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Fire in Eastern Oak Forests—A Primer

Michael C. Stambaugh, Daniel C. Dey, Joseph M. Marschall, and Craig A. Harper

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Abstract

This publication provides an introduction to the concepts that are important to understanding fire in the ecology and management of oak forests in the eastern United States. Fire historically was common in eastern oak forests and woodlands but perceptions of fire changed and suppression became the norm. Research has demonstrated how fire-maintained woodlands and savannas are occupied by plant and wildlife species that require more open conditions than that in closed-canopy forests. Fire is essential to maintaining oak forests. In addition to favoring oaks, fire creates an environment that allows regeneration of other tree species and stimulates germination of a diverse assemblage of herbaceous plants in the understory.

KEY WORDS: prescribed fire, oak management, wildfire, forest community

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Cover Photo

Clockwise from top left: Backing fire through an oak woodland at La Cygne Wildlife Management Area, Kansas; courtesy photo by Michael C. Stambaugh.

Logs and snags burn in the final stages of a prescribed burn conducted in autumn to promote white oak regeneration in central Missouri; courtesy photo by Michael Stambaugh.

Diverse herbaceous understory layer of an oak woodland at Western Star Flatwoods Natural Area, Mark Twain National Forest, Missouri; courtesy photo by Joseph M. Marschall.

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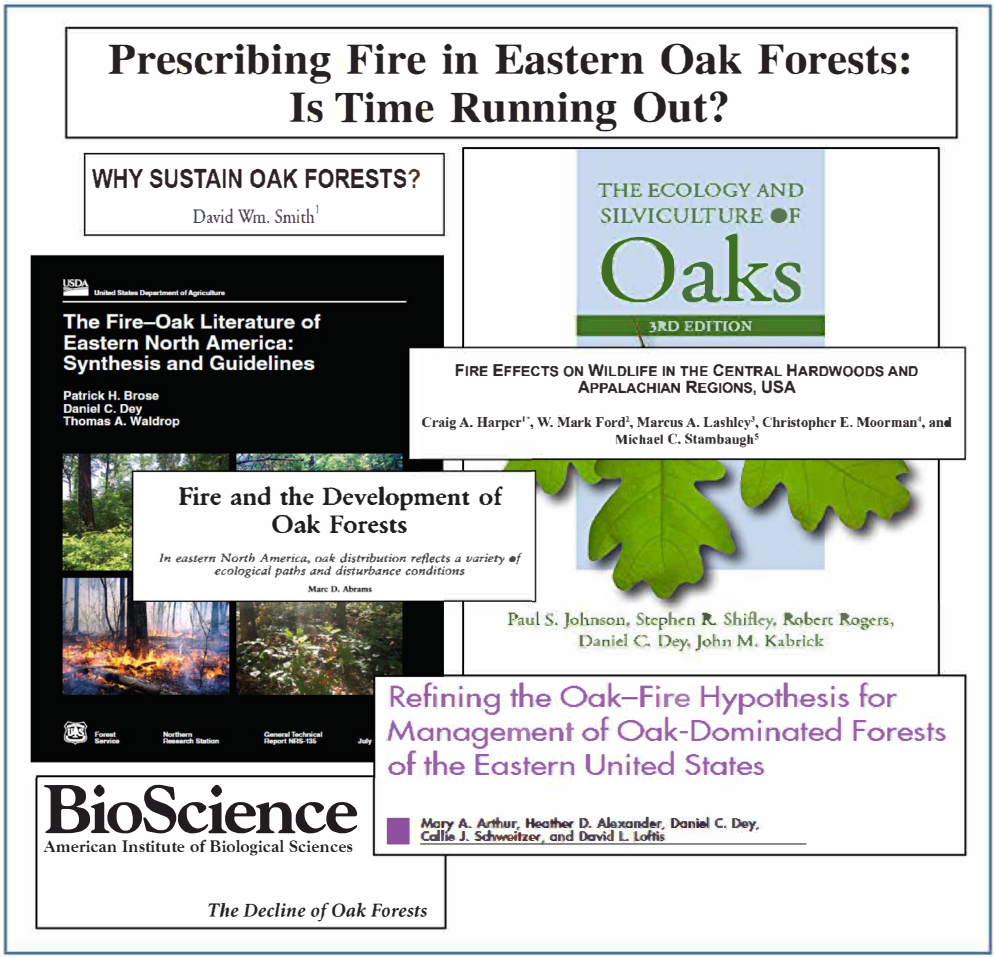
INTRODUCTION

