

FIRE IN THE PINES

A 341-year fire and human history at Big Spring Pines Natural Area, Ozark National Scenic Riverways

By Michael Stambaugh, Richard Guyette, and Charles Putnam

The relationship between humans and fire bears directly upon National Park Service policy and park management. The National Park Service strives to restore natural processes and conditions to areas disturbed by human activities such as fire suppression (National Park Service 2001). Information about fire history and historical and current vegetation conditions and processes helps land managers identify desired future conditions for natural communities. This information also helps to justify and set targets for wildland fire practices.

In the Ozark Highlands of Missouri, fire scars on shortleaf pine (*Pinus echinata* Mill.) tree rings date to the 16th century and possibly earlier. These scars reveal one of the world's densest fire-history networks surrounding the Ozark National Scenic Riverways. In general, fires occurred throughout the region every 8–15 years from the 16th to 19th centuries. With the immigration of eastern Native American tribes and European settlers into the Ozarks, fire frequency increased during the late 18th and early 19th centuries. Fires occurred frequently during the mid to late 19th and early 20th centuries, but extensive burning ended abruptly about 1930, and tree density subsequently increased (Schroeder 1983, Ladd 1991, Nelson 1997).

During this study, we documented the history of fire at Big Spring Pines Natural Area by analyzing fire scars on tree rings. Our study objectives were to (1) create a fire history from pine remnants, (2) relate the fire record to human population, and (3) identify implications for fire management.

STUDY SITE

Our study area consists of approximately 200 acres (80 ha) including the Big Spring Pines Natural Area (fig. 1).

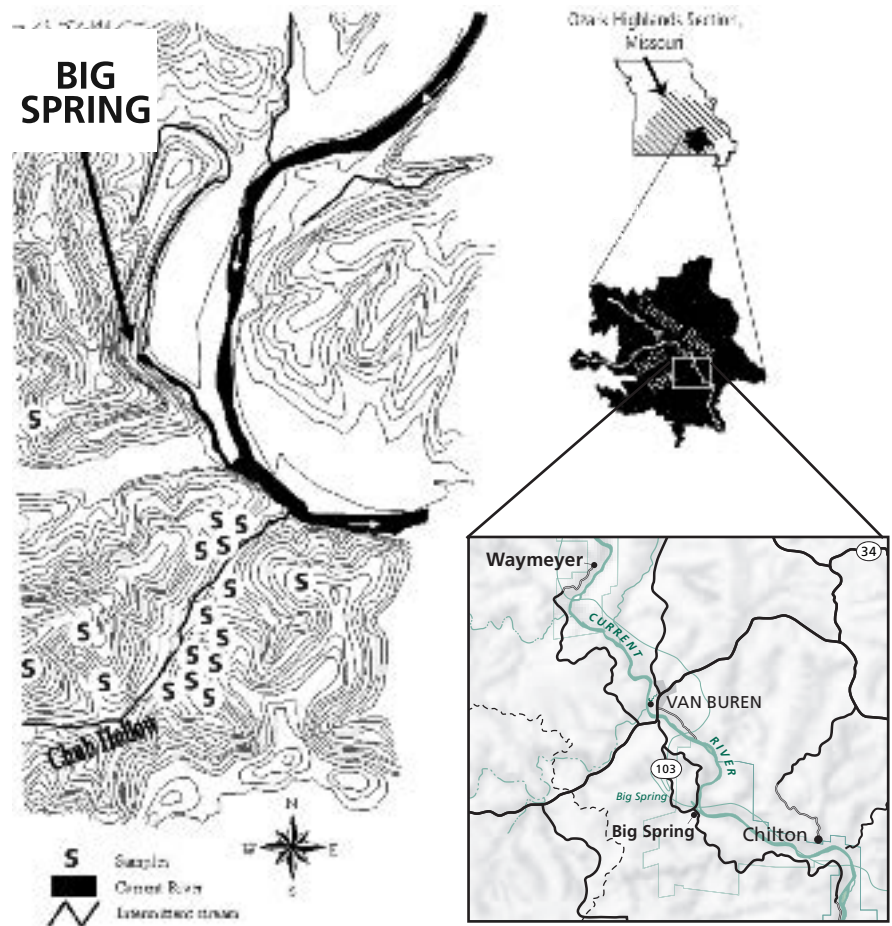


Figure 1. The study area consists of approximately 200 acres (80 ha) that includes the Big Spring Pines Natural Area. This map of the study area shows topography, the location of Big Spring, and the Current River. The letter "S" indicates locations of sample trees with their sample number. Insets are (top) state of Missouri showing location of Ozark Highlands subsection (Nigh and Schroeder 2002), (middle) Current River Hills subsection, and (bottom) the landscape of the Big Spring vicinity. MISSOURI TREE-RING LABORATORY



The natural area is a 345-acre (140-ha) old-growth pine-oak forest that lies adjacent to the third largest spring in North America. It is noteworthy for 200-year-old shortleaf pines, lack of pine regeneration, floral diversity, and a topographically rough landscape with many valleys and ridges.

