Oak System Recovery

A vision for sustaining oaks in southern Illinois.

Funded by the USDA, Forest Service, Northeastern Area, State and Private Forestry
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Introduction

Oaks are a critical component of the ecology of southern Illinois. They were historically the most abundant trees in the region and they are keystone species that strongly influence the region's ecosystems. However, these ecosystems are imperiled. A variety of stresses, including the suppression of fire, introduction of invasive species, poorly designed timber harvesting practices, climate change and habitat fragmentation have put the future of oaks in doubt. Other species such as maples and beeches have taken over the understory of the forests, and the next generation of oak trees is not growing. If these trends continue, oaks will no longer be the dominant species in southern Illinois's forests, and many of the plants and animals that depend on oak ecosystems may be lost.

Land managers in southern Illinois recognize that they are at a crossroads; they must act to ensure the continued dominance of oaks. Concerned parties have created a set of goals to help guide these efforts:

- Diversify the age distribution of trees in oak ecosystems;
- Increase and maintain native biodiversity and decrease the abundance of invasive species;
- Reduce forest fragmentation across the landscape;
- Increase public involvement and appreciation of oak ecosystems.

Reaching these goals will require that the many and diverse landowners in southern Illinois understand the factors that shape oak ecology and work together. This vision document provides a framework for unified action, first describing the history and ecology of oak ecosystems, the importance of oaks to biodiversity, and the threats that imperil oaks. Ultimately, this plan outlines primary management practices that are being employed to restore oaks and details projects that are doing exemplary work.

This document was adapted for southern Illinois from the *Chicago Region Oak Ecosystem Recovery Plan: Sustaining Oaks in the Chicago Region* and advances the goals of the "Let the Sun Shine In" campaign.

Ecology of oaks

When Europeans first arrived in North America, oaks predominated in the eastern forests (Whitney 1994, Abrams 2003, Fralish and McArdle 2009). Many oak species are adapted to live with frequent disturbance, including drought, extreme weather and fire (Abrams 1992, Nowacki and Abrams 2008, McEwan et al. 2011). Oaks are very drought tolerant and have thick bark that

Glossary

Biodiversity: The assemblage of organisms—plants, animals, fungi and microorganisms—that live in an area. Biodiversity can be an indicator of ecosystem health; places that sustain a greater diversity of organisms are often healthier.

Disturbance: A process that causes disruption in an ecosystem. Common examples include fire, storms, droughts and timber harvesting. Disturbance can create openings in ecosystems, which allow new individuals to regenerate.

Forest Stand Improvement (FSI): A management practice that involves the manipulation of forest species composition and structure by cutting or killing selected trees and understory vegetation.

Non-native invasive species: An exotic species that harms an ecosystem. An invasive species can be any sort of organism. For example, invasive plants might colonize a site, choke out native species, alter soil conditions and prevent natives from re-establishing. An invasive insect could attack a plant species that lacks defenses to protect itself.

Mesophication: A feedback loop in which an ecosystem becomes shadier and moister. In oak ecosystems, it is generally caused by removing disturbance (especially fire), thereby allowing the proliferation of fire-intolerant trees. Oaks and other shade-intolerant species are unable to reproduce in these conditions.

Mesophytic species: Species that are adapted to moist, shady environments (e.g. maple, ash, elm, beech and ironwood).

Oak ecosystem: Any area where oaks are the dominant trees. This document focuses solely on upland oak ecosystems, as their ecology and management are different from that of bottomland oak ecosystems.

Prescribed burn: A planned and controlled fire that is used to meet management objectives such as controlling invasive species, improving habitat for wildlife, removing ground-level woody vegetation or mesophytic species, or removing fuel to reduce fire risk.

Proclamation boundary: The external boundary of a national forest that Congress has authorized. Land within the proclamation boundary is not owned solely by the federal government, but also by private individuals, non-profit organizations, the state of Illinois, and local governments.

Regeneration: The process by which a species or ecosystem reproduces and continues into future generations.

Southern Illinois: In this document “southern Illinois” refers to the 11 southernmost counties in the state, which are Alexander, Gallatin, Hardin, Jackson, Johnson, Massac, Pope, Pulaski, Saline, Union and Williamson counties.

Thinning: Selective removal of individual canopy or mid-level trees to increase the growth and health of remaining trees and to bring light to the forest floor.

allows them to withstand low intensity flames. Oaks also put much of their energy into root growth, enabling the tree to resprout even if the above ground part of the tree is destroyed by fire (Rowe 1983, Peterson and Reich 2001). Fallen oak leaves are especially flammable, which further encourages regular fires in oak ecosystems (Nowacki and Abrams 2008).

Oaks are adapted to live in areas that are kept open and sunny by disturbance and are unable to reproduce and develop in dense, shady forests (Fralish 1997). Oaks are declining across the eastern United States as well as in southern Illinois, where many of the historic disturbance regimes have been disrupted (Abrams 2003, Ozier et al. 2006, Holzmueller et al. 2011). Without action, oaks will no longer be the dominant species in southern Illinois, as forests are becoming wetter and shadier.

Ecology and disturbance regimes of southern Illinois

Southern Illinois hosts rich biodiversity, in part because it lies at the juncture of four physiographic provinces (See Box 1). The forests of all of these provinces are oak-dominated, but the oak species and ecosystem types vary (Parker and Ruffner 2004). The assemblage of plants and animals that occupy a site in southern Illinois is shaped by that site's unique soils, hydrology and topography of these provinces—but also by natural and human disturbances (Fralish 1997). Severe weather, droughts and periodic fires have occurred regularly.

Severe weather in southern Illinois is not uncommon, and can include tornadoes, windshear and ice storms. All of these weather events can remove limbs and even mature trees from the canopy layer. This disturbance is still present, as storm severity has not reduced from historic times. However, another type of canopy disturbance has been removed from oak ecosystems: passenger pigeons. Millions of these birds would roost and nest in trees, and their weight frequently broke limbs and caused openings in the canopy (Ellsworth and McComb 2003, Buchanan and Hart 2012). Additionally, the roosting birds would produce tons of guano. It was distributed in such enormous quantities that it would smother vegetation, leaving large expanses devoid of undergrowth (Ellsworth and McComb 2003).

Long-term drought events occur regularly in southern Illinois and can have intense effects on the landscape. McEwan et al (2011) identified eight decadal-scale droughts between 1500 and 1900. These regular, long-term droughts can kill mesophytic plants and trees, but not oaks and other drought tolerant plants. However, the last century has had higher moisture availability than the previous four centuries, and there have been no droughts of similar magnitude (McEwan et al. 2011).

Fire can profoundly shape the ecology of a region. In southern Illinois, fires were relatively common (Robertson and Heikens 1994), typically ignited by lightning or indigenous people who used fire to hunt and to manage vegetation (Pyne 1982). These fires removed leaf litter, promoted grasses and other fire-tolerant plants, and limited the distribution of fire-intolerant tree species to more moist environments (Hicks 2000). Fire-dominated landscapes tend to have fewer trees and more open canopies than areas without this disturbance. The low density of trees lets more sunlight reach the ground, fostering sun-loving species such as oaks.

Box 1 Physiographic Provinces

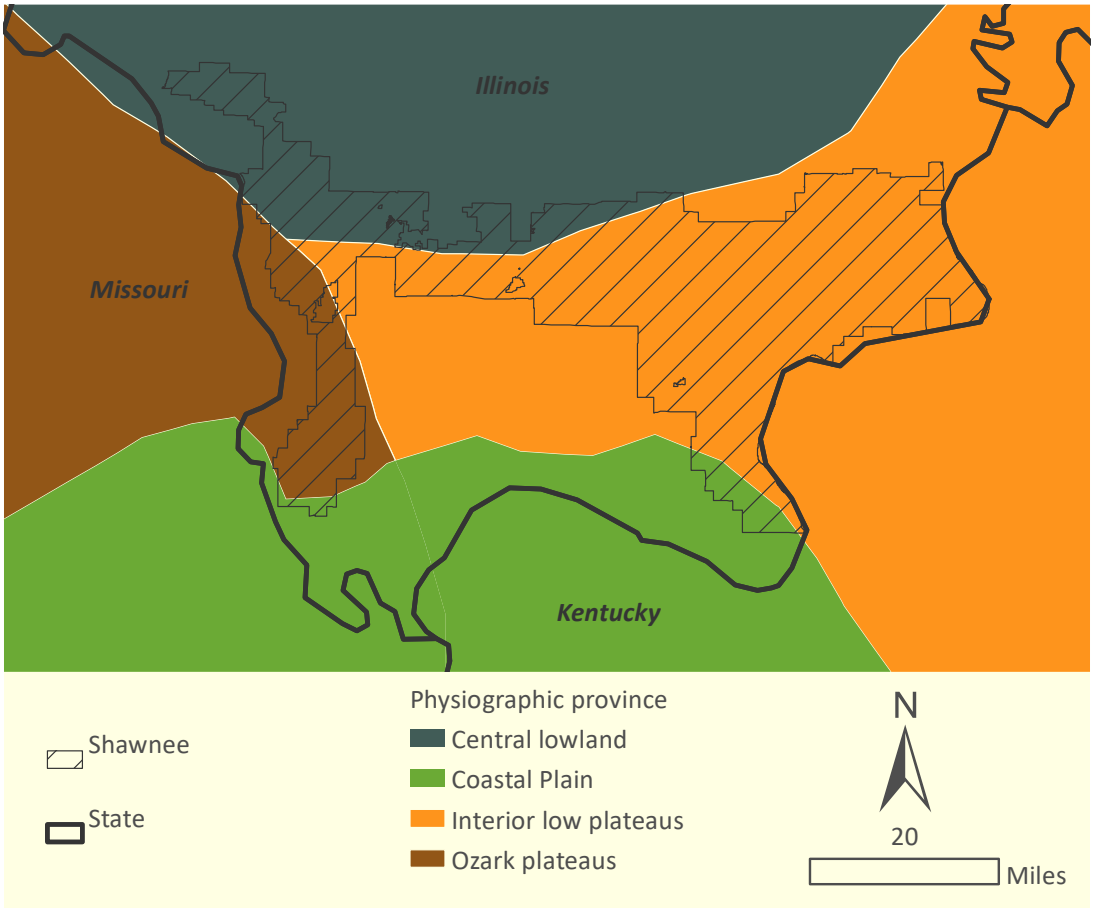
Southern Illinois is situated at the intersection of four major physiographic regions. This unique geography contributes to the overall biodiversity of the area. These regions all have distinct topography, soils and ecology, which greatly influence the biological variation within the forest communities of Southern Illinois.

Central Lowland Province: Largely level and has a maximum elevation of less than 1,000 feet. The lowlands were subjected to repeated glaciations. Southern Illinois is part of the Till Plain region of the Central Lowlands, which is characterized by glacial outwashes. Mesic, bottomland forests and swampy forests are common in the lower sites, and mixed oak and hickory forests are common in the more upland areas.

Ozark Plateaus: Primarily limestone and dolomite, with some shale and chert. In the eastern part of the province these layers have been eroded, revealing granite features. This region is largely forested and oak dominated, but mixed stands of oak and pine are also common, especially in the southeastern part of the region.

