A photograph of a lush oak woodland or savanna. The foreground is filled with tall, green grasses and various plants. In the middle ground, several tall, slender oak trees stand prominently. The background shows a dense forest of similar trees, with sunlight filtering through the canopy, creating a dappled light effect on the ground.

Ecology and Management of Oak Woodlands and Savannahs

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What Is an Oak Savannah?

Oak savannahs are transitional zones between open prairies of the Great Plains and the more mesic deciduous forests of the East. Historic oak savannahs were interspersed throughout many of the eastern forests from New England to Florida (Figure 1). The existence and distribution of savannahs, wherever they occur, has always been strongly linked to natural fire regimes resulting from lightning strikes or those set by Native Americans. Without the regular occurrence of fire, most savannahs will follow natural succession and end up as closed-canopy forests. Soil characteristics and landscape position also influence oak savannah distribution. Historic oak savannahs were more common on south and west slopes and along ridgelines and knolls; fires burned hottest on these upper slope positions. They also were common on sites with well-drained or shallow soils where tree growth was restricted by limited nutrients and moisture. Oak savannah communities have a diverse grass- and forb-dominated understory and an overstory composed of scattered, open-grown and fire-tolerant oak trees. The oak overstory has a canopy cover that allows sufficient sunlight to reach the wide diversity of grasses and flowering plants below (Figure 2).

Historically, from west to east, the oak savannah transitioned from open

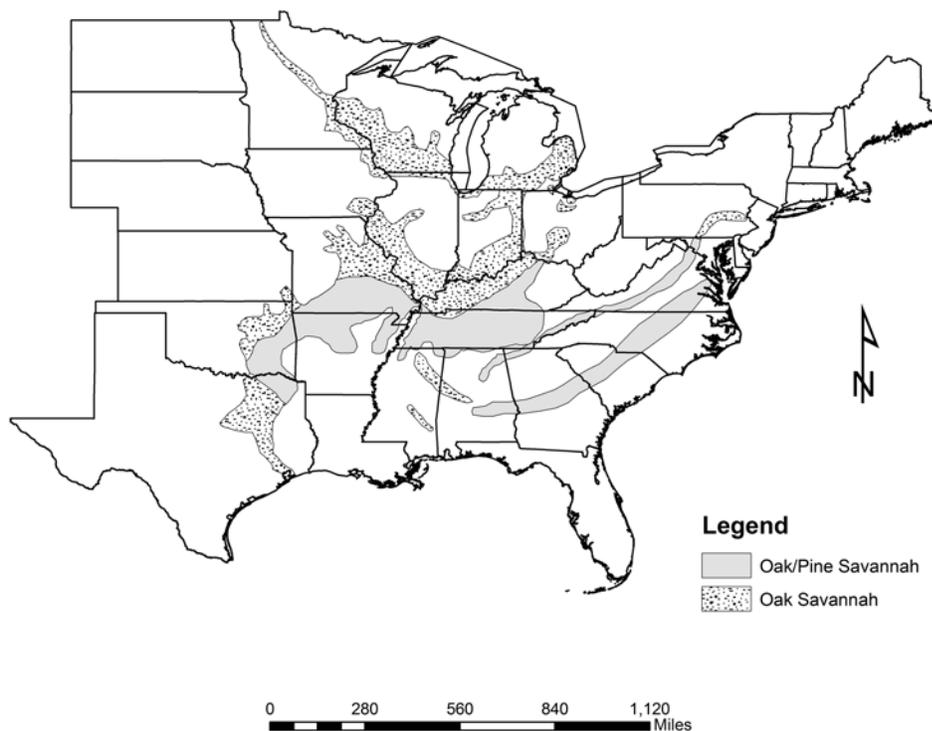


Figure 1: Approximate distribution of presettlement oak and oak/pine savannahs in central North America. Adapted from Haney and Apfelbaum (1993) and Henderson and Epstein (1995).

prairie with few trees to areas with widely spaced trees, balanced with an understory rich with grasses and forbs that were commonly found on the open prairie. Closer to the forests of the East, the tree component became more dominant, and the oak savannah gave way to the oak woodland (see sidebar, What is a “woodland” on page 3) where more trees than grass grew, and then to the forest proper. To the south, oak savannahs had substantial pine components in the overstory. As the southern limit of glaciation was approached, the pine component diminished markedly. Other types of oak savannahs with different oak and understory compositions also occur in North America on the West Coast (California and Oregon) and in the Southwest (Arizona, New Mexico and

Mexico). While some of the general characteristics and corresponding restoration techniques are similar in these other areas, this publication addresses the eastern oak savannahs specifically.

