OAK ECOSYSTEM RESTORATION AND MAINTENANCE IN SOUTHERN ILLINOIS

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Abstract—Oak dominance in southern Illinois appears to be a consequence of long-term anthropogenic disturbances, including burning, grazing, and cutting. The increased prevalence of thin-barked, shade tolerant species, such as sugar maple and beech on presently oak-dominated upland sites appears to be a result of the extremely low-intensity disturbance regimes of the late 20th century. Our preliminary work indicates that moderate intensity fall burns top-kill 40 percent of pre-burn sugar maple and beech seedlings (< 2 inches in diameter at breast height (d.b.h.)) and increase herbaceous cover between 15-25 percent. However, sapling sized stems are largely undamaged suggesting that burning alone will not effectively restore oak dominance. Thus, a replicated study has been implemented to test the effectiveness of periodic burning and partial cutting, alone and in combination, to control mesophytic tree species and regenerate upland oak stands. Vegetation dynamics will be assessed on a long-term basis to document the effects of fire and cutting towards maintaining oak dominated ecosystems.

INTRODUCTION

Late Holocene forests of southern Illinois were comprised of oak-hickory and mixed mesophytic forests with inclusions of glades, prairies, and savannas. Braun (1950) classified regional forests as Oak-Hickory in the Ozark Hills of southwestern Illinois and Mixed Mesophytic across the Shawnee Hills of southeastern Illinois and western Kentucky. Küchler (1964) mapped the potential vegetation of this region as Oak-Hickory. Much has been published concerning the ecology of these forests, particularly species-site, productivity, and diversity relationships (Fralish 1988, 1997; Fralish and others 1991). While edaphic factors affecting vegetation structure have been explored, few studies have investigated the role that disturbances, particularly human disturbances, have had on these forest ecosystems.

Several key natural disturbance regimes have been characterized across the southern Illinois landscape. Primarily, these include tornado and wind damage, ice storms, periodic drought, and floods (Parker and Ruffner, in press). These occur rather sporadically, and the effects of single events are relatively localized on the landscape. While it is accepted that these natural disturbances have some impact on forest composition and structure, it is widely held that long-term human disturbances, including burning, grazing, and cutting, have been the primary forces shaping the oak-hickory forests of southern Illinois (Olson 1996, Fralish 1997, Ruffner and others 2003, Parker and Ruffner, in press).

Oaks have several biological adaptations to fire. Oak stems have thick, corky bark, a tenacious ability to repeatedly resprout following top-kill due to a high root:shoot ratio and dormant buds near the root collar, and the ability to compartmentalize wounds (Abrams 1992, Johnson 1993, Van Lear and Watt 1993). Smith and Sutherland (1999). In addition, oaks benefit from post-fire site conditions, such as the open understory and reduced impact of fire-intolerant competitors, and xerification of the site through consumption of duff and exposure of soil to greater solar radiation, allowing oak to dominate the advance regeneration pool (Van Lear and Watt 1993).

Despite the conceptual acceptance of the importance of anthropogenic disturbances, little fire scar evidence from the pre-settlement period exists because of the widespread logging of the primary forests and deterioration of cut stumps (Robertson and Heikens 1994, Olson 1996, Batek and others 1999). While pre-settlement fire scar data are likely lost forever, researchers have compiled substantial evidence of fire’s role in post-settlement forests of southern Illinois by using an historical ecology approach including analysis of vegetation structure (Anderson and others 2000), witness tree distributions (McArdle 1991), fire scar analysis (Robertson and Heikens 1994), documentary evidence (Hall and Ingall 1910, Miller 1920), and land-use history studies (Ruffner and others 2002, van de Gevel 2002).

Historical accounts depict the region as heavily influenced by natives (Allen 1945, Temple 1966, Brown 1985). The landscape encountered by early European settlers reflected nearly 10,000 years of Native American manipulation and transformation. Native American use of fire and agricultural clearing was probably much greater prior to the 1500-1600s when large epidemics decimated regional native populations. Reduced disturbance regimes allowed an overall expansion of forest canopy cover. Thus, when European settlement began in the late 1700s-early 1800s, the anthropogenic landscape resembled a mosaic of oak-hickory woodlands and forests interspersed with small patches of barrens, savannas, and glades (Olson 1996, Dey and Guyette 2000, Parker and Ruffner, in press).

