A Land Managers Guide to Prairies and Savannas in Michigan: History, Classification, and Management

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Cover photo: Oak barrens in Newaygo County, Susan R. Crispin, MNFI

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Introduction & Purpose

This publication is a summary of information related to the history, classification, and management of prairie and savanna communities in Michigan. Information has been synthesized from a wide variety of sources, including peer-reviewed journal articles, practical handbook publications, published and unpublished field research, and historical and anecdotal accounts.

This publication is not intended to be a comprehensive stand-alone reference, but rather to serve as a user-friendly guide to prairie and savanna communities for land managers, other natural resource professionals, and non-professional naturalists and land stewards. Readers are encouraged to seek additional information from publications listed in Recommended Reading sections as well as from cited literature.

The classification of ecological communities can be difficult. Discrete bounds are placed around communities that occur along a natural continuum of ecosystem conditions and associated vegetation. Correctly classifying any particular site on the ground can be difficult at best. Managing remnant sites is even more difficult, especially when faced with economic, social, and political factors that may limit management options. It is hoped that this guide will help address some of these issues, bridge the gap between technical and non-technical publications, and enable the reader to make informed, effective land management decisions.

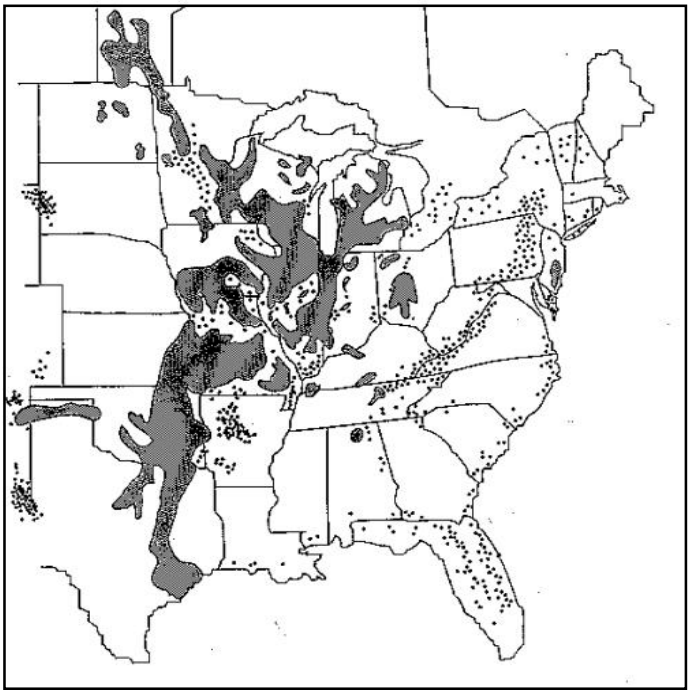
What was Michigan Like?
Distribution of Prairies and Savannas circa 1800s

When the Midwest was settled by Europeans in the early 1800s, the landscape was vastly different than today. Circa 1800, savannas occupied between 11 and 13 million acres of the Midwest, and prairies covered a similar or larger amount of the region. Currently, prairies and savannas now occupy just 1% and 0.02% of their respective former extent, a loss of over 99% (Nuzzo 1986, Kline 1997).

Although Michigan is generally thought of as a state primarily dominated by forest, prairies and savannas made up a significant component of the circa 1800s landscape. Because of the state's northerly latitude and relatively abundant rainfall, prairies and savannas were concentrated in areas that had difficulty supporting trees, and were found especially in landscapes with frequent fires or in sites with either droughty or very wet soils. The majority of prairies and savannas were located in a broad swath stretching from Cass and Van Buren counties in the southwest to Oakland County in the southeast (Figure 1). Known as the Kalamazoo and Jackson Interlobate, this region was located between lobes of glacial ice advancing from the Lake Michigan, Saginaw Bay, and Lake Erie basins during the Pleistocene glaciation. When the ice melted between 10,000-15,000 years ago, it left behind large deposits of sands and gravels that historically supported prairie and savanna. Other important regions in the state include the droughty and infertile soils of the Newaygo Outwash (located primarily in Newaygo County but stretching north to the Leelanau Peninsula) and the extremely dry, fire-prone pine barrens of the High Plains region centered around Grayling, as well as portions of the central Upper Peninsula such as the Shakey Lakes area and Yellow Dog Plains region.

Gary Reece, MNFI

Savannas with prairie vegetation beneath a scattered oak canopy were once common in Michigan.



Estimated distribution of prairies (black) and savannas (gray) prior to European settlement (Nuzzo 1986).

Michigan had over 2,000,000 acres of savanna circa 1800. Currently, only 8,000 acres remain, mostly on extremely droughty soils in the northern portions of the state.

Prairie vs. Savanna: Historical Context

Currently, an emphasis is generally placed on prairie or grassland planting. Historically however, savannas were much more common in Michigan. In a 1932 soil survey of Branch County, the landscape was described thus:

> The so-called prairies were not entirely treeless, but supported a scattered growth, consisting principally of bur oak [*Quercus macrocarpa*],…but the tree growth was not sufficiently dense to prevent the growth of heavy grass cover (Moon et al.1932, cited in Chapman 1984).

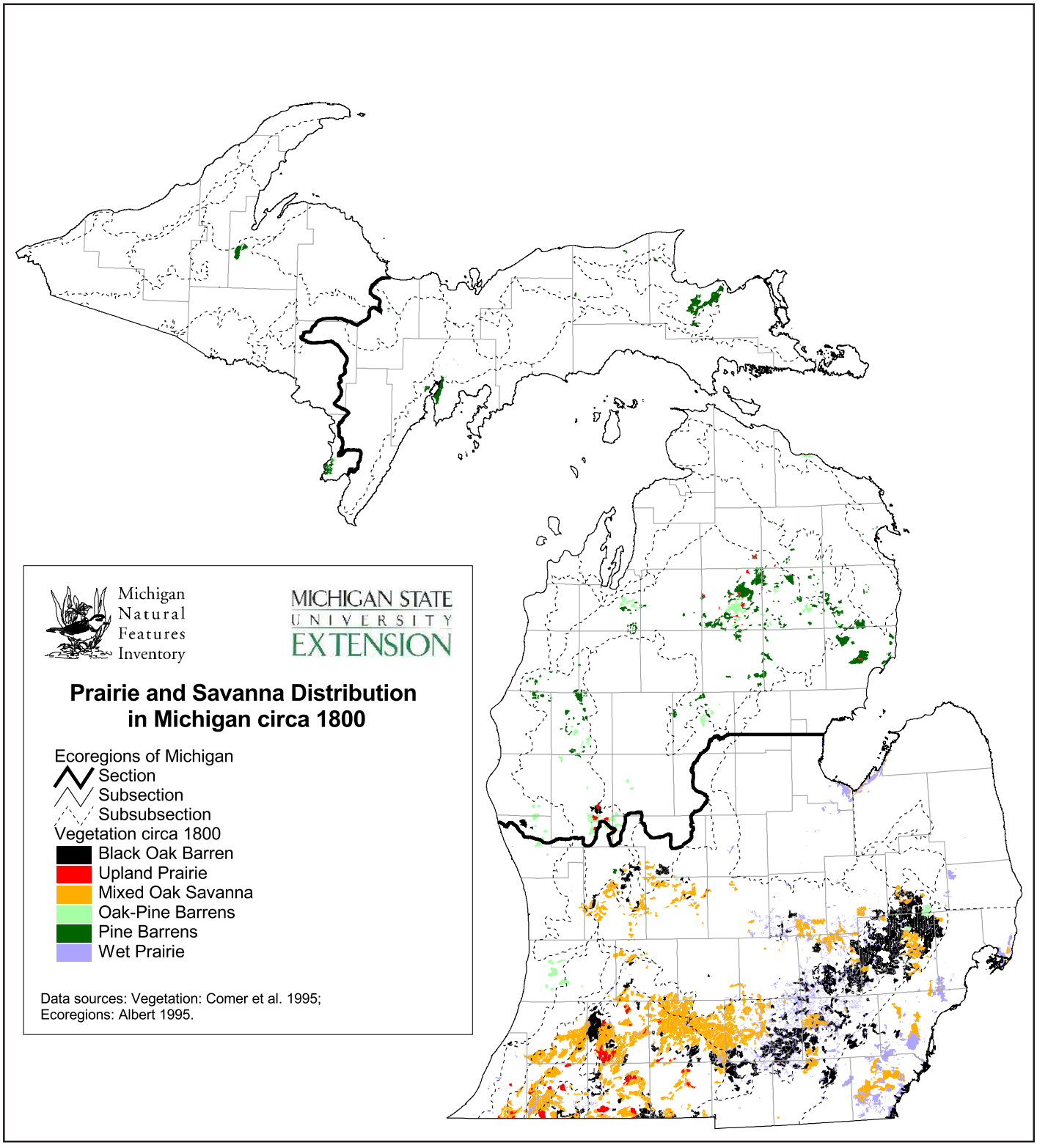


Figure 1. Distribution of prairie and savanna communities circa 1800, based on the General Land Office Survey, conducted 1816-1856. Prairie and savannas were concentrated in a band from Cass and Van Buren county in the southwest to Oakland county in the southeast. Other major regions include the Newaygo County area and the pine barrens region in the north-central portion of the Lower Peninsula and central Upper Peninsula. Overall prairies and savannas made up 7% of the landscape circa 1800, the vast majority of which was savanna.

A summary of the General Land Office Survey, conducted in Michigan from 1816 to 1856 reveals that savanna and prairie occupied 7% of the state at the time of European settlement (Comer et al. 1995). Savanna made up the vast majority of this open landscape, accounting for 5.8% of Michigan's natural environment (Figure 2). By comparison, wet prairies (which include lakeplain prairies and prairie fens), made up only 1% of the state total, and upland prairies (which include dry or shortgrass prairie in addition to mesic or tallgrass prairie) made up only 0.2% of the state total. Overall, savanna was more abundant than upland prairie by a factor of nearly 30:1.

What is the difference between prairie and savanna? In general, a prairie is commonly described as a grass-dominated community with less than one tree per acre (Curtis 1959). Savannas range from having 4 to nearly 50 trees per acre (a maximum of approximately one tree every ten meters) (Chapman 1984). Canopy cover estimates range from 5% to 60%, depending on the type of savanna. As discussed below, however, savannas and prairies existed along a natural continuum, with prairie grading into savanna and savanna grading into woodland and forest.

Historically, fire was the single most important process that maintained savannas and prairies in an open condition. Fire stimulated grasses and wildflowers while simultaneously limiting the growth of woody trees and shrubs. The fire frequency of any given site is difficult to determine and is based on factors such as topography, the amount and type of fuel, and natural firebreaks. The time between fires may have been as much as 20 years in the wettest systems, but annual fires were also common, as noted in several historical accounts.

> The annual fires burnt up the underwood, decayed trees, vegetation, and debris in the oak openings, leaving them clear of obstructions. You could see through the trees in any direction, save where the irregularity of the surface intervened, for miles around you, and you could walk, ride on horse-back, or drive in a wagon wherever you pleased in these woods, as freely as you could in a neat and beautiful park (Van Buren 1884 as quoted in Chapman 1984).

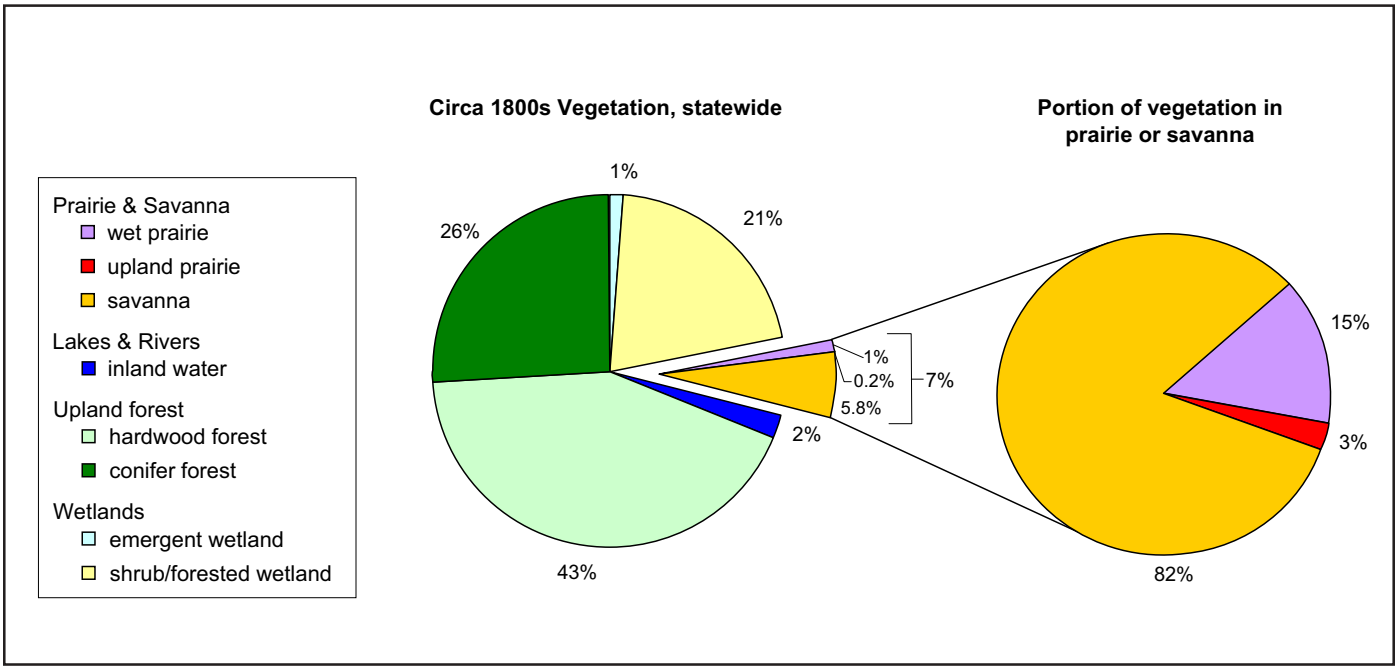


Figure 2. Vegetation of Michigan circa 1800. Prairies and savannas made up 7% of the total landscape. Of this, savannas comprised the vast majority (5.8% statewide). Wet prairie, which includes lakeplain prairies and prairie fens, comprised 1% statewide. Upland prairies, which include dry prairie in addition to mesic or tallgrass prairie, made up only 0.2% of the state total.

Christopher Hoving, Michigan DNR

Historically, fires that began in the open also burned into the surrounding woods, creating a mosaic of savannas interspersed with prairies.

"To-day, for the first time, I saw the meadows on fire. They are of vast extent, running far into the woods like the friths on a lake....

These fires, traveling far over the country, seize upon the largest prairies, and consuming every tree in the woods, except the hardiest, cause the often-mentioned oak openings, so characteristic of the Michigan scenery."

-Charles Fenno Hoffman, 1835

It is estimated that oak openings occupied 900,000 acres in Michigan circa 1800. The community has been almost completely lost, with only three acres remaining in one known site.

While some lightning-strike fires certainly occurred, fires were also deliberately set by Native Americans for a myriad of reasons, ranging from stimulating berry and forage production to assisting with hunting by driving game, to maintaining open landscapes for ease of travel to increased visibility and protection from enemies. In addition to mentioning some of these benefits, Hoffman (1835) also describes the important process of fire burning into the surrounding woods, creating a mosaic of habitat:

> To-day, for the first time, I saw the meadows on fire. They are of vast extent, running far into the woods like the friths on a lake; and as wild grass, which they supply in the greatest profusion, furnishes the new settler with all the hay he uses for his stock, they are burnt over thus annually to make it tender. These fires traveling far over the country seize upon the largest prairies, and consuming every tree in the woods, except the hardiest, cause the often-mentioned oak openings, so characteristic of the Michigan scenery. (Hoffman 1835, as quoted in Chapman 1984).

As Hoffman observed, fires burning into the woods created a mosaic of prairies grading into savannas and savannas grading into more closed-canopy forest. Changes in fire frequency would cause this mosaic to shift, with more frequent fires thinning savanna trees, and opening the forest canopy. Conversely, and far more common following European settlement, less frequent fires allowed tree seedlings and stump-sprouting oaks (oak grubs) to fill in the prairie and rapidly turn the savanna into a closed-canopy forest.

Changes in Savannas and Prairies circa 1800s to present

With the advent of European settlement, the changes to savannas and prairies were radical and rapid. Sites with loamy soil were among the first areas chosen for farmland, and those savannas not converted to agriculture were often selected as sites for towns, college campuses, and cemeteries. Fire frequency decreased as Native American populations declined, towns grew and the need to protect homes and crops from wildfire increased. As more roads were built, the landscape became more fragmented, and those fires that did occur were far less widespread.

Even by the 1870s this change was well under way, as described by Hubbard 35 years after an 1837 expedition near modern-day Pontiac in Oakland County with the renowned Michigan explorer Douglas Houghton:

> The surrounding country seemed to our eyes far enough removed from the gloomy morass [surrounding Detroit] which wild imaginations had depicted it twenty years before. It appeared to me the most beautiful the sun ever shone upon. It was of the character then beginning to be classed as "openings," chararacterized by a gravelly soil and a sparse growth of oaks and hickories. I speak in the past tense, because, though the rural beauty of the country is still unrivaled, little remains of the original character of the openings. This is a result partly of the progress of cultivation, and partly of the thick growth of small timber that has covered all the uncultivated portions since the annual fires have ceased, which kept down the underbrush (Hubbard 1872, from Chapman 1984).

The conversion from prairie and savanna to forest was astonishingly rapid. In many cases the change occurred within decades (25 to 40 years) (Curtis 1959), with more mesic communities like bur oak plains converting even more rapidly (Abrams 1992, Packard 1993). Often, this was due to the presence of oak "grubs," oak trees made shrubby by being repeatedly top-killed by frequent fires (Chapman 1984). Despite their lack of stature above ground, their root system was extensive and could be more than one hundred years old. Following even a brief cessation of fire, they sprouted and grew vigorously, rapidly changing the renowned savannas into a young forest. As the trees grew, they quickly shaded out the prairie grasses that provided the fuel for frequent fires, further reducing fire frequency.

In addition to changing fire frequency, European settlers also introduced livestock grazing to the prairie and savanna ecosystem. While grazing by buffalo and other large mammals did occur historically, grazing patterns of cattle and sheep were much more intensive and often concentrated in a confined (fenced) area. Grazing by livestock resulted in further reductions of grasses and forbs and, in addition to lack of fire and closed canopy conditions, has contributed to the low floristic diversity often seen in savanna remnants today. Grazing also facilitated the introduction of exotic weeds such as Kentucky bluegrass (*Poa pratensis*) by disturbing the soil.

Savannas and prairies were also prone to invasion by other exotic, invasive species such as common buckthorn (*Rhamnus cathartica*) and autumn-olive (*Elaeagnus umbellata*), a problem that began in the mid 1900s and has been accelerating ever since. Often planted for wildlife cover or landscaping in the past, the bird-dispersed fruit of these shrubs quickly found its way to savannas and prairie edges, as many edge-loving bird species preferentially perch on large open-grown oaks and disperse the seeds in droppings when they fly off. This can create an easily-observed spatial pattern of clusters of exotic shrubs beneath large oaks

"It appeared to me the most beautiful the sun ever shone upon. It was of the character then beginning to be classed as 'openings,' characterized by gravelly soil and a sparse growth of oaks and hickories. I speak in the past tense, because, though the rural beauty of the country is still unrivaled, little remains of the original character of the openings."

-Dr. Bela Hubbard, describing the rapid conversion from savanna to forest on an 1872 expedition with Douglas Houghton near Pontiac.

Susan R. Crispin, MNFI

in old fields. With numerous edges relative to their size, savannas and prairie remnants (often small and surrounded by fencerows, woodlots, or forests) were particularly susceptible to invasion by exotic shrubs (Apfelbaum and Haney 1991). As invasives became established, they had compounded negative effects. In addition to competing directly with native species they also reduced fire-prone fuels such as prairie grasses, decreasing fire frequency and intensity, leading to even further declines in native species.

Many former savanna remnants have almost completely closed canopies today and form much of the oak "forests" we now find in southern Lower Michigan. It is estimated that only 0.02% of the savanna originally found in the Midwest remains, declining from around 11 to 13 million acres to just a few hundred acres spread across a dozen states (Nuzzo 1986). In Michigan, the loss of savanna is most dramatic in the oak openings community, once described as being "so characteristic of the Michigan landscape." It has declined from an estimated 900,000 acres to just 3, a loss of 99.9996% (Comer et al. 1995, Cohen 2004b). Tiny remnants and restorable pockets also likely exist, but the loss has been tremendous by every possible accounting.

Of the 11 to 13 million acres of savanna found in the Midwest circa 1800, only 0.02% remains.

Ryan P. O'Connor, MNFI

In southeast Michigan, the federally threatened eastern prairie fringed orchid (*Platanthera leucophaea*) is largely restricted to growing in roadside ditches and lawn edges because so little of its lakeplain priaire habitat remains.

Many of the oak "forests" in southern lower Michigan are actually remnants of former oak savanna.

Christopher Hoving, Michigan DNR

Fire is the one of the most important processes that maintain prairies and savannas.

The defining character of prairies and savannas is their open canopy. With enough sunlight reaching the ground, prairie grasses and wildflowers flourish and provide the necessary structure and food sources for the associated wildlife community. Without natural processes to maintain an open canopy, trees and shrubs quickly dominate and as canopy cover increases, prairie and savanna species decline and are replaced by more shade-tolerant plants, leading to a wholesale change in the entire community.

The Landscape Context of Fire

Fire is the one of the most important processes in maintaining an open canopy of prairies and savannas, but it must be understood in the context of the overall landscape. Fires burned more frequently in regions with a predominance of dry, gravelly soils, such as the interlobate and high plains regions. Open wetlands that were a part of this landscape were often juxtaposed with oak savanna and when the upland burned, the wetland did as well. Thus soils and overall glacial geology are important landscape factors that influenced fire frequency. Dry, nutrient-poor sand and gravel soils of outwash plains and ice-contact landforms promoted far greater fire frequency than did the relatively rich, comparatively moist moraines and till plains.

In mesic sites where soils are ideal for tree growth, fire is the only process that keeps back woody species.

