Bringing Fire Back

The Changing Regimes of the Appalachian Mixed-Oak Forests

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ABSTRACT

Since vegetative associations stabilized about 4,000 years ago, the Appalachian mixed-oak forests have experienced three profoundly different fire regimes. Periodic, low-intensity surface fires lit by American Indians characterized the first regime, and this regime helped perpetuate oak as one of the dominant species groups. The Industrial Revolution led to high-intensity, stand-replacing fires, causing extensive damage to the forests. Modern fire protection created a "no-fire" regime that permitted the forests to recover but allowed mesophytic species to begin replacing the oaks. Today, research is under way to identify how to reintroduce fire to solve this oak replacement problem.

Keywords: oak regeneration; pre-European settlement; wildfire

Of all the alterations to fire regimes brought on by European settlement of North America, perhaps the most far-reaching impacts have been caused by the near elimination of the periodic, low-intensity surface fire. Its reduction in frequency and extent in the Interior West and Southeast is well-documented and widely known: succession of open pine forests to dense mixed-species forests, resulting in catastrophic, stand-replacing fires. Less well known and documented is the integral role this fire regime played in helping perpetuate the mixed-oak forests of the Appalachian Mountain region (central and western Pennsylvania southward to northern Georgia) before European settlement and the effects that changing this regime in the 19th and 20th centuries had on the continued dominance of this widespread forest type.

Until recently, for a variety of reasons, fire was not thought of as an important, much less desirable, disturbance in mixed-oak forests. However,

Above: **Prescribed low-intensity, early-spring (left) and late-spring (right) surface fires similar to those set by American Indians and early settlers.**


Photos by Patrick Brose

an emerging hypothesis holds that periodic, low-intensity surface fires were crucial to the perpetuation of mixed-oak forests for millennia (Van Lear and Waldrop 1989; Abrams 1992; Lorimer 1993). Briefly stated, this fire–oak hypothesis is that (1) periodic, low-intensity surface fires were common prior to European settlement due to Indian burning practices; (2) oaks are directly and indirectly adapted to this disturbance regime; and (3) cessation of that regime is at least partly responsible for the intractable, widespread oak regeneration problem (Loftis and McGee 1993). This article explains this hypothesis by highlighting the changing fire regimes through time for the mixed-oak forests of the Appalachian Mountains, discusses the positive and negative consequences of these changes, and reports on efforts to reintroduce fire to this forest type and region.

Pre-Settlement Use of Fire

After the Wisconsin glaciation peaked about 18,000 years ago, plant species, including oaks, gradually migrated to their current landscape positions in response to the warming climate. The modern-day eastern hardwood forest has been in place for at least the past 4,000 years, with the oaks, pines, and American chestnut *(Castanea dentata)* often dominating (Delcourt and Delcourt 1997). However, this migration was affected by factors other than just climate change.

At least 12,000 years ago, Indians arrived in North America and spread throughout the continent, including into the Appalachian Mountains (Williams 1989; Bonnicksen 2000). Although their exact pre-Columbian population numbers are unknown, demographers estimate that the Indian population of North America in 1500 was about 18 million (Dobyns 1983), although Stannard (1992) more recently suggested that the continent may have been occupied by as many as 100 million Indians. Regardless of the accuracy of these estimates, there is no doubt that the Appalachian landscape was not an unpeopled wilderness at the time of Columbus, and millions of Indians had been modifying the forests of what is now the eastern United States for millennia prior to European settlement. Their main tool for modifying the forest was fire.

Over thousands of years, Indians became expert in using fire for various purposes to enhance their survival and improve the quality of their lives (Williams 1989; Pyne et al. 1996; Bonnicksen 2000). Fire was used to encourage fruit and berry production; expose acorns and chestnuts for collection; prepare planting sites for agriculture; control undesirable pests; fireproof villages; create and maintain open woodlands, savannahs, and prairies for desired early-successional wildlife; concentrate game in areas convenient for hunting; and facilitate travel along extensive trail systems. Generally, fires used by Indians were periodic, low-intensity surface fires ignited in the spring or fall. Early settlers observed that American Indians varied fire frequency according to fuel type and objectives (Williams 1989). Cereal grasses often were burned annually, mast-producing shrubs somewhat less frequently, and the woodlands about once a decade. Exceptions to this regime undoubtedly occurred, e.g., areas going unburned for decades; spring and fall fires in the same year; high-intensity, stand-replacing fires after a major ice or windstorm. However, through trial and error over millennia, Indians learned to use fire as a powerful tool and with it made extensive modifications to the vegetation over most of North America, including the Appalachian Mountains.