Why are they important?

Oak savannahs once covered more than 32 million acres but have declined to only about 0.02 percent (640,000 acres) of their presettlement range, making them one of the most imperiled plant communities in North America. The clearing of these areas for agriculture coupled with a dramatic change in fire regimes that created and maintained these systems were the primary causes of their decline. The extirpation of bison (*Bison bison*)



Figure 2. Oak savannah showing oak overstory and lush, herbaceous understory. (A. Vander Yacht). Lush, prairie-like vegetation in parts of a white oak savannah. Photo courtesy of <http://oaksavannas.org>.

What is a “woodland”?

Just as savannahs represent a transitional type between the open prairie and the closed canopy forest, woodlands are a transitional type between savannahs and forests (Figure 3). Regarding canopy cover, prairies have an occasional tree, and savannahs have approximately 10-35 square feet of basal area per acre of mature trees, while woodlands have more like 40-65 square feet per acre of overstory stems. These distinctions vary in the field and are not rigid definitions. Woodlands also have well-developed herbaceous ground layers, provide excellent wildlife habitat and contain high levels of biodiversity. Both savannahs and woodlands can occur on similar sites, although the more densely covered woodlands may be more common on more mesic sites. Also, both can occur in the same place, shifting between forest, woodland and savannah conditions through time as fire frequency, droughts or other disturbances become more or less frequent.

and elk (*Cervus canadensis*) and the introduction of domestic livestock and non-native grasses for grazing also have contributed to this dramatic decline.

Not only were these open, parklike savannahs aesthetically pleasing, they also were highly beneficial for a wide array of wildlife species. The diverse understory of legumes, forbs

and fire-adapted grasses included as many as 300 species, many of which have become imperiled along with these communities. The more widely spaced oak overstory with its full crowns produced plentiful mast. Native songbirds, ground-nesting birds, cavity-nesting birds, small game animals and large vertebrates all thrived in these savannahs, and some savannah obligates are associated



Figure 3. Oak woodland showing greater overstory canopy cover with a substantial herbaceous groundlayer. (C. Coffey).

directly with only these communities. Part of the reason that savannahs provide high-quality habitat for many species of wildlife is that the repeated fires maintain a diverse understory dominated by early successional species with high net productivity. In addition, savannahs have a complex structure that includes woody and overstory components that allow early and late successional species to thrive. Oak savannah habitat is nearly ideal for the wild turkey (*Meleagris gallopavo*), the largest game bird in North America. The large, open-grown oaks are excellent roost trees, and their acorns are a dependable and preferred food source. The open to moderately dense understory also is ideal for turkey nesting, thick enough to conceal the nest but just low enough to allow the hen to survey her surroundings. The prairie-like vegetation also supports a bounty of insects, which are vitally important for brood-rearing in the spring.

A number of birds associated with savannahs have declined, including the northern flicker (*Colaptes auratus*), red-headed woodpecker (*Melanerpes erythrocephalus*) (Figure 4), vesper sparrow (*Pooecetes gramineus*), warbling vireo (*Vireo gilvus*), lark sparrow (*Chondestes grammacus*), northern bobwhite (*Colinus virginianus*) and eastern kingbird (*Tyrannus tyrannus*). Oak savannah restoration efforts have been shown to increase the populations of many of these open-canopy species (Davis et al. 2000).

While information on oak savannah invertebrates is limited, arthropods (primarily insects and arachnids) seem to be largely unaffected by changes in fire frequency (Siemann et al. 1997). However, a number of savannah Lepidoptera are considered rare or are listed as threatened and endangered. The Karner blue butterfly (*Lycaeides melissa samuelis*) (Figure 5), the Persius duskywing (*Erynnis persius*) and the frosted elfin butterfly (*Incisalia*



Figure 4. Red-headed woodpecker in an open oak savannah area.
Photo courtesy of <http://oaksavannas.org/>.

irus) are restricted to oak openings and use sundial lupine (*Lupinus perennis*) as a larval host (Figure 6) (Shuey et al. 1987). The phlox moth (*Schinia indiana*) and tawny crescent (*Phyciodes batesii*) also are being considered for federal listing. Other rare species include three savannah skippers — Leonard's skipper (*Hesperia leonardus*), cobweb skipper (*H. metea*) and dusted skipper (*Atrytonopsis hianna*) — and the buck moth (*Hemileuca maia*). All of these species require early successional habitats and probably have declined since fire was eliminated from oak savannahs.