Extreme soil conditions

Soils can also affect canopy cover by limiting tree and shrub growth in extreme moisture and nutrient conditions. Droughty soils, which are also often nutrient-poor, lack sufficient moisture during the growing season and result in slow tree growth and an overall sparse canopy. Conversely, too much moisture also can inhibit tree and shrub growth. As tree roots grow they respire metabolically, a process that requires oxygen from air trapped in the soil pores. When soil is saturated, these pores are filled with water instead of air and most trees are unable to grow. Many herbaceous plants have specific adaptations that allow them to tolerate high water levels and thrive where most woody plants cannot. Thus both extremely dry and wet soils limit tree growth and promote a more open canopy.

Michael A. Kost, MNFI

Fires burned more frequently in regions with a predominance of dry, gravelly soils, such as the interlobate and high plains regions. Open wetlands that were a part of this landscape were often juxtaposed with oak savanna and when the upland burned, the wetland did as well.

Fire and soil extremes in concert

Soil moisture and nutrient availability vary along a continuum; the greater the extreme the greater the limiting effect on woody plant growth. In general canopies are naturally more open on the driest and wettest sites. As conditions become less extreme on the continuum, they have less impact on limiting canopy cover and fire frequency becomes more important in maintaining an open condition. In mesic sites where soils are ideal for tree growth, fire is the only process that keeps back woody species and promotes prairie and savanna vegetation. When fires cease, these sites are the first to fill in, followed by dry-mesic and wet-mesic sites, and

lastly by very dry and very wet sites with the most extreme soil conditions. This partially explains why mesic prairie and savanna are so rare in the state and comparatively drier and wetter prairie and savanna are more common. Other reasons for this pattern include the fact that more mesic sites were better for agriculture and cities and towns often developed in close proximity.

Altered ecological processes

The alteration of ecological process is one of the primary reasons prairies and savannas are so rare today relative to their historical extent. Suppression of fires has had the largest impact, but changes in soil moisture regimes can also radically alter vegetative composition. For more than a century, open wetlands have been tiled, ditched, and filled in an attempt to make them more suitable to agriculture and development. At other sites, overuse of groundwater has been suspected of lowering the water table in adjacent groundwater-fed prairie fens. Alteration of hydrology directly or indirectly affects plant growth and composition. Often, even a slightly lower water table makes a site dry enough for trees and shrubs to gain a foothold. Sites with a disturbed hydrology are also more susceptible to invasion by non-native species like glossy buckthorn (*Rhamnus frangula*), narrow-leaf cattail (*Typha angustifolia*), and giant reed (*Phragmites australis*). As trees and shrubs begin to dominate, their greater leaf surface area also transpires and translocates more water than herbaceous plants, creating a feedback loop that further lowers the water table and promotes more canopy closure.

John M. Randall, The Nature Conservancy

Glossy buckthorn (*Rhamnus frangula*) and other invasive species not only outcompete native plants and eliminate wildlife habitat, but can also lower the water table due to excessive evapotransporation.

In some systems such as lakeplain prairies and savannas along the coast of the Great Lakes, the natural water level fluctuates. Periodic high and low water cycles prevent dominance by any small group of species for long periods of time, and combined over time help create an exceptionally diverse community. In mesic sand prairies, seasonal water level fluctuations are the norm, with high water in the spring followed by a drop in water levels and a seasonal drought in late summer. Maintaining the process of naturally fluctuating water levels in these systems is just as critical as maintaining a constant supply of groundwater in a fen system. From a conservation standpoint, re-establishing proper hydrology may be as or more important than prescribed fire in the restoration of some sites.

Dennis A. Albert, MNFI

Ditching, installation of drain tiles, and fire suppression have radically altered ecological processes that once maintained lakeplain prairies and savannas.

Numerous animals and plants require prairies and savannas for their primary habitat. Many common as well as rare species are specially adapted to thrive in the diverse, dynamic environment. Due to the near complete loss of these systems, however, many of these species have experienced drastic declines. Overall, prairies and savannas support a greater number of rare and declining species than any other single terrestrial habitat type in Michigan (Eagle et al.2005). For a complete list of rare species associated with prairies and savannas, please see Appendices A and B.

Fauna

Prairies and savannas support all types of wildlife, including mammals, reptiles, birds, and insects. Some species are generalists and will utilize any suitable grass-dominated habitat including both native prairie, planted prairie, and even exotic cool season grass-(brome) dominated fields. Examples of generalist species include grassland birds such as grasshopper sparrow (*Ammodramus savannarum*), meadowlarks (*Sturnella* spp.), and bobwhite (*Colinus virginianus*); mammals like prairie vole (*Microtus ochrogaster*); and reptiles such as black rat snake (*Elaphe obsoleta obsoleta*) and eastern hog-nosed snake (*Heterodon platirhinos*).

Other species are more restricted in their habitat preference and are only found in prairie and savanna with specific vegetation structure. For example, Henslow's sparrow (*Ammodramus henslowii*) requires large blocks of open land (40 acres or more) and a buildup of thick grass litter. Other species, such as the popular introduced game species ring-neck pheasant (*Phasianus colchicus torquatus*), thrive where particular plants like switch grass are abundant. More often, the type of prairie and savanna determine what species might be found there. For example, reptiles like eastern massasauga (*Sistrurus catenatus catenatus*) and Kirtland's snake (*Clonophis kirtlandii*) are usually associated with prairie fen and adjacent habitat in southern Lower Michigan, while box turtles (*Terrapene carolina carolina*) are more likely to be found in upland oak savanna.

Insects comprise the largest group of prairie and savanna fauna. Many are found only in very specific habitats and are highly dependent on particular plant species. Butterflies are one of the most visible and charismatic groups, and include exceptionally rare species like the Karner blue (*Lycaeides melissa samuelis*), a small butterfly found only in oak barrens and dry prairie edges with an abundance of lupine (*Lupinus perennis*), its larval host plant. Other species like the borer moths (*Papaipema* spp.) are also highly

Close Up: Wildlife

Prairies and savannas support more rare and declining wildlife than any other terrestrial habitat in Michigan. Threatened by decades of habitat destruction, conversion of habitat to shrub and forestland, overcollection, and exploitation, they are one of the primary focuses of land managers in numerous public agencies and conservation organizations.

They include charismatic reptiles like box turtles, which can reach 100 years in age. Once relatively common through the Midwest, many turtles are threatened by the loss of sandy, open nesting areas and ensuing road mortality as females go in search of places to lay eggs.

Eastern box turtle

Other species like the eastern massasauga rattlesnake have suffered from persecution, despite their relatively docile nature. Michigan is one of the last strongholds in the nation for this species, which inhabits a wide variety of communities ranging from prairie fens to pine barrens and adjacent habitats.

Brian Piccolo, Michigan DNR

Eastern massasauga

The Karner blue is a federally threatened butterfly that is found primarily in Michigan and Wisconsin. Larvae feed only on wild lupine, a plant of the once-common oak barrens. Due to the near complete loss of this habitat, however, lupine and the Karner blue are now often restricted to road edges and utility rights-of-way, the only areas that remain partially open. Fortunately, biologists are making great strides in the recovery of this species by restoring oak barrens with prescribed fire and by forming strong partnerships between government agencies, NGOs, and private land owners.

Jennifer Kleitch, MNFI

Karner blue butterfly on flowering lupine

specialized, with different species utilizing particular plant species. Examples include the blazing star borer (*P. beeriana*), Culver's root borer (*P. sciata*), and Silphium borer (*P. silphii*). Many insects are much less visible, but no less unique and important to the prairie and savanna ecosystem. Invertebrates like beetles, spittlebugs, leaf hoppers, grasshoppers, katydids, crickets, and spiders are also important parts of the diversity as well as function of these systems, whether they act as mirco-herbivores to break down vegetation, predators helping to keep other insect pests in check, or just to serve as a food source for game species like wild turkey.

Many insects are dependent on natural prairie remnants. While highly mobile species like grassland birds can move to new areas after a disturbance like fire or colonize newly planted grasslands on former cropland, many insects are restricted to tiny relict patches of former habitat. Recovery from disturbances like fire may be slow; if fire consumes all available habitat, some species may even be extirpated from the site, a process made more likely by the loss of habitat and connectivity between remnant patches. Perhaps more significantly, remnant-dependant insects have not yet been found to colonize planted prairies, even after a half-century of careful stewardship and management and when they are exceptionally high in plant diversity (Mlot 1990). For these species, an emphasis on careful restoration and management of natural remnant prairies and savannas over planted sites is critical.


Ryan P. O'Connor, MNFI

Prairie wildflowers like black-eyed susan (*Rudbekia hirta*) are not only showy but provide an important nectar source for rare species like the poweshiek skipperling (*Oarisma poweshiek*).

Flora

Plants form the key structural and functional component of prairies. Typically grasses and sedges form the dominant matrix of biomass, with a diverse mix of forbs scattered throughout. In savannas, oaks are also critical in providing woody structure and a partial canopy cover. With quick-drying litter containing volatile chemical compounds, both oak leaves and grasses and sedges provide much of the fine fuel needed to carry fire through the system. Likewise, both oaks and grasses are characterized by extremely deep roots (6 -12 feet or more) that stabilize and enrich the soil as well as help plants tolerate drought as well as soaking up large amounts of rainfall and minimizing surface runoff.


Ryan P. O'Connor, MNFI

Big bluestem (*Andropodon gerardii*)

Like wildlife, plants of these systems vary in their distribution and abundance. Some, such as big bluestem (*Andropogon gerardii*) and Indian grass (*Sorghastrum nutans*) can be found in nearly every community type throughout the state. Others, like side-oats grama grass (*Bouteloua curtipendula*, state threatened) were never common in Michigan and are restricted to isolated hillsides and dry bowl prairies. Flora also likely differed between relatively open prairies and the partially closed canopy of savannas. Although many of these savanna specialists can be found in limited amounts in treeless prairies, they likely were much more abundant filtered light conditions once found in


Ryan P. O'Connor, MNFI

Indian grass (*Sorghastrum nutans*)

savannas. Because virtually no high-quality remnant sites remain, determining which species are savanna specialists is difficult, but may have included plants such as lupine, Culver's root (*Veronicastrum virginicum*), and woodland sunflower (*Helianthus divaricatus*).

A lack of diversity of native plants is an increasing problem in both natural and planted prairies and savannas. Historically, all but the driest prairies and savannas easily contained over 100 native species of grasses, forbs, and woody species. In a typical planted prairie, diversity may be limited to ten native species or less, of which only one or two almost completely dominates.

Many natural prairie remnants are still high in diversity, but abundance has likely shifted over time. A lack of fire often leads to an over abundance of dominant grasses and a decline of small-seeded, short-stature wildflowers. Invasion by trees and shrubs, as well as livestock grazing has also led to drastic decline, especially in former savannas. Non-native species have also become tremendously problematic. In addition to competing for growing space, some, such as spotted knapweed (*Centaurea maculosa*), are suspected of releasing allelopathic chemicals that kill or inhibit the growth of native plants (Weir et al. 2003).

High-quality remnant prairies and savannas can easily contain over 100 native plant species, making them some of the most diverse natural communities in the state.

Close Up: Plants

Throughout the seasons, the flora of prairies and savannas in Michigan is perhaps more diverse, showy, and characteristic than any other habitat in the state. From the purple violets and phloxes of spring, to the intricate orchids of summer, to the tall, waving amber-colored grasses of the fall, a tremendous array of plant species graces our prairie and savanna landscape.

Dan Kennedy, Michigan DNR

Birdfoot violet (*Viola pedata*)

Many plants are indicators of remnant prairie and savanna habitat. They include early-flowering species like birdfoot violet (*Viola pedata*), found in drier sites including oak openings and pine barrens, as well as plants that flower in mid-summer like black-eyed susan, found in a variety of both wet and dry prairies, and hoary puccoon (*Lithospermum canescens*), found primarily in dry sand prairie and oak barrens remnants.

Hoary puccoon (*Lithospermum canescens*)

Prairies and savannas are at their most colorful in late summer and fall, when blazing star (*Liatris* spp.), goldenrods (*Solidago* spp.), and prairie grasses are at their peak.

Dan Kennedy, Michigan DNR

A silver-spotted skipper nectars on northern blazing star (*Liatris scariosa*).

Regardless of their shape, size, and color, virtually all prairie and savanna plants are adapted to and benefit from periodic burns. Without fire, woody species encroach, thatch builds up and smothers small wildflowers, and seeds have no exposed mineral soil on which to germinate. Prescribed burns are increasingly being used to maintain remnant prairies and savannas and ensure these diverse parts of our natural heritage will not be lost.

Dennis A. Albert, MNFI

Marsh blazing star (*Liatris spicata*), goldenrods (*Solidago* spp.), and prairie grasses after a prescribed burn.

Prairie and Savanna Classification in Michigan

Numerous types of prairie and savanna communities have been described in Michigan. Because many types were uncommon and were quick to be altered upon European settlement, almost no objective historical descriptions of their original flora and ecology exist. Adding to the confusion, they have been drastically altered over the past 200 years and little remains of their original extent and character. As a result they are often poorly understood by many natural resource professionals from a conceptual standpoint. Without an understanding of their characteristics and classification, identifying similar communities from one another in the field can be difficult at best with an untrained eye. This overview is intended to outline both broad and specific differences between various communities and give field personnel a resource to assist in identifying particular sites on the ground.

Rarity

Prairies and savannas are among the most endangered ecosystems in the world. Ecologists assign state (S) and global (G) ranks that correspond with the rarity of species and communities, ranging from 1 to 5, with 1 being critically imperiled and 5 being common and secure from a state (S rank) or global (G rank) conservation perspective. Of the seventeen prairie and savanna communities found in Michigan, all are rated G3 or rarer, with many falling into the globally endangered and threatened categories of G1 and G2 (Table 1). Plants and animals with similar rating of G1 and G2 are often legally protected and listed on the federal endangered species list.

Classification

Prairies and savannas can be classified in part by overall structure. As mentioned above, the number of trees present can be used to distinguish prairies from savannas, with savannas generally having more than 1 tree per acre (Curtis 1959). This equates roughly with a 5% canopy or more (assuming one tree per acre with a minimum crown diameter of ~50 feet). Keeping these general guidelines in mind, it is also important to remember these communities often existed side by side one another in a shifting landscape mosaic. With the combined effects of more than a century of agriculture, grazing, and fire suppression, this shifting mosaic has been radically altered, and remnant prairies may now appear to resemble savanna or shrub land, and remnant savanna may appear nearly completely forested. There is also an issue of scale. What may appear today as a small remnant prairie is often just a

Table 1. Prairie and savanna community types found in Michigan with global and state ranks. A rank of S1 or G1 designates a community as critically imperiled in the state or world, S2 or G2 as imperiled, and S3 or G3 as rare and vulnerable. SX designates a state-extirpated community. GNR denotes a community has not yet been ranked on a global scale.

Community Name	State Rank	Global Rank
Prairie		
Dry sand prairie	S2	G3
Hillside prairie	S1	G3
Lakeplain wet prairie	S1	G2?
Lakeplain wet-mesic prairie	S1	G1?
Mesic prairie	S1	G2
Mesic sand prairie	S1	G1?
Northern wet-mesic prairie	S1	GNR
Prairie fen*	S3	G3
Wet prairie	S2	G3
Wet-mesic prairie	S2	G2
Woodland prairie	S2	G3
Savanna		
Bur oak plains	SX	G1
Lakeplain oak openings	S1	G2?
Oak barrens	S2	G2?
Oak openings	S1	G1
Oak-pine barrens	S2	G3
Pine barrens	S2	G3

*Prairie fen is included due to its similar vegetative composition, though it is not considered a true prairie community because it occurs in wetlands with organic (peat) soils rather than mineral soils.

Of the seventeen prairie and savanna communities found in Michigan, all are rated G3 or rarer, with many falling into the globally endangered and threatened categories of G1 and G2.

small opening within a much larger former savanna. This was also the case historically, as most prairies existed as small pockets within a savanna landscape. It is important to recognize both the current condition (i.e. closed canopy forest) as well as the historical condition (i.e. savanna) of any given site, especially in the context of land management, restoration, and conservation.

Prairies and savannas can also be classified based on a variety of ecological characteristics. One of the most basic and universal characteristics is moisture regime. Prairies exist across a wide spectrum of moisture conditions, ranging from very wet to very dry (xeric) (Table 2). Likewise, savannas exist across a similar gradient, ranging from wet- mesic to dry.

Communities are also classified by the glacial landforms on which they occur. Some types occur only on specific landforms, such as lakeplain prairies, which are limited to the glacial lakeplain areas of Saginaw Bay, southeast Michigan, and portions of extreme west Michigan (Figure 3). Other communities are classified by their soil type, as in mesic sand prairie. This differentiates it from mesic prairie, which shares a similar moisture regime but has loamy soils. Many other communities, while not classified by landform or soil, nonetheless characteristically occur only on sites with specific soil and landform conditions (Figures 4 & 5).

For a complete list of Michigan communities please refer to Michigan's Natural Communities: Draft List and Descriptions, available online at http://web4.msue.msu.edu/mnfi/data/MNFI_Natural_Communities.pdf. All prairie and savanna communities are briefly described in Appendix C: Natural Community Descriptions. Many of the communities are also more thoroughly discussed in abstracts. Also available on the MNFI website, they provide detailed information on ecological characteristics, distribution, flora and fauna. Due to the ongoing development of these abstracts, the reader is encouraged to periodically check the website as more are added each year.

Recommended Reading:
Prairies and Savannas in Michigan

Albert, D.A., J.C. Cohen, P.J. Comer, M.A. Kost, and J.B. Spieles. Natural Community Abstracts. [dates various] Michigan Natural Features Inventory, Lansing, MI. Available online at: http://web4.msue.msu.edu/mnfi/pub/abstracts.cfm#Communities

Michigan's Natural Communities: Draft list and Descriptions. 2006. Michigan Natural Features Inventory. Lansing, MI. Available online at: http://web4.msue.msu.edu/mnfi/data/MNFI_Natural_Communities.pdf

Table 2. Prairie and savanna community distribution across a moisture gradient. Categories are generalized, and any given community may actually fall across multiple moisture conditions.

	Wetlands		**Uplands**		
Moisture	**Wet**	**Wet-mesic**	**Mesic**	**Dry-mesic**	**Dry**
Prairie type	Wet prairie Lakeplain wet prairie Prairie fen*	Wet-mesic prairie Lakeplain wet-mesic prairie Northern wet-mesic prairie	Mesic prairie Mesic sand prairie	Woodland prairie Hillside prairie	Dry sand prairie
Savanna type		Lakeplain oak openings#	Bur oak plains	Oak openings Lakeplain oak openings#	Oak barrens Oak-pine barrens Pine barrens

*Prairie fen is included due its similar vegetative composition, though it not considered a true prairie community because it occurs in wetlands with organic (peat) soils rather than mineral soils.

#Lakeplain oak openings can occur on both wet-mesic and dry-mesic sites.

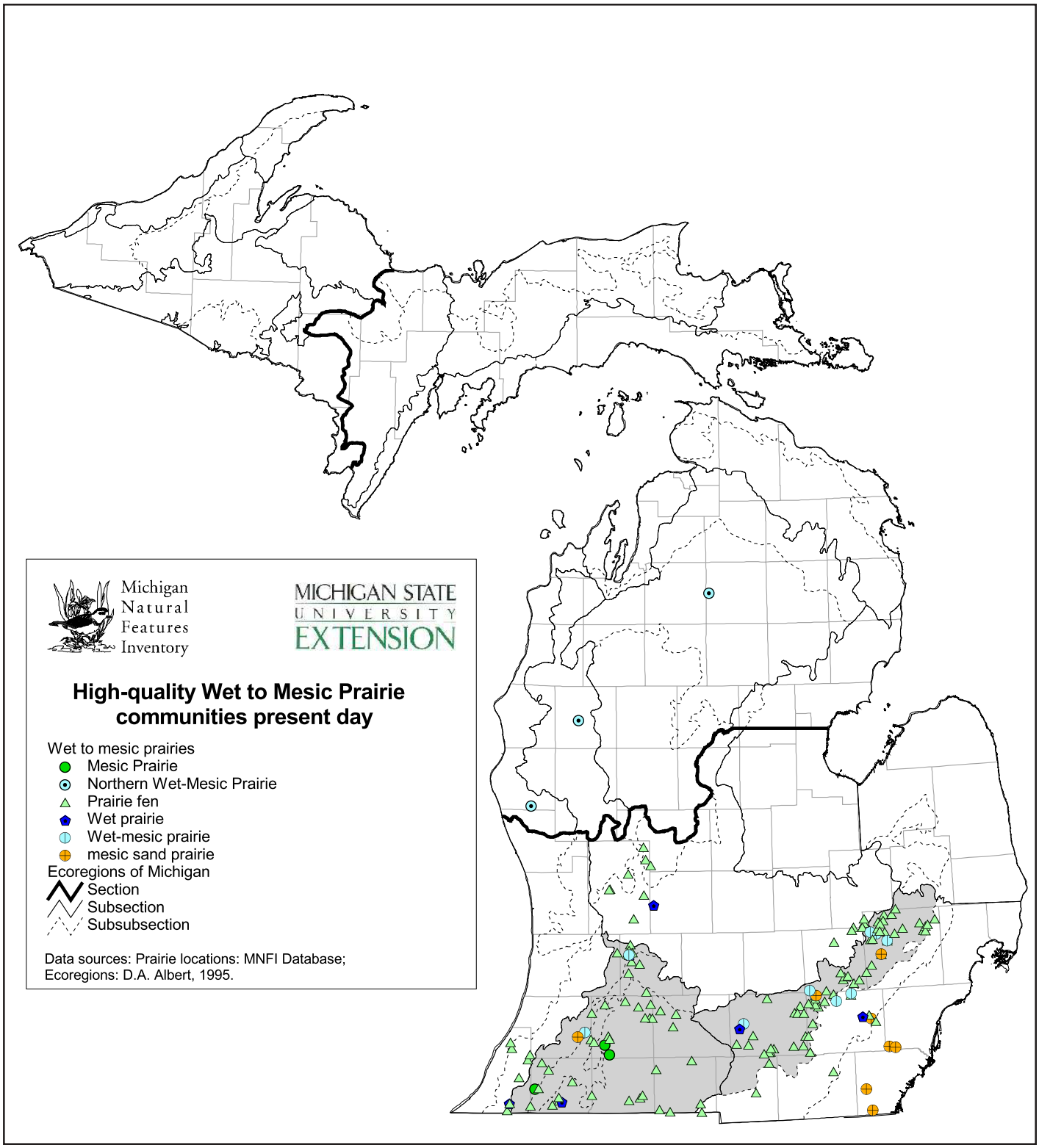


Figure 3. High-quality wet to mesic prairie communities present day, based on MNFI database. Note the clustering of communities in the Jackson and Kalamazoo interlobate regions of southern Michigan (area shaded in gray).

