



National Park Service Ice Age National Scenic Trail Fire Effects Monitoring Plan



Ice Age Trail at Cross Plains. Photo credit: Dan Jorgensen.

January 14, 2026
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1.0 PURPOSE

Fire Monitoring Plans are required by “all NPS units applying prescribed fire, managing wildfire for multiple benefits, or altering the arrangement of wildland fuels for the purpose of modifying fire behavior... .” (USDI National Park Service 2024). This plan describes in detail how monitoring is conducted at Ice Age National Scenic Trail fee property (henceforth the Trail).

Prescribed fire and mechanical fuels treatments will be used to maintain and restore fire-adapted ecosystems at the Trail and appropriate monitoring is conducted to document their effectiveness and extent. Monitoring is the primary way the fire program determines if goals and objectives are being met and provides data for adaptive management.

This plan also serves as a guide for the Great Lakes Fire Ecology Program, including all the necessary information needed to implement monitoring at the Trail. It is important that monitoring techniques be consistent over time, and this plan helps to ensure that.

2.0 INTRODUCTION

2.1 SITE DESCRIPTION

Ice Age National Scenic Trail is a 1200-mile trail winding through 30 counties in Wisconsin roughly following the terminal moraine and other geologic features created by the last glaciation. The National Park Service (NPS) manages and owns in fee parcels of land along the Trail. The NPS actively manages 161 acres, located in the town of Cross Plains, WI, 15 miles west of Madison. Besides containing important geologic features, the site is home to historic oak savannas, prairies, some mesic hardwood forests, agricultural fields. The NPS also owns 79 acres of upland forest in Langlade County, WI (informally referred to as Mueller Lake). There are currently no plans to conduct monitoring on this parcel, however.

The climate of southern Wisconsin is humid continental with cold winters and warm humid summers. The average January and July daily temperatures for Cross Plains, WI is 19°F (-7°C) and 72°F (22°C) respectively (University of Wisconsin 2025). Approximately 37 inches of precipitation is received across the area annually.

2.2 SURROUNDING LANDS

The 161-acre site is part of the Glacial Passage Area (GPA) (formerly the Complex) managed by four partner agencies: NPS, U.S. Fish and Wildlife Service, WI Department of Natural Resources Dane County Parks, as well as the Ice Age Trail Alliance (the non-profit partner of IATR). The GPA contains more than 1200 acres of land managed by the partners. More detailed information on the GPA can be found in the Ice Age Trail Fire Management Plan, Section 1 (Department of Interior 2025) and the Vegetation Master Plan for the Complex (Van Cleve et al. 2021).

2.3 VEGETATION

The 2025 Updated Vegetation Management Plan provides an in-depth analysis of the vegetation communities at the GPA, past and current management activities, species lists, seedings, and restoration efforts. What follows is derived from that report as well as from information gathered from site visits.

The 1833 survey records indicate that the GPA was dominated by oak savanna and dry mesic prairie. All the prairies have since been plowed under and the savannas were grazed and have since become invaded with black walnut and invasive species, primarily European buckthorn (*Rhamnus cathartica*) and honeysuckle (*Lonicera x bella*). Remnant trees from the former savannas remain as scattered open-grown white and bur oaks. Portions of the property are currently being restored.

2.5 DESIRED FUTURE CONDITIONS

There has been much debate in the Park Service surrounding the establishment of desired future conditions for terrestrial landscapes. Stephenson (1999) compares two widely used approaches to address desired future condition: structural restoration and process restoration. Structural restoration focuses on restoring forests to a particular time period while process-oriented restoration restores natural processes, namely fire, with the idea that restoring the process will restore the system. While neither approach is perfect, our knowledge of fire regimes is far more accurate than our knowledge of forest conditions during the past 100 to 300 years, the common time period chosen for restoration. Suffice to say, neither approach will turn back time and managers will need to be content with the fact that landscapes can only be restored to a relatively broad range of conditions considered as “natural”. This broad condition, known as the natural range of variability (NRV), is established based on what we know of plant communities, how they function, and what we know about past conditions when human influences were relatively minimal. This serves as the basis for setting goals for the protection and maintenance of ecosystems (Landers et al. 1999). Process Restoration is recommended for use at the Trail and is outlined in greater detail in Section 4.0 of this document.

3.0 DESCRIPTION OF THE ECOLOGICAL MODEL

Two fire dependent community types will be monitored at the complex, dry/mesic prairie and oak savanna. Successional patterns as influenced by the natural disturbance regime will be described for each community/monitoring type. Important plant species within each type are described as well as the silvical characteristics of the dominant species.

The plant communities being monitored for short- and long-term effects were chosen based on management objectives and which types were likely to be treated with prescribed fire or mechanical means. Prescribed fire and mechanical thinning treatments are implemented at the Trail for ecological and fuel reduction purposes.

3.1 DRY MESIC PRAIRIE

The Trail currently does not have any fully restored prairie ecosystems. Agricultural fields at the Trail are maintained by haying until money is available to restore them to prairie. The dry/mesic prairie system (henceforth tallgrass prairie) is the closest approximation to the planned restoration.

3.1.1 Ecosystem Processes and Management

In its natural state tallgrass prairie is highly diverse and dominated by big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), Indian grass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*) and a wide variety of herbaceous plants (Risser 1990). It is nearly absent of woody vegetation.

Tallgrass prairies depend on fire every 3-4 years (Knapp et al. 1998) to prevent invasion by woody species and to favor native herbaceous vegetation (Bragg and Hulbert 1976, Anderson 1990, Murphy and Grant 2005) (Fig. 1). However, prairie restoration treatments often require more frequent fire, every one to two years, in combination with mechanical, chemical and cultural treatments (Bragg 2001). After restoration the more natural 3 to 4-year fire return interval is sufficient to maintain it. Less frequent fire, every five to ten years, may allow encroachment of woody species, and once established even high frequency burning will not extirpate them (Briggs et al. 2005). Periodic drought may be the only way to revert this successional progression (Faber-Langendoen and Tester 1993). Long-term regional climate and associated weather extremes regulate ecosystem changes and distribution (Transeau 1935, Overpeck et al. 1990, Brown and Wu 2005), and likely to what extent prairies and other fire dependent ecosystems can be restored. The climate, by regulating drought occurrence, alters fire frequencies and thus influences community structure.

