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BIODIVERSITY CONSERVATION FOR OAK WOODLANDS

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ABSTRACT

Oak woodlands, formerly one of Illinois' most species rich and abundant ecosystems, undergo alterations in habitat structure and loss of species during periods of extended fire absence. Today only a small proportion of woodlands receive fire. Woodland biodiversity warrants sustainable conservation and restoration practices. Efforts to conserve oak woodlands gained greater clarity from a revision of the Illinois Natural Areas Inventory Standards and Guidelines in 2011, which recognized woodlands as distinct from savanna and forest community types. The future of many rare plants, animals, and other elements of biodiversity may depend on effective restoration and expansion of the best-quality oak woodland remnants. This paper offers review and perspective and supports revised approaches to oak woodland conservation and management including more frequent fire, tree thinning, species restoration, and strategic mowing.

SOME BITS OF HISTORY

A practical understanding of oak woodlands ecology and conservation has been slow in coming. Because fire-dependent wooded ecosystems lose structure and species rapidly in the

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absence of fire (Nowacki and Abrams 2008), the impressions of early observers may offer insights into characteristics that were later obscured. A country doctor, Samuel B. Mead, recorded 262 plant species of the woodlands and forests of west central Illinois (Mead 1846; Kluge 2025); he included *Andropogon gerardii* (big bluestem) and *Sorghastrum nutans* (Indiangrass) on that list, suggesting higher available light levels than typically found under canopies today. Frederick Brendel (1887) listed only three shrubs as prominent in white oak forest: the light-loving *Ceanothus americana* (New Jersey tea), *Rhus glabra* (smooth sumac), and *Salix humilis* (prairie willow). Sixty-seven years after Mead, Henry Allan Gleason (1913) still pointed out that "various prairie species are found within the forest margin, and their number and density is greatly increased by even a small increase in the amount of light." Arthur Vestal (1936) recommended conservation of oak barrens and pointed out that the "prairie grasses" found there "are the grasses of the forest region also in most cases."

In recent decades, ecologists and land managers have steadily improved scientific understanding and conservation practice for oak savannas and woodlands (Leach and Ross 1995; Taft 1997; Fahey et al. 2015; Darling 2021). Since the historic exclusion of fire from most sites, beginning in the 1800s, remnant biodiversity (Wilson 1988) of oak communities is being lost, grazed away, or shaded out year after year (Ebinger 1986; Shotola et al. 1992; Abrams 1992). Such losses are widespread in the eastern United States as demonstrated by Nowacki and Abrams (2008), who described a process they termed "mesophication", pointing out that for oak forests: "Stand-level species richness is declining, and will decline further, as numerous fire-adapted plants are replaced by a limited set of shade-tolerant, fire-sensitive species. As this process continues, the effort and cost required to restore fire-adapted ecosystems escalate rapidly." Alexander, et al. (2021) agree and discuss potential research that could better inform conservation and restoration.

Earlier, in the late 1970s, the nation's (and possibly the world's) first comprehensive natural areas inventory was conducted in Illinois (White 1978). The Illinois Natural Areas Inventory (INAI) was funded by the Illinois Department of Conservation (now Department of Natural Resources) and conducted by the Natural Land Institute and the University of Illinois. The goals of this systematic two-year inventory were to find and evaluate natural areas of statewide significance and provide accurate and detailed information about their location and characteristics. The INAI established a natural community classification system and a qualitative habitat grading framework still largely used today. It sought nature in an "undisturbed" state of "high quality." The INAI found that little remained; nearly all the State's prairies had been plowed, forests cut, and wetlands drained. No frequently burned woodlands existed to evaluate. Since then, our understandings of the important role of fire and other disturbance in the dynamics of natural communities have continued to evolve (Abrams 1992; Noss et al. 1995; Dey et al. 2016; Hipp et al. 2020; Iverson and Taft 2022).