The combination of periodic firing of the woods by Indians and occasional lightning-caused fires served as a stabilizing disturbance in the mixed-oak forests of the Appalachians, favoring the perpetuation of oak, pine, and chestnut. Mature oaks withstood surface fires because of their thick bark and ability to compartmentalize rot (Brose and Van Lear 1999; Smith and Sutherland 1999). Oak reproduction survived periodic surface fires because of its superior sprouting ability (Brose and Van Lear 1998), allowing the regeneration to capture the growing space and resources made available by the demise or exclusion of fire-sensitive competitors. Periodic surface fires probably also facilitated oak seedling establishment by preparing seedbeds, reducing acorn insect pests, and encouraging acorn-caching by birds and small mammals (Van Lear and Watt 1993).

Effects of European Settlement

European settlement of the Appalachians displaced the Indians from the mid-18th to early 19th century. However, that change did not alter the fire regime as settlers readily adopted Indian burning practices (Pyne et al. 1996) and used the forests for new reasons, e.g., charcoal and iron production. The frequency and intensity of fires probably increased in some locations and decreased in others with European settlement, but fire regimes did not change enough to cause region-wide shifts in species composition.

The periodic, low-intensity surface fire regime was dramatically altered to high-intensity, stand-replacing fires by the onset of capital-intensive forest harvesting practices in the Appalachians *(fig. 1, p. 32)*. Such practices characterized the period from about 1880

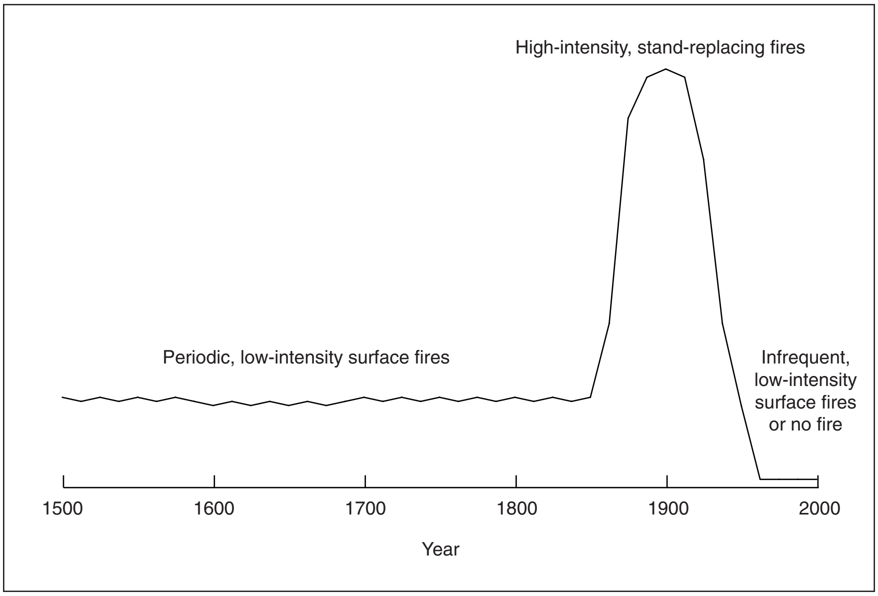


Figure 1. **Conceptual model of the changes in fire regimes for the mixed-oak forests of the Appalachian Mountains since 1500. Periodic, low-intensity surface fire was the dominant regime until the mid-1800s, when it was supplanted by a high-intensity, stand-replacing regime. Since the early 1900s, an infrequent or no-fire regime has been the rule.**

to 1930 and incorporated the use of steam power for transportation and processing of raw material. Steam engines combined with the newly developed gear-driven locomotives made it economically feasible to harvest timber from vast areas of mountainous terrain. The ensuing large quantities of timber were processed using improved band saw technology, which became the dominant type of mill during this period. Such mills were capital-intensive operations that required large quantities of timber to remain profitable. For example, one large mill in Greenbrier County, West Virginia, used three band saws and required 17 acres of virgin timber per day to keep busy. In 1909, 83 similar mills were operating in West Virginia alone, resulting in a rapid depletion of the timber supply (Brooks 1911).