Interior Low Plateaus: Comprised of horizontal beds of sandstone shale and limestone. This province is characterized by extensive cave systems, and also widespread coal, petroleum and natural gas production.

Coastal Plain: Flattest of all of the provinces. Soils range from thick loess to fine-textured and poor draining. Upland forests consist of oak and hickory.



Historical perspectives

Southern Illinois's ecology has never been static. It's changed over the millennia with climate and disturbance. In this section, we describe some of the factors that have shaped the region's ecology and outline how current management is altering the composition of the region's forests. For a more in-depth discussion of the ecological history of southern Illinois, see Parker and Ruffner (2004).

Distant past

The most recent advance and subsequent retreat of continental glaciers across the Midwest extended from 85,000 to 10,000 years ago (Pielou 2008). This glaciation greatly affected the ecology of southern Illinois even though the region was not covered by ice. When the glacier was at its southernmost extent, boreal forests dominated southern Illinois. After the glacier retreated, temperate forests—or even prairies during especially warm periods—replaced the boreal forest. Temperate, oak-dominated forests stabilized in the region when the Ice Age ended around 10,000 years ago (Franklin 1994).

Native American era (before 1750)

Native Americans moved into the region soon after the final retreat of the glacier, so the current iteration of oak ecosystems of southern Illinois has always been influenced by humans (Delcourt 1987). They were adept at manipulating the landscape to suit their needs. They lit fires to improve wildlife habitat, to clear undergrowth, to push game while hunting, and to encourage the production of acorns and hickory nuts for sustenance (Stewart 2002, Williams 2003). The effects that indigenous people had may have waned before Euro-American settlement. Pandemics decimated native populations in the 17th century (Lovell 1992), meaning that southern Illinois forests were largely undisturbed in the century before Euro-Americans began extensive settlement.

Wild turkeys were abundant in this era; there were an estimated 10 million in North America in the pre-Columbian era (NWTF 2012). Deer populations were estimated at 8 to 11 per square mile before Euro-American settlement (McCabe and McCabe 1997). Wolves, bears, cougars and bobcats were also present.

Euro-American settlement and development (1750 to 1930)

The first Europeans came to live in southern Illinois in the early 1700s, with settlement intensifying in the early 1800s. The Illinois Department of Natural Resources analysis of 1830s land surveys indicates that 93 percent of southern Illinois was wooded at that time. Euro-Americans managed the oak ecosystem very differently than Native Americans: They cleared forests for farmland, felled trees for lumber and grazed cattle in the woods (MacCleery 1992, Hicks 2000).

Disturbance increased during Euro-American settlement and development. Forests were burned more often to clear understories and improve them for livestock (Guyette and Cutter 1991). Continual, intense grazing by livestock impoverished woodland biodiversity by depleting many sensitive herbaceous species (Harrington and Kathol 2009). Farming led to severe soil erosion, so fields were abandoned and new fields were cleared from the woods. No large areas of virgin forest survived this treatment, although many small stands of oak on dry ridges in the Shawnee Hills appear to have escaped cutting and clearing.

Euro-American settlement also had a dramatic effect on wildlife. Cougars, bears and wolves were soon killed off (Hoffmeister 1989). Elk and bison were extirpated by the earliest settlers. Turkeys and deer were important food for the growing human population, so they were decimated by over-hunting. By the 1940s, turkeys remained only along the southwest edge of Illinois (Mosby and Handley 1943). The North American population of wild turkeys dropped to an estimated 200,000 birds at its lowest point (NWTF 2012). Deer were extirpated from most of the Midwest by the late 1800s, and they were almost entirely wiped out in Illinois. If these trends had continued, all these important game species would have been lost like the passenger pigeon, which once moved in flocks of millions but was hunted to extinction by the early 1900s.

Beginnings of soil and land conservation (1930-1980)

Many farms in southern Illinois were abandoned during the Great Depression because of soil depletion. During the 1930s, agricultural practices began to change, soil conservation was promoted and exploitation of forests was reduced. Beginning in 1933, private lands were acquired to establish the Shawnee National Forest, with the goals of repairing the soils and creating a timber resource (Soady 1965, McCorvie 1994). The Civilian Conservation Corps planted pines, cut trails, and built fire towers and other infrastructure.

This era also saw the beginning of widespread fire suppression. Southern Illinois's wooded areas went from periodic, low-scale disturbance under Native American management, to intense, regular disturbance by early European-Americans, to little disturbance other than timber harvesting.

Box 2 Changes

Southern Illinois has changed tremendously in the last two centuries. Increasing settlement and a rising population has led to a landscape that is heavily developed and fragmented. Figure 1 shows the difference in land cover types in the mid-18th and early 20th centuries. More than half of forested ecosystems have been converted to agriculture or into other grassy land cover types.

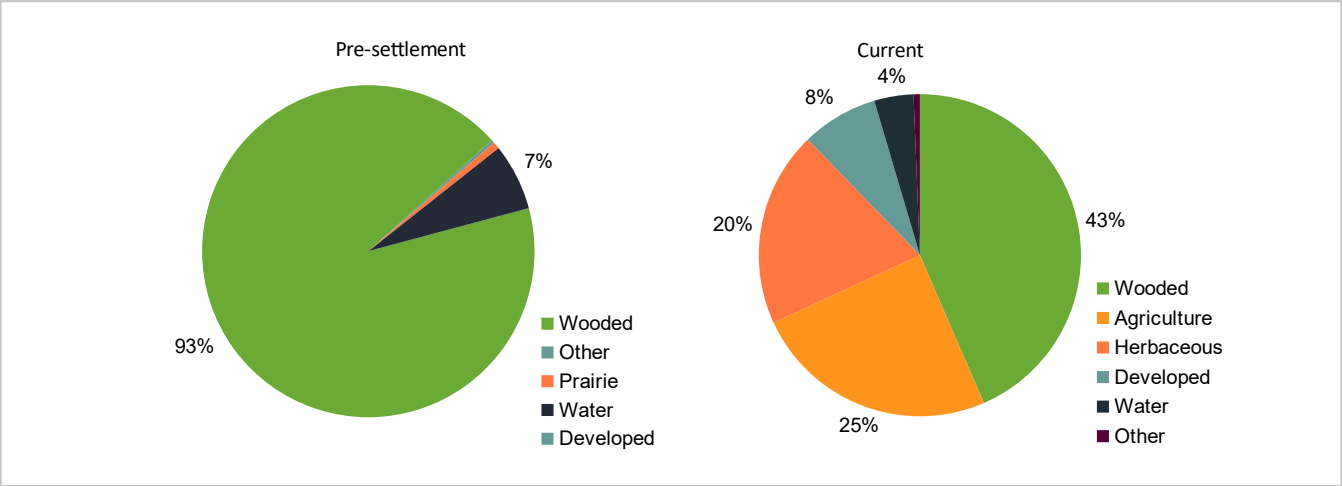


Figure 1: *In the 1830s, presettlement surveys found that the majority of the region was forested. In 2011, the National Land Cover Database showed that more than half of those forests had been converted to agriculture, development or herbaceous land cover types.*

Not only were thousands of acres of forested ecosystems lost, but the composition of the remaining trees also changed (Fig 2). In the 1830s, oaks made up more than half of all trees in the region. Currently, they make up just over 10%. Mesophytic species like elms, ashes, and maples have become more abundant.

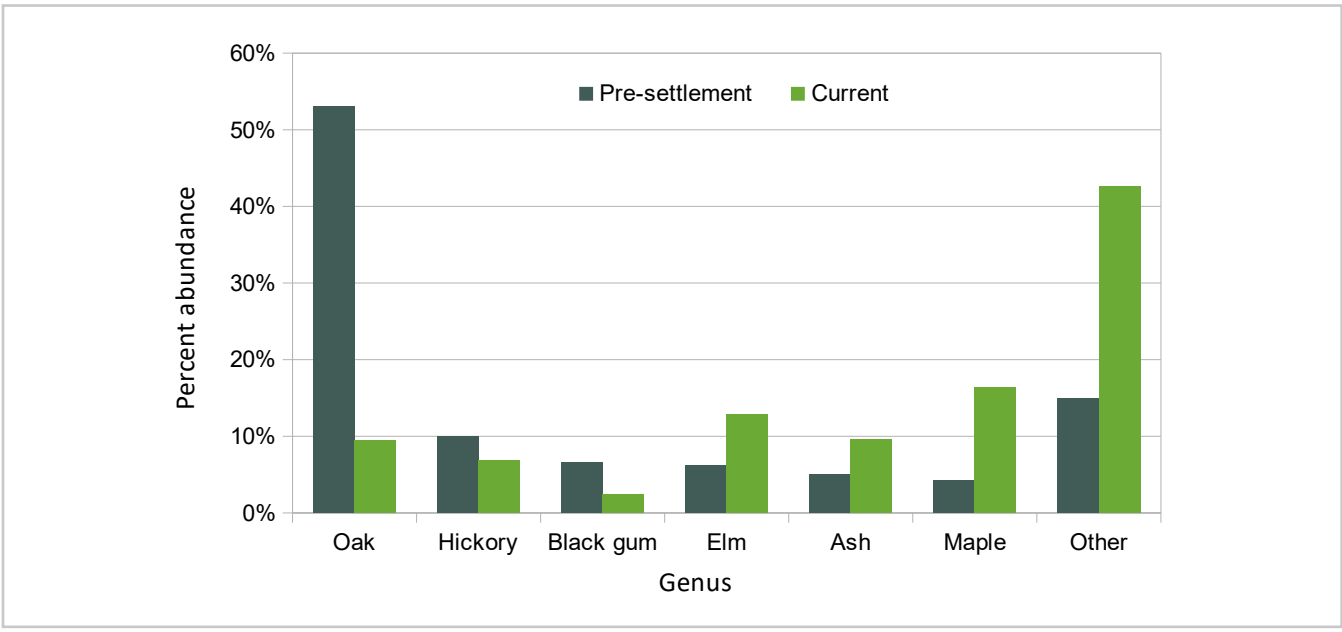


Figure 2: *Mesophytic species have increased in abundance from the pre-settlement era. Pre-settlement data came from 1800s surveys of bearing trees (PalEON 2017), and current forest composition was found using US Forest Service's Forest Inventory and Analysis data (Miles 2018).*

Southern Illinois oak ecosystem types

Southern Illinois has a wide variety of ecosystem types, in part because so many ecological regions converge here. The resulting heterogeneous landscape is rich in biodiversity, and many species find niches within the varied ecosystems. The following descriptions are adapted from the Illinois Natural Area Inventory Standards and Guidelines (IDNR 2013).

Upland forests have layered canopies with nearly closed overstories and dense understory layers. Upland forests do not flood but can have moist to dry soil conditions. Dominant species largely depend on soil moisture, and can include northern red, white and black oaks, sugar maple, basswood, and beech.

Woodlands have less than 80 percent canopy cover because tree growth is limited by soil conditions or frequent disturbance. Woodlands were once the most common ecosystem type in the region, but they have largely become closed forests because of reduced disturbance. White oak, black oak and hickories are the dominant trees. The understory is comprised of species that are associated with prairies, including sedges, grasses and flowering plants.

Flatwoods occur on hardpan with level terrain. The substrate does not drain well, leading to seasonal pooling. In summer, these pools evaporate and plants can be stressed by lack of water. Dominant tree species include post, blackjack and black oaks.