This paper is focused on conservation efforts, particularly in northeastern Illinois, for oak woodlands on silt-loam soils, as defined by the updated INAI Standards and Guidelines of 2011. It does not address conservation strategies for the important oak ecosystems of sandy or shallow soils (e.g., Sand Woodland, Sand Savanna, Barrens, Flatwoods).

When the original INAI was completed in 1978, it revealed that a mere 7/100^{ths} of 1% of the state qualified as natural area (White 1978). Nevertheless, today's natural area conservationists have learned a great deal about remnant ecosystems and setting management goals from studying the highest quality examples (Grade A) of natural communities. The INAI became fundamental to Illinois conservation strategies and practices (Robertson 2001). Amounts of natural areas found were uneven for the various community types. Consider the acreage of very-high-quality (Grade A) remnants found on mesic silt-loam soils:

Mesic Forest: 2,388 acres

Mesic Prairie: 204.4 acres

Mesic Savanna: 0.3 acres

According to the 1978 INAI definition: “Savannas are communities with a grassy groundcover and an average tree canopy of less than 80% but greater than 10%. These communities were maintained by fire in presettlement times. They were among the most widespread and characteristic communities in Illinois, but few high-quality stands remain.” The savanna category was intended to include what is now classified as woodland at the higher range of canopy coverage.

Oak communities had been the “dominant vegetation types” in much of eastern North America (Dey et al. 2016). However, the lack of oak woodlands undergoing conservation management was a substantial gap in Illinois’ nature preserve system. Sites classified at the time as dry-mesic oak forests were protected as nature preserves, but in the absence of fire many oak communities set aside for conservation were losing their structural characteristics and species diversity (Bowles et al. 2005), as illustrated in Figure 1.

Prairie destruction had been obvious. But gradual loss of oak-associated biodiversity due to excess shade was less so. In seeking natural areas, the INAI when evaluating an oak woods where trees recently had been cut, may have rejected the site as “disturbed.” But looking back, by reducing shade such cutting in some circumstances had an impact partly analogous to fire and actually helped conserve biodiversity.

As it sought to define natural communities for conservation, the INAI owed much to the trailblazing *Vegetation of Wisconsin* by John Curtis (1959). But neither he nor other midwestern conservationists of his time saw the need to focus on the conservation of fire-dependent woodland biodiversity. Indeed, the terms ‘biodiversity’ and ‘biodiversity conservation’ had not yet been coined or defined.

Curtis’ data showed *Acer saccharum* (sugar maple) to be by far the most common mesic forest tree, but his data show that among the maples grew oaks – including the fire-dependent *Quercus alba* (white oak) and *Q. macrocarpa* (bur oak). As the maples advanced, he reported accurately on a moment in time, but his work seems to have been interpreted by some as defining archetypes and goals for conservation – in perpetuity.

Curtis saw clearly what was happening to the oak communities. Describing what he called “an original stand” of white oak, *Quercus velutina* (black oak), and red oak, he wrote:

> “Due to complete fire protection afforded the stand in the last 50 years, the mesic trees began to spread out, basswood going first and farthest, followed by an almost solid wall of young sugar maples. … (T)he shade from the maples brought about the death of the typical oak forest understory … As the period of exposure to low light lengthened, the oak plants gradually died out altogether, although some persisted for decades in a weak, entirely vegetative condition.”

Bur oaks and associated plant and animal species may especially need frequent or hot fire. Bur oaks have very open (less shady) canopies and, as Curtis determined, cannot reproduce in the shade of any other tree species (Curtis 1959, page 146). Curtis found that bur oak could reproduce only under a canopy of 75% or less. White oak could reproduce up to 85% canopy. Red oak appeared to be able to reproduce up to 90% canopy or higher. He found that in the absence of fire, red oak may suppress reproduction of bur and white oak.

Curtis and others referred to "climax" maple forests as "mesic" and to oak forests as "xeric" (dry). So, as Curtis put it:

> "The xeric forests of southern Wisconsin are seen to be a series of rapidly changing species combinations whose local complexity is the result of progressive and retrogressive processes induced by the biological characteristics of the dominant species and by the repeated interference of outside agents of destruction."