Fire, grazing and small-scale disturbances greatly influence species diversity and abundance (Fig. 2), (Hartnett and Fay 1998). The high diversity in tallgrass prairies is attributed to a large group of forb species, while overall dominance resides within a small group of core species, mainly C₄ grasses. Prolonged high frequency (annual) fires decrease forb richness and overall diversity by increasing competition and dominance of native C₄ grasses (Collins and Gibson 1990, Bowles et al. 2003), while grazing tends to have the opposite effect (Collins and Wallace 1990, Knapp et al. 1998). The greatest diversity is found 6 to 7-years post fire as grass dominance fades and forbs become more abundant (Gibson and Hulbert 1987). Large grazers, preferring grasses over forbs, reduce competition to forb species thus promoting their abundance and propagation. Small scale disturbances, such as badger dens and gopher mounds, create micro-sites for plant colonization. Plants that colonize these sites come from assemblages that are different from those in the surrounding undisturbed area (Hartnett and Fay 1998).

Fire seasonality is widely recognized as having a significant impact on the species composition of a prairie (Fig. 2). Howe (1994, 1995) points out that depending on its flowering guild a plant will be favored or disfavored by the season of fire. C₄ grasses and warm season plants, flowering in late summer, are favored by spring burns, while C₃ and cool season plants that flower in early summer are favored by mid-summer burns (Hover and Bragg 1981, Ewing and

Engle 1988, Engle and Bidwell 2001). Spring or dormant season burns create warmer, shade free and nutrient rich soil conditions prior to C₄ spring emergence, giving them an earlier start than normal, conversely, C₃ plants that have already sprouted are set back. This early start leads to an increase in C₄ biomass (Kucera and Ehrenreich 1962) thus increased competition for C₃ plants (Knapp et al. 1998). Mid-summer burns impact C₄ plants while their reproductive parts are still developing and meristems are exposed, thus causing die-back (Copeland et al. 2002). C₃ plants which have already finished reproduction are thus favored. Mid-summer burning regimes that suppress C₄ grasses often increase plant diversity (Howe 1994, Copeland et al. 2002). Most researchers agree that mid to late-summer prairie fires were the norm since lightning is most frequent at that time and fuel conditions are favorable (Bragg 1982, Higgins 1984, 1986, Howe 1994, Knapp et al. 1998). West (1996) supports the above findings but warns against frequent late summer burns in restored or severely degraded prairies. This may encourage non-native C₃ grasses while suppressing native C₄ grasses that may not be overabundant.

There is a growing body of literature concerning fire and insect populations. Despite known impacts of fire on vegetation, care must be taken to protect insect populations, especially prairie specialists. This should be taken into consideration when determining fire frequencies (N. Pavlovic pers. comm.). Small fire exclusion zones may be used to ensure protection for insects. This 1 to 2-acre zone is moved each time the site is burned.

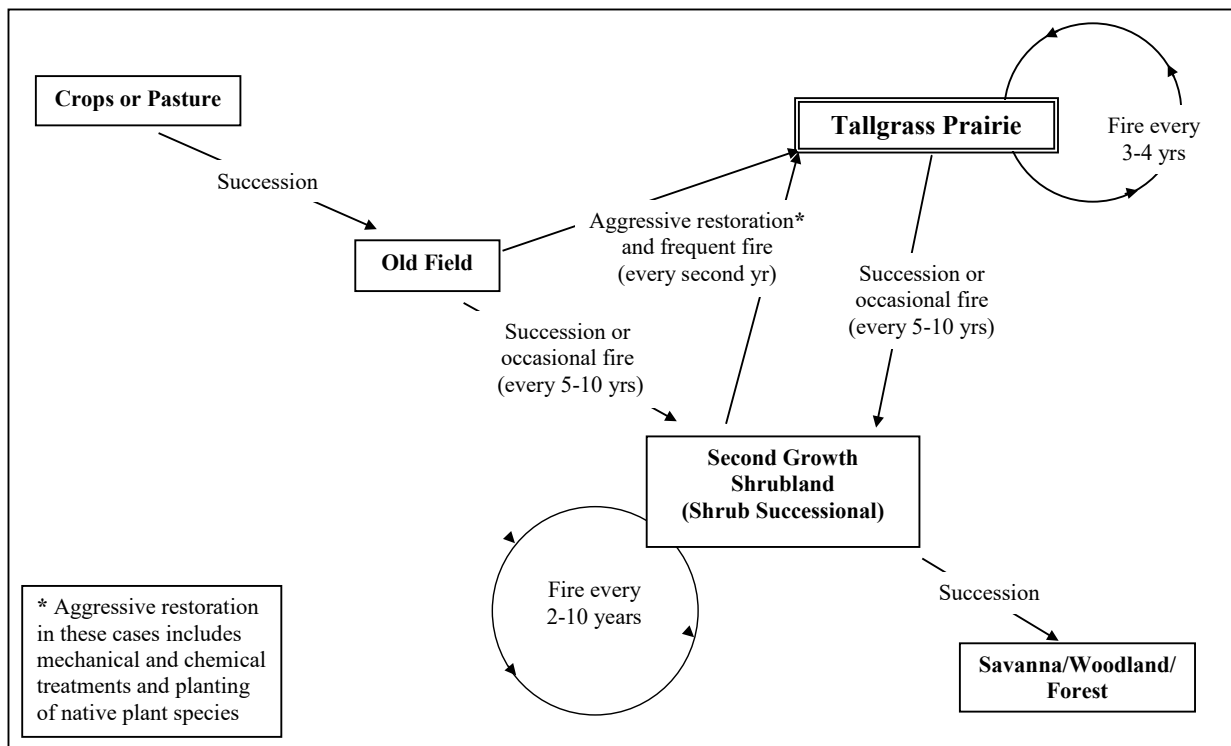


Figure 1. Ecological model for tallgrass prairie.

3.1.2 Successional Pathways (Fig. 1)

After abandonment of agricultural fields and pastures, the site will succeed to an “Old Field” condition composed of a limited variety of typically invasive grasses and forbs. Old Fields are often dominated by smooth brome (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*) Canada goldenrod (*Solidago canadensis*). Continued succession, even in the presence of periodic fire, will result in a shrubland. A tallgrass prairie community can be re-established from the two aforementioned conditions with aggressive restoration efforts, though it becomes increasingly more difficult with succession. The shrubland condition may remain even in the presence of a frequent fire regime (Briggs et al. 2005). Eventually, a woodland or forest condition will result depending on the recurrent fire regime.