Barrens are characterized by few, frequently shrubby trees. They occur wherever soil conditions are insufficient for forest growth or where frequent disturbances restrict it. Most barrens have been lost because of fire suppression. Characteristic species include white, post, black and blackjack oaks.

Hill prairies and glades are natural openings interspersed in oak woodlands and forests. They occur on steep slopes that face south to west, and they are rare in southern Illinois. Although these sites are too exposed and dry for good tree growth, fire suppression has allowed woody species to invade. Characteristic plants include little bluestem and side-oats grama.

Modern era (after 1980)

Southern Illinois has been greatly altered in the last two centuries (See Box 2). Much of the forest has been converted to agriculture and development. Within the forested areas that remain, oaks are no longer the most abundant genus; they have been surpassed by maples and elms. This is due in part to changes in disturbance regimes, but also because of poor harvest practices. High-grading, the removal of the choicest timber trees, has degraded many forest stands, leaving them with damaged, diseased, or low-quality trees. Poor harvest practices can also accelerate the rate of mesophication.

Land ownership is highly fragmented in southern Illinois. Even the land within the boundaries of the Shawnee National Forest is owned by thousands of private individuals and groups in addition to governmental agencies. These owners have different goals and varying capacities to manage their properties. Fragmentation makes it more challenging to manage forests on the landscape scale.

Positive changes are also happening in the modern era. Land managers are beginning to understand the problems caused by suppressing fire and poor timber management. Efforts are under way to address these effects and reverse long-term declines in forest health. These efforts include thinning woodlands to create canopy gaps, which allows sunshine to reach the ground. Prescribed fires are becoming more common, with many people trying to return the land to its historic disturbance regime. Land managers also seek to increase biodiversity by removing invasive species and reintroducing plants and animals that have been lost.

Many game species are rebounding in Illinois and throughout the eastern United States. This population growth is due largely to hunting regulations and improvements in land management. Several wolves, black bears and cougars have been confirmed in Illinois since 2000, but there are no breeding populations. Turkey, however, have been reintroduced and have repopulated

Box 3 Oaks of Southern IL

Southern Illinois is a biologically rich area. The woodlands and forests are diverse, and contain 19 different species of oaks. The Shawnee National Forest may have more species of oaks than any other forest in the U.S. national forest system. These are a few of the most common upland oak species:

White *(Q. alba):* The most abundant oak in southern Illinois. White oak grows from dry, upland soils to well-drained bottomlands and is broadly distributed across eastern North America. Requires full sun and does not regenerate well in closed-canopy forests. Acorns are preferred by wildlife. White oak timber is particularly valuable.

Black *(Q. velutina):* An upland species that grows on rocky or sandy soils. It is one of the most abundant oak species in southern Illinois.

Post *(Q. stellata):* A smaller oak that grows on sandy, gravely or poorly drained sites. Illinois is the northern extent of its range, which reaches into Texas and Florida. It has dense wood that was frequently used for fence posts.

Northern Red *(Q. rubra):* More shade tolerant than other oaks, does well on moist soils and is frequently found in denser woodlands. Northern red oak has a broad range, and grows from northern Minnesota to Mississippi and throughout eastern North America.

Blackjack *(Q. marilandica):* A smaller oak that is present in upland forests and flatwoods. Illinois is at the northern extent of its range.

Scarlet *(Q. coccinea):* Present throughout the eastern United States. Prefers dry, acidic, sandy soils. It is frequently found on upland slopes and ridges.

Chinquapin *(Q. muehlenbergii):* A wide-ranging species found from Arizona to Ontario that grows in dry and rocky soils. The acorns are particularly choice for wildlife.

Southern Red *(Q. falcata):* Occurs throughout the Southeastern United States. It is generally found in sandy, upland sites, but occasionally occurs in bottomland forests as well.

Shumard *(Q. shumardii):* Similar in range and habitat to the southern red oak, but small populations have been found as far north as Southwest Ontario. It does not occur in pure stands and is instead widely spaced among other oak, hickory and ash species.

Shingle *(Q. imbricaria):* Occurs in the eastern United States. Shingle oak has unlobed leaves that are uncharacteristic of oaks. It is a smaller tree that can grow in a wide variety of ecosystems, from upland to slopes and prairie edge.

Rock Chestnut *(Q. montana):* Rock chestnut oak is listed as threatened in Illinois. It grows in dry, rocky upland forest. Illinois is at the western extent of its range.

most of their historic range. It's estimated that there are now more than six million wild turkeys in North America (NWTF 2012). The population is stable in Illinois, but the Department of Natural Resources intends to increase the number of turkeys by 20 percent (IDNR 2005). Deer densities are now much higher than pre-settlement estimates—between 30 and 40 deer per square mile in many southern Illinois counties (Walters et al. 2016). In many sites, they have become so abundant that they damage oak ecosystems (Rooney et al. 2004).

Biodiversity in oak ecosystems

Oaks are foundational species across the temperate zone of America. They create the structure that characterizes ecosystems and support an array of plant and animal life (Fralish 2004). Oak ecosystems have high biodiversity in part because they are heterogeneous environments. Oak woodlands and savannas have open canopies that create highly variable light levels and foster variability in soil moisture, pH, potassium, and organic matter (Ko and Reich 1993). This heterogeneity allows thousands of plant and animal species to inhabit the ecosystem.

Oak savannas and woodlands have an especially high diversity of plants. For example, Nelson (2010) found 500 plant species in a 250-acre oak savanna in Missouri. Oak woodlands and savannas host plants that are characteristic of both forest and prairie ecosystem types, as well as some species that exist almost solely in savannas or woodlands (Packard 1988).

Oak trees offer habitat and food for a variety of birds, invertebrates and mammals. More than 700 species of butterflies and moths live and feed on oaks (Tallamy 2007), meaning that oaks are important for pollinators. These insects, in turn, provide food for migrating and nesting birds. Many migratory bird species prefer oaks over other native trees (Wood et al. 2012), and oak woodlands are used by more bird species than maple-dominated sites (Rodewald and Abrams 2002). If oak woodlands transition into more mesophytic forests, changes in insect populations and reduced acorn production would mean that far fewer birds find habitat in southern Illinois (McShea 2000, Rodewald 2003, Sierzega 2016).

Many critical species identified by the Illinois Wildlife Action Plan inhabit high quality, open oak ecosystems (See Box 3). In addition, energy-rich acorns, hickory nuts, walnuts and hazelnuts are a major food source for a wide variety of birds, mammals and insects, and play a key role

Box 4 Critical Wildlife

These species are among those identified by the Illinois State Wildlife Action Plan as “critical” wildlife in the forest and woodland campaign.

Red-headed woodpecker *(Melanerpes erythrocephalus)*
Open woodlands are important habitat and the birds nest in snags or dead trees. Their numbers are decreasing due to our changing woodlands.

Ovenbird *(Seiurus aurocapillus)*
A ground-nesting bird that resides in upland forest ecosystems. They are highly conservative and negatively affected by development and fragmentation.

Northern flicker *(Colaptes auratus)*
Nest in open woodlands, forest edges and open fields with scattered trees.

Silvery salamander *(Ambystoma platineum)*
This species require seasonal pools in oak woodlands that can support tadpoles. Alterations in hydrology, climate change and fragmentation have limited their populations.

Timber rattlesnake *(Crotalus horridus)*
Reside in forests and rocky slopes, particularly in west-facing bluffs. Fragmentation and development are major contributors to their decline.

in the food webs of the region. Oaks provide shelter for wildlife in the form of tree cavities, standing snags and downed woody debris.

Several game species also depend on oaks. Deer and squirrels rely on acorns over the winter (Strole and Anderson 1992). Restoration of oak ecosystems is a primary strategy for increasing turkey numbers (NWTF 2016). Upland game birds, such as quail, respond positively to restoration activities (Brawn 2006).

For all these reasons, restoration and management of oak-dominated ecosystems is essential to promote biodiversity and to manage wildlife in southern Illinois. The importance of oak ecosystems is reflected by their prominence in the Illinois Statewide Forest Resource Assessments and Strategies, the Illinois Wildlife Action Plan, and The Nature Conservancy's Illinois Ozark Project (See Box 5). All three plans call out the management of oak ecosystems as an essential component of overall ecological land management.

Threats to oak ecosystems

Across the eastern U.S. and in southern Illinois's wooded areas, oaks are not regenerating (Ozier et al. 2006, Nowacki and Abrams 2008, Holzmueller et al. 2011, McEwan et al. 2011). Oak seedlings die before they reach maturity, and although most of the forests in southern Illinois have an oak canopy, the understory is made of maple, ash, beech, and elm (Fralish 1997, Zaczek et al. 2002, Hutchinson et al. 2008). This lack of oak regeneration is caused by several factors, including:

- Fire suppression
- Mesophication
- Fragmentation
- Non-native, invasive species
- Overabundance of deer
- Poor timber harvesting practices
- Changes in climate

Box 5 Overlapping Goals

The goals and strategies of the Oak Recovery Plan for southern Illinois are consistent with other regional plans, as these examples show.

Illinois Wildlife Action Plan

- The Forest and Woodlands Campaign seeks to maintain, expand and enhance forested habitats specifically for the benefit of Species of Greatest Conservation Need.
- Implement sustainable forestry practices, including forest stand improvement, prescribed fire, timber harvesting and invasive species control to enhance oak dominance and maintain understory and herbaceous layer diversity.
- Increase statewide forest and woodland acreage by 350,000 acres, emphasizing restoration of floodplains and riparian corridors, increasing ecological connectivity among forests and other habitat patches, and reducing fragmentation of forests 500 acres and larger.
- Develop high-quality examples of all forest communities, including all Grade A and B Illinois Natural Areas Inventory sites, restored and managed within all natural divisions within which they occur.

Illinois Statewide Forest Resource Assessment and Strategies

- One of the most promising ways identified to increase forest biological diversity, not only of tree species but also of groundcover vegetation, is to intensify canopy disturbances and mid-story control and to reintroduce fire into the system.
- Eradicate, control, and prevent the introduction of non-native invasive species.
- Identify and conserve high priority forest ecosystems and landscapes.
- Programs geared toward encouraging voluntary coordinated management across ownerships could increase the positive impacts of forest management.
- Connect people to trees and forests and engage them in environmental stewardship activities.

Shawnee National Forest Plan

- Utilize vegetation-management activities, such as landscape-level prescribed burning, timber harvesting, and timber-stand improvement to help create and/or maintain the ecological conditions necessary to regenerate and maintain the oak-hickory forest-type.
- The Forest's wildlife and fisheries management program will maintain or enhance habitat for all native species and ensure the diversity of natural communities throughout the forest environment.
- Fire is applied on the landscape to restore and/or maintain desired vegetative communities, ecological processes, and fire-adapted ecosystems; and desired fire regimes, condition classes and desired fuel-loadings.

The Nature Conservancy: Illinois Ozarks Plan

- Increase acreage of forested land in order to reduce fragmentation.
- Promote management to restore upland forest matrix, especially by returning fire to the landscape.
- Build public support for management by hosting outreach activities.
- Conduct early warning, rapid response, and management of invasive species.