This approach followed in the footsteps of Frederick Clements (1936) and the U. S. Forest Service which, during World War II, had launched its "Smokey Bear" campaign to warn against forest fires. Curtis found that savannas had been the most common ecosystem type in the southwest half of Wisconsin at the time of Euro-American settlement but were extremely rare in his day.

As effective concepts needed for conservation were gradually being developed, the term "biodiversity" first emerged in 1986 (Wilson 1988), and the crucial role of fire and other disturbance was codified for scientists in *The Ecology of Natural Disturbance and Patch Dynamics* (Picket and White 1985).

It was becoming clearer that our planetary heritage of biodiversity was created under the influence of ongoing disturbances of many kinds. The evolution of the planet's grasslands and associated oak ecosystems began millions of years ago with the rise of warm-season grasses and oaks (Hipp et al. 2020; Meijers et al. 2025). Today's species and the genetic diversity of species and alleles in natural communities have been evolving all this time. Oak communities today support especially high biodiversity, in part because of their heterogeneity, with open canopies that help create variable light levels, soil moisture, pH, and other features (Ko and Reich 1993; Rodewald 2003; Fralish 2004).

Case in point: When conservationists started searching for quality oak savannas and woodlands, a butterfly, *Glaucopsyche lygdamus* (silvery blue), was thought to have been extirpated from Illinois. At two sites that turned out to have populations of the rare woodland herb, *Lathyrus ochroleucus* (pale vetchling), Dr. Ron Panzer found the silvery blue. While eating that vetchling, the caterpillars were being protected by ants, which stroked them to "milk" them for nutrition. Many such relationships are most likely ancient. But as ecosystems lose species, they lose relationships.

The woodlands and savannas of Illinois have developed only since the most recent glaciers, but their communities of animals and plants had moved back and forth on the continent in response to changing climates. Regardless of where it's been over deep time, much genetic richness may survive today, tenuously, in fragmented remnants of the Midwest. When the authors of the INAI clarified the meanings of "natural area" and "natural community" they established a new and practical definition of "nature," which was soon taken up by the Illinois Nature Conservancy, Illinois Nature Preserves Commission, and others – answering the question, what was most worth conserving and preserving? But they got only so far. The fact that unburned oak woodlands with big trees could lose their current species over time seem not to have been part of what they contended with in the time they had. The INAI was state-of-the-art, but perhaps in retrospect “lack of disturbance” was given undue importance for wooded lands, and degree of surviving biodiversity and restorability potential perhaps deserved more consideration – especially since the results would be used for decades to set goals for acquisition and management. The INAI site reports included recommendations to landowners. For prairies, a need for fire was noted for many sites. In the case of upland oak stands, that perspective was not yet being discussed.

UPDATED STANDARDS AND GUIDELINES

In 2011, in an update of the 1970s INAI Standards and Guidelines (IDNR 2011), savanna and woodland are jointly treated as a class, distinct from the forest class. Here savanna is “characterized by widely spaced trees and an understory of native grasses, forbs, sedges, and shrubs that require high levels of light” with canopy cover of “(-)10-50(+)%.” The new sub-class of woodland is:

> “characterized by canopy cover ranging from (-)50-80(+)%; soil moisture class ranges from dry to dry-mesic. Stand structure is the result of frequent fire and/or dry environmental conditions that limit forest development. Warm season (C4) grasses generally uncommon, but forbs, sedges, and C3 grasses of prairie, savanna, and open woodland habitats are common. This subclass probably was very common and

> widespread, but has become less common due to fire absence. Many examples have been degraded by excessive livestock and deer grazing."

In the update, mesic upland forest features sugar maple, *Fagus americana* (beech), *Asimina triloba* (pawpaw), and *Carpinus caroliniana* (blue beech). Mesic woodland features white and bur oak with an herbaceous understory characterized by species including *Asclepias exaltata* (poke milkweed), *Dichanthelium clandestinum* (deer-tongue grass), *Lathyrus ochroleucus* (pale vetchling), and *Silene stellata* (starry campion).