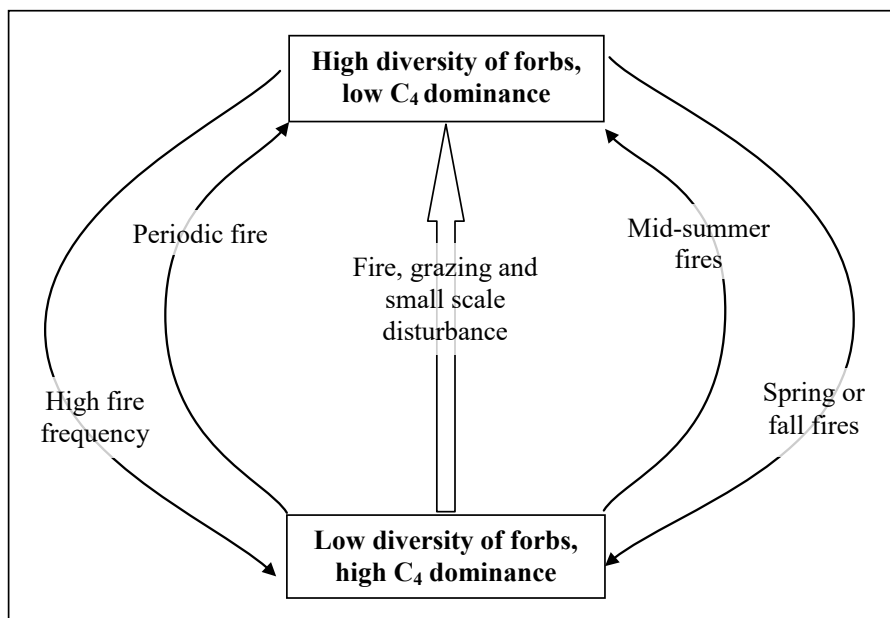


Figure 2. Effects of disturbance on tallgrass prairie diversity

3.3 OAK SAVANNA

The once widespread, oak savannas of the Midwest are now considered imperiled ecosystems (McPherson 1997). It is considered “Vulnerable” Globally (G3), at moderate risk of extinction; and is ranked as “Imperiled” (S2) by the State of Wisconsin. Midwestern oak savannas once covered approximately 12 million hectares from Minnesota to Ohio and south into Missouri (Nuzzo 1986). Only 2/100ths of a percent remains after conversion to agriculture and development. Approximately, 70 acres under NPS ownership will be managed for oak savanna.

Oak savannas are very diverse ecosystems. The variation in light found in savannas leads to a highly diverse understory community of shade tolerant and intolerant grasses and forbs. Though specifics on canopy cover vary, savanna is generally defined as having a single discontinuous and patchy tree or shrub canopy layer of between 15% and 50% closure and a continuous herbaceous layer dominated by grasses (McPherson 1997, Taft 1997, Will-Wolf and Stearns

1999). The precise amount of woody vegetation is not as important an indicator of savannas as is the existence of the two distinct vegetation layers. Treed communities with an understory dominated by low growing shrubs are not considered savannas (McPherson 1997). Savannas can, however, include patches of oak scrub instead of the herbaceous layer.

The oak savannas at the Trail still have some scattered remnant open-grown bur and white oaks (*Q. macrocarpa*, and *Q. alba*). The sites, however, have converted to mesic hardwood forests dominated by mature black walnuts (*Juglans nigra*), with numerous associate species including, paper birch, (*Betula papyrifera*), black cherry (*Prunus serotina*), and shagbark hickory (*Carya ovata*). Except in recently cleared areas, the midstory is choked with a dense layer of brambles (*Rubus* species), honeysuckle and buckthorn. The ground layer is dominated by Pennsylvania sedge (*Carex pensylvanica*).

3.3.1 Ecosystem Processes and Management

Fire history studies show fire as an historical disturbance agent in oak savannas (Henderson and Long 1984, Dorney and Dorney 1989, Taylor 1990) and is essential to a savannas' continued persistence (McPherson 1997). Frequent fire prevents invasion of woody species and maintains an open canopy with a grassy/herbaceous understory. Taylor's 1990 dendro-chronological study estimated the average fire interval for savannas at Indiana Dunes National Park at 5 years with a minimum of 1-2 years and a maximum of up to 24 years. Sites with deep fertile soils will require a higher fire frequency to maintain savannas than infertile sites (McPherson 1997). Variation in fire frequencies has a great impact on the tree density and subsequently the herbaceous layer composition (Peterson and Reich 2008).

When considered in a 100-year time frame, continued short interval fire (<3 years) will convert an oak savanna to oak grub or brush prairie. Frequencies which continually allow ingrowth (>10 years) will convert the system to woodland and possibly forest. Such a transformation can be permanent due to changes in fuel type, shading and subsequently the fire regime (McPherson 1997). Cottam (1949) and Briggs et al. (2005) both found persistence of woody species even with high fire frequencies. Long-term and winter droughts, which stress and/or kill trees by preventing deep recharge of soil moisture, are important in maintaining or restoring prairie and savanna conditions (Britton and Messanger 1969, Anderson et al. 1999). These droughts may be key opportunities where fire can kill significant amounts of persistent woody vegetation (Anderson 1990).

Recent long-term studies at the Cedar Creek Natural History Area (CCNHA) offer some insight into savanna management. Restoration of bur oak/pin oak savannas at CCNHA indicate that fire intervals of <3 years successfully eliminated most fire sensitive species and oak trees $\leq 4"$ (10 cm) dbh (Faber-Langendoen and Davis 1995). Therefore, prescribed fire will have a limited effect on reducing the density of overstory trees and associated canopy cover. Peterson and Reich (2001) found little difference among fire frequencies of 1-3 years, while frequencies less than 20% (2 in 10 years) resulted in thickets. Conclusions of these studies suggest that perpetual high frequency fire will stop ingrowth but will not restore the natural structure. Periodic high intensity fires or mechanical treatments are needed to reduce the cover of large trees and achieve savanna conditions. Additionally, long-term, constant, frequent fire will result in unsustainable

tree populations in which case the community may revert to oak scrub and given enough time, a prairie. The minimum fire frequency necessary to halt degradation by in-growth can be based on the length of time it takes for trees to become resistant to top-kill. Unfortunately, monitoring data from Indiana Dunes (INDU) shows that under normal burning conditions trees as small as 2" (5 cm) in diameter are rarely killed by prescribed fire (Weyenberg 2006). However, much larger trees are killed on occasion e.g. Inland Marsh, 2001 and Dune Ridge, 2006 INDU prescribed fires (Personal observation).