National Wild Turkey Federation

- Shawnee Hills is an NWTF Focal Landscape.
- Use prescribed fire in oak woodlands and savannas.
- Improve the quality of oak ecosystems through timber stand improvement techniques and invasive species management.
- Annually restore 6,600 acres of Shawnee National Forest and Restore 2,000 acres of open woodland in the Shawnee Hills.

U.S. Fish and Wildlife Service

- Southern Illinois is one of three focal areas in Illinois for the Fish and Wildlife service.
- Restoration of forests, timber stand improvement and invasive species management will decrease sediment runoff into the region's streams.

Oaks are also generally absent from the sapling layer, which will make it even more challenging to restore oak dominance in the future.

Fire suppression

Ecosystems in southern Illinois evolved with periodic burning (Fralish 1997). Inhabitants of the region have used fire to manage the landscape for thousands of years (see the *Historical perspectives* section). These fires inhibited the growth of fire-intolerant species, while selecting for species that have evolved to tolerate fire, including oaks (see the *Ecology of Oaks* section). In the 20th century, fire was largely removed from the landscape. This allowed for the proliferation of fire intolerant species, and over the next hundred years forests became denser and shadier.

Mesophication

Much of the region has suitable soils and enough water to support dense forests; however, forests were historically quite open because of regular disturbance (Fralish 1997). There was far less disturbance in the 20th century than in the previous 500 years. Some of the changes in disturbance are linked to human activities. For example, fire was largely removed from the landscape and timber harvesting strategies were greatly altered. These changes in management coincided with a shift in climate.

Box 6 Regeneration Issues

In 2018, a survey was sent to southern Illinois land managers to capture issues that they were experiencing and techniques that they were using to encourage oak regeneration. The survey was sent to 60 land managers and received 24 replies (40 percent response rate).

Managers cited several issues that are causing oak regeneration failure. Chief among them was a lack of canopy disturbance; 70 percent of managers thought that lack of canopy disturbance was a very important factor in limiting oak regeneration (Fig. 3). Managers also said lack of fire and mesophication are important contributors to the issues with oak regeneration.

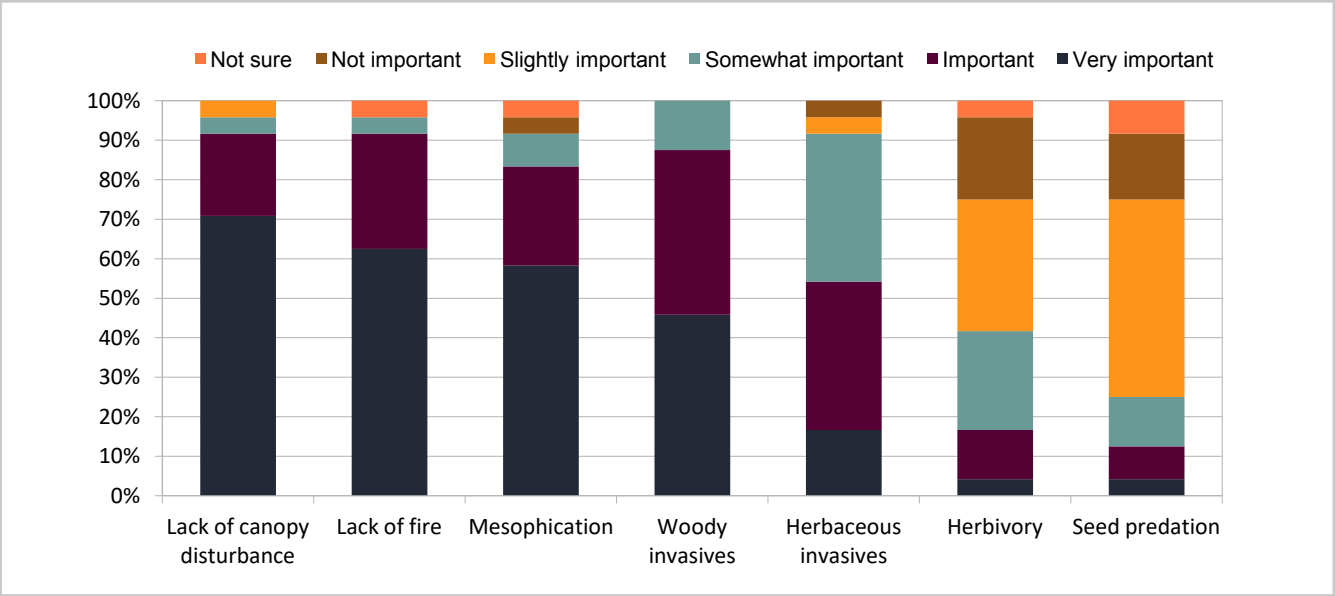


Figure 3: *Percentage of respondents ranking factors that contribute to oak regeneration failure.*

Invasive species are also playing a role in limiting oak regeneration. Nearly 90 percent of managers thought that woody invasives were either an important or very important contributor to limiting oak regeneration, and in another question, 60 percent of managers said invasive species were problematic on the majority of their property.

The last 100 years have been far wetter than the previous five centuries and there have been very few long-term droughts (McEwan et al. 2011). All of these conditions have allowed shade-tolerant, mesophytic species to flourish. These trees have denser canopies, which allows less light to reach the ground. Excessive shade is perhaps the single largest threat to oak woodlands (Nowacki and Abrams 2008). Acorns may sprout in these conditions, but they usually die before they become saplings because they do not receive enough sunlight (Abrams 1992, Aldrich et al. 2005).

Non-native invasive species

The negative effects of mesophication are compounded by non-native invasive species, which can outcompete the native flora and alter soil chemistry. Many invasive shrubs cast heavy shade and grow at densities much higher than native shrubs and saplings. They often leaf out two to three weeks before native plants and stay green four or more weeks later, which gives them an advantage over natives (McEwan et al. 2009). Invasive species are a serious issue in southern Illinois: in a survey of land managers, 60 percent stated that invasive species are a problem on at least half of their lands. Some of the most abundant woody invasives in the region are bush honeysuckle, multiflora rose, autumn olive and oriental bittersweet. Herbaceous invaders include reed canary grass, garlic mustard, Japanese chaff flower and Japanese stiltgrass. As invasives replace native species, the affected areas become less suitable for wildlife and lose biological diversity (Clavero et al. 2009).

Fragmentation

Fragmentation occurs as landscapes are broken up by different ownerships and land uses, which can severely limit wildlife and management in oak ecosystems. As development occurs in and around wildlands, animals that require large, connected ecosystems can become regionally endangered or even extirpated (Davies et al. 2000). Reptiles and amphibians are especially vulnerable to habitat fragmentation because they require ample core habitat to reproduce and are often killed when crossing roads or other barriers (Cushman 2006). Many of the region's sensitive species cannot persist in degraded, fragmented ecosystems.

The destruction of wildlands not only removes available habitat, but it also affects the structure and function of the remaining natural habitats. When forests become fragmented, the ratio of edge to core habitat is increased (Figure 4). The edge of a forest differs from its core: the edge is more exposed and has more sunlight and higher winds (Saunders et al. 1991). Forest communities that have a high ratio of edge to core habitat are more susceptible to invasive species (Charbonneau and Fahrig 2004). Bird nests are more vulnerable to predators and parasites on habitat edges (Hoover and Robinson 1999, Hoover et al. 2006). Many conservative plant and animal species will only in core habitat, not live in edges (See Box 7).

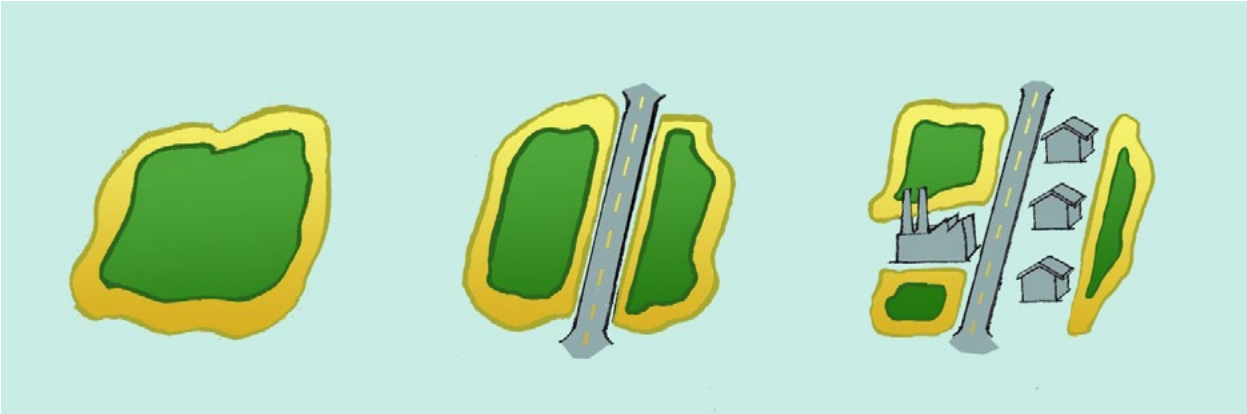


Figure 4: *Roads and developments increase fragmentation of wildlands, reduce core habitat (green), and increase habitat edges (yellow).*

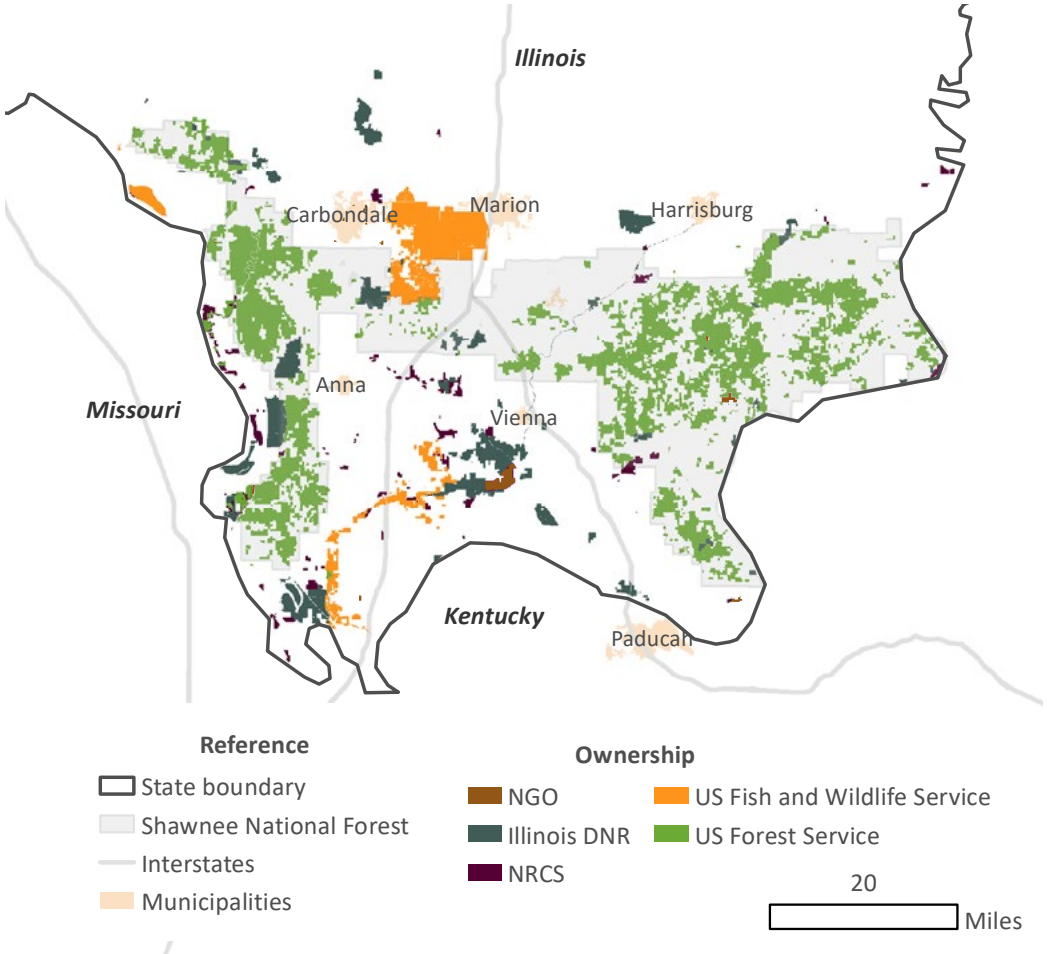


Figure 7: *Much of southern Illinois is public land, owned by a variety of governments. However, most of the land is private, making it hard to manage at a landscape scale.*