Oak (*Quercus* spp.) forests represent a broad grouping of plant communities that have a tree canopy dominated by oaks. In the eastern United States, many oak forests are rapidly changing as a result of fire exclusion. Land managers and scientists now recognize the needs and benefits from reintroduction of fire through controlled burns.

We offer an introduction to the concepts that are important to understanding fire in the ecology and management of eastern oak forests. The information found herein is based on current and published research results and is reflected in the publications listed in "Suggested Readings" on page 14. Our goal is to increase readers' knowledge and interest in using fire in the management of oak ecosystems.



Examples of scientific literature that address concerns for oak ecosystem sustainability with an emphasis on the role of fire.

PERSPECTIVES ABOUT FIRE

Our perspectives change as we get older, gain experiences, and increase our knowledge. Similarly, views of professional land and wildlife managers related to fire in the management of eastern oak forests have changed over time, and in the past 20 years have pivoted toward promotion of fire as an effective management tool. Managers have observed undesirable changes in vegetation and wildlife when fire is excluded from oak forests. In addition, increased understanding of fire ecology and management is informing this changing perspective.

Before the 1900s, fire was common in eastern oak forests and woodlands. In many areas, fires occurred every 3 to 10 years. In some years, fires burned millions of acres. Many of these fires were started by Native Americans, and later, by European settlers. In the early 1900s, perceptions about burning changed from good to bad. At that time, forests had been heavily cutover and burning was considered destructive to their regrowth. Negative fire perceptions also arose from fear of wildfires and concerns for damage to property and threats to livestock and human lives. The perceived need for fire suppression instigated the formation of many state and federal natural resource agencies, which provided strong public media campaigns that were effective at delivering this message. Since then, fires have been aggressively suppressed.

Despite fire being less common today, knowledge of the benefits of fire are acknowledged and, in some places, have been passed down from generation to generation. Since the 1960s, perspectives have been slowly shifting toward an acceptance of the use of controlled burning, also known as prescribed fire. Controlled burning is conducted safely under prescribed conditions, with specific objectives, and supported by science.

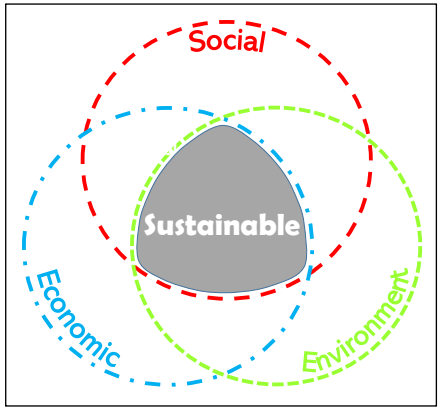
Signs related to fire management representing differences in messaging campaigns, including the increasing acceptance of controlled fires. USDA Forest Service images and photos.

IS BURNING IN FORESTS GOOD OR BAD?

Some people think that controlled burning in forests is good; some think it is bad. However, the answer to this question depends on what vegetation and other resource conditions are desired. Natural resource planners refer to these as desired future conditions.

Desired future conditions are determined before any related activities begin. Professional land managers strive to be good stewards of natural resources, especially when burning forests. As such, management activities should be carried out with a goal to sustain forests in desirable conditions for future generations.

Whether or not a management practice is sustainable is determined by the following question: Is the practice socially acceptable, ecologically sound, and economically viable?