Regional studies reporting historic period fire histories indicate that fire ignitions were high following European settlement due to farmers clearing underbrush from the forest to enhance regeneration of browse and increase ease of travel and hunting (Hall and Ingall 1910, Miller 1920). The amount of land cleared for agriculture peaked in

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the early 1900s after which badly eroded lands were aban-
doned and either planted or naturally regenerated to forest.
Many abandoned farms and cut-over lands were purchased
during the 1920s-30s for public parks and forests and man-
aged as timberlands throughout the 20th century (Parker
and Ruffner, in press). With the development of an effective
fire-suppression campaign in the 1930s-40s, human caused
ignitions dropped, and fire was greatly limited as a force
shaping vegetation.

The virtual elimination of fire from the landscape during the
early 20th century fostered the expansion of mixed meso-
phytic species across the region (Fralish and others 1991).
Numerous authors have studied central hardwood “old-
growth” stands typified by the absence of cutting, burning,
and most forms of management over the past several
decades (Weaver and Ashby 1971, Nelson and others 1973,
Schlesinger 1976, Barton and Smeltz 1987, Fralish and
others 1991, Martin 1992, Robertson and Heikens 1994,
and others 2003, and Groninger and others 2003). These
studies report similar and significant shifts in species com-
positions and forest structure across a spectrum of forested
sites. Overwhelmingly, sugar maple (Acer saccharum) and
American beech (Fagus grandifolia) were found to be increas-
ing in sand density and basal area at the expense of the
oak and hickory species that dominated the over-
story. In particular, still important, but declining overstory
species such as black oak (Quercus velutina) and southern
red oak (Q. falcata) are not represented in younger age
classes. Age-diameter figures suggest that a large cohort of
mixed maple, beech, ash, and black gum (Nyssa sylvatica)
recruited only a few years after the control of understory fire and the reduction of harvesting in some forests of the Ozark
and Shawnee Hills (van de Gevel and Ruffner 2002, Zaczek
and others 2002).

The presence of an understory dominated by mesophytic tree
species has been associated with poor oak seedling and
sapling development (Loftis 1990, Lorimer and others 1994).
However, removal of the mesophytic midstory has aided in
the development of the advance regeneration needed for the
perpetuation of upland oak ecosystems (Crow 1988, 
Johnson 1993). Despite this, operational methodologies to
remove dense midstories are costly and of uncertain reli-
The composition of the understory and midstory may play
an especially important role in the development of the next
overstory in many southern Illinois stands where overstory
dominants such as black oak and southern red oak are
approaching their maximum ages en masse.

Recent studies have conducted prescribed burns in several
transitional forests across southern Illinois with mixed
success (Ruffner 2001, Ruffner and others 2003, Ruffner
and Davis 2002). Understory prescribed burns have been
effective in top-killing seedlings of these mixed mesophytic
species with little or no effect on sapling-sized stems, unless
subjected to multiple burns. Further, these burns have been
ineffective for promoting oak regeneration in these stands.
From these initial results we posit that understory burning is
not effective in top-killing the larger unwanted stems that
are shading the understory and precluding the development
of oak and hickory advanced regeneration. Thus, we have
developed an experiment to test the effects of three silvicul-
tural treatments on controlling unwanted species and induc-
ing oak-hickory recruitment. Recent burning activities will
be discussed in this paper and the current experimental
design and possible implications for oak ecosystem main-
tenance will be explained.

PHYSICAL AND HISTORICAL CONTEXT OF STUDY AREA
The current project focuses on upland forests of the Ozark
Hills of southwestern Illinois and the Shawnee Hills of
southern Illinois.