Box 7 Fragmentation

Many bird species are especially sensitive to disturbance and fragmentation of forests and avoid forest edges. Habitat edges tend to have a higher abundance of nest predators such as snakes, crows and raccoons. Extensive forest fragmentation in southern Illinois has made safe habitat for forest songbirds scarce. This problem is further exacerbated by cowbirds, a brood parasite that lays its eggs in other birds' nests (Fig 5). Cowbird eggs hatch sooner than the host's eggs, and cowbird chicks grow more quickly. Parent birds tend to feed the more demanding cowbird chick first, often resulting in host chicks starving. Cowbirds thrive in habitat where forests are fragmented by agriculture or pastures (they forage on the ground in open areas and lay eggs in nests of nearby forest hosts), meaning that forest songbirds may suffer more cowbird parasitism the closer they nest to the forest edge.

Figure 5: *Cowbird eggs in a forest songbird's nest. © Jeffrey Hoover*

From 1999-2001, a study by Jeff Hoover, Tim Tear and Mike Baltz quantified cowbird and nest predator impacts on a forest songbird, the Acadian flycatcher. It focused on an area within the Shawnee National Forest where a narrow strip of agricultural land cut into an otherwise intact wooded area (Hoover et al. 2006). It found that flycatchers raised too few chicks to offset typical mortality within 2,000 feet of the forest edge, meaning that over time their population would decline if they nested in these areas (known as population sinks). While there was some productive nesting land for the flycatchers, it was greatly reduced by the agricultural inholdings.

Fragmentation (continued)

Researchers determined that converting 500 acres of agricultural land to forest would add more than 3,300 acres of productive nesting habitat for the flycatchers—or every acre that was converted would add six acres of source habitat (Fig 6).

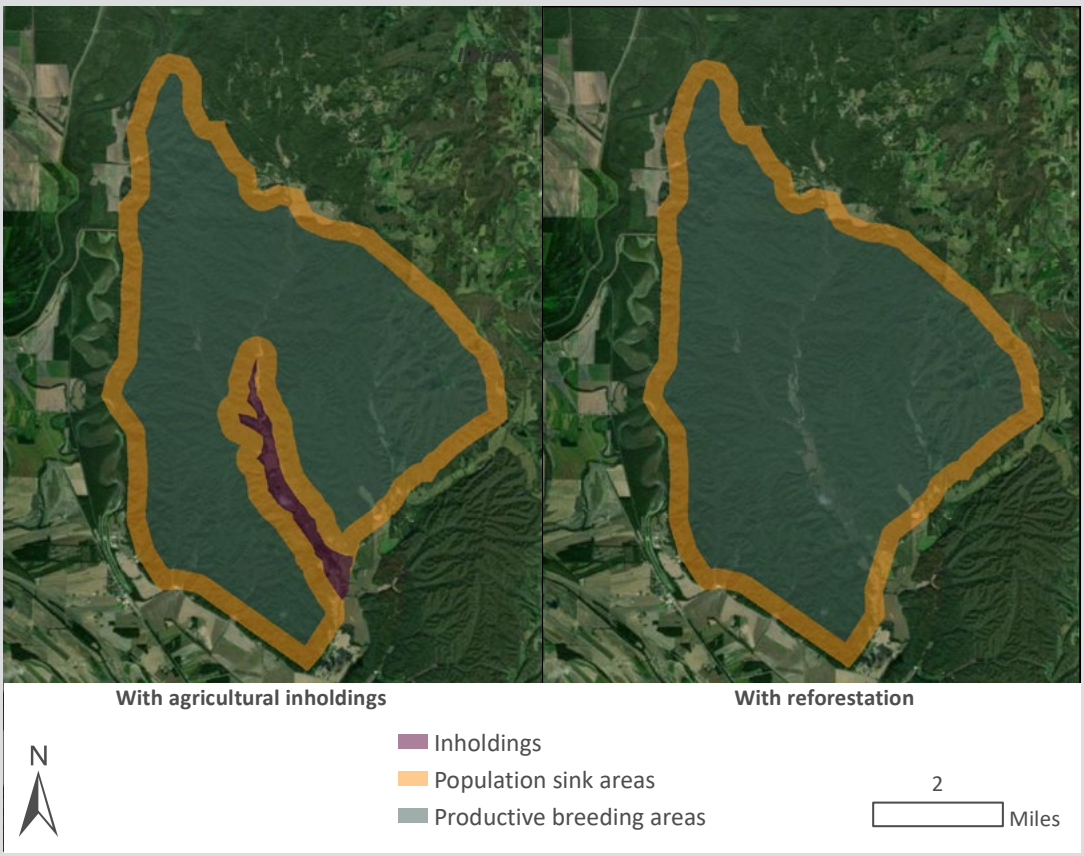


Figure 6: *Returning a small patch of agricultural inholdings to forest would result in a large expansion of productive breeding area for the Acadian flycatcher.*

This research led to action by The Nature Conservancy, which works with land owners in a variety of ways, from altering how the land is used to buying the properties so that they can be reforested. They contacted the land owners to see if they were willing to sell, and found that many in this area were. The newly acquired land was turned over to the U.S. Forest Service for management.

Many of these properties have been or are now being reforested. Going forward, researchers hope to resample this area to measure if and how quickly rates of nest predation and cowbird parasitism are reduced for Acadian flycatchers. The reforestation of the region has had ecological effects beyond the birds. The agricultural inholdings were located along a gravel bottom creek, which is a fairly unique ecosystem in Southern Illinois. Changes in management have reduced erosion and fertilizer run-off into the river, allowing sensitive aquatic species to thrive.

Some areas have a continuous forest cover but are fragmented by ownership. Land in the Shawnee National Forest and elsewhere in southern Illinois is held by a huge number of individual owners. They range from federal, state, and local governments to private landowners and conservation organizations (Figure 7). All these owners have varying capacities for management and different goals for their land.

It is challenging to manage land on a broad scale wherever ownership is fragmented—but it is necessary to restore oak regeneration and increase woodland biodiversity. Prescribed fires, canopy thinning and invasive species removal on small parcels is not as effective as larger-scale activities. Working with land owners across a wide spectrum will improve the outcomes of management activities.

Overabundance of deer

White-tailed deer populations have increased dramatically in the Midwest since the mid-1900s as a direct result of human actions. By the turn of the 20th century deer were nearly extirpated by over exploitation. This loss created pressure to increase their numbers by limiting hunting. Coincidentally, suitable habitat for deer was also increased. Deer live primarily along forest edges, so forest fragmentation provides more habitat. Many of these forest edges border farmland, and agriculture provides deer with much more food than they had historically, alleviating yet another pressure on their population.

High deer densities can adversely affect oak regeneration (Ripple and Beschta 2008). Deer prefer acorns over many other foods, which reduces the number of acorns that grow into seedlings (Strole and Anderson 1992). Deer also eat young trees, so the few acorns that do sprout may be prevented from growing into saplings (Stromayer and Warren 1997, Rooney and Waller 2003). Deer disturbances can facilitate invasive species establishment (Knight et al. 2009), creating forests that are less suitable for oak regeneration. Deer can have a negative impact on other woodland species, especially in deeply shaded forest where fire-adapted plants are progressively lost to shading and competition. Deer also reduce biodiversity in woodlands by browsing on spring flowers and other sensitive plants (Rooney et al. 2004).

Poor timber harvesting practices

Timber harvesting has been an important driver of composition since European-American settlement. In the earliest days of settlement, timber harvesting and intensified disturbance may have encouraged oak dominance—even on more mesic sites. A well-designed timber harvest can be a valuable tool for managing the openness of the canopy and the amount of sunlight reaching the forest floor, which is often the key to developing and maintaining oak regeneration and native plant diversity. Timber harvesting can also be used to remove a sufficient amount of overstory trees to release well-established oak regeneration and ultimately create a new age class of trees. To be successful it is often necessary to combine a commercial timber harvest with additional practices that manipulate the understory and middle canopy layers, such as Forest Stand Improvement (FSI) and prescribed burning. However, poorly designed, selective harvesting practices that became common in the mid-20th century (like high grading and diameter limited harvesting) have accelerated mesophication and reduced oak regeneration. These practices remove the highest quality, most valuable trees and leave the smaller, low-quality trees to grow up in their place. These practices assumed that the remaining trees would quickly grow into the canopy once they received more light, but this is not usually the case. These smaller trees frequently have defects and do not grow to be good timber specimens. Further, selective harvesting does not create adequate light to allow for the regeneration of new oak seedlings. Over time, repeated selective harvesting leads to poor quality, mesic-dominated woodlands.

Changing climate

In the coming decades, southern Illinois is predicted to experience warmer temperatures, changes in precipitation (including dryer overall conditions with more frequent, intense storms) and changes in the length of the growing season (IPCC 2013). The distributions of trees, other plants and animals will change with the climate (Matthews et al. 2011). Warmer and dryer conditions may encourage oak regeneration and result in declines in mesophytic species, as oaks are drought tolerant. However, climate change is also expected to improve conditions for many invasive species (Hellmann et al.