This diagram shows that sustainable management practices are at the intersection of being socially acceptable, economically viable, and environmentally sound. Courtesy image by Michael C. Stambaugh.

Answers to these questions can be difficult, especially because fire can be frightening and intimidating. Also, despite the many benefits of fire, it is difficult to change people's long-held perspectives about fire from something that is bad to potentially good.

As controlled burning becomes more desired, understanding its effects and the benefits is critical. Aldo Leopold, one of the greatest leaders of conservation, offered a land management challenge:

"Intelligent tinkering begins by keeping all of the parts and processes."

Fire is a critical ecological process for our forests and grasslands, and without it, many native plants and animals could disappear.

Aldo Leopold seated above the Rio Gavilan in northern Mexico while on a bow hunting trip in 1938. Courtesy photo from Aldo Leopold Foundation.

FIRE'S ROLE IN OAK ECOSYSTEMS

In dense forests, where trees are the dominant plant type, little sunlight reaches the forest floor, and grasses and forbs are sparse to nonexistent. In the past, eastern oak forests typically were not the dense and dark stands of trees that we see today. Commonly, recurring fires resulted in an appearance like an open park, as fires consumed leaves, woody debris, and small shrubs and trees. Expansive open areas with scattered trees, called savannas or woodlands, were common especially in relatively level areas, ridgetops, or on south- and west-facing slopes. Woodlands and savannas contained diverse plant and wildlife communities. Landscapes with plant communities ranging from dense forests to open savannas were the foundation for many levels of diversity for plants, insects, reptiles, birds, and mammals.

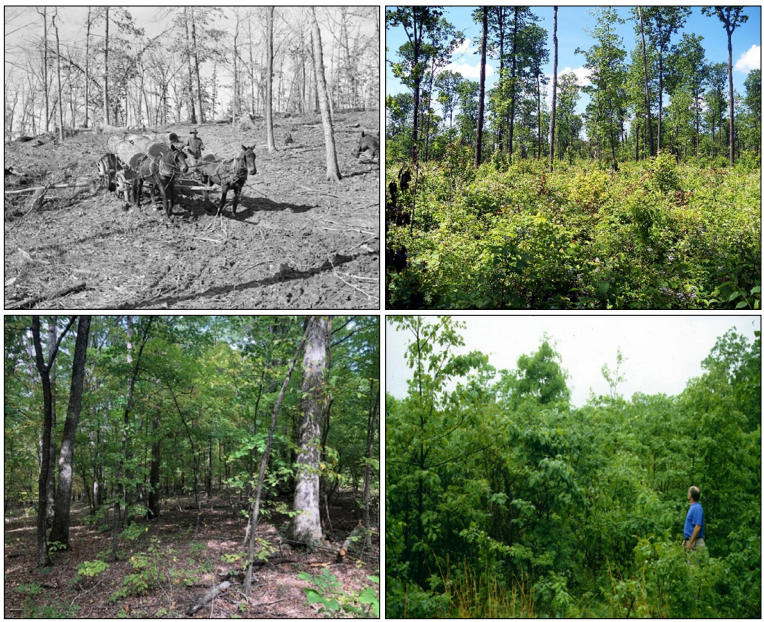
It is ironic that fire is often viewed as destructive for wildlife when the opposite is often true. Indeed, there are some wildlife species, such as ovenbird (*Seiurus aurocapilla*) and various terrestrial salamanders, which are found only in dense forests, and fire does not enhance their habitat. However, there are many other wildlife species that occur only in more open areas typically maintained by frequent burning. For example, red-headed woodpecker (*Melanerpes erythrocephalus*) and northern bobwhite (*Colinus virginianus*) need more open conditions to meet their habitat requirements. It has been documented through research how fire-maintained woodlands and savannas are occupied by species that may require forests or more open conditions, providing "some of both worlds." Furthermore, populations of generalist species that are found in both forests and open areas, such as white-tailed deer (*Odocoileus virginianus*) and wild turkey (*Meleagris gallopavo*), are benefitted greatly by presence of woodlands or savannas because of enhanced conditions for nesting, brooding, foraging, and thermal cover. Overall, wildlife diversity and population vigor of most species are increased significantly by presence of open-oak ecosystem plant communities on the landscape.