Ozark Hills
The Ozark Hills region (113,340 acres) in southwestern Illinois is characterized by mature dissected topography capped with loess deposits and underlain with cherty lime-
stone (Fralish 1997). Ridgetop sites are relatively narrow
spur ridges capped with loess above steep sideslopes of
colluvial materials, which descend to narrow riparian zones
comprised of alluvial soils. Pre-European settlement forests were dominated by oak-hickory species with increased num-
ers of American beech, sugar maple, and tulip-poplar (Lirio-
dendron tulipifera) across more mesic sites (McArdle 1991). McArdle argued that these forests developed under a moder-
ate to infrequent disturbance regime based on the fact that oak-hickory importance increased after European settle-
ment in response to the more intense disturbance regime of
logging, clearing for agriculture lands, and increased grazing
and burning. Indeed, much of the region’s forests were exten-
sively logged between 1880-1920 and frequent fire was
identified as a major problem for forest development in the
1920s (Miller 1920, Miller and Fuller 1922, Fralish 1997).
Fires continued through the 1940s until much of the Ozark
Hills were purchased by the USDA Forest Service in the late
1930s and effective fire control measures were implemented.

Shawnee Hills
The Shawnee Hills comprise a 950.495 acre, unglaciated
east-west escarpment bisecting southern Illinois (Fralish
1997). Topography of this section is characterized by broad
ridgetops bearing deep loess deposits dissected by moder-
ately steep sideslopes opening onto broad flat valleys
(Fenneman 1938). Pre-European settlement forests of this
region were dominated by xerophytic species such as post
oak (Quercus stellata), black oak, and white oak (Q. alba),
with mesophytic species tulip-poplar (Liriodendron tulipifera),
American beech and sugar maple having lower
importance across most sites (Fralish 1997).

Stands disturbed during the early 20th century from harvest-
ing, fire or grazing are 58-84 percent similar to pre-settle-
ment oak hickory forests suggesting compositionally stable
forests (Harty 1978, Fralish 1997). However, the reduction
of harvesting on public land and the eventual near removal of
fire from the landscape during the last century has caused
a shift in importance values particularly across northern
aspects and low slope positions (Fralish 1997). Reduced disturbance patterns have resulted in a distinct increase in
sugar maple and American beech recruitment into the mid-
story and understory positions (Schlesinger 1976, Fralish
Still other midstory species such as winged elm (Ulmus alata), hophornbeam (Ustria virginiana), and dogwood (Cornus spp.) appear capable of limiting oak recruitment on many sites.

Current management objectives of Illinois Department of Natural Resource agencies across this region focus on increasing oak-hickory advance regeneration while reducing mesophyte stem density with experimental prescribed burns coupled with timber stand improvement cuttings (Allen 2001, Ruffner and Davis 2002). Justification for this rests on the assertion that anthropogenic disturbances (either Native American or Euro-American) have been the driving force influencing forest structure and function across this region for at least the last four hundred years (Fralish 1997, Parker and Ruffner, in press).

**PRESCRIBED FIRE TREATMENTS**

Prescribed fire has been widely used to reduce competing vegetation, slow successional transition, reduce pest and pathogen populations, enhance wildlife habitat, facilitate site preparation, and encourage recruitment of resprouting species (Mutch 1994). Many authors have called for the reintroduction of prescribed burning in oak forests of the east, but few have documented the efficacy of this practice (Van Lear and Watt 1993, Brose and others 2001).

Perhaps the most successful experiments to date include those in oak forests of the Piedmont region of Virginia (Keyser and others 1996, Brose and Van Lear 1998, Brose and others 1999). Following shelterwood harvests with a 50 percent basal area reduction, these authors conducted repeated prescribed burns to significantly reduce tulip-poplar regeneration and increase advance oak regeneration. They suggest that this harvest/fire disturbance regime closely mimics the conditions that fostered the development of these oak dominated systems (Brose and others 1999). In addition, they report that allowing several years to lapse between the initial cut and burning is critical. This waiting period allows for several key components including the establishment and growth of vigorous oak seedlings and regeneration of the buried tulip-poplar seed pool. Although burns were also conducted in the winter and summer, spring appeared to be the best time period for burning because it presented the most favorable weather conditions such as warm temperatures, lower humidities, and sunny days (Brose and others 1999).