Dry-mesic woodland is characterized by a list of species, some of which are often associated with prairie including *Ceanothus americana* (New Jersey tea), *Krigia biflora* (two-flowered Cynthia), *Liatris aspera* (rough blazing star), *Trifolium reflexum* (buffalo clover) and *Veronicastrum virginicum* (Culver's root) along with many species not typically identified with prairie including *Poa wolfii* (Wolf's bluegrass), *Liatris scariosa* var. *Nieuwlandii* (savanna blazing star), and *Taenidia integerrima* (yellow pimpernel).

The 2011 INAI suggests that some of the areas classified as dry-mesic upland forest in the 1978 INAI may actually now fit better into the dry-mesic woodland category. If classification as forest resulted from mesophication and woodland biota survives, it might be appropriate to evaluate such areas for woodland restoration and management. The 1978 INAI identified 986 acres as Grade A dry-mesic upland forest and 2,084 acres as Grade B.

The Wisconsin Department of Natural Resources has taken a second look at oak woodlands (Wisconsin Department of Natural Resources 2023) and adopted standards for conservation purposes, which seem useful for comparison with sites in northern Illinois. That summary states:

> "Oak woodland is a type of savanna that is intermediate between more open oak opening and more closed canopied oak forests. It tends to be dominated by members of white oak group … Oak woodlands historically experienced near-annual surface fires."

The Wisconsin list of "best indicator forbs" seems to be a good match with the best northern Illinois remnants:

> "upland boneset (*Eupatorium sessilifolium*), prairie alumroot (*Heuchera richardsonii*), two-flowered Cynthia (*Krigia biflora*), veiny pea (*Lathyrus venosus*), pale vetchling (*Lathyrus ochroleucus*), blunt-leaved sandwort (*Moehringia lateriflora*), wood betony (*Pedicularis canadensis*), eastern shooting-star (*Primula meadia*), yellow-pimpernel (*Taenidia integerrima*), Culver's-root (*Veronicastrum virginicum*), Carolina vetch (*Vicia caroliniana*), and Short's aster (*Symphyotrichum shortii*)."

The new lists of dominant and indicator species were made on the basis of expert judgement. These lists represent helpful hypotheses, but not strict guides to restoration and management. All components of management (including "no action") will work to the benefit of some species and the detriment of others. When managing for biodiversity conservation of degraded oak woodlands, a loss of woodland-associated species (especially conservative species) may indicate a setback. Increases in multiple conservative species may be a positive indicator. The right management may lead to largely self-sustaining systems which increasingly approach high natural quality. But short-term trends may not predict the long term (Taft 2020). Woodlands can be expected to continue to evolve and change – but with niches somewhere for all woodland species, it is to be hoped. This hypothesis deserves long-term testing at multiple sites under a variety of conditions and approaches.

The development of principles and practices of conservation management for degraded woodland remnants is still at an early stage. If woodland preserves are unmanaged, as the INAI update points out, they may take on the structure of forests, but, as shown by Taft and Solecki (2002), "with a loss of considerable floristic diversity."

About white and bur oak woodlands, Wilhelm and Rericha (2017) write, "There are no intact remnants from which we can piece together their aboriginal character inasmuch as grazing, logging, and fire suppression since settlement have obfuscated their physiognomic structure and ground layer composition" (page 29; see also woodland floristics discussions on pages 83 under *Acer saccharum* and 912 under *Quercus alba*). As more remnant woodlands are sustainably burned for longer periods of time and more data become available, more clarity about their character and management needs can be expected.