Figure 5. Karner blue butterfly.
Photo courtesy of Catherine Herms, The Ohio State University, Bugwood.org.



Figure 6. Sundial lupine in an oak opening is ideal habitat for the Karner blue butterfly.
Photo courtesy of Catherine Herms, The Ohio State University, Bugwood.org.

Some amphibian and reptile species associated with oak savannahs are endangered in some parts of their range. The western slender glass snake (*Ophisaurus attenuatus*) and eastern massasauga rattlesnake (*Sistrurus catenatus*) are listed as endangered in Wisconsin, and the latter is being considered for federal listing. A study of the collared lizard (*Crotaphytus collaris*), a species of concern in Missouri, concluded that managed fires positively impacted their populations (Brisson et al. 2003). Another study indicated that the Great Plains skink (*Eumeces obsoletus*), Texas horned lizard (*Phrynosoma cornutum*), ground skink (*Scincella lateralis*) and ringneck snake (*Diadophis punctatus*) all prefer habitats impacted by various burning regimes (Wilgers and Horne 2006). Further research is needed to understand the direct and indirect effects of prescribed fire on savannah herpetofauna (Engstrom 2010).

Conversely, much more information is available on the vegetation, including savannah specialists, that has not adapted to the loss of savannahs. Many of these are now uncommon, such as largeflower yellow false foxglove (*Aureolaria grandiflora*), yellow pimpernel (*Taenidia integerrima*), pale Indian plantain (*Arnoglossum atriplicifolium*), New Jersey tea (*Ceanothus americanus*), upland boneset (*Eupatorium sessilifolium*) and mountain deathcamas (*Zigadenus elegans*). In Wisconsin, Bull's coraldrops (*Besseyia bullii*), plain gentian (*Gentiana alba*) and slender lespedeza (*Lespedeza virginica*) are listed as threatened, and purple milkweed (*Asclepias purpurascens*) (Figure 7) and Atlantic camas (*Camassia scilloides*) are endangered (Cochrane and Iltis 2000).

Species Composition

The individual species that dominate the overstory of oak savannahs vary by geography and available moisture. On



Figure 7. Purple milkweed is rare now but is often found in restored oak savannahs.

Photo courtesy of <http://pleasantvalleyconservancy.org>.

drier sites, especially on the western edge of the range of oak savannahs, blackjack (*Q. marilandica*) and post oaks (*Q. stellata*) are often dominant. To the north, where savannahs often occur on sandy soils, black (*Q. velutina*) and northern pin (or Hill's) oak (*Q. ellipsoidalis*) are the most common. On sites with more moisture where clay-loam soils are more common, bur oak (*Q. macrocarpa*) dominates; such sites tend to have the highest plant diversity among savannahs. On flood plain sites (those on alluvial soils), savannahs are dominated by bur and white oaks (*Q. alba*). Canopies on other mesic savannah sites may consist of white, northern red (*Q. rubra*), black, bur, northern pin and swamp white oak (*Q. bicolor*; Haney and Apfelbaum 1993).

Historically, in the southern portions of the oak savannah range, pines would have been common. On the southern and eastern fringes of the range of eastern oak savannahs, longleaf (*Pinus palustris*) and, to a lesser extent, loblolly (*P. taeda*) pine would have occurred. However, shortleaf pine (*P. echinata*) would have

occurred in savannahs throughout its range (generally, south of the Ohio and Missouri Rivers) as a common associate with overstory oaks. Indeed, it is likely that most savannahs in this region were oak-pine savannahs rather than purely oak savannahs.

The understory of an oak savannah is dominated generally by fire-adapted (pyrophytic) grasses, the most common of which include big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), indiagrass (*Sorghastrum nutans*), broomsedge (*Andropogon virginicus*), silver plumegrass (*Saccharum alopecuroides*) and poverty oatgrass (*Danthonia spicata*). The remainder of the understory is composed of a variety of legumes, including ticktrefoil (*Desmodium* spp.), partridge pea (*Chamaecrista fasciculata*), roundhead lespedeza (*Lespedeza capitata*), slender lespedeza (*L. virginica*), Illinois bundleflower (*Desmanthus illinoensis*), purple prairie clover (*Dalea purpurea*) and many other forbs. Blackeyed Susan (*Rudbeckia hirta*), woodland sunflower (*Helianthus divaricatus*), goldenrod (*Solidago* spp.), blazing star (*Liatris* spp.) and wild bergamot (*Monarda fistulosa*) all would be considered common. The exact composition of the savannah understory varies by region.