Within forests of southern Illinois, land managers have been utilizing prescribed fire since the mid 1980s. While the US Forest Service fire management program has largely been forced into a “suppression” mode due to extensive litigation, several Illinois Department of Natural Resources Divisions actively manage vegetation with prescribed fire (Ruffner 2001). The Divisions of Forest Resources and Natural Heritage both use fire to maintain unique vegetation and habitat types in glade and oak savannas, improve wildlife habitat, and foster oak regeneration while reducing competing mesophytic species in forestlands (Ruffner 2001).

The effect of a fall prescribed burn in an oak-hickory forest stand was investigated using two 0.10 ha permanent plots at Ozark Hills Nature Preserve, Trail of Tears State Forest. Despite the low-to-moderate intensity of the burn caused by fall weather conditions, the burn effectively met the primary objectives of reducing understory competition from mesophytic tree species and increasing diversity of herbaceous species. Analysis of pre- and post-burn data indicates that nearly 40 percent of understory sugar maple and American beech seedlings were top-killed and herbaceous cover increased 15-25 percent within the plots. While these numbers indicate reduction of unwanted seedlings, sapling sized stems were left untouched by this level of burning. Thus, a replicated study similar to those conducted by Brose and his associates was designed to test the effectiveness of periodic burning and partial cutting of midstory, mesophytic trees on the development of oak-hickory regeneration.

This newest project evaluates and demonstrates the use of prescribed fire and partial cutting, alone and in combination with one another, on restoring oak forest health and sustainability. All study sites are in upland forest stands in southern Illinois with an oak-hickory dominated overstory and a midstory consisting of shade tolerant tree species. Site index ranges between 50-80 for upland oaks. Stand basal area averaged 110.1 ft² per acre (+ 4.5 SE) with an average stem density of 226.2 (+ 26.7 SE) trees per acre. A total of five, four acre blocks (each comprising a burned only plot, a cut only plot, a burned and cut plot, and an unmanaged control) have been installed across southern Illinois. Block compartments have 30-50 percent of standing basal area reduced by cutting stems <12 inches in d.b.h., favoring healthy oak-hickory stems for the residual stand. Burn compartments will be treated three times in five years beginning spring (2003) with a typical fuel model 9 prescription aimed at top-killing mesophytic resprouts and generating an advanced regeneration pool of oak-hickory stems. At each site, permanent plots have been installed to permit repeated measurement of the following variables:

- growth and fire damage for trees larger than 4 inches in d.b.h.
- tree species regeneration, shrub species, and tree saplings up to 4 inches in d.b.h.
- herbaceous species composition, cover, and quality for wildlife.

**CONCLUSION**

Perpetuation of oak dominated uplands is a priority among a wide range of constituencies in southern Illinois. Managers addressing this problem are faced with an incomplete understanding of past processes that produced the presently dominant oak overstory. Specific questions concern the timing, frequency, and intensity of anthropogenic and natural fires and the potential impacts of native and agricultural animals in stand establishment and maintenance. Equally puzzling is the extent to which overstory and midstory mesophytes must be controlled in order to carry a cohort of oak and hickory from seedling to overstory status. Also, with the prolonged absence of fire, some mesophytes have developed to the extent that they are now overstory trees. Removal of these now fire resistant individuals through cutting may be necessary to meet ecosystem restoration goals, but is inconsistent with esthetic expectations for public lands. Retention of these trees might necessitate
implementation of prescribed fires of greater than historic intensity and or frequency. These hotter fires may negatively impact the quality and value of maturing timber and thereby alienate some landowners with economic incentives for forest management. Alternatively, retaining large mesophytes may preclude adequate fuel development and result in the failure to secure oak and hickory recruitment.

In the face of these uncertainties, the establishment of demonstration plots such as those described here could serve as a focal point to help interested parties in southern Illinois determine where oak ecosystem restoration is desirable and how it may be effectively implemented. This empirical approach may also help address historical questions which often serve as a justification for ecosystem maintenance and restoration. A network of similar installations across fire-influenced oak dominated portions of North America may serve to increase public understanding of the fundamental roles played by humans and fire in the widespread occurrence of these ecosystems.

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LITERATURE CITED