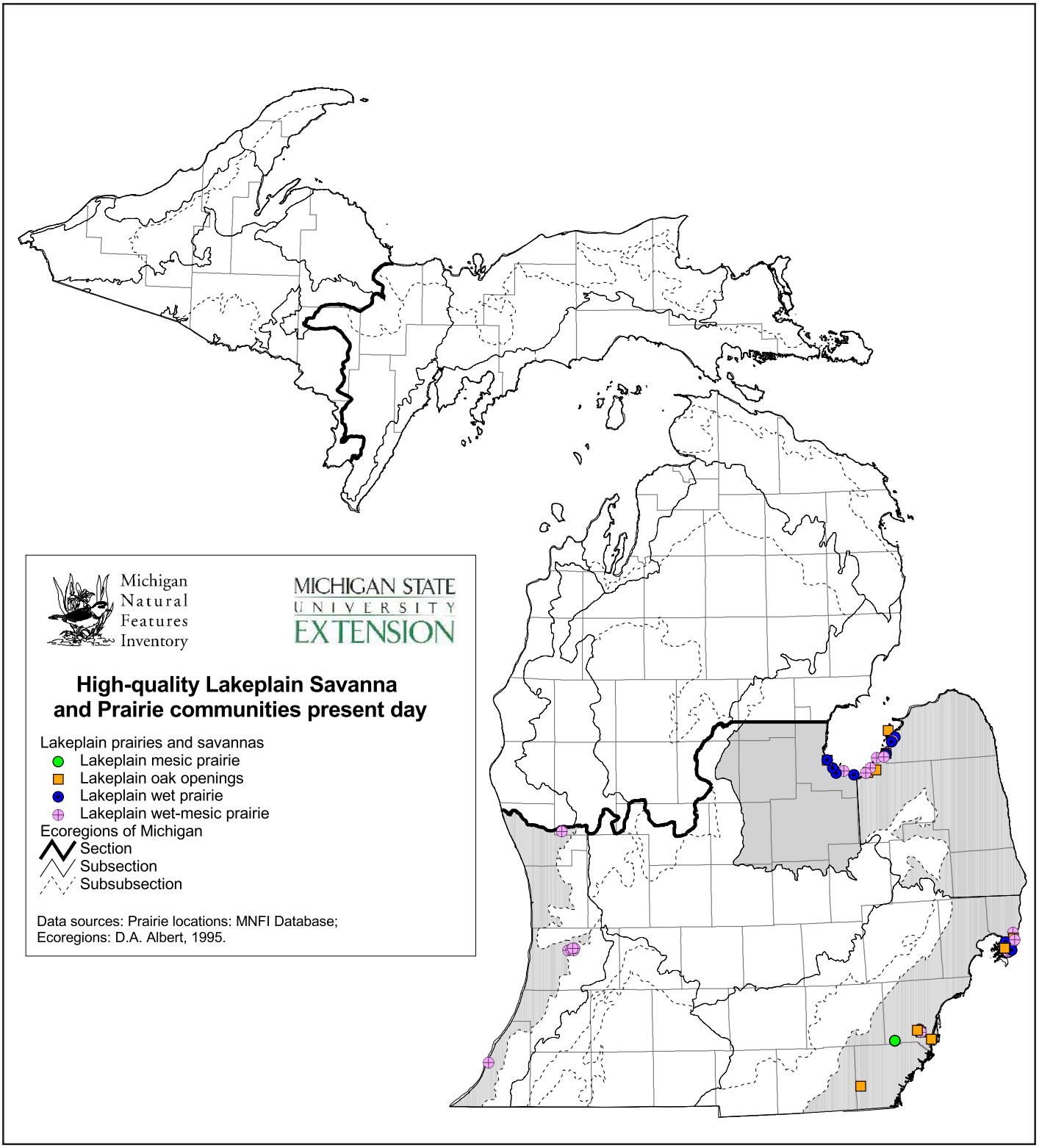


Figure 4. High-quality lakeplain savanna and prairie communities present day, based on MNFI database. In general, circular shapes represent prairie communities, while other shapes represent savannas. Note that all communities are located in glacial lakeplain regions (shaded in gray).

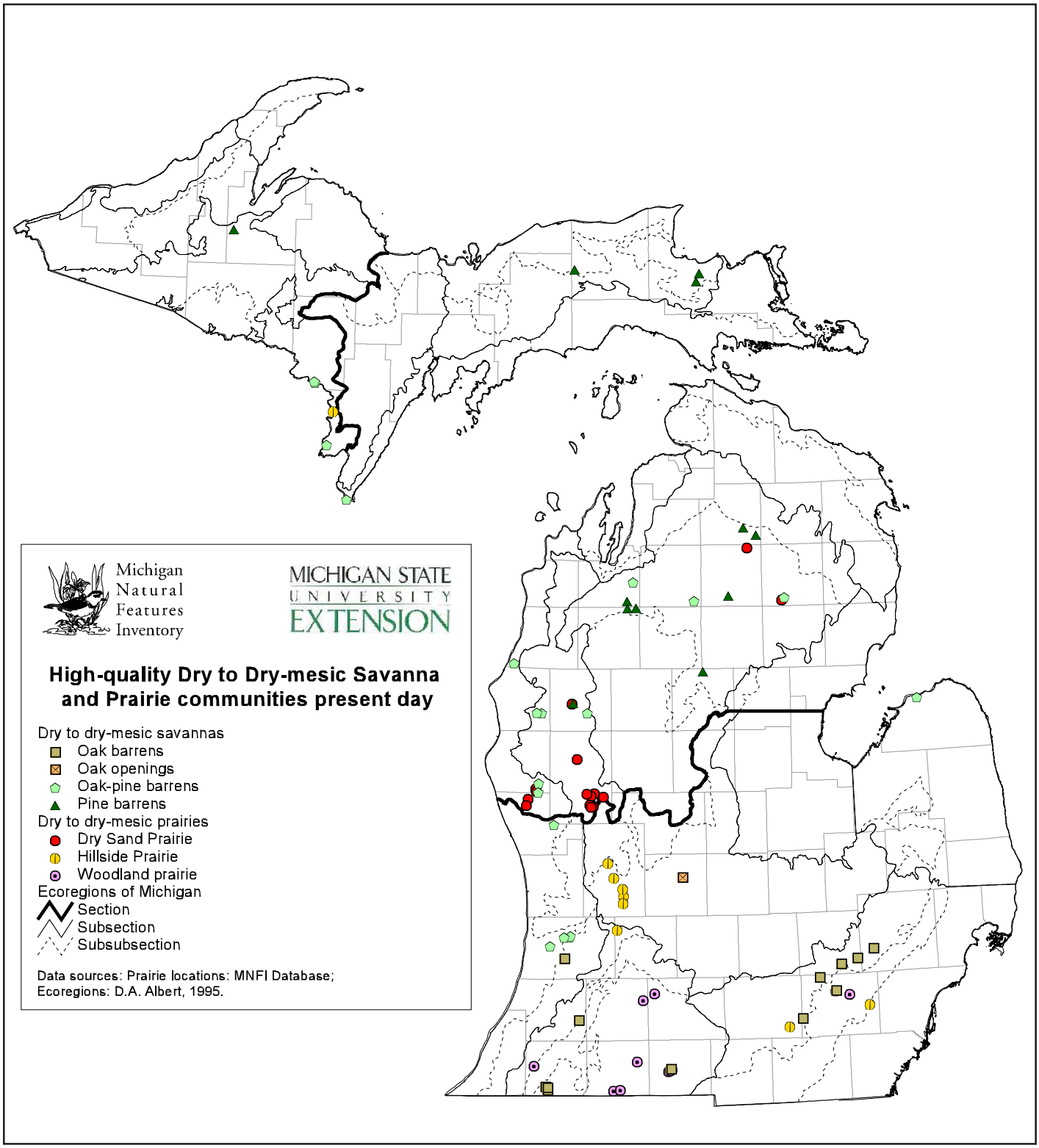


Figure 5. High-quality dry to dry-mesic savanna and prairie communities present day, based on MNFI database. In general, circular shapes represent prairie communities, while other shapes represent savannas.

Nature's Tool: Prescribed Fire

The most effective tool a manager can use to maintain prairies and savannas is fire. Historically, fire promoted the growth of herbaceous plants while setting back woody trees and shrubs. In addition, fire has been shown to stimulate grass growth and improve the browse nutrition of native warm season grasses while hindering exotic cool season grasses (brome, fescue, etc). Fire can also increase wildflower diversity, depending on the timing and seasonality of the burn. Many orchid species respond exceptionally well to fire. For example, at a nature sanctuary in southeast Michigan, the number of flowering state-threatened white lady's slippers (*Cypripedium candidum*) increased tenfold from around 200 to over 2,000 after a prescribed burn.

Christopher Hoving, Michigan DNR

Prescribed fire is the most effective tool land managers can use to maintain prairies and savannas.

Fire Frequency

Historically, it is estimated that fires occurred anywhere from annually to once every 20 years. Fire frequency varied according to community type, topography, fuel load and flammability, and weather. In general, sites in the mesic portion of the continuum burned more frequently than extremely wet or dry sites. Wet sites might only burn during extremely dry spells, and have the added effect of a high water table to limit growth of woody species. Similarly, the droughty soils of very dry sites would both limit tree and shrub encroachment as well as slow the growth and accumulation of sufficient fine fuels needed to carry a burn. In general, a one burn every 2 to 5 years would be appropriate to maintain a high-quality remnant prairie or savanna. If a site is degraded and has not been burned in many years, more frequent burns will likely be necessary at first to restore proper structure and balance of trees and shrubs to grasses.

Fire Seasonality

The seasonality of a burn is one of the most important factors in determining the effects of a fire. In general, fire has the greatest adverse impact on plants that are actively growing. For example, an early spring fire may vigorously burn off herbaceous vegetation and top kill shrubs, but because roots are full of carbohydrate reserves, they resprout vigorously. In contrast, if top-killed by fire when root reserves are at their lowest in late spring burn or summer, sprouting may be significantly less (Richburg 2005).

Spring burns also have the effect of inhibiting actively growing weedy cool-season grasses and stimulating warm-season grasses and late-flowering forbs (asters, goldenrods, etc.) (Howe 1994, 1995) (Table 3). However, spring fires also can decrease early-blooming wildflower species by burning up newly growing plants and increasing competition by stimulating earlier growth of warm-season grasses.

Susan R. Crispin, MNFI

White lady's slipper (*Cypripedium candidum*), a state-threatened orchid, responds exceptionally well to prescribed burns.

The seasonality of a burn is one of the most important factors in determining the effects of a fire. In general, fire has the greatest adverse impact on plants that are actively growing.

Table 3. Changes in dominance of different groups of grasses and forbs in response to fire seasonality (Howe 1994, 1995; Coppedge et al. 1998; Sparks et al. 1998; Copeland et al. 2002).

Time of fire	Early spring (April-May)	Mid Summer (mid-July)	Late summer (Sept)	Fall (Oct – Nov)
Grasses and sedges				
Warm season[W]	Increase	Decrease	No change	Increase
Cool season[C]	Decrease	Increase	Decrease	Decrease?
Forbs				
Early Flowering forbs[E]	Decrease	Increase	Increase	Increase?
Mid-Flowering forbs[M]	Decrease	Increase?	Increase	Increase?
Late-Flowering forbs[L]	Increase	Decrease	Increase?	Increase?
Legumes (Fabeceae)[F]	Increase	Increase?	Increase?	Increase

[W] Examples include: big bluestem, little bluestem, Indian grass, and switch grass.
[C] Includes native grasses such as Canada wild-rye, exotic grasses such as brome and fescue, as well as sedges (*Carex* spp.) and rushes (*Juncus* spp.). Results are likely highly species-specific.
[E] Examples include: black-eyed susan, ohio spider-wort.
[M] Examples include: annual fleabane, milkweeds, yarrow, wild bergamot.
[L] Examples include: goldenrods, asters, blazing stars.
[F] Examples include: lupine, bush-clovers, tick-trefoil, leadplant.


Michael A. Kost, MNFI

Legumes such as lupine (*Lupinus perennis*) display increased growth following a prescribed burn.

Growing season fires may be best for controlling woody shrubs and maximizing wildflower diversity.

In contrast, summer burns reduce dominance of warm-season grasses and yield an increase in early and mid-flowering forbs, sedges, and cool-season grasses. This can be beneficial because over time warm-season grasses often completely dominate and out-compete or even eliminate other native species important for wildlife. Burns during mid-growing season (July) show the greatest increase in forbs and decrease in warm season grasses (Sparks et al. 1998). Late-growing season (September) burns result in a more modest increase in early and mid-season flowering forbs with little to no change in warm season grass dominance (Copeland et al. 2002). Legumes (e.g. lupine, bush-clovers (*Lespedeza* spp.), and tick-trefoils (*Desmodium* spp.)), which are critical for some species of wildlife as well as being important in fixing nitrogen in nutrient-limited soil show increased growth following any fire, in particular after burns in spring or fall (Coppedge et al. 1998).

Currently, most prescribed burns are conducted between late March and early May when humidity is low, winds are light and fine fuels (grasses, sedges, oak leaves, etc.) burn readily without getting out of control. Occasionally, burns are also conducted in mid to late fall when plants have mostly senesced, but appropriate burn days with suitably low humidity and light wind can be limited. Historically, many fires in Michigan did occur during spring or fall, especially if started by Native Americans. Lightning-strike fires were common during the summer as well, but were likely smaller in size. Very few summer prescribed burns are currently

conducted, but may be very effective in encouraging early-flowering wildflowers and maximizing biodiversity. Aiming for a combination of spring, fall, and even occasional summer burns is the best approach in most situations, since it mimics natural patterns and will lead to the most diverse and fully functional system and provide habitat for the greatest range of species.

Impacts on Wildlife: Burn Completeness, Ignition Pattern, and Timing

Never aim for a 100% burn of all prairies or savannas at a given site. While some wildlife species are fire-adapted and can flee or recover quickly from burns, other species can be severely impacted by fire. Of particular concern are species such as turtles, snakes, and insects, including many species of rare butterflies. Leaving unburned refugia as habitat for wildlife is an important component of habitat management, especially where rare or fire-sensitive species are known to occur. This can be accomplished by burning only half to two-thirds of an entire site or breaking up the site into two or three burn units and only burning one unit in a given year. Alternatively, a burn can leave unburned patches scattered throughout the burn unit if weather conditions are less than ideal for a 100% burn. Either of these approaches helps enable fire-sensitive insects in particular to recolonize burned areas from adjacent unburned patches (Panzer 2003).

The type of burn can have large impacts on the survival of semi-mobile wildlife such as snakes and turtles. Fast-moving head fires often overtake these animals before they have an opportunity to seek cover. In contrast, back burns move much more slowly and give species, many of them fire-adapted, a chance to move into burrows or other protected areas.

Likewise, the pattern of ignition and resulting burn impacts wildlife survival. In a typical "ring fire" prescribed burn, a back burn is ignited in the downwind portion of the burn unit, followed by ignition of the burn lines toward the wind direction making a flanking fire, and is finished by lighting the upwind line, creating a head fire that pushes into the center of the burn unit (Figure 6). While this method is safe and time-efficient, it also traps all but the most mobile wildlife. In several case studies, numerous individuals of snakes and turtles, including massasauga and other rare

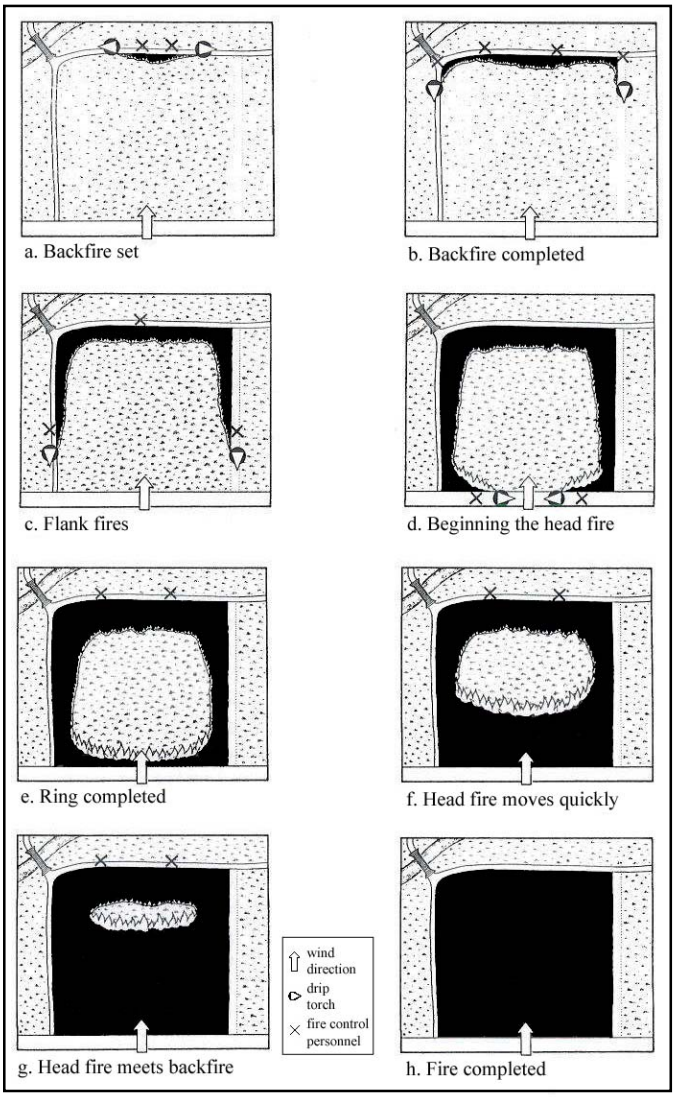


Figure 6. Typical ignition and burn pattern of a ring fire. (Courtesy Wayne R. Pauly, Dane County Park Commission, Madison, WI.)

Christopher Hoving, Michigan DNR

Turtles and other wildlife can be killed when encircled in a ring fire, while back burns or strip fires allow wildlife a chance to escape.

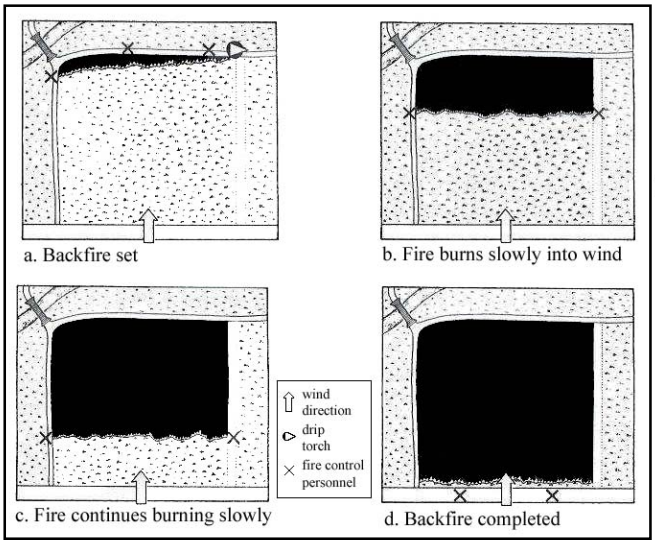


Figure 7. Typical ignition and burn pattern of a back fire or back burn. (Courtesy Wayne R. Pauly, Dane County Park Commission, Madison, WI.)

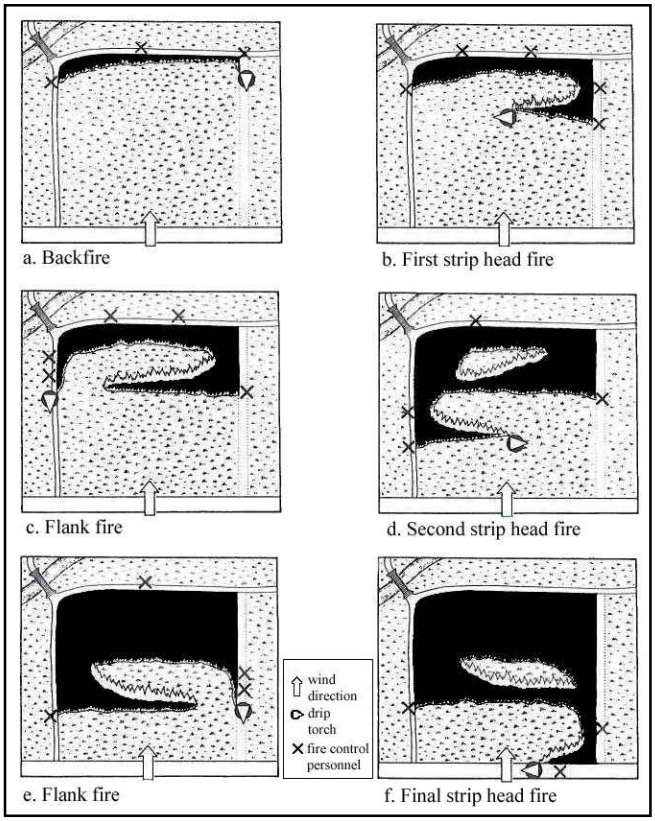


Figure 8. Typical ignition and burn pattern of a strip fire. (Courtesy Wayne R. Pauly, Dane County Park Commission, Madison, WI.)

species, have been killed in this manner. Alternative ignition patterns, such as back-burning the entire unit (Figure 7) or lighting small strip fires (Figure 8) provide wildlife with a chance to escape the burn entirely or seek cover.