The varied conditions of oak ecosystems, from savanna (5 to 30 percent canopy cover), to woodland (30 to 80 percent canopy cover), to forest (80 to 100 percent canopy cover). Courtesy photos by Craig A. Harper and Michael C. Stambaugh.

HISTORY OF FIRE IN THE EASTERN UNITED STATES

Evidence for fire in the eastern United States extends back in time for thousands of years. The lack of fire in the last century is a stark change on that time scale. Since Europeans arrived in North America, dramatic changes to forests have occurred. European diseases decimated Native American populations, consequently eliminating many fires from the landscape, which caused formerly fire-maintained woodlands to transition to closed-canopy forests. As more and more Europeans colonized North America, and as their descendants moved west, most of these forests were cut and some land was used for agriculture production to support a growing and expanding population. In many regions, catastrophic wildfires burned through the logging slash, and wildfire became a national public enemy.

By the early 1900s, after most forests had been cutover and burned, the lands were allowed to regenerate and marginal agriculture lands were left to convert back to forests. At this time, many of the state and federal forest management agencies were born, with the primary mission of halting widespread burning and unsustainable timber harvesting. Supporting these efforts were national policies and laws aimed at eliminating fire from forest lands. As desired, forests regenerated and matured, but they have done so without fire. Now, instead of forests having varying densities of trees, they are overcrowded with multiple, overlapping canopy layers of trees. In many areas, dense forests now exist where previously open savannas and woodlands occurred. This change represents a phenomenon that has swept across the eastern United States where more dense, closed-canopy forests exist now more than ever before.



Clockwise from top left: 1937 horse logging in cutover oak stand near Omaha, Illinois; photo by Lee Russell, obtained from Library of Congress. Dense forest reproduction from resprouting in first years following harvesting; USDA Forest Service photo by Daniel C. Dey. Developing oak forest in a dense sapling stage; USDA Forest Service photo by Daniel C. Dey. Closed-canopy white oak forest; courtesy photo by Michael C. Stambaugh.

TWO DIFFERENT FIRES: PRESCRIBED FIRE AND WILDFIRE

Fire results from a chemical reaction called combustion. Combustion requires heat, oxygen, and fuel. Ignition starts the process and combustion continues as long as there is adequate heat, oxygen, and fuel. As molecular bonds break during the combustion reaction, heat, light, and smoke are generated. Smoke is a byproduct of combustion and is comprised of gases, particles (ash), and microbes. Remaining surface ash contains minerals from the fuels that can then enter the soil and become available to plants and animals.

Prescribed fires are controlled fires. Prescribed fires are planned, calculated, and conducted under very specific weather conditions by trained and knowledgeable people. Land managers commonly use prescribed fires to achieve specific objectives for wildlife or plant communities, or to reduce the risk and severity of wildfires. Objectives may be to increase food and cover for wildlife, increase plant germination, or reduce fuels, such as leaf litter, woody debris, brush, and small trees.

In many ways, wildfires are the opposite of prescribed fires (Table 1). Wildfires are unplanned, occur without control, and often have undesired effects. Wildfires in the eastern United States can be as dangerous as those in dry western U.S. regions, especially during prolonged dry weather and droughts. At such times, wildfire can threaten lives and property and instill further fear of fire. Fear of wildfires is a main reason prescribed fires are perceived negatively, despite the many benefits prescribed fires can provide.