SEARCHING FOR PROMISING RESTORATION TECHNIQUES

The need for fire in prairie, savanna, and woodland conservation was once controversial but is increasingly well understood (Bowles and McBride 1996; Bowles et al. 2007; McClain et al. 2021). Bowles and Jones (2013) found that northeastern Illinois tallgrass prairies burned less frequently than every second year suffered from destabilized late-successional vegetation and loss of species richness. As summarized for savannas and woodlands by Dey and Kabrick

(2015), "Fire was arguably the single most influential driver, and the character of savannas and woodlands at any one time was defined by the nature of the fire regime: intensity, season, extent, severity, and frequency." They add, "Plants indicative of prairies, savanna, and open woodlands are adapted to frequent and even annual burning, and fire promotes their flowering, reproduction, and growth by ensuring adequate light, increasing nutrient availability, removing excessive litter, and retarding woody competitors." Results described below provide additional evidence suggesting that savannas and woodlands need frequent burns to sustain biodiversity.

The first Illinois Nature Preserve oak stand to be managed by fire was Reed-Turner Woodland in 1986 (Apfelbaum and Haney 1991). Burning of oak communities at the Morton Arboretum and Somme Prairie Grove began at the same time. Four sites which now have long-term studies are summarized below. Bowles et al. (2007) studied a 17-year annually burned, 7-acre area of the Morton Arboretum's East Woods. An 1840 survey suggested that this general area was then dominated by bur and white oak; the current study site was dominated by red, white and bur oak. An understory of hazel had been largely replaced by maple and other saplings characteristic of mesophication. Bowles documented the success of low-intensity burns in increasing cover and abundance of summer herbs. But "the most important thing we learned … was that ground fire did not increase canopy openness, thereby limiting ground-layer species responses." (Marlin Bowles, personal communication, 2025).

A 34-year study of Middlefork Savanna Nature Preserve, in an area which would now likely be classified as woodland (Jackson 2009; Jackson 2019), documented a sharp increase of shagbark hickory and green ash with declines in *Quercus ellipsoidalis* (Hill's oak), bur, and white oak. Between 1996 and 2019, stems of woodland shrubs and sapling trees decreased dramatically, the per acre number falling from 1200 to 500 for *Corylus americana* (hazel), from 300 to 0 for Hill's oak, and from 20 to 0 for bur oak. Invading green ash sapling stems increased from 0 to 420. Jackson compared a ten-year period of burning under an average fire-return interval of two years with a subsequent fourteen-year period of fire intervals averaging 3.75 years. Jackson concluded that the less-frequent burns may "have contributed to reduced floristic quality and plant diversity." He recommended increased fire frequency, tree thinning, and seeding of areas with apparently reduced species diversity.

A 36-year study in Kettle Moraine Nature Preserve (Schennum 2019), of a white, bur, and black oak woodland, documented the value of frequent burns and invasive woody plant control for recovery of conservative herb populations (including Illinois Endangered species) but also documented the loss of canopy tree reproduction. The canopy oaks were being replaced by more shade-tolerant species including red oak and shagbark hickory. He found that conservative herb species decreased in less managed areas but increased in the areas with more fire and more shade reduction.

At Somme Prairie Grove Nature Preserve, a 32-year study of restoration in a bur and Hill's oak woodland (Glennemeier et al. 2020) demonstrated successful ongoing recovery of conservative herbs and increasing floristic quality (including seven current or former Illinois Endangered or Threatened species). Management included biennial fire, tree thinning, invasives control, species restoration, and deer management. Species restoration consisted mostly of broadcasting seed from nearby sites with similar habitats for then-missing species that likely were present before degradation and for species present in low numbers, in an attempt to make the gene pool for those species more robust. For ‘before’ and ‘after’ photos of this site, the Somme Forest Preserves of Cook County, see Figures 2-4.

All these sites, while perhaps recovering, still seem quite inferior in quality and conservatism to the recently discovered Army Lake Woods in Wisconsin (Carter 2020) – a small but potentially valuable reference site. For a species list see: https://vestalgrove.blogspot.com/2022/06/the-unexpected-discovery-of-real-oak.html.

For sustainable biodiversity conservation, long term studies under a variety of management protocols are needed. In light of the studies to date, promising approaches to oak woodland management being adopted by some site planners and preserve managers include:

- In areas of old oaks, reducing shade by controlling excessively dense trees (including red oaks, if needed) by cutting or girdling.
- More frequent or intense burns.
- Temporary mowing or scything to reduce the negative impact of aggressive herb and shrub species – especially *Solidago altissima* (tall goldenrod) and *Rubus* species (briars) – that may result from increased light. An important goal is a conservative turf that can keep such aggressive species in balance (Economou et al. 2025).
- Restoring diverse species of herbs and shrubs by seed or plugs.