Finally, the timing or seasonality of prescribed fire also can have a great deal of impact on wildlife. For example, burning when wildlife is generally dormant, such as early spring or late fall has been officially recommended to minimize impacts to eastern massasauga (state special concern, federal candidate species). However, other species, such as insects over wintering in the duff layer, may be more susceptible at this time of year. Borer moths are one example. In early spring and late fall eggs are present in leaf litter, but in the growing season they are burrowed safely underground in the roots of host plants. Also of particular concern are the Mitchell's satyr (*Neonympha mitchellii mitchellii*) and Karner blue butterflies, both federally endangered species. It is not yet known if and how these species may be adapted to fire, and a conservative approach that follows Fish and Wildlife Service guidelines is recommended if working in habitats occupied by these species.

In general, concern over wildlife impacts should not prevent prescribed burning. A strict approach to leaving a particular percentage of unburned refugia is not usually necessary, but care should be taken to balance burn objectives while minimizing adverse impacts to wildlife. Overall, managers should seek to manage and maintain the ecosystem without eliminating all habitat for grassland-dependent species.

Doug Landis, Michigan State University

Burn objectives should balance the need to maintain the ecosystem without adversely impacting wildlife populations, especially for rare species like the federally endangered Mitchell's satyr.

The rest of the management toolbox: mowing, grazing, disking, and herbicides

Though prescribed fire is usually the best tool from an ecological perspective, if it is not a viable management option other alternatives may accomplish management goals. These options include, but are not necessarily limited to mowing or brush-hogging, grazing, disking, and spraying herbicides.

Mowing or brush-hogging

If seeking to simply reduce standing vegetation, mowing may be appropriate. The downside of mowing is that if done repeatedly for several years, wildflower species may be eliminated from the site. If a site is being invaded with shrubs or small trees, mowing may temporarily reduce the woody competition and allow growth of more grasses. However, unless stumps are treated with an herbicide, most shrubs and trees sprout vigorously if cut. This results in the woody species regaining similar dominance in just 1 or 2 years, and can lead to an even greater dominance if left untreated for several years.

Ryan P. O'Connor, MNFI

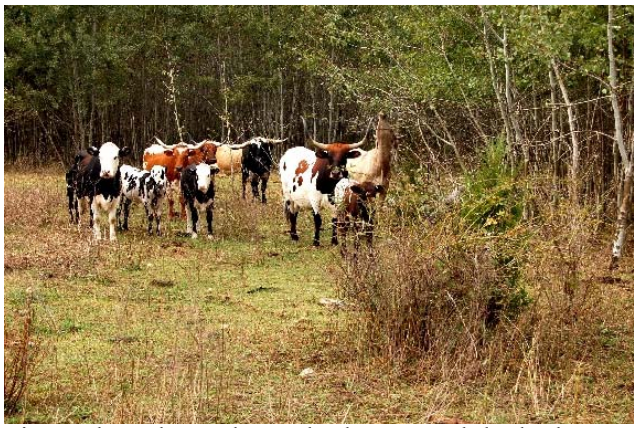
Mechanical equipment like a treaded bobcat with a brushhog attachment can quickly clear thickets of shrubs.

Mowing or brush-hogging is best used in conjunction with another management option, such as prescribed fire. Conducting a late spring or fall burn at a site a year or so after brush-hogging may provide secondary kill on resprouts. Cutting down dense shrubs may also allow more fine fuel to build up and carry a burn more effectively. If too large to cut down entirely, a dense shrub thicket can also be opened up by brush hogging small areas into the interior, allowing the next fire to penetrate the thicket and provide greater control.

Alternatively, brush-hogging could be followed by an herbicide treatment of resprouts, an approach that has been used successfully in Indiana to restore large areas of formerly shrub-dominated fen, wet prairie, and wet meadow. If working in wetlands, be sure the ground is well-frozen before using mechanized equipment and consider using small machines with tank-like treads (such as the Bobcat-like Posi-Trac) that minimize impact to sensitive wetland soils.

Grazing

Grazing with cattle or other livestock has been used in some areas to reduce woody vegetation where using mechanized equipment or herbicides are not appropriate. Short-term effects of grazing may yield positive results, but the long-term effects are mixed at best. Some of the downsides of grazing include the fact that animals will not preferentially eat woody or exotic species, and they often avoid problematic thistles and thorny shrubs like autumn-olive, buckthorn, and multiflora rose (*Rosa multiflora*). Native plants, especially wildflowers, may suffer an initial decline. Another issue is the potential for the introduction of new exotics, especially if livestock manure contains weed seeds from hay or plants eaten at other sites. In wetlands, trampling of sedge tussocks that provide critical habitat for other plants and animals is inevitable. As tussocks recover, they provide an ideal habitat for shrub seedlings, and when grazing ceases, shrubs quickly take over formerly herbaceous wetlands, making the situation worse than prior to grazing (Middleton 2004).



Ryan P. O'Connor, MNFI

Livestock can be used to set back unwanted shrubs, but because they also eat and trample native species their use in high-quality natural areas should be avoided.

Rotational grazing in large upland grasslands 100 acres or more may yield a better outcome, especially when combined with other tools like prescribed burning. Isolating livestock on only a portion of the site helps to control shrubs as well as reduce dominance of grasses and therefore increases wildflower diversity. The need for movable fences can be eliminated by burning a portion of a site (approximately 1/3) every year. Because the flush of new grass growth is more nutritious and palatable than in the unburned portion, grazers naturally congregate and spend the vast majority of their time grazing in the newly burned area (Jamison et al. 2005). Grazing on grasses and localized trampling exposes mineral soil much the way buffalo did in pre-European times, allowing wildflowers to flourish the following year when livestock move on to a newly burned portion (Fuhlendorf & Engle 2001). Continued over time, diversity is maximized as sites are burned & grazed (year 1), recover with a flush of wildflowers (year 2), and return to grass dominance (year 3).

Disking or plowing

Without fire or other disturbance, a thick sod of native or non-native graminoids can form and cause a decline in diversity. A disk or plow can be used to lightly break up thick sod and better facilitate interseeding with other grasses or wildflowers. This approach carries significant risk, however, since the exposed mineral soil provides an ideal habitat for weeds and exotic species. Disking also destroys clump-forming grasses and sedge rhizomes, and may severely impact wildflowers growing from bulbs or corms. Additionally, any soil disturbance on hillsides should be strictly avoided, as it may cause erosion.

In most cases, disking probably carries more risks than benefits unless the site is completely dominated by exotic grasses or other weeds. At most remnant sites, one or two years of prescribed fire will similarly reduce sod and provide microsites for interseeding without the risk of introducing exotics with large-scale soil disturbance. Burning in summer or fall may do more to reduce growth of sod-forming warm season grasses than a spring burn; a late spring burn may more effective for reducing Pennsylvania sedge (*Carex pensylvanica*).

Herbicides: Types

Once rejected by many restorationists for health and environmental concerns, selective use of herbicides is now considered an essential tool to managing and restoring unique habitats. There are a wide variety of chemicals available to managers, ranging from herbicides that kill all green plants (such as glyphosate) to those that target only broadleaves (triclopyr; 2-4, D), to those that are more selective (imazapic, also known by the trade name Plateau®). Some formulations are approved for use in and around wetlands, while others are strictly labeled for use in uplands. For example, glyphosate is commonly mixed with an oil-based surfactant that is toxic to amphibians, and standard formulations such as RoundUp® should never be used in or near water, including ponds and small streams (Relyea 2005, Monsanto Co. 2001). Alternative formulations (such as Rodeo® or Aquastar®) mix the active chemical in a water-based solution which minimizes harm to fish and wildlife.

When choosing an herbicide, always select a chemical and a concentration that minimizes harm to non-target plants and animals while still providing effective control of the target plant species. Always read and follow the label completely, which specifies what the herbicide can and cannot be used to control and provides specific direction for use. Additionally, an herbicide applicator's license is usually required for anyone applying herbicide as part of their job (private landowners applying unrestricted, over-the-counter herbicides to their own property are exempt). To apply for an applicator's license or to find a list of certified applicators in your area, contact the Michigan Department of Agriculture or visit http://www.michigan.gov/mda. For a list of commonly used herbicides in restoration, please see Table 4.

Herbicides: Methods of Application

Different means of application are available also, and may be more or less appropriate depending on the problem and goals of the manager. These include, but are not necessarily limited to foliar spraying, cut-stump application, basal bark application, drill and fill, and other variations. These methods are described in brief below. If actually applying any of the methods in the field, more detailed information should be sought from a more thorough publication such as The Weed Control Handbook by The Nature Conservancy or by consulting an expert in natural areas restoration.

Table 4. Commonly used herbicides in ecological restoration. Adapted from: Tu et al. 2001. Weed Control Methods Handbook. The Nature Conservancy.

Herbicide	Brand Name Examples	Typical use	Target Species	2006 Cost/acre (broadcast)	Notes
2,4 D	Navigate® Class® Weed-Pro® Justice®	foliar	broadleafs; doesn't kill grasses	generic: $3.95	Inexpensive and common herbicide used for over 50 years. Mobile in soil. Petroleum-based formulations can volatize and drift above 75 degrees F.
Clopyralid	Reclaim® Curtail® Transline®	foliar	broadleafs, especially spotted knapweed	Transline: $44.15	Highly selective herbicide developed as an alternative to picloram. Mobile in soil.
Fluazifop-p-Butyl	Fusilade DX® Fusion® Tornado®	foliar	cool season grasses	Fusilade DX: $29.10	Toxic to most grasses except annual bluegrass and all fine fescues.
Glyphosate	RoundUp® Rodeo® Accord® Aquamaster®	foliar, cut-stump	virtually all actively growing species	Glypro Plus: $5.73 Aquamaster: $7.75 RoundUp Pro: $10.46, $0.25/oz (cut stump)	Little to no soil activity, binds to soil particles. The surfactant used in RoundUp and similar products is highly toxic to aquatic organisms, always use wetland formulations near water.
Imazapic	Plateau® Journey® Cadre®	pre-emergent	varies by species	Journey: $8.45	Degree of control depends on selectivity of individual species.
Imazapyr	Habitat® Arsenal®	foliar	grasses & broadleafs	Habitat: $37.75	Long half-life (up to 141 days). Provides long-term total vegetation control. Especially used for Phragmites, cattail, and reed canary grass.
Picloram	TordonK®	cut-stump	broadleafs, vines, and woody plants	$0.28/oz (cut stump)	Environmental persistence and high soil mobility, can kill adjacent trees via root contact, potential for groundwater contamination.
Sethoxydim	Poast®	foliar	grasses	Poast: ~$15.00	Rapid degradation (5 day half-life, hours in sunlight) can limit effectiveness.
Triclopyr	Garlon4® Garlon3A®	foliar, cut-stump, basal bark	broadleafs; doesn't kill grasses	Garlon 3A: $7.88 Garlon 4: ~$13.50, ~$0.30/oz (cut stump, basal bark)	Commonly used herbicide. Garlon 4 is for use in uplands, but can volatize and drift above 80 degrees F. Garlon 3A is for use in wetlands.

Foliar spraying

Foliar spraying is one of the most commonly-used application methods, and simply involves spraying a diluted mist of herbicide onto the foliage of a plant. In situations where invasive plants completely dominate, this can be very effective. However, where weeds are more scattered and interspersed with desirable natives, it can often result in significant damage to non-target plants, unless done with extreme care or in situations where damage can be minimized. Such cases might include plants with a very dense canopy that will intercept all of the chemical, or spraying over-wintering rosettes like garlic mustard (*Alliaria petiolata*) in late fall or very early spring when most other plants are dormant. Foliar spraying is only effective when plants are green and actively growing. For most species this is spring through fall, but plants that stay green year-round may be treated at any time as long as the air temperature is above 32 degrees Fahrenheit.

Chris Evans, University of Georgia

Because it stays green year-round, garlic mustard (*Alliaria petiolata)* can be controlled by spraying rosettes with herbicide in late fall and early spring when most other plants are dormant and are unlikely to be harmed.

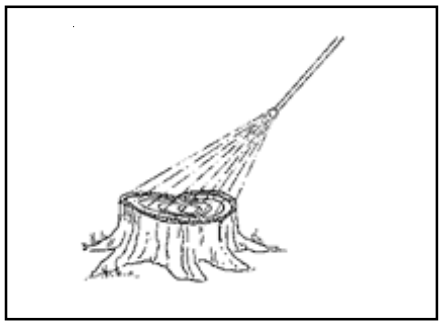


Image courtesy Randall Heiligmann, Ohio State University Extension.

Figure 9. Cut-stump application of herbicides.

Shrubs that are cut will resprout vigorously unless the stumps are treated with an herbicide.

Ryan P. O'Connor, MNFI

Applying herbicides to cut stumps with a PVC applicator is a labor-intensive but very effective means of controlling invasive species in natural areas.

A variation of foliar spraying that targets specific plants is wicking. A cloth or cotton glove worn over top of a chemical-proof rubber glove is soaked with herbicide and then swiped over the stem of individual plants. Though this practice is very labor-intensive, it virtually eliminates the risk of overspray and non-target damage and may be appropriate in high-quality natural areas with few invasives.

Cut-stump application

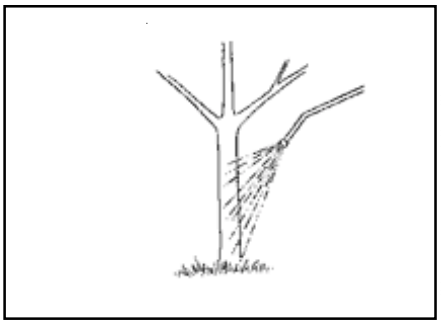
Cut-stump application is also commonly used in natural areas management and involves first cutting down a shrub or small tree and then spraying or dabbing a concentrated dose of herbicide onto the cut stump, which kills the root and prevents resprouting (Figure 9). Though it is the most effective way to eliminate especially hard-to-kill woody species like buckthorn and autumn-olive without killing non-target plants, it is also very labor intensive. Traditionally, when treating a multi-stemmed shrub or clone every single stem was cut and herbicided to prevent resprouting. However, recent research suggests that entire multi-stemmed clones of common buckthorn can be killed if only the largest stem in the clone is cut (or girdled) followed by an application of concentrated herbicide (Pergams and Norton 2006). Because only one stem of a large clone must be treated, significant time, effort, and money are saved. It is not known if this approach works shrub species other than common buckthorn, but experimentation and careful research on this topic is encouraged.

Dabbing herbicide onto cut stems can be difficult. Staff from The Nature Conservancy have designed an applicator constructed from PVC pipe and a sponge that is simple but effective. Design and use instructions can be found online at: http://tncweeds.ucdavis.edu/products/handbook/22.PVCapplicator.pdf.

Cut-stump application should not be used at the height of spring when plants are flushing, since rapid upward sapflow prevents the chemical from being draw down into the roots. Unlike foliar spraying, cut-stump application does not require a plant to be actively growing and can be done nearly year-round, as long as cold temperatures don't cause the herbicide mixture to freeze on the stump. If using glyphosate, stems should be treated as soon as possible after cutting, ideally within 5 minutes. If using triclopyr, prompt application is less critical.

Basal-bark application

Basal-bark application has long been used in forestry operations and is gaining popularity with other land managers. It can be used selectively on individual trees and shrubs without the labor-intensive process of cutting the stem. A chemical such as triclopyr (Garlon4®) mixed with oil is sprayed around the entire lower portion of an uncut woody stem (Figure 10). Stems must be six inches or less in diameter for basal bark spraying to be effective. Traditionally, diesel fuel was used as the carrier oil, but this carries significant risk to non-target plants as well as animals. In natural landscapes, a generic, non-toxic, bark-penetrating oil can be used instead and yields equally effective results. Commonly-used premixed formulations such as Pathfinder II® are also commercially available. Because of the surfactant oils used, basal-bark treatments should never be done in or near wetlands. It should be noted that basal bark treatment may not be equally effective for all species, as a recent study revealed significant sprouting of common buckthorn six months following treatment (Pergams and Norton 2006).



All images courtesy Randall Heiligmann, Ohio State University Extension.

Figure 10. Basal bark application of herbicides.

Drill and fill / Girdling

Drill and fill is a method of killing large trees and shrubs without cutting them down. A small hole is drilled at an angle down into the stem and concentrated mixture of herbicide is placed into the hole, allowing it to soak into tree. Though seemingly quick and efficient, it is seldom used by natural areas managers except perhaps to treat large clones of trees that might otherwise resprout, such as black locust (*Robinia pseudoacacia*) or tree-of-heaven (*Ailanthus altissima*). From a practical standpoint, the stems of the shrub or tree must be sufficiently large to drill into, making it impractical for smaller shrubs or multi-stemmed clones that contain young sprouts.

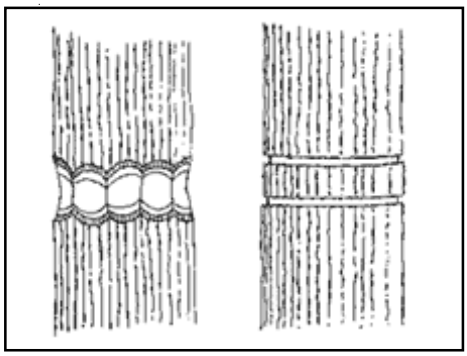


Figure 11. Girdling with a hatchet (left) or chain saw (right).

Girdling (Figure 11) can also be used in combination with herbicide in a similar fashion, as can frilling. Frilling is accomplished by using a hatchet to completely encircle the stem with deep notches that peel back the bark and cambium without completely removing it from the tree (Figure 12). Following girdling or frilling, the notch is filled with herbicide (Figure 13). A recent study on shrub control methods showed girdling combined with herbicides to be equally effective as cut-stump herbicide on large common buckthorn 3 to 15 inches in diameter (Pergams and Norton 2006).

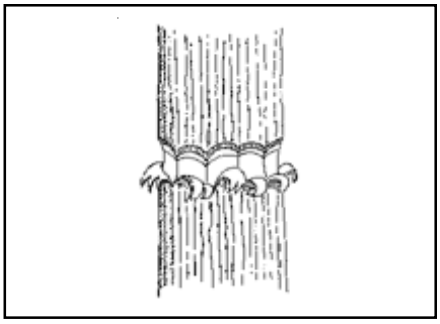


Figure 12. Frilling with a hatchet.

John M. Randall, The Nature Conservancy

Common buckthorn (*Rhamnus cathartica*)

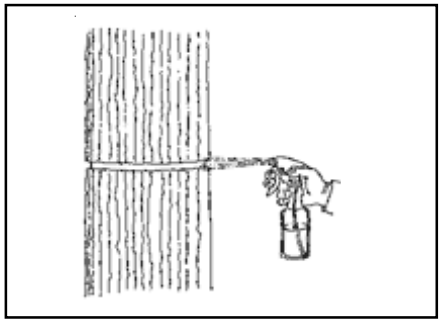


Figure 13. Application of herbicide onto a girdle.

What are your goals?

There are several tools that can help determine the potential for restoration at a site. Vegetation circa 1800s is an excellent source of information on the former distribution of prairies and savannas, and is easily accessible in both paper and digital (GIS) form. This data is best used at the scale of a region, county, or township, because it is compiled from GLO survey data based primarily along section lines (each one mile apart), although surveyors did note when they cross large expanses of prairie.

The second primary source of information useful in assessing restoration goals is the vegetation at the site itself. The presence of large open grown "wolf trees" in an otherwise young forest can be a sign of former savanna. Additionally, the presence of prairie grasses and forbs in an oak forest likely indicates a restorable savanna. A small stand of prairie vegetation surrounded by shrubs or forest may actually be a remnant pocket of prairie within a much larger former savanna. For more examples and an on-the-ground key to assessing restoration options, please refer to the Tallgrass Restoration Handbook (Packard 1997). In general, it is best to start with the highest quality area and work outwards, gradually enlarging the target restoration area as time and resources allow.

Goal: Maintenance of a high-quality remnant

If managing a site that already has an ideal mixture of grasses, forbs, and trees and shrubs, conducting burns every 3-5 years is appropriate in most cases. This should be frequent enough to maintain a dominance of grasses and sedges while allowing a diversity of wildflowers to thrive. From a habitat perspective, it provides cover for wildlife that prefer built up thatch, such as the state-threatened Henslow's sparrow, as well as bare ground and new growth for browse in freshly burned areas.

Goal: Reducing native or invasive shrubs in a remnant

In most remnant sites, shrub invasion by both native and non-native species has become a major problem due to fire suppression. If there is sufficient fine fuel to carry a fire, conducting a prescribed burn is often very effective. Burn late in the spring, mid summer, or early fall to maximize shrub kill and limit resprouting. Root reserves, the source of energy for resprouts, are at their lowest when shrubs are flowering and fruiting

Close Up: Invasive Species

Exotic invasive species are one of the primary issues facing land managers today. Often introduced from Europe and Asia, they outcompete native species and wreak havoc on natural ecosystems by growing rapidly, seeding prolifically, reproducing vegetatively, and even releasing toxic chemicals into the soil. Biological controls that keep them in check in their native range are often absent in the U.S.

James R. Allison, Georgia DNR

Autumn-olive (*Elaeagnus umbellata*) cannot be controlled by fire alone.

There are several ways of controlling invasives. One of the most effective is to restore disrupted ecological processes, such as returning fire to the landscape through prescribed burning or restoring hydrology in wetland systems.

Mechanical control, either by cutting or pulling by hand or with larger equipment is also effective, especially when infestations are of sufficient size that prescribed burning alone is ineffective.

Cutting is more effective when combined with chemical control, with herbicides either applied to the cut stump or in a foliar spray to resprouts. Timing herbicide applications to hit target species when they are most susceptible while minimizing impact to native species is critical.

Biological control agents have also been effective in controlling some species like purple loosestrife (*Lythrum salicaria*), but years of extensive careful testing are required to ensure agents don't cause other negative impacts.

Elizabeth Czarapata, Wisconsin DNR

Swallow-wort (*Vincetoxicum* spp.) is a rapidly spreading new invasive in Michigan.

Ryan P. O'Connor, MNFI

"Wolf trees", or open grown oaks, may indicate a forest is actually a remnant savanna that may benefit from restoration.

Many of our oak woodlands are actually former savannas that have closed in due to fire suppression.

Bradford Slaughter, MNFI

A site will likely respond well to savanna restoration if prairie grasses, sedges, and forbs are still present beneath the oak canopy.

(Richburg 2005). Both back burns as well as vigorous head fires can provide effective kill. Consider burning the same unit several years in a row, especially if shrubs resprout. Larger shrubs and trees are often only weakened by an initial fire; it is often the second or third fire that causes mortality. It is important to note that fire does not impact all species equally. A burn may set back dogwoods and small diameter buckthorns, but it is generally ineffective at controlling large buckthorns and autumn-olive.