Widespread logging during this period created a landscape prone to wildfire. Intensive logging left vast acreages with dried slash that were easily ignited and would burn with unusual intensity during dry periods. The steam power that facilitated transportation and processing also provided the source of most wildfire ignitions. A 1907 survey from West Virginia attributed 71 percent of all wildfires to locomotives and 20 percent to mills processing the timber (Brooks 1911).

The practice of cutting timber from the most to least accessible tracts of large ownerships also contributed to wildfires. Usually, track would be built and the timber removed from the most accessible area, then the track would be extended. This meant that drying fuels were constantly in jeopardy of being ignited by passing locomotives and the pervasive sparks emitted from the engines. Once ignited, these intense slash fires were difficult, if not impossible, to attack with hand tools.

The size and the intensity of the fires during this period were much greater than fires set by Indians and early settlers, and therefore they produced very different effects. Fires burning in cutover areas during this period could be deleterious to soils, waterways, and adjacent uncut forests. If they occurred in montane coniferous forests, these communities would be degraded and often converted to low-quality northern hardwood forests or shrub-dominated glades (Stephenson 1993). Partially as a result of the intense fires that occurred during this period, Appalachian montane coniferous forests have been greatly reduced in extent and are considered among the most threatened ecosystems in the United States (Christensen et al. 1996).

These intense, widespread fires and unregulated logging dramatically changed the structure of the Appalachian forests. In the early 1900s, nearly 1 million acres burned annually in Pennsylvania (Banks 1960). Other Appalachian states had similar experiences with fire. Because of their tenacious sprouting ability, oak and chestnut rootstocks were able to withstand this new fire regime and may have actually benefited relative to other species (Abrams 1992). However, these new oak and chestnut stands could not develop until the frequent burning stopped (Banks 1960). That cessation was soon forthcoming with the advent of wildfire control.

Enter Fire Protection

The massive wildfires of the late 1800s and early 1900s contributed to a nationwide conservation movement that identified wildfire as an undesirable, destructive force that must be controlled. Although the Weeks Act of 1911 provided the legal authority for establishing federal forests in the Appalachians and fire prevention became one of the first priorities of the newly formed US Forest Service, the states shouldered the brunt of the responsibility for controlling the wildfire problem in the eastern United States. The Pennsylvania experience in solving the wildfire problem is typical of most Appalachian states.

In Pennsylvania, the first wildfire control actions were preventive legislation and actually predate the wildfire era of the late 1800s (PA-DCNR 1975). A number of statewide laws were enacted during the 18th and 19th centuries to prohibit the burning of the forest and make county commissioners responsible for suppressing and punishing anyone responsible for starting open fires in the forest. For example, the 1879 fire law read, "Any person who shall wantonly and willfully kindle any fire shall pay a fine not to exceed three hundred dollars and undergo imprisonment not exceeding twelve months." However, enforcement of these early laws was spotty.

In 1901 the Pennsylvania State Department of Forestry, later the Pennsyl-

Patrick Brose

A mixed-oak forest that has experienced no fires for at least 40 years. Note the abundance of midstory and understory stems and the dense shade on the forest floor.

vania Bureau of Forestry, was formed and charged with solving the wildfire problem (Stout et al. 2000). It used the three-prong approach of detection, suppression, and prevention. In 1905 the first wooden fire tower was constructed in south-central Pennsylvania, and by the mid-1920s more than 250 towers had been built and were in use. These early fire towers were linked by telephone, and by the mid-1930s the Pennsylvania Bureau of Forestry had more than 1,000 miles of telephone line connecting fire towers with local fire wardens.