While the frequent fires that maintained these savannahs would have eliminated most of the midstory, some shrubs and brambles, such as blueberries (*Vaccinium* spp.) and blackberries (*Rubus* spp.), also would have persisted. Correspondingly, some of the other fire-tolerant hardwood species, such as the hickories (*Carya* spp.), blackgum (*Nyssa sylvatica*) and common persimmon (*Diospyros virginiana*), also would have been present, although much less prominent than the oaks.

Restoring and Maintaining an Oak Savannah

In nearly all cases, the restoration of an oak savannah begins with reducing denser forest canopy cover to levels typical of historic savannahs, or approximately 5-30 percent. This initial step often can be accomplished in a short period of time, as canopy reduction can be applied quickly over an entire area, particularly if commercial timber harvesting is an option. The other critical step is restoration of the understory, which requires reintroduction of the periodic, low-intensity fire regime that created and maintained these communities in the first place. These two primary restoration activities — thinning and burning — need to be considered initially when choosing a site for potential restoration to an oak savannah.

Choosing a Site

In general, drier low-quality sites are better suited for restoration because, historically, they would have burned more frequently. Moister, high productivity sites, such as floodplains, riparian areas, coves and northern slopes, would have burned less frequently and may be best left to high-value timber production, without the increased risk of fire damage. Upland sites with remnant understory grasses and forbs are preferred for restoration. Specific inventories of the overstory trees and the understory plants, both woody and herbaceous, can provide a good measure of a site's suitability for restoration. Reintroducing trees and understory plants by direct planting stock or by seeding is much more difficult and costly than by enhancing remnant populations that have just been neglected.

Of the more suitable upland sites, those with mature trees are easiest to work with because commercial timber harvesting can be used to open the

canopy. These more mature trees also are more resistant to the reintroduced fire due to thicker bark. If access to these sites is limited and roads need to be established, their placement should accommodate the potential for future use as firebreaks.

For both harvesting and burning, the size of the site also is an important consideration. Small tracts with irregular boundaries have a higher risk of fire escape and higher cost per unit area. Tracts less than 25 acres also may not support enough timber volume to make commercial harvesting feasible. Larger tracts are more likely to support the thinning and burning required to make restoration successful and are preferred more by most wildlife species associated with early successional habitat.

Opening the Canopy

Prior to opening the canopy, you should identify invasive plant species that need to be controlled. These invasive species can outcompete more desirable native species, suppress germination, degrade structure and alter fuel loads. Japanese stiltgrass (*Microstegium vimineum*), miscanthus (*Miscanthus sinensis*), honeysuckle (*Lonicera sp.*), autumn olive (*Elaeagnus umbellata*), multiflora rose (*Rosa multiflora*), kudzu (*Pueraria sp.*), buckthorn (*Rhamnus cathartica*) and

prickly ash (*Xanthoxylum americanum*) are some invasives that may occur already in the understory of some sites and can preclude successful restoration. They must be controlled before other restoration activities begin. For the invasive tree or shrub species, cut stump and foliar herbicide applications can be very successful, although repeated applications may be necessary to control resprouting. Johnsongrass (*Sorghum halepense*), tall fescue (*Lolium arundinaceum*), bermudagrass (*Cynodon dactylon*) and sericea lespedeza (*Lespedeza cuneata*) are all species that are not likely to occur under intact canopies but may quickly invade from nearby roads or fields. Controlling invasives before opening the canopy is more effective and efficient (Brock 2004).

If the site chosen for restoration can support a commercial timber harvest, the opening of the canopy is simply a matter of conducting a timber sale. Marking the removal or leave trees would be very similar to a seed tree or heavy shelterwood cut (Figure 8). Target basal areas of 35-50 square feet per acre will open the canopy enough to allow herbaceous ground cover to respond to the increased sunlight. Leaving a few extra trees above what will ultimately comprise the overstory (final target of 10-35 square feet per acre) at this point allows for some



Figure 8. Recently completed timber harvest in preparation for savannah restoration. Note the large amounts of slash that will contribute to fuel loads and the lack of a herbaceous groundlayer. Photo courtesy of P. Keyser.

additional mortality after thinning due to stress, wind-throw, ice or ensuing prescribed fires.