If burning fails to control shrubs or is not a feasible option, use cut-stump application of herbicides to remove specific shrubs or small trees. Brush can be scattered if it is limited in quantity, or piled and burned in winter to minimize soil damage. If the site is moderate to low in quality, and there is less risk of herbicide damage to non-target plants, consider basal bark application with triclopyr. It kills broadleaf shrubs and forbs, but will not harm grasses and sedges. Both cut-stump and basal bark application can also be used in conjunction with prescribed fire to control specific large or hard-to-kill shrubs such as glossy buckthorn or autumn-olive.

Finally, a more industrialized approach to reducing shrubs may be to use large mechanized equipment such as a brush hog, Positrack, HydroAx. Be aware that many shrubs and small trees will resprout. Stumps are often shattered by the massive blades, making them nearly impossible to treat with traditional cut-stump herbicide applications. Additionally, it is often difficult to get equipment back into an area for follow-up treatment since the shattered stems can easily puncture tires, though resprouts can be treated by hand with a backpack sprayer. New equipment like the Brown Brush Monitor simultaneously cuts and applies an herbicide to stems, which should reduce resprouting. Despite drawbacks of where and when it can be used, mechanized equipment may be the most efficient and cost-effective option if working to restore large areas.

<u>Goal: Restoring a closed-canopy oak woodland into savanna</u>

Many of our oak woodlands are actually former savannas that have closed in due to fire suppression. When evaluating a potential savanna restoration site, it is important to look for two key components: 1) presence of open-grown or "wolf" oak trees and 2) presence of herbaceous prairie or savanna species in the groundcover (see community descriptions for examples). The latter is often more critical to a successful savanna restoration.

It is important to keep in mind that it took several decades for sites to become degraded and it may take equally long to restore them. Quick fixes often backfire. If aiming for a 30% canopy, cutting out the other 70% of the trees may lead only to a large patch of brambles. A better approach might be to gradually thin the canopy while conducting prescribed burns to stimulate the herbaceous layer. Oak leaves burn readily in both spring and fall, and are sufficient to carry a fire at most sites with a

dominant oak canopy. In some cases, cutting trees may not even be necessary, since even large trees of red maple (*Acer rubrum*) and black cherry (*Prunus serotina*) will be killed by fire if sufficient fuel is present to burn repeatedly.

One of the most effective ways to restore savanna might be to allow a fire on an adjacent prairie to simply burn into the woods. The intense flames near the prairie will cause greater tree mortality on the outer edge of the savanna, creating a "feathered" edge over time. Several yards into the woods, fuel load and flame heights will quickly diminish, having less of an effect on trees, and creating a more natural spatial gradation from prairie to savanna to closed canopy forest. Additionally, allowing fires to burn into adjacent upland woods also minimizes the need for large firebreaks. Instead of a disc or plow line, two tracks or trails may be sufficient burn breaks due to lower flame heights. In the woods, a leaf blower or hand rake can be used to quickly clear a small firebreak down to bare soil.

Christopher Hoving, Michigan DNR

By creating larger burn units that use foot trails and two tracks as fire breaks in oak woodlands rather than small burn units that rely on disked fire breaks at the edges of openings, prescribed fire can restore both prairie and adjacent savanna simultaneously.

Goal: Control of exotic grasses and wildflowers

Exotic grasses and wildflowers are problematic in both natural remnant prairies as well as planted grasslands. Specific techniques for controlling unwanted plants differ depending on the target species. A late spring prescribed fire can be very effective in reducing cool season grasses like brome and fescue, especially if native warm season grasses are present to provide competition. For spotted knapweed, a late spring, very hot fire has provided effective control at some sites. However, knapweed may only be stimulated following a low-intensity, relatively cool fire. Some invasive plants like white sweet clover (*Melilotus alba*) have a large seed bank and respond vigorously to fire the season following the burn. However, since this biennial only produces a large bushy rosette the first year, it can be successfully controlled with back to back burns. Knowing the biology of any problem species is of utmost importance when assessing control options.

Herbicides can also be used to control weeds, but care must be taken to avoid indiscriminant spraying where other desirable species will also be killed. Imazapic (Plateau®) has been widely used to help establish grassland planting because it kills troublesome weeds without harming most warm-season grasses and selected wildflowers. Other herbicides like clopyralid (Transline®) are especially effective in controlling spotted knapweed but do not harm grasses and sedges. Likewise, triclopyr (Garlon®) and 2-4, D effectively control broadleaf plants without harming graminoids.

Recommended Reading: Management

Czarapata, E.J. 2005. Invasive Plants of the Upper Midwest: An Illustrated Guide to Their Identification and Control. The University of Wisconsin Press, Madison, WI. 215 pp.

Packard, S. and C.F. Mutel, eds. 1997. The Tallgrass Restoration Handbook for Prairies, Savannas, and Woodlands. Island Press, Washington, D.C. 463 pp.

Tu, M., C. Hurd, and J.M Randall. Weed Control Methods Handbook: Tools and Techniques for Use in Natural Areas. The Nature Conservancy. http://tncweeds.ucdavis.edu/handbook.html Version date: April 2001.

Various authors: Element Stewardship Abstracts [on the control of invasive species]. The Nature Conservancy, Arlington, VA. http://tncweeds.ucdavis.edu/esadocs.html

Appendix A. Wildlife Species of Greatest Conservation Need occurring in prairies and savannas (Eagle et al. 2005). Under "Status", E is state endangered, LE is federal endangered, T is state threatened, LT is federal threatened, SC is state special concern, and C is federal candidate species.

Common name	Scientific name	Status	Prairie	Savanna
Amphibians				
Blanchard's cricket frog	*Acris crepitans blanchardi*	SC	x	
Blue-spotted salamander	*Ambystoma laterale*		x	x
Smallmouth salamander	*Ambystoma texanum*	E	x	x
Eastern tiger salamander	*Ambystoma tigrinum tigrinum*		x	x
Fowler's toad	*Bufo fowleri*		x	x
Pickerel frog	*Rana palustris*		x	
Northern leopard frog	*Rana pipiens*		x	x
Birds				
Cooper's hawk	*Accipiter cooperii*	SC		x
Northern goshawk	*Accipiter gentilis*	SC		x
Henslow's sparrow	*Ammodramus henslowii*	T	x	
Grasshopper sparrow	*Ammodramus savannarum*	SC	x	x
Blue-winged teal	*Anas discors*		x	x
American black duck	*Anas rubripes*		x	
Short-eared owl	*Asio flammeus*	E	x	x
Upland sandpiper	*Bartramia longicauda*		x	
American bittern	*Botaurus lentiginosus*	SC	x	
Common nighthawk	*Chordeiles minor*			x
Northern harrier	*Circus cyaneus*	SC	x	
Sedge wren	*Cistothorus platensis*		x	x
Yellow-billed cuckoo	*Coccyzus americanus*			x
Northern flicker	*Colaptes auratus*			x
Northern bobwhite	*Colinus virginianus*		x	x
Prairie warbler	*Dendroica discolor*	E	x	x
Kirtland's warbler	*Dendroica kirtlandii*	E, LE		x
Bobolink	*Dolichonyx oryzivorus*		x	x
Least flycatcher	*Empidonax minimus*			x
Merlin	*Falco columbarius*	T		x
Northern shrike	*Lanius excubitor*			x
Migrant loggerhead shrike	*Lanius ludovicianus migrans*	E		x
Red-headed woodpecker	*Melanerpes erythrocephalus*		x	x
Northern mockingbird	*Mimus polyglottos*			x
Savanna sparrow	*Passerculus sandwichensis*		x	x
Eastern towhee	*Pipilo erythrophthalmus*			x
Vesper sparrow	*Pooecetes gramineus*		x	x
Purple martin	*Progne subis*		x	x
Dickcissel	*Spiza americana*	SC	x	x
Field sparrow	*Spizella pusilla*		x	x
Eastern meadowlark	*Sturnella magna*		x	
Western meadowlark	*Sturnella neglecta*	SC	x	x

Appendix A. Continued

Common name	Scientific name	Status	Prairie	Savanna
Brown thrasher	*Toxostoma rufum*			x
Sharp-tailed grouse	*Tympanuchus phasianellus*	SC	x	x
Eastern kingbird	*Tyrannus tyrannus*		x	x
Barn owl	*Tyto alba*	E	x	
Insects: beetles				
American burying beetle	*Nicrophorus americanus*	E, LE	x	
Insects: Butterflies and Moths				
Dusted skipper	*Atrytonopsis hianna*	T	x	x
Pipevine swallowtail	*Battus philenor*	SC		x
Boreal fan moth	*Brachionycha borealis*	SC		x
Henry's elfin	*Callophrys henrici*	SC		x
Frosted elfin	*Callophrys irus*	T	x	x
Three-staff underwing	*Catocala amestris*	E	x	x
Quiet underwing	*Catocala dulciola*	SC		x
Gorgone checkerspot	*Chlosyne gorgone carlota*	SC	x	x
Wild indigo duskywing	*Erynnis baptisiae*	SC	x	x
Persius duskywing	*Erynnis persius persius*	T	x	x
Northern hairstreak	*Fixsenia favonius ontario*	SC		x
Barrens buckmoth	*Hemileuca maia*	SC		x
Ottoe skipper	*Hesperia ottoe*	T	x	x
Karner blue	*Lycaeides melissa samuelis*	T, LE	x	x
Doll's merolonche	*Merolonche dolli*	SC		x
Newman's brocade	*Meropleon ambifusca*	SC	x	
Mitchell's satyr	*Neonympha mitchellii mitchellii*	E, LE	x	
Poweshiek skipperling	*Oarisma poweshiek*	T	x	
Blazing star borer	*Papaipema beeriana*	SC	x	x
Golden borer	*Papaipema cerina*	SC	x	
Maritime sunflower borer	*Papaipema maritima*	SC	x	
Culvers root borer	*Papaipema sciata*	SC	x	
Silphium borer moth	*Papaipema silphii*	T	x	
Regal fern borer	*Papaipema speciosissima*	SC	x	
Tawny crescent	*Phyciodes batesii*	SC		x
Sprague's pygarctia	*Pygarctia spraguei*	SC	x	x
Grizzled skipper	*Pyrgus wyandot*	SC		x
Phlox moth	*Schinia indiana*	E	x	x
Leadplant flower moth	*Schina lucens*	E	x	x
Spartina borer moth	*Spartiniphaga inops*	SC	x	
Regal fritillary	*Speyeria idalia*	E	x	x


Mary Rabe, MNFI

Karner blue (*Lycaeides melissa samuelis*)


Ryan P. O'Connor, MNFI

Spotted turtle (*Clemmys guttata*)

Appendix A. Continued

Common name	Scientific name	Status	Prairie	Savanna
Insects: Cicadas and Hoppers				
A leafhopper	*Dorydiella kansana*	SC	x	
A leafhopper	*Flexamia delongi*	SC	x	
Huron River leafhopper	*Flexamia huroni*	SC	x	
A leafhopper	*Flexamia reflexus*	SC		x
Angular spittlebug	*Lepyronia angulifera*	SC	x	
Great Plains spittlebug	*Lepyronia gibbosa*	T	x	x
A spittlebug	*Philaenarcys killa*	SC	x	x
Red-legged spittlebug	*Prosapia ignipectus*	SC	x	x
Insects: Grasshoppers and Crickets				
Secretive locust	*Appalachia arcana*	SC	x	x
Davis's shield-bearer	*Atlanticus davisi*	SC		x
A spur-throat grasshopper	*Melanoplus eurycercus*			x
Blue-legged locust	*Melanoplus flavidus*	SC	x	x
Hebard's green-legged locust	*Melanoplus viridipes*			x
Conehead grasshopper	*Neoconocephalus retusus*	SC		x
Tamarack tree cricket	*Oecanthus laricis*	SC	x	
Delicate meadow katydid	*Orchelimum delicatum*	SC	x	
Barrens locust	*Orphulella pelidna pelidna*	SC	x	x
Atlantic-coast locust	*Psinidia fenestralis fenestralis*	SC		x
Mammals				
Southern red-backed vole	*Clethrionomys gapperi*			x
Least shrew	*Cryptotis parva*	T	x	x
Prairie vole	*Microtus ochrogaster*	E		x
Woodland vole	*Microtus pinetorum*	SC		x
Least weasel	*Mustela nivalis*		x	
Indiana bat	*Myotis sodalis*	E, LE	x	x
Deer mouse	*Peromyscus maniculatus gracilis*			x
Southern bog lemming	*Synaptomys cooperi*			x
Reptiles				
Six-lined racerunner	*Apidoscelis sexlineatus*	SC	x	x
Spotted turtle	*Clemmys guttata*	T	x	x
Kirtland's snake	*Clonophis kirtlandii*	E	x	
Blue racer	*Coluber constrictor foxii*		x	x
Eastern fox snake	*Elaphe gloydi*	T	x	
Black rat snake	*Elaphe obsoleta obsoleta*	SC	x	x
Blanding's turtle	*Emydoidea blandingii*	SC	x	x
Eastern hognose snake	*Heterodon platirhinos*		x	x
Smooth green snake	*Liochlorophis vernalis*		x	x
Eastern massasauga	*Sistrurus catenatus catenatus*	SC, C	x	x
Eastern box turtle	*Terrapene carolina carolina*	SC	x	x

Appendix B. Rare plants associated with prairie and savanna communities. Under "Status," E is state endangered, T is state threatened, LT is federal threatened, SC is special concern, and X is state extirpated.

Scientific Name	Common Name	Status	wet prairie	lakeplain wet prairie	prairie fen	lakeplain wet-mesic prairie	wet-mesic prairie	mesic prairie	mesic sand prairie	bur oak plains	lakeplain oak openings	hillside prairie	woodland prairie	oak openings	dry sand prairie	oak barrens	oak-pine barrens	pine barrens
Agalinis gattingeri	Gattinger's gerardia	E		x												x		
Agalinis skinneriana	Skinner's gerardia	E		x														
Agoseris glauca	Prairie or Pale agoseris	T																x
Amorpha canescens	Leadplant	SC													x			
Androsace occidentalis	Rock-jasmine	E													x	x		
Angelica venenosa	Hairy angelica	SC									x							
Arabis missouriensis var. deamii	Missouri rock-cress	SC		x												x		
Aristida dichotoma	Shinner's three-awned grass	X													x			
Aristida longespica	Three-awned grass	T		x														
Aristida tuberculosa	Beach three-awned grass	T													x	x		
Artemisia ludoviciana	Western mugwort	T														x	x	
Asclepias hirtella	Tall green milkweed	T		x					x									
Asclepias ovalifolia	Dwarf milkweed	E														x	x	
Asclepias purpurascens	Purple milkweed	SC		x		x								x				
Asclepias sullivantii	Sullivant's milkweed	T		x														
Aster praealtus	Willow aster	SC		x														
Aster sericeus	Western silvery aster	T													x		x	
Astragalus canadensis	Canadian milk-vetch	T														x		
Astragalus neglectus	Cooper's milk-vetch	SC														x		
Baptisia lactea	Prairie false indigo	SC						x						x				
Baptisia leucophaea	Cream wild indigo	E														x		
Bartonia paniculata	Panicled screw-stem	T				x												
Berula erecta	Cut-leaved water-parsnip	T			x													
Besseya bullii	Kitten-tails	T										x						
Botrychium pallidum	Pale moonwort	SC														x		
Bouteloua curtipendula	Side-oats grama grass	T										x				x	x	
Cacalia plantaginea	Prairie indian-plantain	SC		x	x													
Calamagrostis stricta	Narrow-leaved reedgrass	T			x													
Carex festucacea	Fescue sedge	SC		x														
Carex gravida	Sedge	X													x	x		
Carex richardsonii	Richardson's sedge	SC														x		
Celtis tenuifolia	Dwarf hackberry	SC														x		


Susan R. Crispin, MNFI

Leadplant (*Amorpha canescens*)

Sullivant's milkweed (*Asclepias sullivantii*)

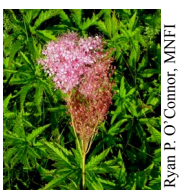

Michael R. Penskar, MNFI


Bradford Slaughter, MNFI

Prairie coreopsis (*Coreopsis palmata*)

Appendix B. Continued

Scientific Name	Common Name	Status	wet prairie	lakeplain wet prairie	prairie fen	lakeplain wet-mesic prairie	wet-mesic prairie	mesic prairie	mesic sand prairie	bur oak plains	lakeplain oak openings	hillside prairie	woodland prairie	oak openings	dry sand prairie	oak barrens	oak-pine barrens	pine barrens
Cirsium hillii	Hill's thistle	SC														x	x	x
Coreopsis palmata	Prairie coreopsis	T						x										
Corydalis flavula	Yellow fumewort	T								x				x				
Cuscuta indecora	Dodder	SC														x		
Cuscuta pentagona	Dodder	SC														x		
Cypripedium candidum	White lady-slipper	T		x	x													
Dalea purpurea	Purple prairie-clover	X														x		
Dasistoma macrophylla	Mullein foxglove	T														x		
Digitaria filiformis	Slender finger-grass	X													x			
Dodecatheon meadia	Shooting-star	E			x			x										
Draba nemorosa	Whitlow-grass	X						?	?				?					
Draba reptans	Creeping whitlow-grass	T										x						
Drosera anglica	English sundew	SC			x													
Echinacea purpurea	Purple coneflower	X						x					x					
Eleocharis engelmannii	Engelmann's spike-rush	SC		x														
Eleocharis tricostata	Three-ribbed spike-rush	T				x												
Eragrostis capillaris	Love grass	SC														x		
Eryngium yuccifolium	Rattlesnake-master	T			x		x								x			
Festuca scabrella	Rough fescue	T															x	x
Filipendula rubra	Queen-of-the-prairie	T			x													
Fimbristylis puberula	Chestnut sedge	X		x														
Gentiana flavida	White gentian	E						x					x			x		
Gentiana puberulenta	Downy gentian	E														x		
Gentiana saponaria	Soapwort gentian	X														x		
Geum triflorum	Prairie-smoke	T													x		x	
Gillenia trifoliata	Bowman's root	T														x		
Gratiola virginiana	Round-fruited hedge hyssop	T	?	?		?	?											
Helianthus hirsutus	Whiskered sunflower	SC			x											x		
Helianthus microcephalus	Small wood sunflower	X											?	?	?	?		
Helianthus mollis	Downy sunflower	T							x							x		
Hieracium paniculatum	Panicled hawkweed	SC														x		
Hypericum gentianoides	Gentian-leaved St. John's-wort	SC		x														
Ipomoea pandurata	Wild potato-vine	T														x		
Juncus vaseyi	Vasey's rush	T		x		x												


Ryan P. O'Connor, MNFI

Queen-of-the-prairie
(*Filipendula rubra*)


MNFI

Prairie smoke
(*Geum triflorum*)

Appendix B. Continued

Scientific Name	Common Name	Status	wet prairie	lakeplain wet prairie	prairie fen	lakeplain wet-mesic prairie	wet-mesic prairie	mesic prairie	mesic sand prairie	bur oak plains	lakeplain oak openings	hillside prairie	woodland prairie	oak openings	dry sand prairie	oak barrens	oak-pine barrens	pine barrens
Kuhnia eupatorioides	False boneset	SC														x		
Lactuca floridana	Woodland lettuce	T														x		
Lechea minor	Least pinweed	SC														x		
Lespedeza procumbens	Trailing bush-clover	X														x		
Leucospora multifida	Conobea	SC		x														
Liatris punctata	Dotted blazing-star	X													x			
Linum sulcatum	Furrowed flax	SC													x		x	
Linum virginianum	Virginia flax	T														x		
Lithospermum incisum	Narrow-leaved puccoon	X													x			
Ludwigia alternifolia	Seedbox	SC		x		x												
Lycopodiella margueriteae	Northern prostrate clubmoss	T				x												
Muhlenbergia richardsonis	Mat muhly	T			x													
Onosmodium molle	Marbleweed	X											?	?	?	?		
Oryzopsis canadensis	Canada rice-grass	T																x
Oxalis violacea	Violet wood-sorrel	T				?	?	?		?								
Panicum leibergii	Leiberg's panic-grass	T										x		x	x			
Panicum polyanthes	Round-seed panic grass	E		x														
Paronychia fastigiata	Low-forked chickweed	SC														x		
Penstemon calycosus	Smooth beard tongue	T														x		
Penstemon gracilis	Slender beard-tongue	E														x	x	
Penstemon pallidus	Pale beard tongue	SC													x	x		
Phaseolus polystachios	Wild bean	SC									x							
Phlox bifida	Cleft phlox	T														x		
Phlox maculata	Spotted phlox	T			x													
Platanthera leucophaea	Prairie fringed orchid	E,LT		x														
Polemonium reptans	Jacob's ladder	T	x		x													
Polygala cruciata	Cross-leaved milkwort	SC		x														
Polygala incarnata	Pink milkwort	X		x			x	x							x			
Polygonatum biflorum var. melleum	Honey-flowered solomon-seal	X									x							
Polytaenia nuttallii	Prairie-parsley	X												x				
Prunus alleghaniensis var. davisii	Alleghany plum	SC													x	x	x	x
Pycnanthemum pilosum	Hairy mountain-mint	T										?	?	?				
Ranunculus rhomboideus	Prairie buttercup	T										x		x				

Pink milkwort
(*Polygala incarnata*)

Ryan P. O'Connor, MNFI

Prairie buttercup
(*Ranunculus rhomboideus*)

Susan R. Crispin, MNFI

Appendix B. Continued

Scientific Name	Common Name	Status	wet prairie	lakeplain wet prairie	prairie fen	lakeplain wet-mesic prairie	wet-mesic prairie	mesic prairie	mesic sand prairie	bur oak plains	lakeplain oak openings	hillside prairie	woodland prairie	oak openings	dry sand prairie	oak barrens	oak-pine barrens	pine barrens
Rhynchospora macrostachya	Tall beak-rush	SC				x												
Rudbeckia subtomentosa	Sweet coneflower	X					?	?		?			?	?				
Ruellia humilis	Hairy ruellia	T										x		x	x			
Sanguisorba canadensis	Canadian burnet	T	x		x													
Scirpus clintonii	Clinton's bulrush	SC		x														
Scleria pauciflora	Few-flowered nut-rush	E		x		x										x		
Scleria triglomerata	Tall nut-rush	SC		x		x	x						x		x			
Scutellaria incana	Downy skullcap	X														x		
Scutellaria parvula	Small skullcap	T										x						
Silene stellata	Starry campion	T														x		
Silene virginica	Fire pink	T														x		
Silphium integrifolium	Rosinweed	T						x										
Silphium laciniatum	Compass-plant	T						x										
Sisyrinchium atlanticum	Atlantic blue-eyed-grass	T				x												
Sisyrinchium farwellii	Farwell's blue-eyed-grass	X						?	?	?	?		?	?				
Sisyrinchium strictum	Blue-eyed-grass	SC						x										
Solidago bicolor	White goldenrod	SC														x		
Solidago missouriensis	Missouri goldenrod	T													x			
Spiranthes ochroleuca	Yellow ladies'-tresses	SC		x		x												
Spiranthes ovalis	Lesser ladies'-tresses	T						x										
Sporobolus clandestinus	Dropseed	SC														x		
Sporobolus heterolepis	Prairie dropseed	SC			x				x									
Strophostyles helvula	Trailing wild bean	SC							x									
Tomanthera auriculata	Eared false foxglove	X												x				
Tradescantia bracteata	Long-bracted spiderwort	X													x			
Tradescantia virginiana	Virginia spiderwort	SC													x	x		
Trichostema brachiatum	False pennyroyal	T													x			
Trichostema dichotomum	Bastard pennyroyal	T													x	x		
Triplasis purpurea	Sand grass	SC													x	x		
Vaccinium cespitosum	Dwarf bilberry	T													x			
Valeriana edulis var.	Edible valerian	T			x													
Viola novae-angliae	New England violet	T							x									
Viola pedatifida	Prairie birdfoot violet	T						x										
Zizia aptera	Prairie golden alexanders	T										x						


MNFI

Fire pink (*Silene virginica*)

Compass-plant (*Silphium laciniatum*)


Bradford Slaughter, MNFI


Bradford Slaughter, MNFI

Virginia spiderwort (*Tradescantia virginiana*)

Prairie Community Descriptions

Wet Prairie

General Description
Wet prairie is a lowland grassland of southern Lower Michigan found on saturated, level, seasonally inundated sites. It often occurs along the margins of lakes, streams, and rivers. Almost exclusively occurring on glacial outwash landforms, wet prairies are usually found near the base of moraines. Soils are generally loam with a neutral pH (average 6.9). Water levels may vary both seasonally as well as from year to year, with several inches of water or more generally occurring in the spring.