Fire suppression began in earnest when the 1915 fire law established the fire warden program—a network of chief, district, and local fire wardens. This fire suppression program continues today and has become a model for several other Appalachian states. Firefighting equipment and techniques have also evolved over the past century. Initially, work crews suppressed wildfires with hand tools, but fire engines and bulldozers were quickly added to the firefighting arsenal as they became available. Aircraft began playing an important role in fire suppression in the 1960s.

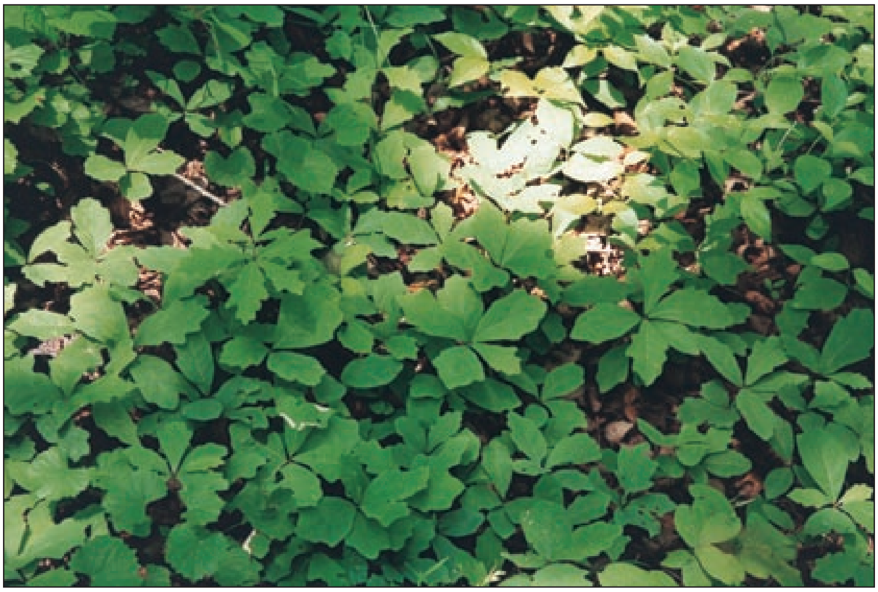
Fire prevention efforts included the previously mentioned laws as well as public education efforts through the Smokey Bear campaign. This joint federal–state advertising campaign began in 1944 and has had dramatic success, not only teaching millions of people to be careful with fire but also teaching that fire has no role in the maintenance and perpetuation of America's forests.

This improved firefighting technology coincided with the decline of the logging industry to quickly reduce the extent, frequency, intensity, and severity of wildfires (PA-DCNR 1975; Stout et al. 2000). Timber companies were moving out of the Appalachians, and railroad tracks were being removed for use elsewhere. Without steam locomotives traversing the region's forests, ignitions were much less common. When they did occur, they were not nearly as widespread as they had been only a few decades earlier (Abrams and Nowacki 1992). For example, by the 1920s, forestland burned in Pennsylvania had decreased to 180,000 acres per year, and this average has continued downward, to 31,500 acres by the 1950s and 3,300 acres today. Comparable trends occurred in other Appalachian states. The vast hardwood forests of the Appalachians were redeveloping for the most part in the near-complete absence of fire, for the first time in perhaps thousands of years.

Unintended Consequences

Solving the wildfire problem of the early 1900s is the greatest success story of professional forestry in the Appalachians during the past century. However, like any management action, the advent of fire control has had both positive and negative consequences. The obvious positive is the development of the high-quality hardwood forests throughout the region. In the early 1900s, fire had become so frequent and pervasive that new hardwood forests simply could not develop.

Just like in the open pine forests of the Rockies and the Southeast, the elimination of the periodic, low-intensity surface fire regime from the mixed-oak forests of the Appalachians led to denser-than-normal stands, with midstories and understories of fire-sensitive, shade-tolerant shrubs and trees, especially on mesic upland sites. However, unlike the open pine forests, this accumulation of vegetation and woody debris generally did not translate into a stand-replacing fire regime. Instead, it proved to be a major contributor to the oak regeneration problem. In the dense shade of these overstocked, historically oak-dominated stands, oak reproduction quickly dies because it is not adapted to deal with those conditions. Harvesting such stands was often found to hasten the conversion from oak to mixed mesophytic species (Abrams and Nowacki 1992; Schuler and Gillespie 2000). Throughout the Appalachians and eastern North America, this shift in species composition



Photos by David Van Lear

A mixed-oak stand treated twice with a low-intensity, late-spring surface fire. In the first photo, note the open understory conditions, dead midstory stems, presence of several herbaceous species, and an unburned stand in the background. The second photo shows the abundance of new oak regeneration possible in a periodically burned oak forest.

from oak to mixed mesophytic is unprecedented and often undesirable due to oak's many ecological and economic benefits.