Shortleaf pine and oaks are the most important species in the overstory. Because of fire suppression, shortleaf pine is nearly absent in the understory and regeneration layers. Shortleaf pine has characteristics adapted for fire disturbances: seeds that germinate on sites with little soil and litter, seedlings' ability to resprout following top-kill, and sapling-sized trees having high resistance to death following burning. Currently, the most frequent natural disturbance is canopy gaps created from dead overstory trees. However, in similar Ozark shortleaf pine forests, canopy gaps are ineffective for promoting shortleaf pine (Stambaugh et al. 2002).

FIELD SAMPLING AND TREE-RING DATING

Fire history projects like this cost between \$15,000 and \$25,000. Fieldwork typically requires one week of two to four persons. Locating and collecting samples is often time intensive. The process of project proposal, sample cataloging, fieldwork, sample preparation, tree-ring measurement and dating, fire scar identification and analysis, and report writing typically occurs over a one-year period. Actual time on this study was less than typical because the study was part of a larger parkwide research project in which certain efforts could be combined.

In 2001 we collected cross sections from 23 shortleaf pine stumps and dead standing trees (fig. 2) on all aspects and elevations

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including alluvial terraces of the Current River. We applied dendrochronology, a method that uses tree-ring variation caused by weather, to precisely date annual growth increments (Stokes and Smiley 1968, Guyette and Cutter 1991). We sanded cross-sections to a high polish (fig. 3), measured tree rings to an accuracy of 0.00394 inch (0.01 mm), and imported measurements into COFECHA (Grissino-Mayer 2001), a program that checks the accuracy of dating and measurements. We identified fire scars by features of callus tissue, cambial death, and charcoal, and designated fire scar years as the first year of growth in response to the fire injury. We used FHX2 software (Grissino-Mayer 1995) to develop a fire

chronology and descriptive statistics for both the composite and individual tree mean fire intervals. We grouped fire intervals into corresponding cultural periods: Native American (before 1780), Native American and European transition (1780 to 1850), agriculture (1851 to 1930), and fire suppression (after 1930) (fig. 4, page 46).

COMPOSITE FIRE CHRONOLOGY

Shortleaf pine cross sections yielded a continuous 341-year-long tree-ring record from 1634 to 1974. No fires have occurred at the site from 1974 to present. Of the original 23 cross sections, we selected 16 to sample based on wood quality, presence of fire scars, and number of tree rings; seven samples were not used because of dating difficulty or lack of fire scars. We dated a total of 193 fire



Figure 2. Stumps of shortleaf pine trees that were cut around the end of the 19th century still persist throughout much of the Ozark Highlands region. Although the tree is gone, the resinous stump in this photo has persisted for a century following cutting. Important historical information about past climate and fire, often dating to the 16th century, exists within remnant stumps. The blackened oval-shaped surface on the stump is the charcoal created from past fires. Here, a worker begins to cut a cross section of a stump that will be polished to reveal cellular detail of annual rings and fire scars. MISSOURI TREE-RING LABORATORY

scars from the 16 sample trees. The mean fire interval was 2.8 years and ranged from 1 to 58 years for the entire record (table 1). Variation in mean fire intervals corresponded to cultural and land use periods. Nearly annual burning occurred at the site from 1813 to 1888. Conversely, the longest intervals without fire were from 1668 to 1726 and from 1932 to 1974. The percentage of trees scarred provides an estimate for the size or intensity of a fire event. In 14 different years of the fire record, more than 30% of the trees sampled were scarred. The highest percentage of trees scarred in any single year was 57% (1877) and six other years had more than 40% trees scarred. The average percentage of trees scarred for all years with fires was 18%. More than 90% of the scars resulted from fire occurring during the dormant season (i.e., September through March).