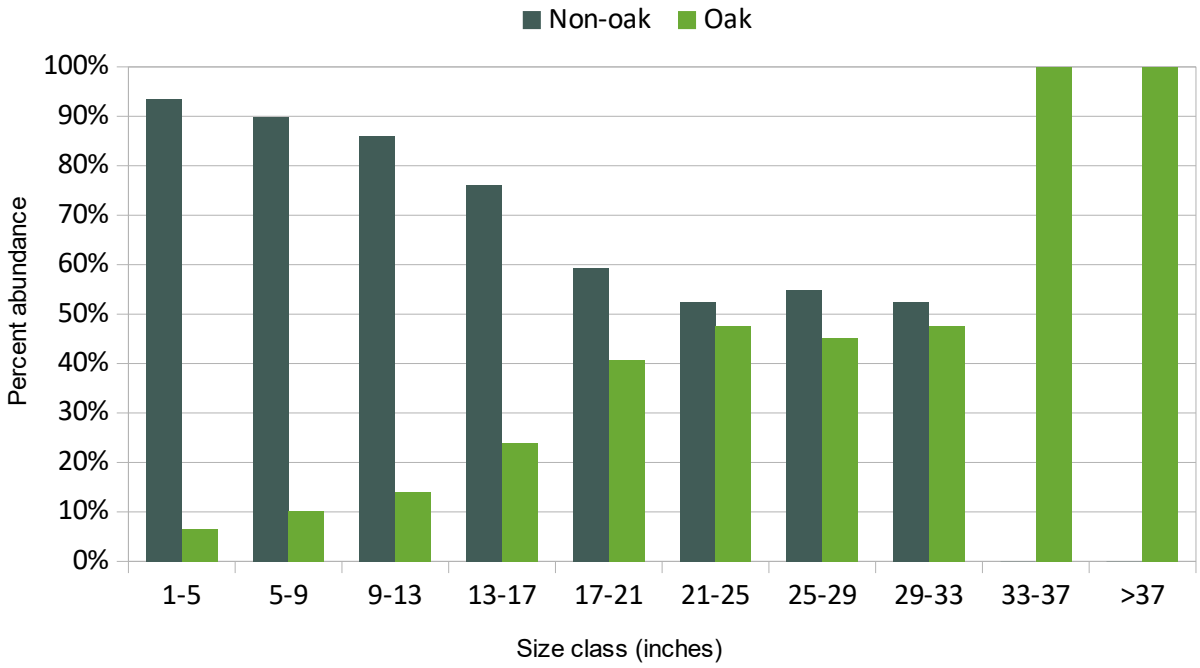


Figure 8: *FIA data show that in southern Illinois, non-oak trees make up the majority of the smaller trees, and the largest size classes are entirely comprised of oaks.*

2010). For more information about how individual species may respond to climate change, see Prasad et al. (2007). This database includes information on approximately 135 tree species and is updated regularly.

Climate change exerts extreme stresses on ecosystems. Plants and animals will need to adapt to new conditions relatively quickly—or else they will perish. Healthy, connected, resilient ecosystems will be more able to adapt to a changing climate than ones that are imperiled with invasive species, fragmentation and diseases (Millar et al. 2007).

Unsustainable size distribution

Oaks have not been growing beyond the seedling layer for several decades, which has led to an unsustainable size distribution. Forest Inventory Analysis (FIA) data (Miles 2018), reveal that the vast majority of the smallest trees in southern Illinois are not oaks (Figure 8). Oaks account for less than 10 percent of all trees under nine inches in diameter, but they make up most of the largest trees. This dichotomy not only points to the changing species composition in the region, but also illuminates another issue: There are not enough young oaks to replace mature trees as they die. This could result in a precipitous decline in the oak canopy in the coming decades.

A vision for sustaining oak ecosystems in southern Illinois

Given the decline in oak dominance, lack of oak regeneration and severe landscape fragmentation in southern Illinois, significant actions must be taken to sustain oaks. Our vision for the future of oak ecosystems in southern Illinois is:

A physical landscape in which:

1. A regional network of oak ecosystems is created and maintained, one that maximizes high-quality large, unfragmented habitat and landscape-level connections;
2. Oak ecosystems are protected and managed to restore and maintain oak regeneration, the diversity of native plants and animals, and ecosystem structure and function;
3. Threats to oak ecosystems are managed proactively and removed or preempted whenever feasible; and
4. These management activities take place across all ownerships, both public and private.

A social landscape in which:

5. A coordinated, regional forest stewardship network is focused on maintaining and enhancing oak ecosystems;
6. The story of the oak legacy is told widely and to a large variety of audiences in an engaging manner;
7. The many values associated with oak ecosystems—including critical habitat for pollinators, migratory birds and game species, water quality regulation, soil conservation, and forest products—are understood and promoted to a wide audience.

This vision is consistent with goals outlined in the Illinois Wildlife Action Plan, the Illinois Statewide Forest Resource Assessments and Strategies plan, the Shawnee National Forest Plan and The Nature Conservancy's Illinois Ozarks plan (See Box Regional plans).

To accomplish this vision, we advance the following primary goals for maintaining the region's oak legacy:

1. **Develop and maintain a regional network of public and private lands consisting of large, high-quality ecosystems buffered and connected by smaller opportunity areas:**
   i. Give priority to restoration in Forest Stewardship Clusters;
   ii. Increase the percentage of private land within clusters that have a Forest Stewardship Plan approved by the Illinois Department of Natural Resources;
   iii. Discourage poor timber harvesting practices (e.g. high-grading and diameter limit cutting);
   iv. Maintain or restore characteristic species assemblages within clusters by improving ecosystem structure and function, thereby creating conditions that can be sustained with limited future management inputs;
   v. Continue to identify and recognize opportunities for collaborative work beyond the management clusters;
   vi. Reduce fragmentation across the region to increase core habitat for sensitive species and to connect wooded areas;
   vii. Use the Forest Stewardship Database to target landowners for outreach.

2. **Develop, promote, teach and implement best management practices for restoring and maintaining oak ecosystem biodiversity and increase the amount of sunlight that reaches the forest floor:**
   i. Promote the use of prescribed fire;
   ii. Encourage appropriate removal of canopy and midstory mesophytic trees to bring light back to the understory and forest floor;
   iii. Use treatments that can eradicate or slow the spread of invasive species;
   iv. Plant and seed native species when necessary—targeted to specific conditions or goals;
   v. Draft forest stewardship management plans for private property.

3. **Proactively address threats to oaks and oak ecosystems through management, monitoring, and outreach programs:**
   i. Connect fragmented ecosystems to increase resilience to climate change and help maintain biodiversity;
   ii. Eradicate bush honeysuckle and other invasive plants that harm oak regeneration and oak ecosystem function;
   iii. Plan for impacts of pests and diseases, and try to avoid future introductions;
   iv. Control deer populations and assess their impacts on oak regeneration and biodiversity;
   v. Create the ecological conditions needed to regenerate oaks and associated species.

4. **Quantify and promote the values associated with oaks and oak ecosystems, including:**
   i. Oak ecosystems provide critical habitat for many endangered and threatened plants and animals;
   ii. Contiguous, managed oak ecosystems are better than other forest types for most wildlife, including many game species. More open woodlands are especially important for bats and many birds;
   iii. Oak ecosystems store carbon, regulate stormwater and improve water quality;
   iv. Timber harvesting can—and often should—be a component of oak woodland management, and revenue generated can pay for other management activities;
   v. Oak ecosystems can attract birdwatchers and tourists.

5. **Convey the story of the region's oak legacy to a wide array of stakeholders across the region:**
   i. Create promotional materials and media opportunities describing "Let the Sun Shine In!" (See Box Let the Sun Shine In!);
   ii. Participate in the state-recognized oak awareness month, "OAKtober";
   iii. Create a regional website to serve as a resource for southern Illinois forest landowners;
   iv. Educate and persuade decision-makers to support the care and management of oaks and oak ecosystems;
   v. Develop lesson plans and outreach materials in partnership with local educators from a variety of institutions (including primary schools through college and continuing education);
   vi. Engage stakeholders (especially landowners) in activities to maintain or enhance oak ecosystems—including tree planting and maintenance, prescribed burning, invasive species removal, pest and disease monitoring, and data collection;
   vii. Develop a network of demonstration areas where stewardship practices can be viewed and interpreted.

6. **Foster a better understanding of the status of oak ecosystems through data collection and research:**
   i. Develop a regional monitoring network;
   ii. Use stewardship management plans to map and quantify biodiversity in oak ecosystems;
   iii. Increase the tracking of rare species across land ownership types;
   iv. Prepare a document that describes the historical oak ecosystem in southern Illinois, including the fires, grazing animals and other ecological factors that shaped it;
   v. Improve and promote a regional data-sharing effort, including the invasive species, prescribed burning and forest stewardship plan databases;

Box 8 Let the Sun Shine In

Let the Sun Shine In is a regional, landscape-scale conservation campaign to recover southern Illinois's oak ecosystems. The campaign works with regional partners, across boundaries, to address the threats to our woodland and forest communities. It relies on the best science available to guide recovery efforts, which include emphasizing diversity of oak species and oak dominance, maintaining and increasing the region's natural biodiversity, and reducing forest fragmentation by implementing forest management at the largest (most effective and efficient) scale possible to restore and maintain healthy forests.

Let the Sun Shine In also aims to raise awareness about the declining oak ecosystem, to encourage people to act and to advocate for data-driven, science-based, forest management intended to recover oak systems.

Let the Sun Shine In began because one of the main threats to our oak ecosystems is a process called mesophication. Mesophication is the widespread conversion of our historically open forests and woodlands to closed, dark forest. Oaks are slowly disappearing from southern Illinois forests because of the lack of sunlight in our forests. Without more sunlight, southern Illinois forests may be the first in central North America to convert completely from oak forests to forests that are dominated by shade-loving species, such as maple. A darker forest means fewer songbirds, pollinators and other wildlife. That's because sunlight gives life to wildflowers, grasses, and shrubs. Bees, butterflies and other pollinators feast on these flowers, while the forest floor provides cover for birds and other wildlife to raise their young. Hence, *Let the Sun Shine In*.

The campaign gets the word out through a series of flyers and handouts, published articles, workshops, private landowner outreach and demonstration plots. These tools show private property owners how their lands can be part of a larger conservation effort and that letting the sun shine in can also improve prospects for hunting and bird conservation. Go to https://letthesunshinein.life/ to learn more. Landowners interested in the project area may email info@letthesunshinein.life

The project is coordinated by the Shawnee Resource, Conservation and Development Area.

vi. Use the above datasets to foster research and to create adaptive management strategies (See Box Research needs for oak ecosystems).

7. **Formalize the Oak Recovery Working Group as a regional planning group to guide the implementation of the Oak Recovery Vision:**
   i. Coordinate regional stakeholders and leverage and amplify ongoing efforts;
   ii. Document efforts at a regional scale.

Box 9 Research needs

The management of oak ecosystems is an adaptive process; the strategies that work today will need to be altered with changing conditions. Continued research will allow managers to understand whether current techniques are working and indicate how management should be adapted going forward. There are pressing research needs now, including:

- **Fire in oak ecosystems**
  - How will drought affect fires?
  - How do invasive species affect fires?
  - What timing and frequency of prescribed burns following cutting treatments are the most effective?
  - What can dendrochronology tell us about historic burn frequency?

- **Invasive species**
  - How do invasive species react to extreme disturbance events (e.g., derecho, tornado blowdown, timber harvest, forest pest outbreaks)?
  - How does stiltgrass respond to varying light levels?
  - Is aerial spraying a viable method for bush honeysuckle control?
  - What are the interactive effects of stiltgrass invasion on soil fertility, tree recruitment and site productivity?

- **Regenerating hardwoods in pine plantations**
  - What harvest intensity, light levels, post treatments work best using shelterwood approach?
  - How do poor soil conditions affect regeneration and future growth?
  - Are invasive impacts different in these ecosystems, and how should they be managed?