Comparisons between prescribed fire and wildfire

	Prescribed fire	Wildfire
Planning	conducted years to months before and during fire; firebreaks established	unplanned; after wildfire starts, staff and resources react to control or manage it
Location	located in specific and appropriate areas	located randomly (lightning) or often along roads by people
Fire behavior	behavior predetermined using computer models and/or professional experience	behavior unplanned, often under undesirable conditions of wind or drought
Smoke	directed to disperse quickly and away from sensitive areas	unplanned and uncontrolled until fire extinguished
Effects	fire is applied for desired effects; effects are monitored for success	uncontrolled fire increases possible negative effects
Timing	timed for appropriate season to minimize negative effects	timing is unknown
Duration	typically, 1 day, sometimes few days	can be long-lived; strongly determined by weather, access, and resources for control

MAINTAINING FIRE…HUMANS ARE THE KEY

Humans learned to use and control fire millions of years ago. Studies have theorized that increased human brain capacity is linked to our ability to harness fire to cook food. Fire was our first tool used to change our surroundings. Yet today, acceptance of fire in the management of forests seems contrary to "modern" living whereas, in fact, we may use fire more heavily today than any time in the past, though in a remarkably different form. The combustion process has moved to more easily used fuels (e.g., petroleum products) and repackaged to be more efficient (e.g., combustion engines).

Humans continue to cause most fires in the oak ecosystems. Prescribed fires are set intentionally for a future "benefit." Lightning-caused fires are not intentional or intellectual and are rare. Locations and timing of lightning-caused fires are a result of weather conditions, climate patterns, and topography. Lightning-caused fires occur with thunderstorms and rain during the spring and summer when humidity is high and fuels are green, moist, and resistant to ignition.

Now and in the future, burning to achieve desired vegetation conditions and maintain safety will depend on humans. For this reason, humans are the key to the future of fire, especially its use to maintain specific ecosystems.

Prescribed burning an oak-dominated forest. USDA Forest Service photo by Daniel C. Dey.

WHY FIRE IN EASTERN OAK FORESTS IS ESSENTIAL

There are many types of forests in the eastern United States, but oak forests are among the most common and valued. Over thousands of years with fire, most oak species have developed characteristics that allow them to tolerate and survive frequent fires better than most tree species. Many oak characteristics allow the trees to resist or tolerate fires. These characteristics include thick bark, ability to resprout, and ability to seal off fire injuries to the stem.

Repeated burning maintains more open forest conditions that can vary across landscapes. Dense forest conditions are often not desirable because oaks and companion species cannot regenerate in deep shade. Fire-created woodlands provide enough sunlight for new oaks to germinate and grow. Young oak seedlings can sprout from the roots if the shoot is top-killed by fire or other causes, such as browsing or drought. Thick bark of larger oaks allows them to survive relatively low-intensity fires and outcompete other tree species. Conversely, if too much time elapses without fire, then undesirable forest conditions develop. These forest conditions typically are comprised of trees that flourish in the shade, have thin bark, and produce litter that is less susceptible to burn compared to oak leaves. As dense forests develop, associated understory species that require considerable sunlight are no longer present because of the dense shaded conditions. Also, as forests become crowded, they become susceptible to a multitude of forest health issues.