It is recommended that management of fire frequency and intensity should be scheduled on decadal scales (Peterson and Reich 2001) to provide more flexibility in treatments and allow managers to address concurrent resource objectives. Irregular fire frequencies that burn only parts of an area have been the most effective management for multiple resource concerns (Anderson et al. 1999), provided the site is large enough.

Fire frequency is only one consideration among many. Fire intensity and behavior, soil type, nutrient cycling, topography, climate and their interactions are all important factors that must be considered when managing this system (Anderson 1990, Reich et al. 2001). Reich et al. (2001) provides an in-depth evaluation of the interactions between fire and vegetation type, and resulting positive feedback loops, which can perpetuate a conversion from grass-dominated systems to tree-dominated systems. Intrinsic differences in fine root turnover rates, leaf and litter chemistry and nitrogen (N) mineralization rates between grasslands and forests facilitate further differences over time causing the systems to diverge. Frequent fires limit woody species invasion and volatilize N leading to N deficiencies (Hernandez and Hobbie 2008), which are perpetuated by the graminoid communities favored by fire. In contrast, fire intervals that allow invasion of woody species will lead to increases in N mineralization and eventually canopy cover, shading out of grasses and promotion of more woody species. Even with similar fire frequencies N mineralization rates in woodlands are substantially higher than those of grasslands.

The overstory cover regulates light, moisture and nutrient regimes, which in turn have controlling effects on the understory. McPherson (1997) states the relationship between the understory and overstory cover is logarithmic. With little canopy cover, small increases will result in large decreases in grass and forb cover. As the canopy approaches closure, increases in tree cover will have little effect on the already diminished herb layer.

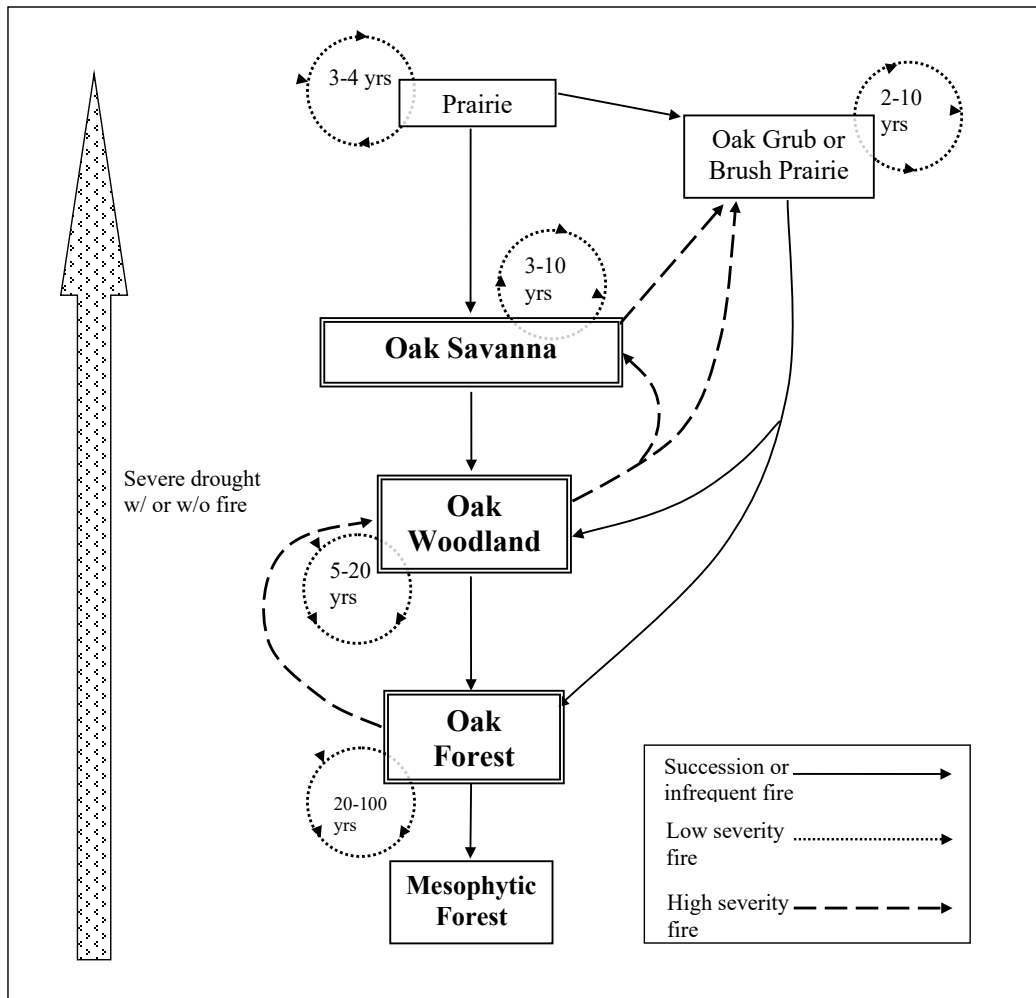


Figure 3. Ecological model for oak savanna, woodland and forest.

In this figure fire severity, low and high, generally refers to plant mortality caused by fire. High severity implies high mortality and other associated fire effects on soils, fuels, etc. Fire severity is not meant to imply a fire type, e.g. surface fires can be low, medium or high severity.

3.3.2 Fire Regime and Succession (Figure 3)

The prairie/savanna/woodland/forest complex is a result of the interaction of fire with numerous environmental factors. In general, systems will succeed without fire or with infrequent fire from a prairie toward a mesophytic forest. Depending on the frequency of fire, succession may be halted at any point along the way. Within each community type there is variability in stand structure which allows gradation from one type to another. Low severity surface fires within the range given will maintain a system once it is established. There is an overlap in fire frequencies among systems since low severity fires will not destabilize these systems. Severe fires or drought will destabilize systems and set them back to an earlier or alternate successional stage depending on the severity and type of disturbance. Severe fires in woodlands and savannas tend to create oak grub or brush prairie shrublands since the roots of the former trees re-sprout vigorously. This stage may also be produced from prairie given the right soils and a long enough lapse between fires. Shrublands left unburned will succeed to oak thickets and woodland or forest. More frequent fires will produce savannas while less frequent fires lead to woodlands.

Oak forest will increasingly grade toward mesophytic forest as the time since fire increases. Windthrow and oak wilt will speed up this process by releasing pockets of mesophytic species. Mesophytic forests rarely experience fire; return intervals are in the range of once every 100 to several hundred years for low severity surface fire. High severity fires are as rare as once every 2000-3000 years (Frelich 2002).