Fire exclusion is not the only major change for the Appalachian mixed-oak forests. Since European settlement other key ecological events have occurred, including loss of the American chestnut; extirpation of some predators, i.e., gray wolf *(Canus lupus)* and mountain lion *(Felis concolor);* reduction followed by overpopulation of white-tailed deer *(Odocoileus virginianus);* and extinction of the passenger pigeon *(Ectopistes migratorius).* These events and others undoubtedly affected mixed-oak forest compositional dynamics and coincided with the change in fire regimes, thus confounding the interpretation of past fire influence. However, because of the intractable widespread nature of the oak regeneration problem, the fire–oak hypothesis is becoming more accepted, as reflected in the growing interest in using prescribed burning in oak management (Yaussy 2000).

Reintroducing Fire

The interest in prescribed fire takes two forms: reintroducing fire to mature mixed-oak stands to mimic Indian burning and using fire as an interim treatment in a shelterwood harvest sequence. Prescribed burning in mature mixed-oak stands is intended to recreate the open forest described by many early settlers. These fires are usually set in early spring or after leaf drop in the autumn and are generally low-intensity. They remove the thin-barked shrubs and trees from the midstory and understory strata without harming the dominant oaks, consume the litter layer, promote grasses and herbaceous plants, and encourage establishment of oak regeneration through decreased acorn predation by insects and increased acorn caching by wildlife (Van Lear and Watt 1993; Barnes and Van Lear 1998).

Using fire as a follow-up treatment to the first cut of a two-step shelterwood mimics the multiple disturbance regime of the mid- to late 1800s and focuses on releasing oak regeneration from intense competition from faster-growing but fire-sensitive species. This technique, called the shelterwood-burn technique (Brose et al. 1999), targets basic silvical differences in germination and root-development strategies between the oaks and many of their competitors. It is a three-step process: a shelterwood cut to create about 50 percent canopy opening, followed by a several-year wait for the existing regeneration to develop, then a moderately hot growing-season fire to favor the oak reproduction over that of other species.

Although both of these approaches emphasize manipulation of the vegetative composition and structure, current research is taking a much broader view. In southern Ohio, the USDA Forest Service Northeastern Research Station, Mead Corporation, and Ohio Department of Natural Resources are involved in a long-term, multidisciplinary project examining the ecological effects of reintroducing fire into mature mixed-oak stands after its extended absence and how those effects compare to mechanical thinning. A comparable study is also being done in western North Carolina by the Southern Research Sta-

Patrick Brose

A mixed-oak shelterwood stand treated with a moderate-intensity spring fire to change composition of the regeneration pool. Most of the dead saplings are tulip-poplar, and most of the green sprouts are oak and hickory.

tion and several cooperators. In West Virginia, the Northeastern Research Station is involved with University of Pittsburgh personnel to examine the interactions of fire and deer on mature mixed-oak forests, and in Pennsylvania the impact of the shelterwood-burn technique on herpetofauna will soon be studied.

Even with these studies, much remains to be done. As noted, past ecological events confound a complete understanding of the historical role of fire in perpetuating mixed-oak forests, so more research is needed to clarify this important concept. With more than 70 percent of the Appalachian forestland in private ownership, prescribed fire on these lands involves major legal and social questions.

Much is unknown about the ecological ramifications of reintroducing fire to forests from which it has been absent for 80 years or more. Comparisons of the effects of singular and combination herbicide, mechanical thinning, and prescribed fire treatments await research. Unfortunately, programs such as the National Fire Plan (USDA Forest Service and US Department of Interior 2000) fail to recognize the role of fire exclusion in the impaired regeneration of a major species group as a problem worth funding, so continued fire–oak research is uncertain.

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