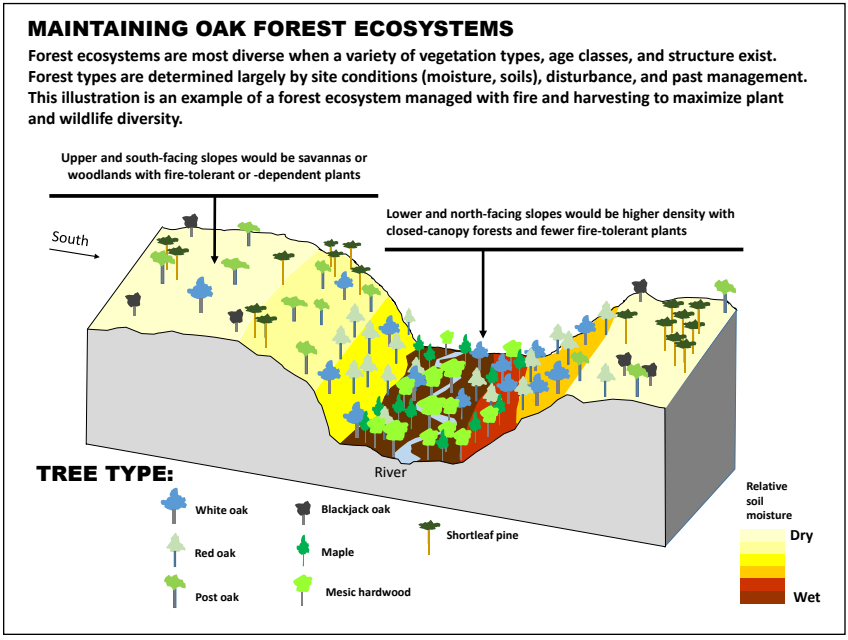


Diagram of an oak forest ecosystem with varied structure and composition expected following long-term repeated burning and with the influence of topography. Courtesy image by Michael C. Stambaugh.

FOREST HEALTH

What is a "healthy' forest"? Most people, including many foresters, think forest health is in reference to the health of the trees, but managing forests is more than just about the living trees. In fact, the presence of dead trees and downed logs increase the health of a forest or woodland significantly because dead wood provides food and shelter for many wildlife species and enables some plant species to occur in that space that otherwise would not be present. Therefore, if increased plant and animal diversity helps define forest health, then some dead and downed trees are beneficial.

Diverse plant groups occupy a recently burned and thinned oak forest including milkweeds, sunflowers, grasses, and legumes. In areas of historical woodlands that have transitioned to closed-canopy forests, many plant species can persist as dormant seeds and roots. Courtesy photo by Michael C. Stambaugh.

Trees are only one component of a forest; many additional organisms comprise "the forest." When forests are viewed as communities and the components are considered beyond the economic value of timber, it is understandable how the trees actually are of lesser value than some of the other components to various people with different objectives. For example, wildlife, rare plants, and aesthetics are components heavily valued by some people, causing woodlands and savannas to provide values that forests cannot, integrating both grassland and forest conditions for wildlife and plants.

For the oak forest, fire is essential. In addition to favoring oaks, fire creates an environment that allows other tree species to regenerate and stimulates germination of a diverse assemblage of grasses and flowering plants. Throughout the eastern United States, the lack of fire in the last century has caused a precipitous decline of these plants. Fire-dependent plant and animal species are in decline and are in danger of disappearing without human intervention and increased use of prescribed fire.

FUEL TO BURN

Fuels consist of living and dead plant materials such as plant leaves, and woody debris. The types and amounts of fuels vary by region, forest type, and age of the forest. Some fuels, such as leaves and herbaceous vegetation, are replenished every year. Other fuels, such as small twigs and logs, usually take longer to accumulate and are more difficult to ignite. Oak leaves are particularly flammable, which further facilitates fire.

In many ecosystems, controlled burning is commonly conducted to reduce fuels, especially where safety is a concern should a wildfire occur (e.g., wildland-urban interface). Reducing fuels can lessen the intensity and severity of potential wildfire. The type and amount of fuel affects the spread and intensity of fires. An estimate of the amount of fuel also can be used to predict smoke emissions.

Once fuels are consumed by fire, the increased available growing space allows new plant growth. Sunlight to the forest floor is increased when fuels, shrubs, and small trees are consumed or reduced. Increased light further promotes plant growth and regeneration from either buds on surviving roots or from newly germinating seeds. In oak forests, the lack of adequate sunlight to the forest floor is a major limiting factor for oak seedling establishment and the diversity and productivity of the understory plant community.

Active flaming of a backing fire in oak leaf litter passing a small eastern redcedar seedling (left) and surface fire ignites and torches the crown of an eastern redcedar tree. Courtesy photos by Michael C. Stambaugh.

COSTS AND BENEFITS OF BURNING

Fire is critical to sustaining most ecosystems because it is required for plants and animals to survive. Without fire, forests gradually change in type. When forest types change, the services they provide also change. In this way, forests that are adapted to fire, but are not burned, can become less beneficial to people. Forest type change, though slow, can be an undesirable consequence of excluding fire.