4.0 MANAGEMENT OBJECTIVES

4.1 INTRODUCTION

The Trail's vegetation has changed dramatically since European settlement and for several reasons it is difficult to know the historic plant community composition with precision. A reasonable approximation may be determined based on 1833 Government Land Office (GLO) notes, historic aerial photos and landscape/vegetation associations. The goal is not to recreate the past landscape, but to create representative one (Van Cleve et al. 2021). Management objectives were developed for each vegetation type to help guide the actions toward the desired future condition. Knowledge of likely past vegetation of the Trail and the disturbance regimes for each ecosystem were used as a template for the objectives.

The goal of creating landscape conditions representative of the recent past encompasses restoring the vegetation structure and composition of the selected types to their "natural" condition. At which point periodic maintenance using prescribed fire and invasive species control measures should sustain the ecosystems. Important aspects of each ecosystem's natural condition are selected as management objectives.

The Desired Future Condition is based on those outlined in the Trail's Vegetation Master Plan (2021), which coincides with the Natural Range of Variability (NRV) for each community type as found in the scientific literature. The NRV describes elements of each ecosystem and assigns realistic and acceptable limits to characteristics such as canopy cover, and plant lifeform composition as appropriate.

4.2.1 Dry Mesic Prairie (Restored tallgrass prairie)

The target condition is to produce a dry to mesic tallgrass prairie that transitions into the surrounding oak savannas. This community, though not currently present, is dominated by native grasses such as big bluestem and switchgrass with a mixture of numerous native forbs. Many exotic invasive species such as Kentucky bluegrass, (*Poa pratensis*) smooth brome (*Bromus inermis*), clovers (*Trifolium* spp), Canada goldenrod and tall goldenrod (*Solidago altissima*) dominate the Old Fields.

The following management and prescribed fire objectives will be met by using prescribed fire, as well as mechanical and chemical treatments.

- a) Treat the area with prescribed fire 1 out of 3 years, i.e. a fire frequency of 30%.
- b) Tree canopy cover between 0 and 10% of open-grown bur or white oaks.

- c) Shrub cover of <5%.
- d) At least 80% of the herbaceous layer species richness is attributed to forbs.
- e) A minimum of 15 native graminoid species and 60 native forb species occur on the site.

4.2.2 Oak Savanna

Currently overgrown oak savannas are to be restored to natural conditions. Quantifiable target characteristics include a single layer canopy dominated by bur and/or white oak, canopy closure between 10% and 30% and a single understory layer dominated by grass (cover) excluding Pennsylvania sedge.

The following management and prescribed fire objectives will be met using prescribed fire, as well as mechanical and/or chemical treatments.

- a) Treat individual sites with fire 1 out of every 3 years, (fire frequency 30%).
- b) Canopy cover 10 – 30%.
- c) Open-grown oaks constitute 80% of the overstory canopy.
- d) Shrub cover <10%.
- e) Non-native plant cover <1%.
- f) Greater than 75% of the herbaceous layer species diversity is attributed to forbs.
- g) Graminoid cover is 30 - 60%.

5.0 MONITORING OBJECTIVES

The monitoring objectives build upon the management objectives listed above by adding quantitative measures of precision (how narrow of a confidence interval around the sample statistic is acceptable), power (the ability to detect a change of a particular size ($1-\beta$)) and false and change error rate (alpha level, a measure of how willing we are to say a change has occurred when in fact it has not).

All implied changes refer to pre- vs. post-burn levels and/or year-to-year variation, and we are willing to accept a 10% chance of falsely detecting a change ($\alpha = 0.1$)

Given the size of the sites after accounting for edge-effect and required plot spacing it may not be possible to achieve the desired levels of precision, since the number of plots that can be installed is limited.

Establishing a time frame for the stated goals is difficult given that multiple applications of fire, thinning and chemical are required to achieve the restoration. Each treatment is dependent on the success of the previous ones. Achieving an acceptable restoration in a highly degraded system may take 20 – 30 years. As such, restoration goals stated below for this landscape should be achieved by 2040.

5.1 DRY MESIC PRAIRIE

- a) Be 80% certain that the mean canopy closure is between 0 - 10%.
- b) Be 80% certain that the mean percent cover of shrubs is <5%.
- c) Be 80% confident that 80% of the mean total species richness is composed of native forbs.
- d) Be 80% certain that the species composition is composed of at least 15 native grasses and 60 native forbs.

5.2 OAK SAVANNA

- a) Be 80% certain that the mean canopy closure is between 10 - 30%.
- b) Be 80% certain that the mean percent cover of shrubs is <10%.
- c) Be 80% certain that the mean percent cover of non-native species is <1%.
- d) Be 80% confident that 75% of the mean total ground layer species richness is composed of native forbs.
- e) Be 80% certain that the mean percent cover of native grasses is between 30 – 60%.

6.0 MONITORING LEVELS

Different monitoring levels are employed to assess fire effects. Levels 1 and 2, Environmental and Fire Observation, provide background information needed for decision making and assess fire behavior. This knowledge is critical for implementing prescribed fire and when analyzing the aftereffects on vegetation. Level 3, Surveying Immediate Post-Fire Effects, and Level 4, Evaluating Long-term Change, address whether the management objectives are being met, and whether any negative impacts are being produced.

Wildland fires that are suppressed will be monitored at Level 1 and, if possible, Level 2. Prescribed fires will be monitored at least at Levels 1 and 2.

6.1 LEVEL 1

6.1.1 Environmental

Weather, fire danger rating, fuel conditions, resource availability, concerns and values to be protected, other biological, geographical and sociological data.

The above elements are fulfilled by the fire management staff. Weather can be monitored hourly via nearby RAWS stations or the National Weather Service Office in Madison, WI. From these data, fire danger ratings, drought indices and fuel moistures are computed. Fuel loading may be determined by using LANDFIRE fuel model maps and/or ocular estimates based on experience and natural fuels photo series. Fuel load data are collected as requested by fire operations staff. Areas of high fuel loading within the burn units at the Trail are patchy and not of great concern unless near fire lines. For this reason, as well as the small size of the units and the fuel types involved, onsite fuel measurements have not been requested.

6.2 LEVEL 2

6.2.1 Reconnaissance

Fire cause/origin, location, size, fuel type, vegetation, activity, potential for spread, current and forecasted weather, resource or safety threats and constraints, and smoke volume and movement.