Table 1. Summary statistics of fire record at Big Spring Pines Natural Area

Record of period	Interval (n)	Mean fire interval ($\pm$ SD)	Range (years)
Entire period	95	2.8 ($\pm$ 6.5)	1– 58
Native American (before 1780)	5	22.4 ($\pm$ 21.5)	5– 58
Euro-American settlement (1780–1850)	38	1.8 ($\pm$ 1.2)	1– 6
Agriculture (1851–1930)	50	1.56 ($\pm$ 1.0)	1– 6
Fire suppression (after 1930)	–	70 ^a	2 ^b – 75

Note: Periods of record were delineated by cultural and land use changes in the region.

^aMean fire interval is based on the last fire recorded at the site and information of no subsequent fires occurring at the site between 1974 and 2002.

^bTwo-year interval is a result of 1932 fire and is not representative of the larger fire suppression period.

FIRE INTERVALS FOR INDIVIDUAL TREES

Fire intervals ranged from 1 to 87 years with a mean of 6.2 years ($\pm$ 8.0 SD). The median fire interval was 5.0 years (table 1). The average number of years from all initial scars to the second scar was 8.8 years and ranged from 2 to 21 years. One tree (#8), located approximately 328 feet (100 m) from the edge of the Current River and less than 16 feet (5 m) above its bank-full water level (see fig. 1), had 40 fire scars between 1780 and 1925.

DISCUSSION

During this study, we found that fires were most commonly low intensity and rarely scorched tree crowns. We found an association between human population density and fire frequency, which suggests that fires were of anthropogenic origin at least as early as the 17th century (Guyette et al. 2003a). During the 20th century, humans have caused nearly all fires in the state (Missouri Rural Fire Departments, unpublished data, 2003).

The inside ring dates, or regeneration dates, of our sample trees and the current size class structure of pines at Big Spring Pines Natural Area show a continual regeneration of pine from the 17th to 19th centuries despite a variable burning frequency of 1 to 58 years (table 1). Applying this

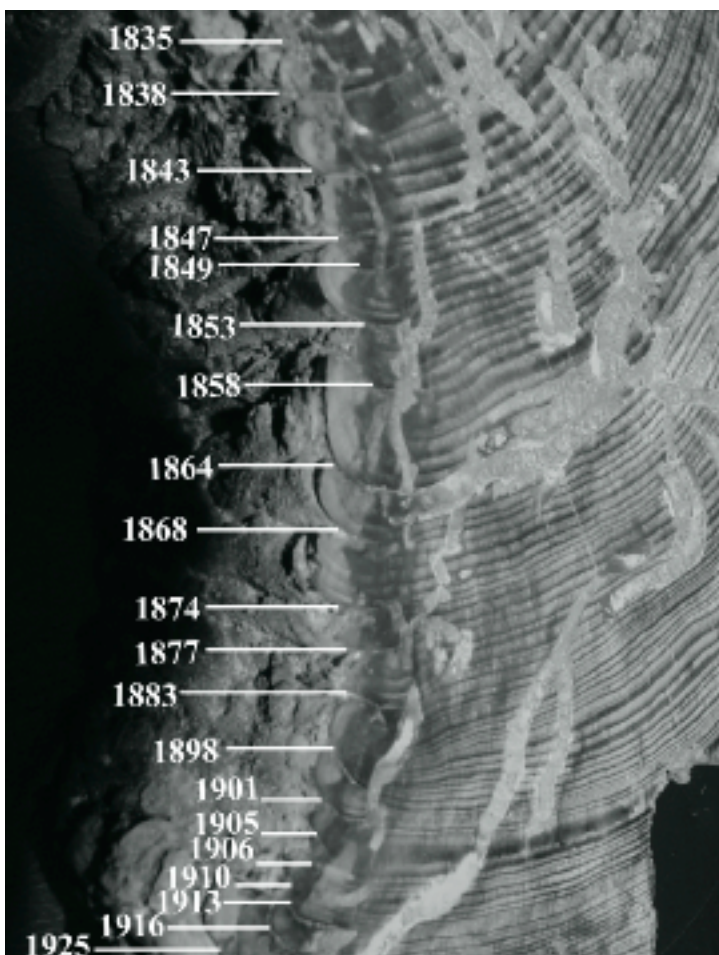


Figure 3. From the 1830s to the 1920s, fire disturbance was common throughout much of the Missouri Ozarks. A polished cross section of shortleaf pine tree rings from Big Spring Pines Natural Area shows curling scar tissue that represents the year of response to injury from fire. Lines and corresponding calendar years point to the scar tissue. MISSOURI TREE-RING LABORATORY