- **Wildlife**
  - How can management activities such as harvesting, burning and tree stand improvement be conducted without harming bat populations?
  - How has a changing climate affected the phenology of herptiles, and how could this impact burning seasons?
  - How do restoration activities impact wildlife assemblages?
  - How does forest management with the objective of reversing mesophication affect pollinators?

- **Climate change**
  - How will climate change affect the resilience of central hardwood forests to disturbances such as fire, pests and disease?
  - When is assisted migration of southern genotypes a viable strategy?
  - How capable are standing oaks of adapting to changing conditions?

- **Forest stand improvement**
  - Can forest stand improvement techniques be used to promote oak regeneration and increase biodiversity in oak ecosystems?

- **Social considerations and private property**
  - How does development of private property forestry plans impact property owners' views about invasive species, prescribed fire and timber harvesting on public land?
  - What outreach strategies would be most effective at encouraging woodland management on private property?

Strategies for management

Southern Illinois managers aim to restore oak regeneration by improving oak size distribution, increasing biodiversity in oak ecosystems and reducing fragmentation. In this section, we describe methods that will help meet those goals. No single method is enough to recover forested landscapes, nor will the same combination work for every site. We describe a few of the most widely used strategies, give examples of how they are being used in southern Illinois, and outline some challenges. For more details about management techniques, see Dey and Kabrick (2015).

Buffer and connect wooded properties

Wildlands in the Shawnee National Forest and throughout southern Illinois are extremely fragmented. Restoring connections among these lands is a priority for restoring oak ecosystems. This can be done in a variety of ways, including public land acquisition and private conservation easements. Whenever landowners are interested in selling, public or not-for-profit purchase of the land can be an especially effective way to reduce fragmentation and improve forest management (see box Fragmentation on page 17).

Many private property owners are not interested in selling their land but are willing to put an easement on their property. Federal programs such as the Conservation Reserve Program (CRP) help landowners reforest marginal farmland. Easements can also bring tax deductions. Outreach efforts can help private landowners navigate the process of putting environmental protections on their property and applying for financial benefits.

Land acquisition is expensive and creating easements can be time-consuming. Therefore, it is important to set priorities and target properties that will contribute to landscape-scale goals (See Box 11).

Cooperation among owners

Because of the intricate ownership patterns in southern Illinois, it is necessary to work across property lines to achieve landscape-scale management. This could

Box 10 Stewardship Clusters

Southern Illinois is a vast forested area and there are limited resources to manage it. Recognizing this, partners in the region including the U.S. Forest Service, U.S. Natural Resource Conservation Service, the Illinois Department of Natural Resources, U.S. Fish and Wildlife Service, The Nature Conservancy, the National Wild Turkey Federation, Southern Illinois University-Carbondale, Shawnee Resource Conservation and Development Area, the University of Illinois Extension and the Central Hardwoods Joint Venture met to discuss overlapping objectives, including reducing fragmentation, increasing biodiversity, and ensuring that oaks remain keystone species.

They identified eight Forest Stewardship Clusters where they could work together to achieve these goals. These clusters are large (around 15,000 acres each), continuously forested blocks that have unique biodiversity and a mixture of state, federal and private ownership (Fig 9). While the core of the clusters contains a hard boundary, clusters are actually dynamic and can grow as properties adjacent to the core follow Forest Stewardship Plans aimed to restore oak systems. In theory, clusters could grow into each other to form a healthy regional forest. The group is now working together to develop management and coordination strategies within these clusters that supersede ownership—a form of shared stewardship.

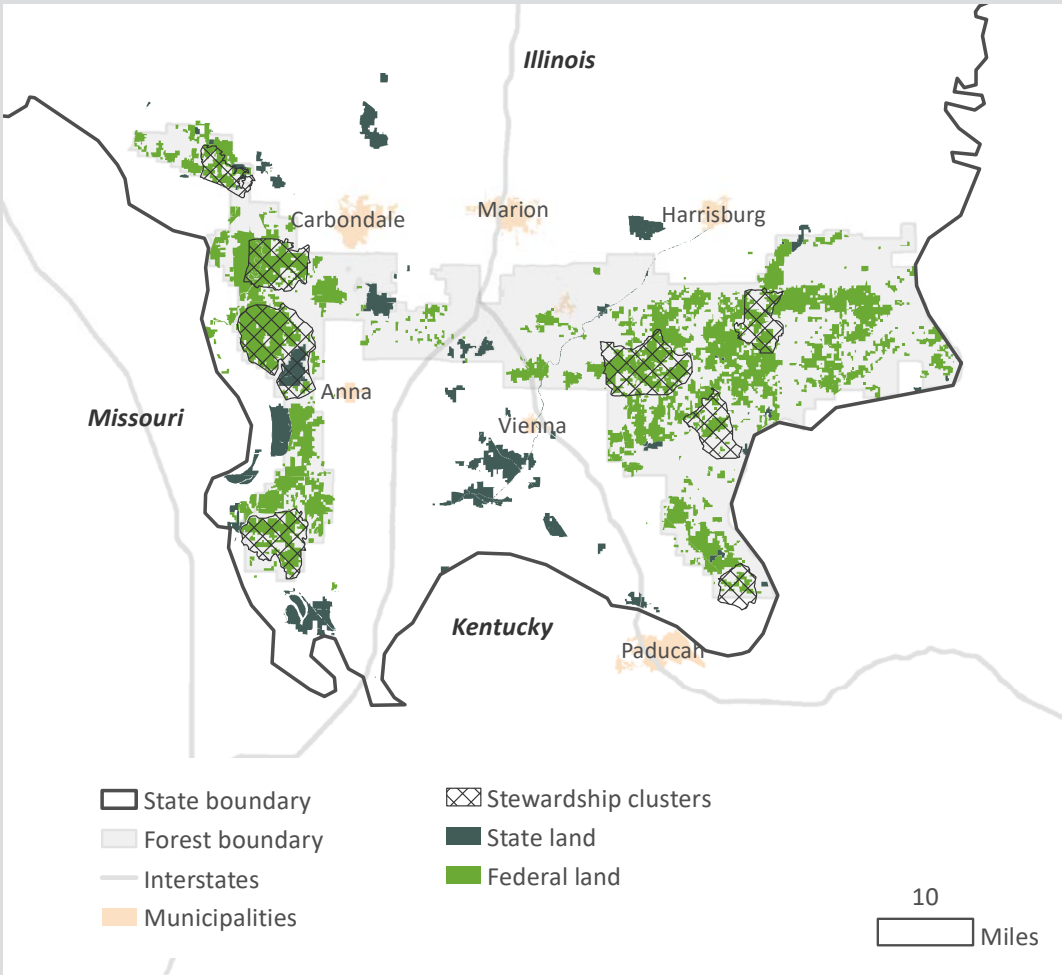


Figure 9: *Stewardship clusters are scattered across southern Illinois, and are made up of state, federal and privately held land.*

Box 11 Cooperation

Southern Illinois's oak ecosystems are owned by a wide group of people and organizations. Even the land that is publicly owned is managed by various agencies including local, state and federal governments. This fragmentation of ownership and cost has always presented a challenge for restoring and recovering the region's oak ecosystem. Restoration practices such as prescribed fire, canopy thinning and invasive species management are much more biologically effective and less costly when done on a landscape scale. In southern Illinois, success in recovering forest communities requires landscape-scale conservation—a framework to conceive, plan, finance and manage projects with significant conservation value across ownership.

The Nature Conservancy's Southern Illinois Invasive Species Strike Team is an excellent example of landscape-scale conservation. While team members are employees of the Nature Conservancy (and are funded by grants that the Conservancy has secured), they work across ownerships to implement oak system conservation. The team works in partnership with private landowners, the U.S. Forest Service, Illinois Department of Natural Resources and a host of local not-for-profit groups. The team primarily focuses on the highest quality oak communities on state and federally owned natural areas and adjoining private properties. The Strike Team was created in 2008 to focus on early detection and rapid removal of invasive plant species. Originally, the team worked in southern Illinois exclusively on IDNR natural areas where it used prescribed fire, chemical and manual methods to control invasive species. More recently, the team has begun to work with organizations such as the Southern Illinois Prescribed Burn Association and the Forest Service to work more broadly in oak ecosystems.

The Strike Team is particularly effective because it is able to quickly get into the field to address invasive threats and fire management. Its members are highly trained and extremely mobile, and spend the vast majority of their time in the field rather than in the office. Currently, the Strike Team has only four members, but in 2016 that small team treated more than 14,000 acres across 51 properties.

One helpful facet of the Strike Team is its ability to work with private land owners. All too often private lands can act as source populations for invasive species and provide pathways onto adjoining public lands (and vice versa), which makes controlling these species across all lands nearly impossible. The Strike Team specializes in working with these land owners. Its interactions are often the first step in helping the land owners create forest stewardship management plans.

Going forward, the Strike Team hopes to expand its operations and become even more efficient. Much of its time is currently spent on traveling across the 11-county region. In the coming years, it plans to have separate teams that are stationed in the eastern and western parts of the region, which will cut down on time spent traveling to sites.

come in the form of cooperative burning, or sharing equipment and staff to manage invasive species and timber harvesting (See Box 11). Cooperation across governmental properties has improved tremendously in the last decade. Prescribed burns and invasive species management are routinely done across boundaries and by a mix of staff.

Cooperation across private property is also increasing and can be further aided by programs such as the Illinois Forestry Development Action Plan, the southern Illinois Prescribed Burn Association, the River to River Cooperative Weed Management Area and conservation easements through conservation reserve programs.

Prescribed burning

Fire can be used to restore and maintain woodlands; oaks have evolved to live in landscapes that experience periodic burns and can thrive with this sort of disturbance. Fire also limits the growth of mesophytic and invasive species.

Managers usually burn in the late autumn and early spring. In these seasons there is enough dead vegetation to carry a fire, and the flames are less likely to harm wildlife and sensitive vegetation. Prescriptive fires are carefully planned and carried out not only when conditions are safe but also to meet ecological objectives. Using prescribed fire can be challenging. There are few days with suitable weather, and many managers say a lack of trained staff hampers their efforts (Fig 10).

The frequency of prescribed fires will vary by ecosystem type and management goals. A survey of southern Illinois land managers found that fires are used more frequently when restoring a site than when maintaining it (Fig. 11). Managers burn the most often to restore barrens (two-thirds of managers burn every other year or more often), and they burn the least to maintain flatwoods (where most managers burn less than once every five years).

Prescribed burns are not possible or appropriate for all sites. Fires create air pollution and smoke can cause respiratory ailments and aggravate asthma. This can be especially problematic if populated areas lie downwind from prescribed burns. In very small sites or areas that are surrounded by development, alternative methods (e.g. mowing) may need to be used to introduce disturbance. For a more thorough discussion of fire management in oak ecosystems, see Frelich et al. (2015).

Promoting canopy openness

Over the past century, fire suppression, a wetter and cooler climate and changes in harvesting have caused increased canopy closure and the proliferation of mesophytic species in southern Illinois. Prescribed burns are now being used at many sites to restore historic disturbance regimes. While fire can reduce establishment of mesophytic species, it generally does not open up the canopy enough to encourage oak regeneration (Hutchinson et al. 2005, 2008). To do that, it is sometimes necessary to remove some canopy or mid-story trees.