Wildfires have not occurred on Trail property as of this writing. If they do, the following procedures will be used as needed. The origins, locations and sizes of all fires greater than 1 acre are mapped in GIS. Smaller fires are only identified by a point, e.g. a single set of coordinates. Depending on the situation, the Incident Commander, fire monitors or other qualified personnel document fuel and vegetation type(s), fire activity, spread potential, weather, smoke characteristics and threats to safety and cultural and natural resources. These data are maintained electronically by the Great Lakes Fire Management Program (GLFM). A fire report is produced by the fire incident commander including all the above information plus logistical information.

For prescribed fires, reconnaissance information is detailed in the burn plan. It includes a prescription describing acceptable weather conditions such as temperature, relative humidity, wind direction, mixing height and transport winds.

6.2.2 Fire Observation

Fire monitoring period, ambient conditions, duff moisture, fuel models, and fire and smoke conditions.

On the day of the prescribed fire, spot weather forecasts are requested from the National Weather Service. On-site weather observations are taken immediately prior to the test burn and hourly thereafter. Weather observations include location, dry bulb temperatures, relative humidity, wind speed and direction and cloud cover.

Fire behavior and smoke dispersal data may be collected during the burn. Data include flame length and depth, rate of spread, ignition pattern, fuel characteristics, smoke dispersal and visibility on nearby roads. Pictures may be taken of ignition, holding, and fire behavior. The ignition pattern and method, and any unusual occurrences are documented i.e. media on scene, smoke complaints, etc.

6.3 LEVELS 3 AND 4 MONITORING

6.3.1 Immediate Post-burn & Long-term Trends

Attributes collected to identify trends are selected based on the goals and objectives for the burn and the vegetation community. The basic attributes are listed below; more may be added as needed.

- *Post-burn Conditions* - Average scorch & char heights, burn severity based on substrate and vegetation mortality.

- *Overstory Layer* – Density, diameter & height by species, canopy closure.
- *Understory Layer* – Frequency, cover &/or density by species, diversity

7.0 SAMPLING PROTOCOLS

7.1 INTRODUCTION

The standard Park Service FMH plots, as described in the NPS Fire Monitoring Handbook (USDI National Park Service 2003), are not installed at the Trail. Given the size of these plots (50 x 20m) and the small sampling area, only 2 or 3 would be installed in each monitoring type. Alternate protocols, named Project Level Monitoring or PLM plots, are installed. These protocols use some of the FMH methods as well as other standard forestry methods. These plots are smaller, easier to install, and faster to sample, which allows for a greater number of plots to be established within each monitoring type. This in turn allows staff to answer questions on fire effects with some statistical relevance. A brief description of the methods follows (Figures 4 & 5). More details on these protocols can be found in the Fire Effect files at Indiana Dunes National Park.

As of 2025, there were nine project level plots installed within the Oak Savanna monitoring type and no monitoring plots in the grassland type.

The protocol for monitoring grasslands is a subset of that used for the oak savannas. Two methods are used for monitoring in the grasslands, they are *Plot Photos*, and *Herbs, Graminoids and Small Shrubs*. Plots installed within the Oak Savanna type use all the methods described below.

7.2 NEW PLOT ESTABLISHMENT

Additional plot installations will be based on prescribed burn priorities and information gaps. Within each monitoring type, 3 - 15 plots should be established, depending on the size of the unit. Plots will be located at least 40 m apart, and 40m from ecosystem boundary. Plot centers are marked with a re-bar or conduit stake labeled with an aluminum tag indicating the plot number along with the word “FIRE”. Prior to the completion of thinning and mowing operations “trail ticklers” will be used instead of stakes. Standard metal stakes would damage equipment and endanger the operator. The azimuth and direction from one plot to the next are recorded and all plot locations are geo-referenced.

7.3 PLOT LOCATION

Coordinates of plot locations are recorded using UTM’s and the NAD83 projection. Directions to each plot are available in electronic form and in hard copy at the Great Lakes Fire Effects Office. A geographic information systems (GIS) shapefile of the plot locations is also maintained. See also Appendix A, for the map of plot locations and coordinates.

7.4 TIMING OF MONITORING

An attempt is made to read all plots during the peak growing season, preferably between mid-June and late-August, while the herbs and grasses are flowering and setting seed.

The initial pre-burn sample should be taken within 2 years of the planned burn. For subsequent burns, the “pre-burn” sample should be less than 5 years prior to the next burn.

Sampling after fires is ideally done on a set schedule. Post-burn assessments are performed within 4 weeks after a burn. Post-burn plot sampling is done at years 2, 5, 10, and 20 after the last burn. Years indicate the number of growing seasons since the burn, as opposed to a 12-month period. The FMH recommended year-1 post-burn read was eliminated due to the overwhelming number of plots in multiple parks that would have to be read each year. Each time a plot is burned, whether in a prescribed burn or a wildfire, the schedule is re-set.

After identifying all the plots in need of monitoring, sites are prioritized based on last read, previous and upcoming burns, park priorities and Resource Management requests. Given the workload, all plots are not always monitored as per the standardized schedule.

7.5 PLOT PHOTOS

Plot photos are taken from the plot center facing due north. Digital photographs are taken at eye level, with the camera fully zoomed out, i.e. ~35 mm. A dry erase board is placed in each photo to record the site, date, status (PRE, POST, etc.), plot number, and azimuth of the photo. If for some reason, it doesn't make sense to take the picture facing north, try east, south and west in that order.

When resampling a plot, a copy of the previous events photos is used help match the scene exactly.

7.6 OVERSTORY

7.6.1 Large Trees

All live and dead trees greater than or equal to 6 inches DBH (15.2 cm) will be tallied by species using a 10 basal area factor prism. Trees are tallied clockwise from due north. Record the species, DBH, Live/Dead/(Fallen) status and azimuth for each tree. In addition, select two of the closest trees to the plot center and record the distance from the PC to the face of each tree. This will help staff relocate the plot in the future. The diameter of each tree is recorded initially and every ten years thereafter until it dies. During interim reads the overstory is merely checked for mortality and in-growth.

Each tree is marked at breast height with a horizontal strip of white tree paste. The first tree is marked with a “+” sign. The two trees whose distance to the PC was measured are to be marked

at their base with tree paste. The first tree is marked with one dot and the second with two dots. Record on the data sheet how they were marked.