These studies and management approaches are suggestive but hardly definitive; nevertheless, land management decisions must be made. Consequently, land managers must use judgement to make year-by-year decisions about site resources. Conservation and restoration of woodlands and savannas are “increasingly becoming major management goals of public agencies and conservation organizations" (Dey et al. 2016). This work may hold promise for Midwest oak savannas and oak woodlands, which have long been identified as global conservation priorities (Noss et al. 1995).

Examples of related efforts include "Let The Sunshine In" (https://www.letthesunshinein.life/about/), Central Hardwoods Joint Venture (https://www.chjv.org/), Oak Woodlands and Forests Fire Consortium (https://oakfirescience.com/), and the Chicago Wilderness Oak Ecosystems Recovery Project (https://mortonarb.org/plant-and-protect/chicago-region-trees-initiative/oak-ecosystems-recovery-project/).

The data in Table 1 combine work by Fahey et al. (2015) and the Illinois Prescribed Fire Council (2025). Despite the apparent need for frequent fire, many oak community preserves seem to be burned infrequently or not at all. The data indicate that Illinois Nature Preserve System oak communities (savannas, woodlands, and forests) in non-sand areas of northeastern Illinois total 10,167 acres. No more than 33% (3,392 acres) have burned as much as biennially in recent years. Areas with sandy soils were removed from these calculations by omitting sand areas shown in the Natural Divisions of Illinois map (Schwegman et al. 1973) – that is: sections 03B, 03C, and 04E (IDNR 2023). There is no way of knowing from the data how many of the sites are degraded woodlands, for which frequent fire could promote biodiversity recovery.

The acreage figures in Table 1 are similar to those in a survey of land managers of the Chicago Wilderness Oak Ecosystems Recovery Plan (https://mortonarb.org/app/uploads/2024/09/Oak-Ecosystem-Recovery-Plan.pdf), which reports that no savannas, woodlands, or forests are being burned annually, but an average of 35% may be burned biennially. Thus, the data may suggest that 65% continue to degrade, especially if the areas classified as oak forests are degraded savannas or woodlands – and, for other sites, if oak forests also need biennial burning for sustainability. All these questions need more research. It would also be helpful for research to provide additional clarity on how various levels of both fire frequency and intensity would impact all the plant, animal, and other biota of oak savannas, woodlands, and forests.

How do we determine whether management is successful? The value of reference sites is not as great as it was for prairies because, as Bowles and McBride (1998) pointed out, as high quality examples of fire-maintained savannas on silt-loam soils are essentially gone, "there are no precise models for restoring this vegetation." That may be even more true for fire-maintained woodlands. In any case, as White (2008) warned, "it may be misguided to try to manage a site with the goal of restoring it to a preconceived prescription."

Given changing climate, composition of air and rain, fragmentation, and other impacts, Schennum advocated an experimental approach in the "Conclusion" of his 2018 study:

> "The product of all this work can never be an exact replica of the original natural ecosystem, nor should that be the project's goal. … The product of restoration will in many ways define what woodlands and savannas are at this location. … Information shared among ecological restorationists in the region will help recreate the "missing links" that woodlands and savannas represent in the long chain of communities that made up the original Midwest."

The four studies summarized above used a variety of measures to evaluate changes including species diversity, floristic quality, mean conservatism (Taft et al. 1997; Freyman et al.

2015), and the loss or recovery of Endangered, Threatened and indicator plant or animal species. If such indicators are rising, the management may be succeeding. It would be helpful to agree on a few authoritative monitoring protocols (see, for example, Taft 2015) and use them to compare varied management regimes over time. Given suggestive results reported above, it may be wise for at least some preserve managers in all regions to use frequent fire, thinning of trees, and other promising restoration techniques to conserve and restore all types of oak woodlands and preserve their biota, adjusting adaptively as needed, and sharing both treatment details and results with other managers and the scientific community.