Canopy thinning can create gaps that allow sunlight to reach the forest floor. Shelterwood cutting is a method of thinning that is commonly employed to encourage growth of new oaks. Some mature and mid-story trees are removed to make gaps in the canopy. Many large trees are left behind to act as a seed source, and to provide continued habitat for wildlife (Lanham et al. 2002). When

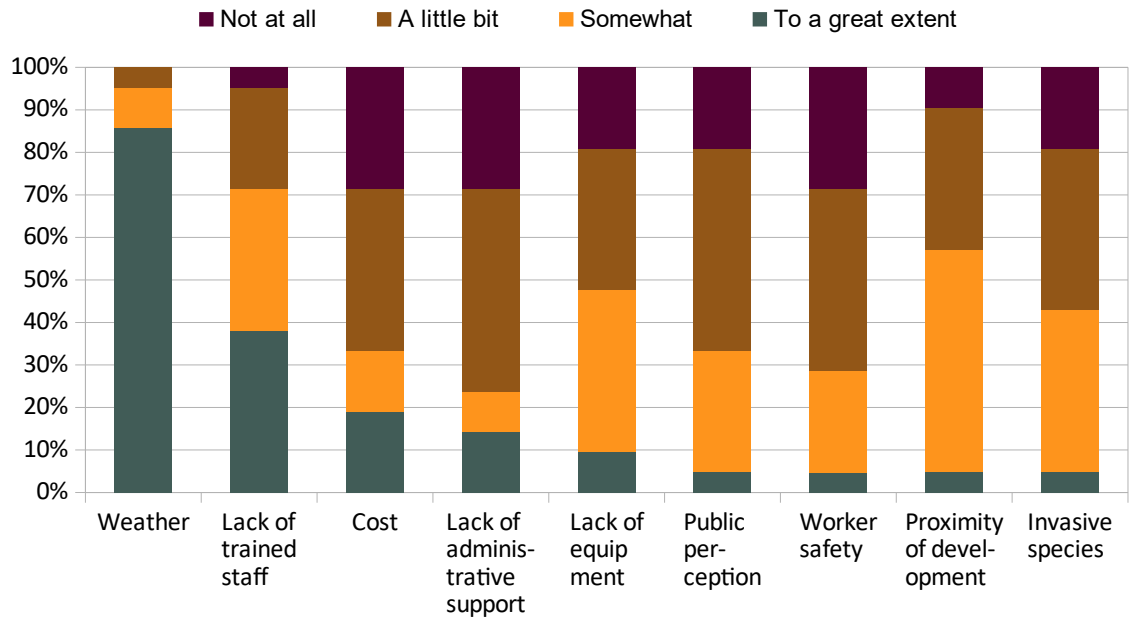


Figure 10: *Reported challenges in using prescribed fire management.*

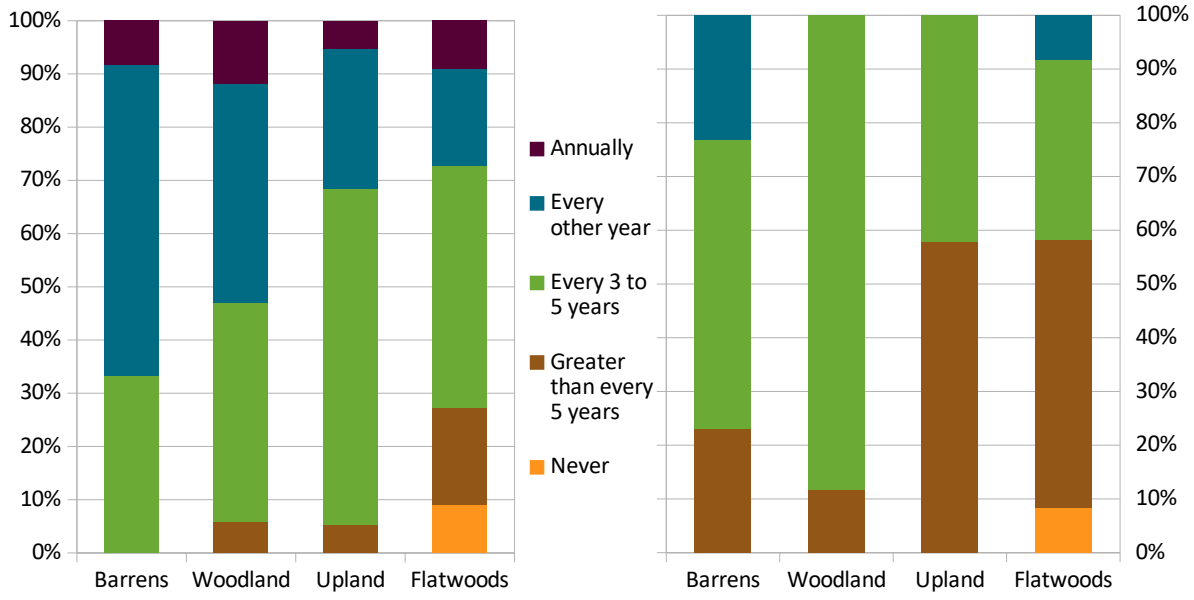


Figure 11: *Frequency of burns used when working to restore a site (left) versus when managing to maintain a site (right) across ecosystem types.*

Box 12 Thinning and Timber Management

Canopy closure and excessive shade is one of the biggest causes of oak regeneration failure (See Box 6). Canopy closure is, in part, caused by a century of fire suppression, but reintroducing fire alone cannot reverse this trend. In many circumstances, removal of canopy and mid-story trees will be needed in addition to fire.

In a survey of southern Illinois managers, all respondents said they removed shade-tolerant species to increase oak regeneration. The majority (65 percent) of respondents also said they removed canopy oaks from their forests as well, and all cited increasing light penetration to the forest floor as a motivation for removing the trees.

Removing these trees is one of the best ways to encourage oak regeneration, and it can also be a source of revenue that supports other management activities. Eighty-eight percent of managers said timber harvesting can be compatible with restoring and maintaining oak communities.

However, timber management needs to be done with care. Trees should be removed to improve conditions for oak ecosystems. Foremost, managers, on both private and public land should have a Forest Stewardship Plan to ensure that timber harvesting is part of a broader strategy to improve ecosystem health. Also, a professional forester should ensure that the appropriate amount and types of trees are removed to achieve ecological objectives and to minimize impacts to soil and water quality. On private land, a consulting forester can be hired to assist the landowner with the process of selling timber. Many private property owners will skip this step in an effort to save money. However, a forester can frequently get better prices for timber and ensure that the timber removal will improve forest health. Further, a well-managed forest will yield more valuable timber in the long term.

Thinning has challenges. Chief among them are the time and cost of removing the trees (Fig 12.). There is not a market for small diameter or low-quality trees, so removing these cannot be offset by timber sales. However, most managers do not struggle to find buyers for their timber, and public opinion is not a major obstacle to using timber management.

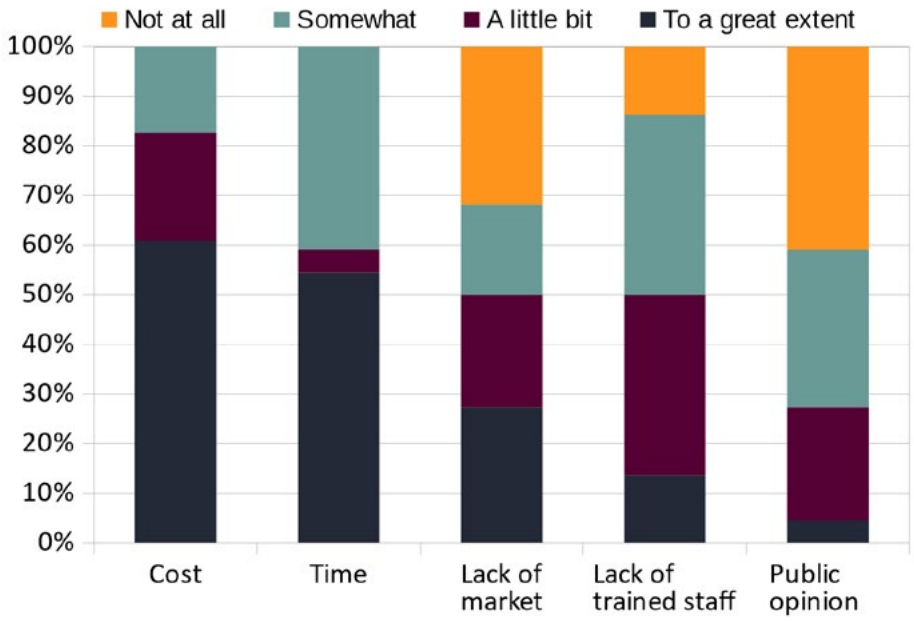


Figure 12: *Survey responses to which factors limit the use of thinning and timber harvesting as a management technique.*

coupled with prescribed burning, canopy thinning facilitates oak regeneration (Iverson et al. 2008).

Harvest and sale of larger trees is commonly done on private property and there may be opportunities for increased logging on public land, too (See Box 12). Timber harvesting, especially when combined with Forest Stand Improvement (FSI) and prescribed burning, provides a means to manage the entire forest structure from the main canopy to the understory to create the desired conditions necessary for developing and maintaining young oak trees as well as native plant diversity. These activities can and often should be components of managing healthy, sustainable and biodiverse oak ecosystems. Sale of harvested trees can help fund other management activities and can contribute to the local and regional economy.

Invasive species management

All managers who were surveyed responded that invasive species are an important factor in limiting oak regeneration. Invasive species can outcompete native species and alter the function of native ecosystems, which can reduce biodiversity and limit use by wildlife. See the threats section for more information about exotic invasive species. Although fire can be used to kill some invasive species, it also increases light, removes litter, and increases the availability of minerals. Many invasive species are adept at colonizing areas with these conditions, so it is necessary to be careful about the timing and severity of fires to maximize their impact on invasive species (Dey and Kabrick 2015). Effective invasive species management requires integration of a variety of management techniques, including cutting, burning and applying herbicides.

Promote resilience to future stressors

Climate change and new pests and diseases will continue to alter and stress oak ecosystems in the decades and centuries to come. Because these threats are largely intangible, strategies to prepare for them are less concrete. Oaks are well adapted to deal with the hotter, dryer climate that is predicted for southern Illinois in the coming century. Generally, healthy ecosystems with high biodiversity and a low abundance of invasive species tend to be more able to cope with stressors such as climate change.

Encouraging biodiversity may not prove to be enough by itself to cope with a rapidly changing climate. Managers may need to use more southern seed sources to introduce genotypes that are adapted to predicted future conditions. For more information about managing for climate change, see Swanston et al. (2016), or the Climate Change Response Framework's web page, which has specific recommendations for southern Illinois http://climateframework.org/central-hardwoods.

Promote and publicize the values of oak ecosystems

People who know more about the environment tend to have more positive outlooks toward natural resource management. However, many in southern Illinois know little about the history and ecology of oak ecosystems. Support for restoring and managing oak ecosystems can be bolstered by outreach efforts such as putting up signs to explain forest management, creating programs for grade school students and working with hunting and fishing organizations. Such actions can encourage private landowners to seek help in managing their properties for oaks.

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Images

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