7.6.1.1 Interim Reads

For interim reads, the Live/Dead status of each tree is checked and additional trees that have grown in are added. Trees that fell down are recorded as F (fallen) or with the word DOWN. Print the data sheet with (or write in) the previous read's data with a few blank rows between the plots so additional trees can be added. Grey out or put dashes in the open data cells of the previous year's data to ensure that new data is recorded in the proper location.

7.6.1.2 Prism Use

A 10 BAF prism has a ratio of 33:1 therefore; a 1-foot diameter tree is just "in" at 33 feet (Table 1). Borderline trees can be determined as "in" or "out" by determining the "limiting distance" from the following equation.

$$(DBH(inches)) \times 2.45 = \text{Limiting Distance}$$

Limiting distance is measured from the plot center to the center of the tree bole. If the distance measured is less than or equal to the calculated distance, the tree is "in".

Table 1. Limiting distance for various tree sizes (10 BAF prism).

Cm	inches	Limiting Dist. (ft)	cm	inches	Limiting Dist. (ft)
5.1	2	5.5	40.6	16	44.0
7.6	3	8.3	43.2	17	46.8
10.2	4	11.0	45.7	18	49.5
12.7	5	13.8	48.3	19	52.3
15.2	6	16.5	50.8	20	55.0
17.8	7	19.3	53.3	21	57.8
20.3	8	22.0	55.9	22	60.5
22.9	9	24.8	58.4	23	63.3
25.4	10	27.5	61.0	24	66.0
27.9	11	30.3	63.5	25	68.8
30.5	12	33.0	66.0	26	71.5
33.0	13	35.8	68.6	27	74.3
35.6	14	38.5	71.1	28	77.0
38.1	15	41.3	73.7	29	79.8
			76.2	30	82.5

7.6.2 Canopy Cover

One canopy photo is taken at the plot center using a fish-eye lens and tripod. Canopy photos are taken every ten years or as needed. There is no data sheet for this method. Simply record the

photo number and plot number on a sheet of paper. After the photos are labelled, the paper copy is discarded.

Alternatively, four densiometer measurements may be taken from the edge of the 11.8' radius plot facing outward in the four cardinal directions. This sampling is done every 10 years or after a significant change to the canopy.

7.6.3 Saplings

Saplings are considered live trees that are taller than breast height (4.5 ft., 1.37 m) and less than or equal to 5.9 inches (15 cm) dbh. Saplings are tallied per species within an 11.8' radius plot in three size classes: **1** (4.5'tall to 1.9" DBH), **2** (2.0" to 3.9" DBH), and **3** (4.0" to 5.9" DBH). Only stems with at least half of its base within the plot are counted. Trees forked below DBH are tallied as two trees. Stems that, because they are bent over, do not reach 4.5' but are obviously longer than 4.5' are counted. Large shrubs such as serviceberry (*Amelanchier* spp) and others are not considered trees.

7.7 UNDERSTORY

7.7.1 Seedlings

All live trees less than DBH and greater than 1 foot (30 cm) tall are considered seedlings and are tallied within an 11.8' (3.6 m) radius plot by species. Only live trees will be tallied; no size classes are used. Estimates may be done for tallies >25 stems.

7.7.2 Herbs, Graminoids and Small Shrubs

Percent covers of tree, shrub, vine, herb and graminoid species are obtained via 30 m point intercept transects. Conduit stakes or "Trail Ticklers" are placed at the ends of the transects at 0 and 30.5 meters. Transects are located at all plots unless otherwise noted and begin at the center of the tree plot. Transects are placed along the direction of travel from one plot to the next. Intercepts are recorded at 1 m intervals starting at 1 m and ending with 30 m. All intercepted plants less than 2 m (6.5') are recorded. Substrates are also recorded. The following are the most common LITT, MOSS, BARE, BOLE. Refer to the FMH handbook for a complete list of substrates.

To assess change in less widespread species 1x1 m frequency plots will be used. Five plots will be placed along the right side of the 30 m transect at 5-6, 10-11, 15-16, 20-21, 24-25, and 30-31 meters. All plants found in each plot are recorded regardless of size.

A brief search (<10 min) is performed in two 2 m belts on either side of the transect for species not recorded in earlier sampling. All tree, shrub, vine, herbaceous and graminoid species found are recorded.

7.8 FUELS

Fuel sampling is not done except in special circumstances. Methods will follow those found in the FMH Handbook (2003).

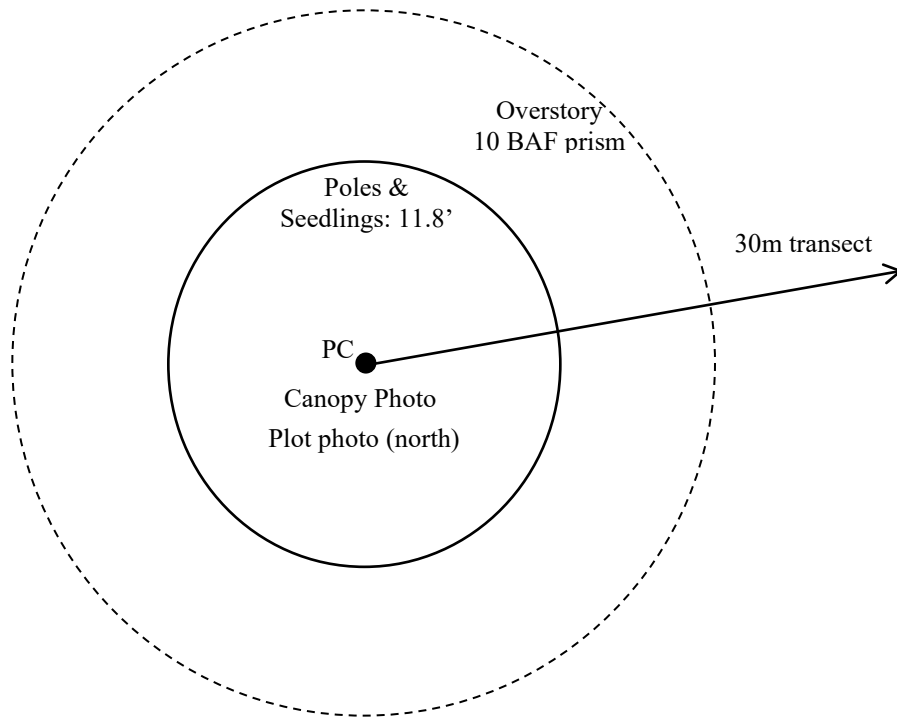


Figure 4. Plot Schematic.

