingency table with continuity correction for the correlation of dichotomous nominal-scale data (Zar, 1996). By using this nonparametric approach with El Niño events and fires scored as being present or absent, assumptions about underlying distributions are minimized. Including ordinal information about the magnitude of the events and fires increased the correlation. Because the proxy index of Quinn et al. (1987) is based on historical records of fishing catches and storms around Peru, it is only a proxy of El Niño events, but one that is independent of tree ring indices.

A high correlation ($r = 0.52$, $P < 0.000$) also existed between the skeleton plots at Aiken Canyon for the period 1753 to 1935 and the eastern Colorado Palmer Drought Severity Index (Woodhouse et al., 2002) when the index was converted to categorical data using the method of Michaelsen and Thompson (1992). Despite interesting trends, further analysis of parameters such as seasonality is limited by the small data set. Nonetheless, the high fire frequencies and apparent links to El Niño events at this site suggest that woodland ecotones might be worthy of additional studies to obtain their unique fire and climate records.

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