Fire affects many components of forest ecosystems that benefit people. Fire can reduce forest pathogens that kill trees. Fire can reduce pests, such as ticks, that spread diseases to humans. Smoke can stimulate seed germination and increase food for wildlife. Fire influences plant composition and structure and can consequently enhance habitat for many species. Fire can increase water availability by reducing the interception and uptake by trees. Fire promotes germination of seeds in the soil, which may increase biodiversity. People are inherently attracted to open woodlands and savannas, thus aesthetics are improved for many people by use of fire, which provides increased visibility and flowering plants.

Burning forests also may result in undesired effects, however many of these can be minimized with proper planning and management. Undesired effects may include damage to desirable trees, smoke, and establishment of nonnative plants. Determining management objectives and designing a fire management plan to meet objectives will aid in increasing benefits and minimizing undesired effects.

Contrasting conditions of burned and unburned mixed oak-hickory forests. Left: A stand that was burned eight times from 2004 to 2020 using low-intensity fire during March, April, and September, and October. Right: A stand that has never been burned and without any canopy disturbance for decades. Courtesy photos by Craig A. Harper.

PRESCRIBED FIRES ARE ADVANCED

Agency professionals and private landowners use technology to better manage controlled burns. They attend training classes and gain supervised experience by working on fires. Qualifications are recorded to ensure experienced personnel are available when fire is prescribed.

Landowners also conduct prescribed burns. Many opportunities exist for private individuals to gain training, experience, and assistance with prescribed burns. Both public and private organizations provide this support, including the development of a burn plan.

Burn plans are written documents for specific burn units. Burn plans detail the prescription to meet specific objectives. The prescription often includes land area, desired weather and fuel conditions, and logistical issues. Burn objectives often describe the desired effects on vegetation and wildlife. Weather data often consider daily temperature, relative humidity, wind speed, and wind direction. With these components, fire behavior can be predicted for specific types of fuels.

Land area descriptions often include maps of the topography, personnel and equipment locations, planned burn area perimeter, ignition locations, and smoke sensitive areas. Fuels are described to predict fire behavior and effects. Logistics include equipment and crew needs as well as contingency plans and emergency contact information.

Once the burn is completed, continued monitoring of the burn area occurs to evaluate response of vegetation and wildlife.

If you are interested in conducting a prescribed burn on your property, contact your state's Service Forester, prescribed fire council, extension office, or state natural resources agency.

Thermal imagery (right) of smoldering fire allows fire managers to visualize patterns in temperature caused by fuels. Small, localized hot spots (bright colors) can result from burning of fruit (e.g., hickory nuts). Courtesy photo by Michael C. Stambaugh.

FIRE MANAGEMENT INTO THE FUTURE

Use of prescribed fire in oak forest management is increasing, but still uncommon. Most state and federal land management agencies promote prescribed burning for various wildlife or vegetation objectives. Management practices, such as tree cutting and herbicide applications, are widely used practices to manage oak forests and initiate oak woodland restoration. However, for thousands of years prior to European colonization of North America, cutting practices did not sustain oak systems—fire did. Fire effects are unique and cannot be fully replaced by mechanical or chemical treatments. Compared to many other management practices, fire is a relatively inexpensive method for managing large areas.

Fire is essential to realize many objectives in oak forests, and fire is requisite to restore and maintain oak woodlands and savannas. Fire promotes plant and animal communities that will not occur without fire, and fire allows many ecosystems to function as they have historically but have declined drastically in the past century. Most importantly, it is critical that people receive accurate information about fire, its use, and its benefits, and to keep an open mind about use of fire to manage our natural resources in the best way possible.

Natural resource managers attend a woodland management workshop to understand fire in the ecology of oak ecosystems and to restore oak woodlands. Courtesy photo by Joseph M. Marschall.

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