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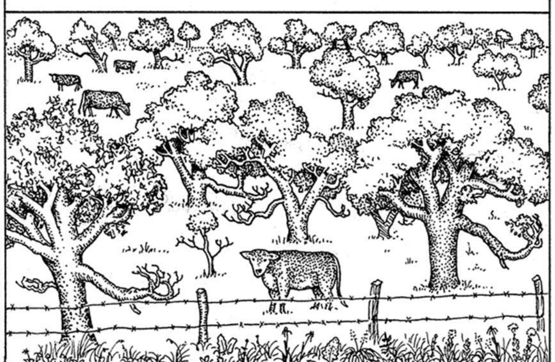
Table 1. Savanna, woodland, and forest burn frequency in northeastern Illinois.

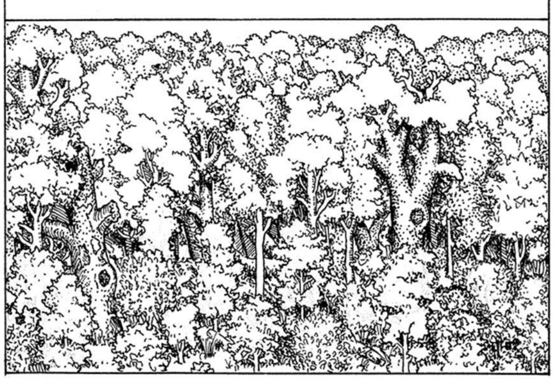
Remnant Nature Preserve Oak Areas:	10,166.8
Burn Season	***Acreage Burned***
2015-2016	1367.7
2016-2017	2634.8
2017-2018	2807.2
2018-2019	1842.3
2019-2020	245.8
2020-2021	1776.8
2021-2022	1921.8
2022-2023	1124.3
2023-2024	1542.1
Total burned in nine years	15,262.8
Theoretical total – if all sites were burned biennially	45,750.6

1800: Much of the Midwest was oak savanna and woodland when first surveyed. Their species and interdependencies had evolved in association with lightning fire for millions of years. For the last few thousand years, these diverse and productive communities were also burned by Native Americans. Thousands of species of animals and plants depended on those fires.



1890: Many savannas and woodlands were used as pastures. Some grasses and wildflowers survived mostly where the livestock was fenced out. But for a while, the grazing did some of the work that the fire once did, keeping down invading woody plants.

1970: On sites protected as preserves – now without grazing – many grass and flower species recolonized sunny understories. But in the absence of fire, shrubs and trees began to shade them out



2025: The tree and shrub canopy is now so dense that many light-dependent species have declined – persisting only in diminished unsustainable populations, oftentimes in edges – or in many cases are now gone.

Figure 2. Woods subject to mesophication appear dense but lose many species. Until stewardship began, tree reproduction in this bur oak woodland in the Somme Forest Preserves consisted mostly of sugar maple, basswood, and red oak with and understory of buckthorn and no young bur oak. The ground underneath was nearly bare, retaining few conservative herbs, especially those of summer and fall.

Figure 3. Bur oak woodland near the area shown in Figure 2 after four decades of restoration. Most herbs here were restored from seed sources along sunnier areas of this site and nearby. A still young restoration, it continues to increase in diversity and quality (conservativeness). The few surviving native shrubs have declined except in areas protected from fire and deer.

Figure 4. Close up of the area in Figure 3. Spring species here include *Anemonella thalictroides* (rue anemone), *Pedicularis canadensis* (wood betony), and *Zizia aurea* (golden Alexanders). Summer species include C*amassia scilloides* (wild hyacinth), *Silene stellata* (starry campion), and *Perideridia americana* (thicket parsley). Fall species include *Eurybia macrophylla* (big-leaf aster), *Helianthus strumosus* (pale-leaved sunflower), and *Brachyelytrum erectum* (awned woodgrass).