The selection of remaining trees is first governed by species, with sound and vigorous fire-tolerant oaks being favored. Where the dominant savannah oaks are not present, fire-tolerant hickories and blackgum and less fire-tolerant oaks, such as southern red (*Q. falcata*) and northern red, also can be retained. Shortleaf and other fire-tolerant pines should also be retained where they still occur. All fire-intolerant species such as maples (*Acer* spp.) and yellow poplar (*Liriodendron tulipifera*) should be removed. Their prolific seeding will continually reintroduce woody vegetation to the understory, which will compete with the desired herbaceous ground layer. Any trees of high value (veneer and grade lumber) should be removed to prevent lost revenue from fire damage. Hollow or damaged trees also can be removed due to fire susceptibility, but consideration should be given to leaving some of these for their high value to wildlife, such as cavity-nesting birds and bats.

If a younger stand without commercial harvesting potential has been chosen, undesirable trees are best killed and left standing by girdling and spraying the wound with herbicide. Felling these trees and then treating the stump may result in too much fuel accumulation at one time, causing problems with subsequent prescribed burning. The standing dead snags break down gradually over three to five years and provide good wildlife habitat while doing so. Exceptions to leaving snags would include areas adjacent to fire lines. An alternative to fell and leave would be to pile and burn in brush piles, but this is labor intensive and, therefore, expensive (Brock 2004). However, hand removal methods are less damaging than commercial logging. Except in limited applications, such as research projects or extremely

small acreages, generally they are impractical.

Reintroducing Fire

The reintroduction of fire is a critical component of savannah restoration because it controls the hardwood and shrub midstory and promotes the fire-adapted grasses and herbaceous species that comprise the appropriate understory (Figure 9) (Peterson and Reich 2001). The initial burn following the opening of the canopy often will have a higher fuel load than subsequent burns, but the higher intensity fire is needed to decrease the unwanted woody competition. Waiting approximately two years after the thinning to conduct the initial burn allows the hardwood rootstocks to resprout and other woody species to germinate and grow just to the point of being very vulnerable to burning. The waiting period also allows the fine fuel layer to restore its continuity after being disturbed by logging, and, conversely, allows the heavier logging slash to degrade somewhat. Where fuel loading is very high, waiting an additional

year, manual fuel reduction and/or planning for a less intense fire (moister, cooler conditions) may be warranted. However, waiting more than three or four years is not advised, as woody regrowth may reach a stage beyond the effective control of fire.

Generally, the first two or three fires should be conducted as growing-season burns, preferably from mid-August to late September, because the hardwood rootstocks are controlled best in late summer. Many of these rootstocks are large, having developed over many years, and will not be controlled completely with one or two fires. Concentrating on growing-season fires at a two-year interval initially will yield the best hardwood control and prevent the woody vegetation from dominating the understory. In cases of higher fuel loading, it may be necessary to conduct a dormant-season burn initially to reduce the risk of escape or damage to overstory trees.

Correspondingly, the growing-season fires will promote the desired pyrophytic



Figure 9. Fire is a critical element in restoring and maintaining an oak savannah. Photo courtesy of A. Vander Yacht.

grasses that are important to the understory structure and maintenance of the fine fuel layer. In cases of very high fuel loading, growing-season burning conditions should be chosen carefully to ensure a low-intensity fire. Removal of slash from the base of trees and possibly even conducting initial winter fuel-reduction burns may be warranted (Hartman 2001).

Maintenance Burning and Oak Regeneration

As the woody vegetation is controlled through a series of fires, the burning cycle should be alternated to include dormant-season fires. Although they do not control hardwoods as well, dormant-season fires are very important in promoting a number of cool-season herbaceous species. These winter burns are often easier to implement, because, typically,

weather conditions are less extreme. Over time, selecting the burning season should balance the needs for controlling woody competition and for encouraging the growth of legumes and other cool-season plants. Fire intensity should remain moderate to low once the initial fires have been conducted and the woody species have been reduced to manageable levels. Thereafter, long-term maintenance of the oak savannah is dependent on the periodic disturbance provided by an appropriate fire regime.

At some point, regeneration of the oak (and pine) overstory will be necessary to perpetuate the savannah. In many cases, varying the timing of the burns will allow a certain amount of advanced oak regeneration to survive. If not, protecting some desirable well-established regeneration from

prescribed fires may be necessary until it is large enough to survive on its own, generally 3-4 inches in diameter at breast height. Suspending the burning regime altogether for a short period of time (three to 10 years) may be necessary to establish adequate regeneration but should not be attempted until the more aggressive fire-intolerant species have all but been eliminated. Excluding smaller sections of the entire unit from fire for this purpose and rotating through the area over time will help to stagger age classes and the distribution of the regeneration. Remember that because the desired canopy is quite open, successful regeneration may require only about 50 trees per acre. Proper management of the newly established ecosystem is critical in maintaining it in the desired state.

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