Ecological Processes
While fires were important historically, a seasonally high, fluctuating water level is the primary process that helps keep wet prairies mostly free of woody plants in present day.

Characteristic Plants
Wet prairies are dominated by plants such as blue-joint grass (*Calamagrostis canadensis*), prairie cord grass (*Spartina pectinata*), twig-rush (*Cladium mariscoides*), and various sedges (*Carex bebbii*, *C. stricta*, etc.).

Threats and Conservation
The primary threats to wet prairies include draining or filling of wetlands, altered hydrology of lake levels and rivers by dams or other structures, and invasive species such as giant reed (*Phragmites australis*), cat-tail (*Typha* spp.) reed canary grass (*Phalaris arundinacea*). Land managers seeking to restore wet prairies should focus on hydrology and maintaining or restoring seasonally high, fluctuating water levels. Fire management and control of invasive plants are also important priorities.

Similar Communities
Communities similar to wet prairie include lakeplain wet prairie, wet-mesic prairie, and prairie fen. Lakeplain wet prairies can be easily separated as they only occur on glacial lakeplain. Wet-mesic prairies generally have a slightly lower water table and are often dry to the feet except in the wettest times of year. They correspondingly have more upland species, particularly of prairie grasses such as big bluestem (*Andropogon gerardii*), Indian grass (*Sorghastrum nutans*), and showy wildflowers such as gray-headed coneflower (*Ratibida pinnata*) and prairie dock (*Silphium terebinthinaceum*). Wet-mesic prairies are closely associated with wet prairies and historically could often be found directly adjacent, separated by a small topographical rise. Prairie fens may have similar vegetation as wet or wet-mesic prairies but have organic (muck or peat) soils rather than mineral (sand, silt, and clay) soils.

Susan R. Crispin, MNFI

Wet prairies are dominated by blue-joint grass and prairie cordgrass, along with less common forbs like gray-headed coneflower (*Ratibida pinnata*).

Lakeplain Wet Prairie

General Description
Lakeplain wet prairie is similar to wet prairie in that it is found on low, saturated, seasonally inundated sites. However, they are exclusively found on the glacial lakeplain of the Great Lakes and in Michigan are limited to the regions of Saginaw Bay, the St. Clair Delta, and the western margin of Lake Erie. There they are usually found on sandy soil (but also occur on fine sandy loam, loam, and silty clay loam) with a high pH (8.0).

Ecological Processes
Like wet prairies, hydrology was one of the key processes that helped keep sites relatively free of trees and shrubs. Standing water is typical during the spring, and some slight depressions may remain wet year-round. In addition to a water table that fluctuates seasonally with precipitation, hydrology is also closely tied the Great Lakes water level, which is known to fluctuate by as much as 2 meters (approximately 6 feet) over a cycle of 15-20 years. As water levels fluctuated, the wet prairie community migrated inland or lakeward across the landscape. Fire was also an important process that maintained graminoid dominance historically.

Characteristic Plants

Plants of lakeplain wet prairies are similar to other lowland prairie communities and include blue-joint grass, prairie cordgrass, Baltic rush (*Juncus balticus*), twig-rush, shrubby cinquefoil (*Potentilla fruticosa*), swamp milkweed (*Asclepias incarnata*), and sedges (*Carex stricta*, *C. aquatilis*, *C. lanuginosa*).

Gary Reece, MNFI

Standing water is often present in lakeplain wet prairies, especially during spring or when Great Lakes water levels are high.

Threats and Conservation

In the past, the primary threats to lakeplain wet prairies have been draining, tiling, and conversion to agriculture. Development, particularly along the lakeshore has also severely reduced the extent of this community. Managers wishing to maintain and restore lakeplain prairies face a difficult task, since the presence of roads, residential and industrial development, and agricultural fields restrict the natural movement of prairie across the landscape as Great Lakes water levels fluctuate. To conserve prairies on the lakeplain most effectively, large sites that extend inland should be identified that allow for gradual shifting of water levels. Where former agricultural fields are present, restoring hydrology by the filing of ditches and breaking of drain tiles may be necessary. Controlling highly aggressive invasive species such as giant reed and narrow-leaved cattail (*Typha angustifolia*) is also a priority.

Similar Communities

Similar communities to lakeplain wet prairie include wet prairie, lakeplain wet-mesic prairie, southern wet meadow, emergent marsh, and Great Lakes marsh. As described above, wet prairies are closely related but are not found on glacial lakeplains. Lakeplain wet-mesic prairies are often found directly adjacent to lakeplain wet prairies but occur on slightly higher ground and with a greater component of upland species such as big bluestem, Indian grass, switch grass (*Panicum virgatum*), Ohio goldenrod (*Solidago ohioensis*), and mountain-mint (*Pycnanthemum virginianum*). Southern wet meadow is more typically found on organic (peat or muck) soils and is usually dominated by sedges (*Carex stricta*, *C. lacustris*). Emergent marsh typically occurs in permanent (though shallow) water and is dominated by sedges (*Carex*, *Eleocharis*) and bulrushes (*Scirpus*) as well as aquatic plants with floating leaves. Great Lakes marsh is a complex community, of which some regions and zones are similar to emergent marsh but located on the margins of the Great Lakes. Where they occurred adjacent to lakeplain prairies, they often formed part of the shifting mosaic in response to fluctuating lake levels. For a more detailed overview of lakeplain wet prairies, please see the abstract available on the MNFI website (Albert and Kost 1998a).

Prairie Fen

General Description

Prairie fen is a wetland found on organic (muck or peat) soils dominated by herbaceous vegetation characteristic of both prairies (such as grasses like big bluestem) and fens (various sedges). As a peatland, it technically is not classified as a true prairie community, which are always found on mineral soils. However, it is included here because of its similar vegetation and importance to conservation of biodiversity. Prairie fens occur in outwash plains and are often located adjacent to moraine or ice-contact ridges, where coarse-textured soil and steep topography result in a constant supply of calcareous

Michael A. Kost, MNFI

Prairie fens are characterized by a mixture of fen vegetation like tamaracks and shrubby cinquefoil and prairie grasses like big bluestem.

groundwater (rich in calcium and magnesium bicarbonates) flowing out of the base of hills next to lakes and small headwater streams. The organic soils have a very high pH (8.0), often with a concentration of bicarbonates so high that they precipitate out of the water in the form of marl.

Ecological Processes

Hydrology is of utmost importance in fens. The constant supply of groundwater keeps the organic soils saturated year-round, and also helps maintain an herbaceous-dominated plant community. Numerous native and non-native shrubs can tolerate saturated soils, however, and periodic fires were critical to maintaining open conditions.

Characteristic Plants

Fens are very complex wetland systems, with at least three vegetation zones that often grade from one to another based on hydrology and fire frequency. Low-lying, inundated flats are often dominated by bulrush (*Scirpus acutus*), twig-rush, and spike-rushes (*Eleocharis* spp.). Fen meadows are the most diagnostic and diverse zone, and is dominated by indicator species such as shrubby cinquefoil, sedges (*Carex stricta*, *C. aquatilis*, *C. sterilis, C. flava, C. tetanica, C. buxbaumii*), big bluestem, Indian grass, mountain-mint, grass-of-Parnassus (*Parnassia glauca*), and goldenrods (*Solidago ohioensis*, *S. riddellii*). The third zone is dominated by woody species such as tamarack (*Larix laricina*), poison sumac (*Toxicodendron vernix*), and bog birch (*Betula pumila*). These woody species can also be found scattered throughout the other zones as well. In general, any open wetland in southern Michigan with saturated organic soils and a combination of tamarack, shrubby cinquefoil, prairie grasses and fine-leaved sedges is most likely a prairie fen.

Threats and Conservation

Prairie fens are among the most biologically diverse natural communities in Michigan, and their conservation priority is among the highest of all wetland systems. Because hydrology and the constant flow of groundwater is so critical to their functioning, protecting fens from ditching, draining, and filling is crucial. In the past, marl mining and the creation of ponds severely altered these systems. More recently, disruption of groundwater flows from aquifer use by large-scale development is suspected of causing hydrologic changes. The cessation of natural fires has also led to broad scale changes as woody shrubs and trees filled in and shaded out the herbaceous vegetation. Exotic plants such as glossy buckthorn have also become established, especially in areas of altered hydrology. Because of their high leaf surface area (compared to native herbaceous plants) and ability to transpire large amounts of water, glossy buckthorn is also suspected of lowering the water table in areas of severe infestations, further disrupting hydrology. Managers seeking to restore prairie fens should 1) maintain hydrology (or restore if necessary), 2) carefully but aggressively control exotic species such as glossy buckthorn, 3) remove overly dense native trees and shrubs that are shading out remnant fen, and 4) consider prescribed burning to control shrubs and stimulate native herbaceous plants.

Gary Reece, MNFI

Prairie fens often occur at the margins of lakes or streams adjacent to oak-dominated uplands.

Similar Communities

Similar communities to prairie fen include wet-mesic prairie, wet prairie, southern wet meadow, shrub-carr, and relict conifer (tamarack) swamp. Wet-mesic and wet prairies may be very similar in vegetative composition but like all true prairie communities they have mineral soils rather than organic soils, a characteristic easily noted by a change in the firmness of the soil surface when walking up from a fen to a drier mineral soil prairie. Southern wet meadow is a wetland community with organic soil but is usually dominated by tall sedges (*Carex stricta*, *C. lacustris*) and cattails. Shrub-carr is a successional wetland community dominated by dense shrubs such as dogwood (*Cornus* spp.), willow (*Salix* spp.), as well as shrubs characteristic of fens. Relict conifer swamp is a forested wetland community dominated by tamarack, and historically was often found adjacent to prairie fens. For a more detailed overview of prairie fens, please see the abstract available on the MNFI website (Spiels et al. 1999).

Wet-mesic Prairie


Michael R. Penskar, MNFI

Firm, mineral soil underfoot is one of the factors distinguishing wet-mesic prairies from prairie fens, which always occur on organic, peat-based soils.

General Description

Wet-mesic prairie is a lowland grassland of southern Lower Michigan found on moist, level, occasionally inundated sites. It often occurs along the margins of lakes, streams, rivers, and sometimes wet marshes. Almost exclusively occurring on glacial outwash landforms, wet-mesic prairies are often found near the base of moraines. Soils are generally loam with a neutral pH (average 6.9) and are moist but rarely saturated, a characteristic easily noted by a change in the firmness of the soil surface when walking up from a wetter community, especially from prairie fens or wet meadows with saturated organic (muck) soils. The water table is generally below the surface, but can vary both seasonally as well as from year to year.

Ecological Processes

Like wet prairie, hydrology and the corresponding seasonally high water table is an important ecological process. However, because standing water is rarely present, it is less of a factor in restricting the growth of trees and shrubs. Fire plays a much more significant role in maintaining the herbaceous community and keeping back woody species.

Characteristic Plants

Wet-mesic prairies are often dominated by grasses such as big bluestem, Indian grass, and prairie cord grass. Wetland sedges (*Carex stricta*, *C. bebbii*) are also common. Characteristic wildflowers include thimbleweed (*Anemone virginiana*), gray-headed coneflower, prairie dock, tall meadow-rue (*Thalictrum dasycarpum*) and Culver's root (*Veronicastrum virginicum*).

Threats and Conservation

Like many communities, wet-mesic prairies are threatened by conversion to agriculture and development. Remnant sites are often highly threatened by invasive shrubs such as autumn-olive, buckthorn, and honeysuckle, all of which grow exceedingly well in the moist soil that characterizes the community. Native shrubs such as dogwood (*Cornus* spp.) can also form large thickets that shade out prairie vegetation. Succession is also a major concern, especially in sites that are not managed with prescribed fire. Because most shrubs sprout vigorously if top-killed by fire or cutting, managers may also want to consider selective use of herbicides on unwanted woody vegetation. If altered, restoring hydrology is also an important step to restoring and conserving wet-mesic prairies.

Similar Communities

Communities similar to wet-mesic prairie include lakeplain wet-mesic prairie, wet prairie, mesic prairie, and prairie fen. Lakeplain wet-mesic prairies can be easily separated as they only occur on glacial lakeplains. Wet prairies generally have a slightly higher water table and often have standing water in the spring. Mesic prairies are drier and have a higher proportion of drier-site species such as sky-blue aster (*Aster oolentangiensis*), prairie coreopsis (*Coreopsis palmata*), and bush-clovers (*Lespedeza capitata*, *L. hirta*). Prairie fens may have nearly identical vegetation as wet-mesic prairies but have organic (muck or peat) soils rather than mineral (sand, silt, and clay) soils.


Ryan P. O'Connor, MNFI

Prairie cordgrass (*Spartina pectinata*)

Lakeplain Wet-mesic Prairie

General Description

Lakeplain wet-mesic prairie is similar to lakeplain wet prairie in that it is found on low, saturated, occasionally inundated sites on glacial lakeplains of the Great Lakes. In addition to the regions of Saginaw Bay, the St. Clair Delta, and the western margin of Lake Erie, they are also occasionally found inland of the west coast of Michigan in Allegan and Berrien counties. Soils generally have a high pH (8.0), usually with a texture of fine sandy loam which is often underlain by clay (1-3 meters below the surface).

Ecological Processes

In lakeplain prairies hydrology is one of the key processes that help keep sites relatively free of trees and shrubs. Soils are generally moist but typically sites are not inundated except in the spring and or during the wettest years. However, with typically sandy soils at the surface and clay deposits beneath, the seasonally fluctuating water level often leads to spring flooding followed by growing season drought. This combination serves to favor specially adapted plants such as grasses and forbs with deep roots that are also tolerant of flooding. In addition to seasonally fluctuation water tables, the hydrology of lakeplain wet-mesic prairies is also closely tied the Great Lakes water level, which is known to fluctuate by as much as 2 meters (approximately 6 feet) over a cycle of 15-20 years. As water levels fluctuated, the prairie community migrated inland or lakeward across the landscape. Fire was also an important process that maintained graminoid dominance historically, and may have played a larger role in keeping sites open in wet-mesic prairies than wetter prairie communities.

Characteristic Plants

Lakeplain wet-mesic are often dominated by big bluestem, little bluestem (*Andropogon scoparium*) Indian grass, switch grass, and sedge (*Carex lanuginosa*). Characteristic wildflowers include pale Indian-plantain (*Cacalia plantaginea*), shrubby St. John's-wort (*Hypericum kalmianum*), shrubby cinquefoil, white lady's-slipper (*Cypripedium candidum*), and goldenrods (*Solidago nemoralis*, *S. ohioensis*).

Threats and Conservation

In the past, many lakeplain prairies have been lost to draining, tiling, and conversion to agriculture. Industrial and residential development has also severely reduced the extent of this community, especially in southeast Michigan. Managers wishing to maintain and restore lakeplain prairies face a difficult task, since the presence of ditches and agricultural drain tiles have lowered the water and disrupted the hydrology. Additionally, roads, residential and industrial development, and agricultural fields restrict the natural movement of prairie across the landscape as Great Lakes water levels fluctuate. To conserve prairies on the lakeplain most effectively, large sites that extend inland should be identified that allow for gradual shifting of water levels. Where possible, conservation agreements on agricultural land adjacent to prairie remnants should be sought. Restoring hydrology by filing ditches and breaking drain tiles may also be necessary. Controlling invasive species is also a priority. Native shrubs such as dogwood (*Cornus* spp.) can also form large thickets that shade out prairie vegetation and succession is also a major concern. Land managers should carefully consider the use of prescribed fire to maintain an open landscape.

Dennis A. Albert, MNFI

Prairie cordgrass and Ohio goldenrod are common on the flat expanses of lakepain wet-mesic prairies.

Similar Communities

Similar communities to lakeplain wet-mesic prairie include lakeplain wet prairie, mesic sand prairie, and wet-mesic prairie. Lakeplain wet prairies generally occur at a slightly slower elevation and can have standing water throughout much of the growing season. Additionally, they tend to be dominated by plants more tolerant of a high water table such as blue-joint grass, rushes (*Juncus* spp.), and tussock sedges (*Carex stricta*, *C. aquatilis*). Mesic sand prairies tend to occur on slightly higher ancient beach ridges and are more prone to drought. Additionally, the soil (usually sand to sandy loam) tends to be a strongly acid (pH 5.5). Wet-mesic prairies are similar to lakeplain wet-mesic prairies but exclusively occur on glacial outwash and never on the glacial lakeplain. For a more detailed overview of lakeplain wet-mesic prairies, please see the abstract available on the MNFI website (Albert and Kost 1998b).

Northern Wet-mesic Prairie

General Description
Northern wet-mesic prairie is a variation of mesic sand prairie occurring in northern Michigan. Primarily occurring on moist, level, occasionally inundated sites, they are most often found in seasonal drainages within outwash depressions, often surrounded by jack pine (*Pinus banksiana*). Soils are generally sand or sandy loam with a slightly acid to circumneutral pH (5.8 to 7.0) and are moist but rarely saturated. The water table is generally below the surface, but can vary both seasonally as well as from year to year. This community type is currently under evaluation by MNFI ecologists and may eventually be lumped into a broader definition of mesic sand prairie (M. Kost, pers. communication).

Ecological Processes
A seasonally high water table and fire play a important roles in maintaining the herbaceous community and keeping back woody species. Due to more northerly latitude and the tendency for the community to occur in open low-lying topographic areas, growing season frosts may also help discourage trees and shrubs.

Characteristic Plants
Characteristic plants include prairie species from southern latitudes such as big bluestem as well as plants of wetlands like bluejoint grass, rushes (*Juncus balticus*), and sedges (*Carex lacustris*, *Dulichium arundinaceum*). Due to their tendency to occur on infertile, sandy soils, jack pine is also common in or adjacent to the prairie.

Threats and Conservation
The primary threat to most sites is damage from illegal ORV activity. Lack of fire may also lead to a greater dominance by woody species over time.

Similar Communities
Similar communities include wet-mesic prairie, lakeplain wet-mesic prairie, mesic sand prairie, and northern wet meadow. All but northern wet meadow are found only in southern lower Michigan. Of these, lakeplain mesic sand prairie may most closely resemble northern wet-mesic prairie in species composition, but they tend to have highly acidic soils and are limited to old lake beds of the Great Lakes. Northern wet meadows occur along the margins of streams and are dominated by sedges (*Carex stricta*, etc.) and bluejoint grass. More importantly, they have organic (muck) soils rather than the mineral soils of prairies.

Mesic Sand Prairie

General Description
Mesic sand prairies occur on sandy glacial lakeplains and outwash plains with a seasonally high, fluctuating water table. Soils are sandy, usually acidic (average pH 5.5), and are prone to drought during the dry summer months, but during a wet spring may be nearly inundated. Consequently, plant species of both wet and dry prairies are found growing together.

Ecological Processes
Seasonally high water levels in spring and sandy, infertile, drought-prone soils in the summer combine to limit growth of trees and shrubs. Fires were also important historically, since these usually small prairies occurred in a larger matrix of fire-dominated oak savanna. Topography is also a key factor in mesic sand prairies, since the smallest changes in elevation (a foot or less) may lead to a gradation towards drier or more wet-mesic conditions.

Characteristic Plants
Most notable about the vegetation is the prevalence of dry prairie species such as big bluestem, little bluestem, poverty grass (*Danthonia spicata*), field milkwort (*Polygala sanguinea*), and arrow-leaved violet (*Viola sagittata*) growing next to species adapted to wetter conditions like mountain-mint, colic-root (*Aletris farinosa*), meadow-sweet (*Spiraea* spp.), and even tall nut-rush (*Sceleria triglomerata*) and spike-rushes (*Eleocharis* spp.).


Gary Reece, MNFI

Mesic sand prairies are characterized by acidic sandy soil that is seasonally wet but prone to drought in the summer.