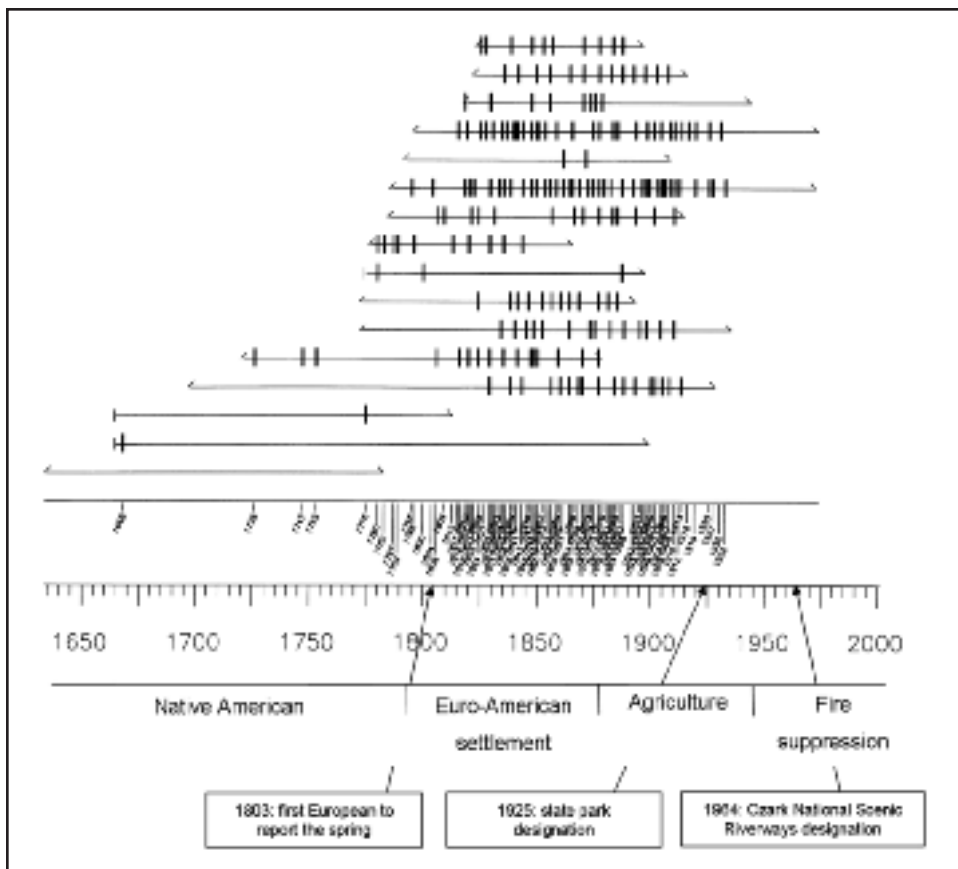


Figure 4. Investigators analyzed 16 trees, which revealed 193 fire scars and 96 years with fire. Calendar years are shown on the x-axis with associated cultural periods and significant historical events denoted beneath. Horizontal lines represent the period of record for each sample tree; bold vertical bars represent fire scar years on the tree. Pith dates (the years of tree regeneration) are represented by short, thin vertical lines at the left end of the horizontal lines, while inside ring dates (first tree ring, pith absent) are represented by diagonal lines (FHX2 software, Grissino-Mayer 1995). Cultural periods are based on population density estimates in Guyette et al. 2002.