Threats and Conservation

Threats to mesic sand prairie include a lack of fire and potential succession to trees and shrubs. Most of the currently known sites also occur in rapidly suburbanizing areas of southeast Michigan, where development is a looming threat. Planners should work with land managers to ensure fully functioning systems (the mesic prairies as well as the wetlands and upland forest that surround them) are conserved. Due to the importance of hydrology, any ditching or filling not only in but also adjacent to the prairies should be prevented. Finally, managers should seek to carefully restore fire to the landscape, being especially cognizant of political and social issues where sites are in close proximity to suburban areas.

Ryan P. O'Connor, MNFI

Tall nut-rush (*Sceleria triglomerata*)

Similar Communities

Similar communities include mesic prairie, dry sand prairie, northern wet-mesic prairie, and coastal plain marsh. Mesic prairies are easily distinguished by their black, loamy soils. While dry sand prairies have similar droughty, sandy soils, they lack the presence of a fluctuating water table and thus have no plants adapted to wetter site conditions. Northern wet-mesic prairies can have similar soils as well as similar plants, but are found only northern Michigan, while mesic sand prairies are mostly found in southern Michigan. One of the closest natural communities may be coastal plain marsh, which often contains a small band of mesic sand prairie on upland edges. The marshes are often wet, and even if no standing water is present, they should be distinguishable by the presence of peat mixed with sand and a dominance by coastal plain species such as bluejoint grass, nut-rush (*Cladium mariscoides*), hyssop hedge-nettle (*Stachys hyssopifolia*), grass-leaved goldenrod (*Euthamia remota*), and black-fruited spike rush (*Eleocharis melanocarpa*).

Bradford Slaughter, MNFI

Prairie coreopsis (*Coreopsis palmata*)

Mesic Prairie

General Description

Mesic prairie, also called tall grass or black soil prairie, is a native grassland community dominated by big bluestem, little bluestem, and Indian grass. Typically, mesic prairie occurred on slightly acid (pH 6.2) loam or sandy loam soils in level, moderately well-drained outwash plains. Mesic prairies were limited to the southwest corner of the state where Transeau's Prairie Peninsula barely extended into Michigan (1935). Although mesic prairie was never common in the state, it did comprise several large, historical sites of note, some of which were even used to identify early settlements and local government units, such as Prairie Rhonde, a 12,000 acre former mesic prairie in Kalamazoo County.

Ecological Processes

Because they fell in the middle of the moisture continuum, neither being too wet nor too dry, the only ecological process that maintained an open condition was frequent fire. Following the cessation of fires, mesic prairies quickly converted to savanna and then to forest, or were converted to agriculture. Today the tiny remnants that remain almost always occur along railroad tracks, where they were kept open by fires sparked by passing trains. Animal disturbances such as buffalo grazing and wallows were historically important small-scale disturbances that helped maintain high species diversity. Today, mound-building ant colonies are also an important small-scale disturbance agent that help mix and aerate the soil, as well as provide microtopography and seed beds when abandoned. Dense clusters of ant mounds (often reaching several feet in height) can serve as an easily identifiable indicator of unplowed ground (at least within several decades) potentially capable of supporting prairie.

Characteristic Plants

Mesic prairies are primarily dominated by big bluestem, but other prairie grasses such as Indian grass, little bluestem, and prairie cord grass can also be frequently found. Other characteristic herbaceous plants include sedges (*Carex bicknellii*), prairie coreopsis (*Coreopsis*

palmata), wild yam (*Dioscorea villosa*), pale-leaved sunflower (*Helianthus strumosus*), false boneset (*Kuhnia eupatorioides*), prairie dock, yellow pimpernel (*Taenidia integerrima*), hoary vervain (*Verbena stricta*), American vetch (*Vicia americana*), and golden alexanders (*Zizia aurea*).

Threats and Conservation

With virtually all mesic prairies lost or degraded by conversion to agriculture or succession, efforts should be to identify, manage, and expand remnants. In particular, where remnants exist adjacent to railroad tracks, managers should seek opportunities to expand prairie vegetation through prescribed burning and/or planting. If planting, carefully consider what method to use as some techniques may produce dense stands of grasses with little ecological resemblance to a true, diverse prairie. In addition, if planting in close proximity to an existing remnant, the use of local genotype seed (from the remnant itself and/or other nearby remnants if at all possible) is strongly recommended, even at the expense of longer restoration time, fewer acres planted, and possibly cost. Frequent fire (every 1-3 years) is also absolutely critical to maintaining prairie vegetation. Lack of fire or less frequent burns will result in gradual succession to woody species.

Similar Communities

Communities similar to mesic prairie include wet-mesic prairie, mesic sand prairie, woodland prairie, bur oak plains, and oak openings. Wet-mesic prairie often has a water table at or near the surface in spring with correspondingly more wet-site species such as mountain-mint, wetland sedges (*Carex stricta*, *C. bebbii*), and tall meadow-rue. Mesic sand prairie has soils that are predominantly acidic (pH 5.0) sands, and is characterized by a seasonally fluctuating water table with a mix of wetland species such as meadow sweet (*Spiraea* spp.) with dry upland species like little bluestem. Woodland prairie is a dry-mesic prairie type with a higher proportion of dry-site indicators such as Pennsylvania sedge (*Carex pensylvanica*), butterfly weed (*Asclepias tuberosa*), western sunflower (*Helianthus occidentalis*) and hairy aster (*Aster pilosus*). Bur oak plains is a state-extirpated mesic savanna community. It is thought to have had a 10-40% canopy cover of bur oak and herbaceous vegetation similar to mesic prairie. Oak openings is a dry-mesic savanna community, now exceedingly rare, with a mixed oak canopy cover also historically ranging from 10-40%. For a more detailed overview of mesic prairie, please see the abstract available on the MNFI website (Kost 2004a).

Woodland Prairie

General Description

Woodland prairie is a dry-mesic grassland dominated big bluestem, Indian grass, and little bluestem. It is found on well-drained level outwash plains and coarse-texture end moraines. Soils are generally sandy loam and pH is moderately acid, ranging from 5.2 to 6.7. Historically, woodland prairie occurred in relatively treeless pockets within oak openings, a dry-mesic savanna community that occupied much of the savanna-prairie complex in southern Michigan.

Historically, woodland prairies occurred in close proximity to oak openings, a dry-mesic savanna community.

Ecological Processes

Fire was the predominant ecological process that maintained an open condition within woodland prairies, with prairie gradually converting to oak openings as fire frequency decreased. With well-drained, relatively sandy soils, seasonal drought also likely played a role in limiting the growth of trees and maintaining an open condition. Animal disturbances such as buffalo grazing and wallows were historically important small-scale disturbances that helped maintain high species diversity. Today, mound-building ant colonies are also an important small-scale disturbance agent that help mix and aerate the soil, as well as provide microtopography and seed beds when abandoned. Dense clusters of ant mounds (often reaching several feet in height) can serve as an easily identifiable indicator of unplowed ground (at least within several decades) potentially capable of supporting prairie.

Vegetation

Woodland prairies are dominated by native grasses such as big bluestem, little bluestem, and Indian grass. Pennsylvania sedge is also often found, along with characteristic wildflowers such as hairy aster (*Aster pilosus*), thimbleweed (*Anemone cylindrica*), western sunflower (*Helianthus occidentalis*), stiff goldenrod (*Solidago rigida*), butterfly weed (*Asclepias tuberosa*), and leadplant (*Amorpha canescens*).

Threats & Conservation

Those woodland prairies that weren't converted to agriculture quickly grew up into closed canopy oak forest following the cessation of frequent fires. Livestock grazing also impacted virtually all sites, resulting in many direct and indirect changes, one of which is the current prevalence of bluegrass at many sites. Today, only tiny remnants of woodland prairie remain, almost always occurring along railroad tracks where they were kept open by fires sparked by passing trains. Where remnants do still exist, managers should seek opportunities to expand prairie vegetation through prescribed burning and/or planting. If planting, carefully consider what method to use as some techniques may produce dense stands of grasses with little ecological resemblance to a true, diverse prairie. In addition, if planting in close proximity to an existing remnant, the use of local genotype seed (from the remnant itself and/or other nearby remnants if at all possible) is strongly recommended, even at the expense of longer restoration time, fewer acres planted, and possibly cost. Frequent fire (every 1-3 years) is also absolutely critical to maintaining prairie vegetation. Lack of fire or less frequent burns will result in gradual succession to woody species.

Similar Communities

Similar communities to woodland prairie include mesic prairie, mesic sand prairie, hillside prairie, dry sand prairie, and oak openings. Mesic prairie occurred on slightly better soil conditions (loam with an average pH of 6.2) with characteristic plants such as rosinweed (*Silphium integrifolium*), yellow pimpernel, prairie coreopsis, and golden alexanders. Mesic sand prairie has sandy soils similar to woodland prairie but they are often strongly acid (pH 5.5) with a seasonally fluctuating water table that facilitates growth of both wetland species such as meadowsweet and dry-site species like Pennsylvania sedge and little bluestem Like woodland prairie, hillside prairie is also largely a dry-mesic community but is found on open, steep hillsides and bluffs, often above large rivers or small kettle lakes. Characteristic plants include American bellflower (*Campanula rotundifolia*), needle grass

Brian Piccolo, Michigan DNR

Butterfly weed (*Asclepias tuberosa*)

(*Stipa spartea*), and the rare kitten-tails (*Besseya bullii*). Dry sand prairie is the driest prairie community found in Michigan and is often dominated by Pennsylvania sedge rather than tall prairie grasses. Oak openings is a dry-mesic savanna community with a 5-80% canopy of white and black oaks. Historically, oak openings graded into woodland prairie in a shifting mosaic determined by fire frequency. For a more detailed overview of woodland prairie, please see the abstract available on the MNFI website (Kost 2004b).

Hillside Prairie

General Description

Hillside prairie is a dry-mesic grassland occurring on steep, open slopes, often on south or west-facing hillsides above large rivers and kettle lakes. Soils range from sandy loam to loamy sand and range from strongly acid (pH 5.3) to circumneutral (6.8). Historically, hillside prairies often had a thin canopy of black and white oak more similar to savanna, in present day they may appear to have an almost completely closed canopy. Various types of oak savanna and dry-mesic oak forest commonly surrounded hillside prairies on adjacent, less steep terrain and slopes with more northern or eastern aspects.

Ecological Processes

Fire was important in promoting herbaceous vegetation and keeping back woody species, but terrain and landscape position played a uniquely critical role in maintaining an open condition on hillside prairies. Steep south and west facing slopes receive a much higher degree of direct sunlight, making them drier and more drought-prone than comparable north and eastern aspects. In addition, open hillsides are constantly exposed to drying winds, further reducing moisture availability.

Susan R. Crispin, MNFI

Hillside prairies occur on steep south or west-facing slopes above large rivers or kettle lakes.

Vegetation

A thin canopy of white and black oak is commonly present, along with other woody species such as pignut hickory, black cherry (*Prunus serotina*), and flowering dogwood (*Cornus florida*). Eastern redcedar (*Juniperus virginiana*) is also an excellent indicator species found on almost all relict hillside prairies, though the prevalence of this fire-sensitive species in present day is likely due mainly to fire suppression. Numerous characteristic herbaceous species can also be found, including little bluestem, needle grass, big bluestem, American bellflower, and the rare plants kitten-tails, side-oats (*Bouteloua curtipendula*), and prairie golden-alexanders (*Zizia aptera*).

Threats & Conservation

Too steep to farm or graze, hillside prairies slowly filled in with woody species with decreasing fire frequency. More recently, exclusive residential developments on scenic river bluffs and hillsides overlooking small inland lakes have resulted in the near complete loss of this community. Several rare plant species endemic to hillside prairies in Michigan such as kitten-tails have declined to such a great extent that their survival in the state is in serious question. Managers wishing to restore hillside prairies should seek out remnant sites and apply prescribed fire if feasible. Due to their unique terrain, many sites facilitate easy use of controlled fire with a natural firebreak in the form a river or lake below and a level area above, at which another firebreak can be created. Thinning of the woody canopy may also be required, and control of invasive species like autumn-olive, honeysuckle, and buckthorn will likely be necessary. Care should be taken to avoid eroding soil on the steep sandy slopes when conducting any management, survey, or monitoring.

Similar Communities

Communities similar to hillside prairie include woodland prairie, oak barrens, oak openings, and dry-mesic southern forest. Like hillside prairie, woodland prairie is also largely a dry-mesic community but is found on mostly level, sandy ground rather than on open, steep hillsides and bluffs. Oak barrens is a dry savanna community and is often dominated by Pennsylvania sedge and scattered black oak. It may be found on excessively dry, flat plains above slopes in close association with hillside prairie. More commonly, dry-mesic conditions predominate, making oak openings a historically common savanna found adjacent to hillside prairie. Where fire frequency is lower due to slope, aspect, or human intervention, more closed-canopy dry-mesic southern forest may prevail instead of the open-canopy savanna of oak openings.

Dry Sand Prairie

General Description

Dry sand prairie is a dry grassland community with short, sparse, vegetation dominated by Pennsylvania sedge with lesser amounts of big and little bluestem. Primarily found on level to rolling outwash plains, soils are well drained to excessively well drained acidic (pH 4.6 – 5.7) loamy sands. Dry sand prairie is located primarily in northern Lower Michigan and is found in close association with oak barrens and oak-pine barrens in the Newaygo Outwash as well as further north where it occupies small patches within the pine in the High Plains Subsection north and east of Grayling.

Ecological Processes

While periodic fire was important in promoting the herbaceous plant community, droughty soils also helped maintain an open condition by limiting tree establishment and growth. In addition, growing season frosts also inhibit growth and establishment of

woody vegetation in the pine barrens, particularly in low depressions known as frost pockets.


Gary Reece, MNFI

Dry sand prairies often occur as open pockets within oak barrens or pine barrens.

Characteristic Plants

Vegetation is often low, short, and sparse, with Pennsylvania sedge often dominating and big bluestem and little bluestem sometimes occurring as co-dominants. Other common grasses include poverty grass (*Danthonia spicata*), hair grass (*Deschampsia flexuosa*), June grass (*Koeleria macrantha*), and rice grass (*Oryzopsis asperifolia*, *O. pungens*). Low shrubs are also common, such as sweet-fern (*Comptonia peregrina*), sand cherry (*Prunus pumila*), blueberry (*Vaccinium angustifolium*), dewberry (*Rubus flagellaris*), and bearberry (*Arctostaphylos uva-ursi*). Wildflowers are typically sparse compared to other prairie systems, but characteristically include rough blazing star (*Liatris aspera*), harebell (*Campanula rotundifolia*), butterfly weed, blue toadflax (*Linaria canadensis*), wild lupine (*Lupinus perennis*), and horsemint (*Monarda punctata*).

Threats and Conservation

Though their open character resulted in many areas being plowed, most dry sand prairies were too dry, sandy, and acidic to be productive agriculturally. Many areas originally held by private landowners reverted back to public ownership when they could not be farmed. The cessation of periodic wildfires allowed woody shrubs and trees to gradually fill in many areas, and those too barren to support natural forest were often planted to red or jack pine, both for timber production as well as to stabilize soil. Despite these attempts to convert dry prairies to other uses, a significant amount of dry sand prairie remnants remain compared to other types of prairie, though they have still suffered a decline by as much as 96%. Land managers seeking to restore and maintain dry sand prairie should seek out remnants and actively keep them in an open condition by periodic prescribed burns. If remnants are small or have filled in with woody vegetation, removal of tree and shrubs may also be necessary. Numerous exotic species such as spotted knapweed (*Centaurea maculosa*), common St. John's-wort (*Hypericum perforatum*), and autumn-olive are also problematic in dry sand prairies, and managers should act to halt their spread, contain existing populations, and remove them if at all possible.


Kitty Kohout, Wisconsin DNR, courtesy Wisconsin State Herbarium

Rough blazing star (*Liatris aspera*)

Similar Communities

Dry sand prairie may be confused with woodland prairie, hillside prairie, oak barrens, oak-pine barrens, and pine barrens. Woodland prairie is a dry-mesic community found on less sandy, slightly more nutrient rich (higher pH) sites with a higher predominance of big bluestem, little bluestem, and Indian grass and correspondingly less Pennsylvania sedge. Hillside prairie is also a dry-mesic community but is found on open, steep hillsides and bluffs, often above rivers or kettle lakes. Oak barrens, oak-pine barrens, and pine barrens are all dry savanna communities and historically had small pockets of dry sandy prairie interspersed within them. As savannas, they typically had more than one tree per acre and a canopy cover ranging from 5-60%. For a more detailed overview of dry sand prairie, please see the abstract available on the MNFI website (Kost 2004c).

Table 5. Comparison of prairie communities in Michigan (listed from wet to dry).
Part A: Wet to wet-mesic communities.

	Wet prairie	Lakeplain wet prairie	Prairie fen*	Wet-mesic prairie	Lakeplain wet-mesic prairie	Northern wet-mesic prairie
Moisture	Wet	Wet	Wet	Wet-mesic	Wet-mesic	Wet-mesic
Glacial Landform	Outwash	Lakeplain	Outwash, Ice-contact	Outwash	Lakeplain	Outwash
Soil texture	loam	Fine sandy loam, silty clay Silty clay loam	Muck (organic) w/ marl deposits	Loam	Fine sandy loam	Loamy sand to sand
Soil pH (avg)	6.9	8.0	8.0+	6.9	8.0	5.8-7.0
Processes promoting open conditions	Fire, very high water table	Fire, fluctuating high water table	Fire, high water table	Fire, seasonally high water table	Fire, fluctuating seasonally high water table	Fire, high water table
Region of state	SLP	Saginaw Bay, St. Clair Delta, extreme SE	SLP interlobate	SLP	Saginaw Bay, St. Clair Delta, extreme SE & SW	NLP, UP
Grank	G3	G2?	G3	G2	G1?	GNR
Srank	S2	S1	S3	S2	S1	S1

*Prairie fen is included due its similar vegetative composition, though it not considered a true prairie community because it occurs in wetlands with organic (peat) soils rather than mineral soils.

Table 5 (continued). Part B: mesic to dry communities.

	Mesic sand prairie	Mesic prairie	Woodland prairie	Hillside prairie	Dry sand prairie
Moisture	Mesic	Mesic	Dry-mesic	Dry-mesic	Dry
Glacial Landform	Lakeplain, outwash	Outwash	Outwash	Outwash cut by rivers or kettle lakes	Outwash, sandy lakeplain
Soil texture	Sandy loam, sand	Sandy loam, loam	Sandy loam	Sandy loam, loamy sand	Loamy sand
Soil pH (avg)	5.5	6.2	5.8	5.3 – 6.8	5.1
Processes promoting open conditions	Fire, seasonal drought	Fire	Fire, drought	Fire, dry aspect/ drought	Fire, extreme drought, frost
Region of state	SLP	Extreme SW	SW, occasional in SE	mostly SW, also SE, UP	Northern SW, central NLP
Grank	G1?	G2	G3	G3	G3
Srank	S1	S1	S2	S1	S2

Table 6. Comparison of savanna communities in Michigan (listed from wet to dry).

	Bur oak plains	Oak openings	Lakeplain oak openings	Oak barrens	Oak-pine barrens	Pine barrens
Moisture	Mesic	Dry-mesic	Dry-mesic Or wet-mesic	Dry	Dry	Dry
Glacial Landform	Outwash	Outwash	Sandy lakeplain	Outwash	Outwash	Outwash
Soil texture	Loam, sandy loam	Outwash, coarse end moraines	Fine sandy loam, loamy fine sand	Sand, loamy sand	Sand, loamy sand	Sand (Grayling series)
Soil pH (avg)	6.1-7.3	6.1-7.3	7.4-7.8	5.6-6.5	5.6-6.5	4.5-6.0
Processes promoting open conditions	Fire	Fire, seasonal drought	Fire, seasonally high water table, seasonal drought	Fire, drought	Fire, drought	Fire, extreme drought, frost
Region of state	Extreme SW	SLP	Extreme SE	SLP	Northern SW, central NLP, UP	Central NLP, UP
Canopy coverage (estimated)	10%-30%	10%-60%	33% (avg)	5%-60%	5%-60%	20%-40%[a]
Grank	G1	G1	G2?	G2?	G3	G3
Srank	SX	S1	S1	S1	S2	S2

[a] Suggested range for management in Camp Grayling Pine Barrens Management Plan by Kost et al. 2000.

Ryan P. O'Connor, MNFI

Many prairie and savanna remnants occur along railroad grades, where they have been kept open by fires sparked by passing trains.

Savanna Community Descriptions

Bur Oak Plains

General Description

Bur oak plains was a mesic savanna community with a 10-30% canopy cover of bur oaks and a groundcover of herbaceous plants comprised of species associated with both open and moderately low-light conditions. Once found on level to slightly undulating outwash with loamy soil, the bur oak plains community has been extirpated from the state and is now known only from historical literature and data derived from severely degraded sites.

Ecological Processes

Because they fell in the middle of the moisture continuum, neither being too wet nor too dry, the only ecological process that maintained a semi-open condition was frequent fire (ranging from annually to once every three years). Following the cessation of fires, bur oak plains quickly grew up into forest or were converted to agriculture. Today no intact remnants remain of this community in the state. Historically, bur oak plains occurred in close conjunction with mesic prairies, grading in and out of one another in a shifting mosaic dependant on fire frequency and other disturbances.

Characteristic Plants

Since bur oak plains have been extirpated from the state, very little is known about their exact vegetative composition. Information is based on historical accounts and extrapolations from similar communities and degraded remnants in neighboring states. Early settlers described bur oak plains as park-like with widely-spaced trees. Bur oaks (with occasional white oaks) likely formed a canopy of 10-30%. Shrubs were noted as being largely absent, but some fire-tolerant such as American hazelnut (*Corylus americana*) were likely scattered through the understory. Herbaceous vegetation was a mixture of prairie grasses such as big bluestem, little bluestem, and Indian grass that likely dominated in more open, high-light areas. Mesic prairie forbs such as prairie coreopsis, mountain-mint, and golden alexanders were also likely common in open areas. Forbs more tolerant of shade were commonly found beneath the tree canopies. Early ecologists such as Curtis (1959) thought the herbaceous plants of savannas included species associated with forests as well as prairies, but modern restorationists such as Packard (1988) believe many species were savanna specialists, thriving in the mottled light created by the scattered canopy of oaks. Some of those plants that many have been found in mesic savannas include state endangered species such white gentian (*Gentiana alba*), cream wild indigo (*Baptisia leucophaea*), and shooting-star (*Dodecatheon media*).

Threats and Conservation

With all bur oak plains thought to be lost or degraded by conversion to agriculture or succession, there may be little hope for this community in the state. However, efforts should still be made to identify, manage, and expand remnants that may exist, especially adjacent to railroad tracks where passing trains may have sparked fires frequent enough to maintain savanna, or adjacent to other existing prairie or savanna sites that may hold promise, such as the edges of cemeteries. If remnants are found, managers should seek opportunities to expand prairie vegetation through prescribed burning and/or planting. If planting, carefully consider what method to use as some techniques may produce dense stands of grasses with little ecological resemblance to a true, diverse savanna. In addition, if planting in close proximity to an existing remnant, the use of local genotype seed (from the remnant itself and/or other nearby remnants if at all possible) is strongly recommended. Frequent fire (every 1-3 years) is also absolutely critical to maintaining prairie vegetation. Lack of fire or less frequent burns will result in gradual succession to woody species.

Similar Communities

Bur oak plains may be confused with several prairie, savanna, or forest communities, including mesic prairie, woodland prairie, oak openings, lakeplain oak openings, and dry-mesic southern forest. Mesic prairies were likely very similar in plant composition but had fewer than one tree per acre (<5% canopy). Woodland prairie is a dry-mesic prairie that share some species found in mesic prairie, but also has less than one tree per acre. Oak openings is a dry-mesic savanna community which may have some bur oak scattered throughout the 10-60% canopy, but is usually dominated by white oaks. Lakeplain oak openings may have more bur oaks, but are found exclusively on the glacial lake plain. Finally, some dry-mesic southern forest typically has a mostly closed canopy. However, some sites with loamy soil may actually be closed-in remnants of bur oak plains, and managers should check for site indicators like large, open-grown bur oaks (wolf trees), herbaceous savanna indicator species, and circa 1800s vegetation maps that may indicate former mesic prairie or savanna. For a more detailed overview of bur oak plains, please see the abstract available on the MNFI website (Cohen 2004a).

Oak Openings

General Description

Oak openings is a dry-mesic savanna community with a 10-60% canopy dominated by white oak and a semi-continuous ground layer of grasses and forbs adapted to both open prairies and the lower-light conditions of savannas. Oak openings were historically found on level terrain of outwash plains and coarse-textured end moraines with sandy loam to dry-mesic loam soils and a slightly acid to neutral pH (6.1-7.3). Once one of the most abundant savanna communities in Michigan, oak openings have now been nearly extirpated with only one small remnant site identified.

Ecological Processes

Fire was the predominant ecological process that maintained a semi-open condition within oak openings. Canopy cover was likely highly variable from site to site and within the same site over time. This highly dynamic environment depended largely on fire frequency, with more frequent fires thinning out trees and shifting sites to a more open, prairie condition and less frequent fires allowing more trees and shrubs to fill in, gradually turning the savanna into a more forested community. In sites with moderately well-drained, relatively sandy soils, seasonal drought also likely played a role in limiting the growth of trees and maintaining an open condition.

Characteristic Plants

Since oak openings have been nearly extirpated from the state, very little is known about their exact vegetative composition. Other than a handful of degraded remnants, most of them in neighboring states, information is based largely on historical accounts. Early settlers described oak openings as park-like with widely-spaced trees. White oaks (with occasional bur and chinquapin oaks) usually form a canopy of 10-60%. Shrub cover varied but included some fire-tolerant species such as American hazelnut and New Jersey tea (*Ceanothus americanus*), as well as less fire-tolerant species like gray dogwood (*Cornus foemina*). Herbaceous vegetation was a mixture of prairie grasses such as big bluestem, little bluestem, and Indian grass that likely dominated in more open, high-light areas. Dry-mesic prairie forbs such as thimbleweed, butterfly-weed, smooth aster, and frost aster were also likely common in open areas. Forbs more tolerant of shade were commonly found beneath the tree canopies. Early ecologists such as Curtis (1959) thought the herbaceous plants of savannas included species associated with forests as well as prairies, but modern restorationists such as Packard (1988) believe many species were savanna specialists, thriving in the mottled light created by the scattered canopy of oaks. Some of those plants that many have been found in dry-mesic oak openings include state threatened species such as upland boneset (*Eupatorium sessilifolium*), false boneset (*Kuhnia eupatorioides*), and starry campion (*Silene stellata*).

Gary Reece, MNFI

Michigan's only documented high-quality oak openings site occurs in an old unmowed cemetary. With restoration of other degraded remnants, more high-quality sites might one day be counted among this once abundant community.

Threats and Conservation

Since virtually all former oak openings are thought to be converted to forest or agriculture, or highly degraded, the primary conservation need is to identify, manage, and expand remnants. If remnants are found, managers should seek opportunities to expand prairie vegetation through prescribed burning. Since so few remnants are thought to exist, other techniques such as selectively thinning closed-in savannas or replanting dry-mesic prairies with scattered oaks may be necessary. Relatively frequent fire is also critical to maintaining prairie and savanna vegetation. Managers should use an adaptive management process that seeks a balance between using prescribed fire to promote grasses and forbs but also allows for the development and maintenance of scattered mature oaks.

Similar Communities

Communities similar to oak openings may include woodland prairie, bur oak plains, lakeplain oak openings, oak barrens, and dry-mesic southern forest. Woodland prairies were likely very similar in plant composition but had fewer than one tree per acre (<5% canopy). Bur oak plains is state-extirpated mesic savanna community which may have some white oak scattered throughout the 10-30% canopy, but was usually dominated by bur oak. Lakeplain oak openings are quite similar to oak openings but are found exclusively on the glacial lake plain. Oak barrens is a drier savanna community with more sandy soils and a high prevalence of black oak in the canopy. Dry-mesic southern forest may have similar canopy dominants to oak openings, but typically has a mostly closed canopy. However, some sites may actually be closed-in remnants of oak openings and managers should check for site indicators like large, open-grown oaks (wolf trees), herbaceous savanna indicator species, and circa 1800s vegetation maps that indicate a high prevalence of mixed oak savanna. For a more detailed overview of oak openings, please see the abstract available on the MNFI website (Cohen 2004b).

Lakeplain Oak Openings

General Description

Lakeplain oak openings is a savanna community that occurs within glacial lakeplains on sand ridges, sandy plains, and slight depressions. Existing in such variable topography, lakeplain oak openings are found along a wide variety of moisture conditions, with sites ranging from wet and seasonally inundated in moist depressions to quite dry on former beach ridges. Soils are commonly very fine sandy loam with a moderately alkaline pH (7.4-7.8), but may vary from site to site in the complex and highly variable glacial lakeplain deposits. The vegetation is dominated by a variety of oaks with an average canopy of 33%, while wet to dry prairie grasses and forbs occupy the groundcover.

Gary Reece, MNFI

Lakeplain oak openings support a wide variety of grasses and forbs beneath an open canopy of bur oak (*Quercus macrocarpa*).

Ecological Processes

In addition to periodic fire, the unique hydrologic cycle of fluctuating Great Lakes water levels, both seasonally and from year to year historically helped maintain the character and composition of lakeplain oak openings. In many flat or low sites, a seasonally high water table inhibited the growth of most trees and shrubs. On former beach ridges, droughty soils were an important factor maintaining open conditions, especially in late summer when water levels typically were at their lowest. Since the time of settlement, the lack of frequent fire has lead to gradual succession and a closing in of the canopy, decreasing diversity. Additionally, the hydrology of many sites has been radically altered by ditching in an attempt to drain the land for farming or development. Beaver activity is also often cited as an historically important process that created large impoundments behind dams and resulted in seasonally flooded areas, especially along streams in southeast Michigan.

Characteristic Plants

Vegetation is highly variable depending on landscape position (depression, sand plain, or beach ridge). Oaks typically dominate in all conditions, with bur oak, pin oak (*Quercus palustris*), and swamp white oak (*Q. bicolor*) found in poorly drained areas, and black oak and white oak occurring on droughty beach ridges. Other trees and shrubs are even more variable, ranging from red ash (*Fraxinus pennsylvanica*), cottonwood (*Populus deltoides*), and red maple in wetter sites to dry ridges with a predominance of serviceberry (*Amelanchier* spp.), huckleberry (*Gaylussacia baccata*), blueberry (*Vaccinium angustifolium*), and pasture rose (*Rosa carolina*). In addition to being dependent on topography, identifiable herbaceous vegetation also varies by season. In wet sites in spring, sedges (*Carex aquatilis*, *C. lanuginosa*, and *C. stricta*) are most visible; summer may bring such indicators as colic root (*Aletris farinosa*), blue-joint grass, twig-rush, and Baltic rush, while in fall one might find swamp milkweed (*Asclepias incarnata*), prairie dock, and prairie cord grass. On dry beach ridges, bastard toadflax (*Comandra umbellata*), hoary puccoon (*Lithospermum canescens*), and prairie ragwort (*Senecio plattensis*) might be visible in spring, with summer dominated by thimbleweed, butterfly weed, and woodland sunflower (*Helianthus divaricatus*), and fall bringing on

characteristic prairie species such as big bluestem, little bluestem, Indian grass, blazing star (*Liatris aspera*, *L. spicata*), and stiff goldenrod (*Solidago rigida*).

Gary Reece, MNFI

Remnant lakeplain oak openings with a partially closed canopy are often restorable with prescribed fire.

Threats and Conservation

Since the time of European settlement, many lakeplain oak openings have been lost due to conversion to agriculture, development, or have been drastically altered by fire suppression and disruption of hydrology. Land managers seeking to restore lakeplain oak openings should focus efforts on expanding existing remnants through the use of prescribed burning and where former savanna has converted to forest, careful and gradual thinning of the canopy. Restoration of hydrology may also aid in the restoration of some sites. As in most communities, control of invasive species, in particular shrubs such as common and glossy buckthorn is also a priority.

Similar Communities

Similar communities to lakeplain oak openings include lakeplain wet prairie, lakeplain wet-mesic prairie, bur oak plains and oak openings. Both wet and wet-mesic lakeplain prairies may have very similar herbaceous vegetation and likely graded in and out of lakeplain oak openings based on fire frequency, hydrology, and topography. However, like all prairies, they have less than one tree per acre (<5% canopy). Bur oak plains and oak openings are mesic and dry-mesic savanna communities, respectively, and are also dominated oaks. While they may have similar groundcover, they are found primarily on glacial outwash and never on the glacial lakeplain. For a more detailed overview of lakeplain oak openings, please see the abstract available on the MNFI website (Cohen 2001a).

Oak Barrens

General Description

Oak barrens is a dry savanna community found primarily in southern Lower Michigan on droughty glacial outwash plains. White and black oaks form the dominant canopy, which ranges from 5 to 60%, with short, sometimes sparse layer of grasses and forbs. Soils are typically infertile, coarse-textured sand with a moderately acid pH (5.6 – 6.5).

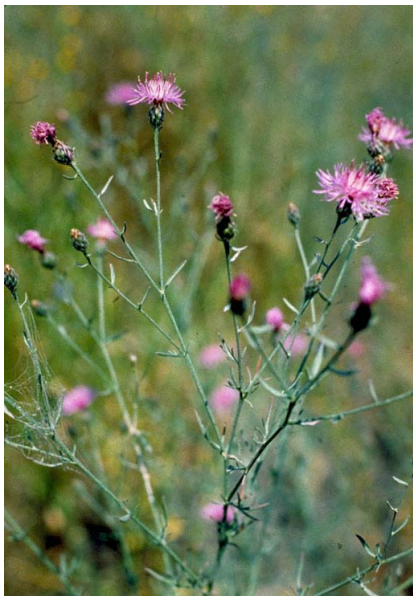
Ecological Processes

While periodic fire was important in promoting the herbaceous plant community, droughty soils also helped maintain an open condition by limiting tree establishment and growth to slow-growing, drought and fire-tolerant oaks. Canopy cover was likely highly variable from site to site and within the same site over time. This highly dynamic environment depended both on soil characteristics and fire frequency, with more frequent fires thinning out trees and shifting sites to a

Kim A. Chapman, MNFI

Pennslyvania sedge (*Carex pensylvanica*) and little bluestem (*Andropogon scoparius*) dominate the ground cover beneath black and white oak in a typical oak barrens.

more open, prairie condition and less frequent fires allowing more trees and shrubs to fill in, gradually turning the savanna into a more forested community.


University of Idaho

Spotted knapweed (*Centaurea maculosa*), an exotic invasive species

Characteristic Plants

Oak barrens are highly variable in vegetation structure, ranging from nearly completely open, park-like stands with only a 5% canopy of widely spaced trees to relatively dense thickets of trees and brush forming up to a 60% canopy. The overstory is dominated by white and black oaks, with pignut hickory (*Carya glabra*) often also present. Characteristic shrubs include hazelnut, serviceberry, sweet-fern (*Comptonia peregrina*), huckleberry, blueberry, and prairie willow (*Salix humilis*). The ground layer is often dominated by graminoids, including little bluestem, Pennsylvania sedge, poverty grass, hair grass, and needle grass (*Stipa avenacea* and *S. spartea*). Forbs are often sparse, but may include dry savanna specialists such as wild lupine (*Lupinus perennis*), goats-rue (*Tephrosia virginiana*), false foxglove (*Aureolaria* spp.), and columbo (*Swertia caroliniensis*) in addition to prairie species like blazing star (*Liatris aspera* and *L. cylindracea*), bush-cover (*Lespedeza hirta, L. capitata*), and wild bergamot (*Monarda fistulosa*).

Threats and Conservation

Like many other prairie and savanna communities, oak barrens have sharply declined as a result of fire suppression and conversion to other land uses. Because the soils are relatively infertile, many sites once cleared for agriculture have been abandoned and have returned to a semi-natural, though degraded, condition. Maintenance of existing remnants and restoration of degraded sites through the use of prescribed burning is recommended. Sites that have succeeded into more closed-canopy conditions may also benefit from careful, selective thinning of the canopy. Control of both herbaceous invasive species (such as spotted knapweed) and woody invasive species (particularly autumn-olive) is also often necessary. Where wildflower diversity has severely declined, replanting key species such as lupine may be beneficial if several years worth of other management fails to promote dormant plants or stimulate the native seed bank.


Brian Piccolo, Michigan DNR

Wild bergamot (*Monarda fistulosa*)

Similar Communities

Oak barrens may be confused with dry sand prairie, oak openings, oak-pine barrens, and dry southern forest. Dry sand prairie is a dry prairie community that historically existed in close proximity with oak barrens with very nearly identical herbaceous species. However, like all prairies, is has less than one tree per acre (<5% canopy). Oak openings is a dry-mesic savanna community found on slightly more productive, less droughty soils, and was historically dominated by white and bur oak, with more dry-mesic ground flora including higher proportions of big bluestem and Indian grass, and less Pennsylvania sedge. Oak-pine barrens is a dry savanna that may have very similar vegetation to oak barrens, but has a co-dominance of white, red, or jack pine (*Pinus strobus*, *P. resinosa*, *P. banksiana*) and exists primarily in northern Lower Michigan and the UP rather than southern Lower Michigan. Finally, dry southern forest may have similar canopy dominants to oak barrens, but typically has a mostly closed canopy. However, some sites may actually be closed-in remnants and managers should check for site indicators like large, open-grown oaks (wolf trees), herbaceous savanna indicator species, and circa 1800s vegetation maps that indicate a high prevalence of black oak barrens. For a more detailed overview of oak barrens, please see the abstract available on the MNFI website (Cohen 2001b).

Oak-pine Barrens

General Description

Oak-pine barrens is a dry savanna community found primarily in northern Lower Michigan and the UP on droughty glacial outwash plains. Canopy coverage is variable, ranging from 5-60%, and is dominated by white, black, and northern pin oak (*Quercus ellipsoidalis*) along with white, red, and jack pine. The herbaceous layer is typically short and dominated by Penn sedge, and soils are typically infertile, coarse-textured sand with a moderately acid pH (5.6 – 6.5).

Ecological Processes

Low-intensity fire and periodic drought are the key process that maintained an open savanna environment in oak-pine barrens. Fires burning adjacent prairie historically spread into surrounding woodlands, burning out fire-intolerant trees and shrubs and over time, thinning the canopy. This in conjunction with periodic drought on the sandy, infertile soils inhibited tree growth and development and helped maintain a partial canopy coverage of oaks and pines.

Michael A. Kost, MNFI

Oak-pine barrens often have a partially open canopy and occur on dry, sandy soils in northern Michigan.

Characteristic Plants

Like many savannas, oak-pine barrens can be highly variable in structure depending on site-level soil characteristics, land use history, and fire frequency. White, black, and northern pin oak typically co-dominate with white, red, and jack pine to form a canopy that ranges from 5% to 60%. Shrubs are similar to other dry barrens, and can include hazelnut, serviceberry, huckleberry, blueberry, and prairie willow. Herbaceous vegetation is very similar to oak barrens, being typically short and sometimes also sparse, and is dominated by little bluestem and Penn sedge with lesser amounts of big bluestem. Other grasses and forbs typically include poverty grass, hair grass, sand tickseed (*Coreopsis lanceolata*), woodland sunflower (*Helianthus divaricatus*), and sky-blue aster (*Aster oolentangiensis*). Ground layer diversity is often low and may be dominated almost exclusively by Penn sedge in areas that have been grazed and/or fire suppressed.

Threats and Conservation

Like many other prairie and savanna communities, oak-pine barrens have declined as a result of fire suppression and conversion to other land uses. Because the soils are relatively infertile, many sites once cleared for agriculture have been abandoned and have returned to a semi-natural, though degraded, condition. Maintenance of existing remnants and restoration of degraded sites through the use of prescribed burning is recommended. Sites that have succeeded into more closed-canopy conditions may also benefit from careful, selective thinning of the canopy. Control of both herbaceous invasive species (such as spotted knapweed) and woody invasive species (particularly autumn-olive) is also often necessary.

Similar Communities

Communities similar to oak-pine barrens include dry sand prairie, oak openings, oak barrens, pine barrens, and dry northern forest. Dry sand prairie is a dry prairie community that historically existed in close proximity with oak-pine barrens with very nearly identical herbaceous species. Like all prairies, it can be differentiated by having less than one tree per acre (<5% canopy). Oak openings is a dry-mesic savanna community found in southern Lower Michigan on slightly more productive, less droughty soils, and was historically dominated by white and bur oak. Oak barrens is a dry savanna that may have very similar vegetation to oak-pine barrens, but is located primarily in southern Lower Michigan and is dominated by white and black oak with little to no pine component. Pine barrens is also a dry savanna community, but as the name implies is dominated by red and jack pine with few oaks. Dry northern forest may have similar canopy dominants to oak-pine barrens, but typically has a more closed canopy. Since many sites may actually be closed-in remnants, managers should check for site indicators like large, open-grown oaks (wolf trees), herbaceous savanna indicator species, and circa 1800s vegetation maps that indicate a high prevalence of oak-pine barrens. For a more detailed overview of oak-pine barrens, please see the abstract available on the MNFI website (Cohen 2000).

Pine Barrens

General Description

Pine barrens is a dry coniferous savanna dominated by scattered jack pine located in northern Lower Michigan and the UP. Occurring on level to rolling glacial outwash, soils are typically very infertile, strongly acidic (pH 4.5 – 6.0), coarse-textured sands.

Pat Comer, MNFI

Pine barrens occur on sandy rolling terrain with scattered jack pine and a groundcover of Pennslyvania sedge and little bluestem.

Ecological Processes

The pine barrens and surrounding jack pine forests are known for infrequent, catastrophic, stand-replacing fires, largely as a result of fire-promoting adaptations of jack pine such as flaky, thin bark, volatile oils in the needles, and serotinous cones (only opening following extreme heat). Under some circumstances, low-intensity fires that burned primarily herbaceous vegetation also likely occurred. Pine barrens typically dominated the most frequently burned and most infertile sites. In addition to periodic severe drought, frosts are also common in low depressions (frost pockets) and can occur throughout the growing season, severely limiting growth of deciduous trees and shrubs.

Characteristic Plants

Pine barrens are typically dominated by irregularly scattered jack pine, with lesser amounts of northern pin oak. Shrubs may range from sparse clumps to extensive colonies and include characteristic species like bearberry, blueberry, and sweet-fern. Though not a shrub, bracken fern (*Pteridium aquilinum*) is another common plant reaching the a similar height (2-4 feet). Groundcover is often dominated by grasses and sedges such as Penn sedge, little bluestem, and poverty grass. Forbs are typically sparse but may include indicator species like birdfoot violet (*Viola pedata*), rough blazing star (*Liatris aspera*), and Hill's thistle (*Cirsium hillii*).

Merel Black, Wisconsin State Herbarium, University of Wisconsin-Madison

Little bluestem (*Andropogon scoparius*)

Threats and Conservation

Fire suppression is the primary threat to remaining pine barren remnants. Due to the catastrophic nature of wildfires in jack-pine dominated areas, social and political concern over potential dangers of fire remains high throughout the pine barrens region. In addition to fire suppression, many areas of former pine barrens are under active timber management, and sites are typically mechanically furrowed and replanted following harvest. Natural succession and the planting of trees into barrens has led to a decline of species dependent on natural, irregular openings. Rare plant species in particular are threatened by the furrowing of the ground and dense plantations. Managers seeking to maintain and restore pine barrens should aim for canopy coverage of 10-40% (Kost et al. 2000). If possible, prescribed fire should be carefully used to stimulate the herbaceous vegetation and seed bank.

Similar Communities

Similar communities include dry sand prairie, oak-pine barrens, and dry northern forest. Dry sand prairie is a dry prairie community that historically existed in close proximity with pine barrens with nearly identical herbaceous species. Like all prairies, it can be differentiated by having less than one tree per acre (<5% canopy). Oak-pine barrens is also a dry savanna that may have very similar vegetation to pine barrens, but has a co-dominance of white, black, and northern pin oak in addition to a white, red, and jack pine. Dry northern forest may have similar canopy dominants to pine barrens, but typically has a more closed canopy. Since some sites may actually be closed-in remnants, managers should check for herbaceous indicator species and circa 1800s vegetation maps that indicate a high prevalence of pine barrens. For a more detailed overview of pine barrens, please see the abstract available on the MNFI website (Comer 1996).

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