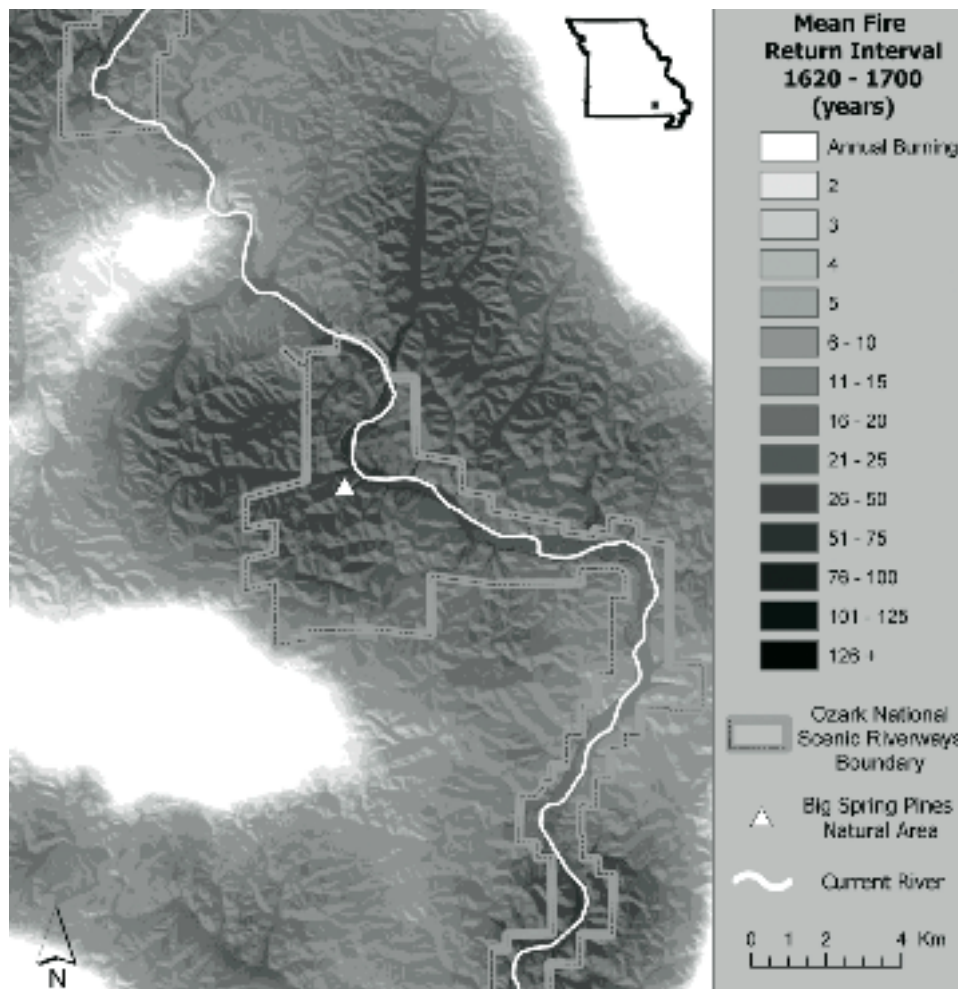


Figure 5. Investigators use models that combine topography (i.e., digital elevation models), fuels, and human population density of fire history sites to estimate mean fire intervals across a landscape. Estimates of mean fire intervals for the period 1620 to 1700 in the vicinity of the Big Spring Pines Natural Area are illustrated on this map. The map is based on calibrated equations that explain 46% of the variance in the mean fire intervals of 35 fire history sites (Guyette et al. 2003b). White areas of the map are topographically smooth surfaces (i.e., few valleys and ridges) of the Ozark Plateau that encompass the more deeply dissected vicinity of the Big Spring Pines Natural Area. DATA SOURCE: MISSOURI TREE-RING LABORATORY

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finding to management suggests that incorporating variability in the number of years between burns would best mimic the presettlement fire regime. Longer

intervals likely allowed pines to attain sizes large enough to survive subsequent fires. Restoration of a variable fire regime might be achieved by burning every 1 to 3 years until hardwood vegetation is reduced and pine significantly regenerates, followed by a lengthened and variable burning frequency (e.g., 10 to 15 years) to ensure the survival of the newly established cohort into the sapling size class.

The long-term variability in fire frequency, human population density, and cultural practices reveals the historical importance of human influence on vegetation not only at the Big Spring Pines Natural Area but, by extension, in the entire region of Ozark National Scenic Riverways. The high density of fire history sites around this unit of the National Park System allowed us to describe the spatial and temporal variability in the fire regime. Broader scale studies that combine data on topography (i.e., digital elevation models), fuels, and human population density have provided the means for modeling mean fire return intervals for the entire park (Guyette et al. 2003b). These models, empirically derived from fire history sites such as the natural area, are used to generate maps that assign estimates of mean fire intervals to all locations on a landscape for a given time period (Guyette et al. 2003b) (fig. 5).

Reconstructed fire histories provide information that land managers need to justify and set targets for wildland fire practices such as Fire Regime Condition Classes (FRCCs). To identify desired future conditions for park natural communities, managers must identify historical and current vegetation conditions and processes. Fire history information quantifies the fire disturbance process and its characteristics in the park environment, and can provide supporting evidence for historical vegetative conditions and the influence of humans on those conditions.

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