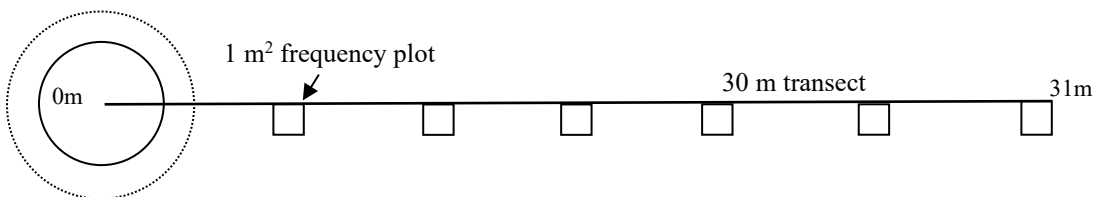


Figure 5. Diagram of 1m frequency square placement.

7.9 FIRE SEVERITY

In lieu of direct fire severity sampling a site walk-through is performed. The monitoring type is traversed at the discretion of the observer. Notes are taken on: average litter depth, average char height, burn severity on vegetation and substrate, mortality, the mosaic and on other noteworthy effects. A relatively complete assessment of the unit is done, including areas where plots are located. As such, the assessment may or may not be tied to a permanent vegetation plot. If the burn is relatively uniform fewer plots will be required. It is understood that all areas of the burn may not be accessible.

7.9.1 Timing

Burn severity estimates are best done from one day two weeks after the burn. Given the typical uniformity among burn severity from year to year as well as the distance from the home park (Indiana Dunes), these estimates are not always done.

7.9.2 Plot Location and Size

The location of the plot (area) being assessed recorded using UTM's or a general description such as "the east side of the burn unit". These "plots" will not be revisited so a general description is fine.

The plot size is not exact and in that sense is not really a "plot". The assessment area is approximately a 50' radius or what can be easily seen or accessed by the observer.

7.9.3 Scorch Height

If conifers or leaves were not present prior to the burn, this element is skipped.

The average maximum scorch height to the nearest foot is visually estimated. The goal is to obtain a general average for the site. Averages are done mentally; they are not computed. Sides of trees that are not scorched are not included in the average. If trees were generally not scorched, i.e. the limbs were above the scorch height, record "Not scorched", do not record "0". Zero means scorch height was less than 1". Not scorched, means the limbs were above the scorch height, and though present the actual scorch height cannot be determined.

7.9.4 Char Height

Char height can only be determined on large woody stems, mainly trees. Estimates are completed in the same manner as described for Scorch Height.

7.9.5 Vegetation and Substrate Severity

If vegetation had not leafed out prior to the burn it may not be possible to complete a vegetation severity assessment.

Use the modified FHM burn severity guide (Table 2) to estimate the burn severity on the understory vegetation and substrate.

7.9.6 Area Burned

Visually estimate the percent area burned within your plot to the nearest 10%.

7.9.7 Litter

This method is optional.

The depth of the remaining litter is estimated by measuring the litter depth at 5 – 10 locations to the nearest 0.1 inches. The average may be estimated mentally or calculated at a later time. Do not include zeros in the average. Zeros are included in the Percent Area Burned.

7.9.8 Comments

General observations are described at the observer's discretion. Observations may be redundant with the numeric data collected. If conditions are the same at a previous plot, record "Same as plot number #".

7.9.9 Mapping

Mapping of the burn area is at the discretion of the observer. In most cases it is not necessary to map the area burned. However, in cases where larger areas were unburned or there was considerable variation in burn severity, mapping may be desirable. Because walking the perimeter of burned and unburned areas is grossly impractical, it is recommended that mapping be performed by drawing perimeters on a map (aerial photo or topo map) then digitizing them into GIS back in the office. Alternatively, an I-pad may be used for this purpose. However, a paper map should be on hand as a backup. As a last resort, sketch the burn area and areas of interest and complete the task from memory in GIS and/or on a paper map when back at the office.

In addition to mapping the burned areas, identify areas of differing burn severity and document locations of particular interest. This may include areas of burned-out trees, spot fires, damage to resources, etc.

Table 2. Modified burn severity categories for forest and grass plots.

	Unburned (5)	Scorched (4)	Lightly Burned (3)	Moderately Burned (2)	Severely Burned (1)	Not Applicable (0)
Substrate	Not Burned	Litt partially blackened, litter materials still recognizable, Duff unchanged, CWD only scorched.	Litt charred and partially consumed, some parts still recognizable, Duff may be charred but mostly unchanged, 1's & 10's partially burned; Logs scorched or blackened, not charred, Rotten wood scorched to partially burned.	Litter mostly to entirely consumed, leaving coarse, light-colored ash; duff deeply charred; underlying soils are not visibly altered; fine woody debris is mostly consumed; logs are deeply charred; burned stump-holes may be present.	Litter and duff completely consumed, leaving fine white ash; Mineral soil visibly altered, often reddish; sound logs ar deeply charred, rotten logs are completely consumed. This code applies to less than 10% of the burn are in general.	No litter or duff present pre-burn
Vegetation	Not Burned	Foliage scorched and attached to supporting twigs, grass scorched not consumed, burns are patchy.	Foliage and twigs partially to completely consumed; branches mainly intact, ~2" of grass stubble remains, forbs partially to completely consumed, stems may still be standing, plant bases not deeply burned & are still recognizable.	Foliage , twigs and small stems consumed, some branches intact, minor amounts (<2") of grass stubble remain, Forbs burned to the ground. Burns tend to be uniform.	All plant parts consumed leaving only some major stems/trunks; all remaining are deeply charred. Stubs may be left of shrubs, no unburned herbaceous veg. This condition is rare in grasslands due to the short burn out time.	No vegetation present pre-burn

7.10 FIRE MONITORING

7.10.1 Fuel Moisture

Fuel moisture is calculated from weather observations. Weather data are collected and maintained by the Fire Operations staff. When direct measurements are taken, the following protocol is used.

Fuel moisture measurements are taken the day of or prior to the burn. Moisture estimates may come from one or more of the following: the calculated fine dead fuel moisture, 10-hour fuel moisture stick, or direct fuel moisture sampling of live and dead fuels.

Calculations of fine dead fuel moistures are based on temperature, humidity, shading, elevation, aspect and time of day and year. Tables used to determine fuel moisture and Probability of Ignition are found in the Incident Response Pocket Guide.

Ten-hour fuel sticks are weighed, and the moisture is calculated based on its oven dry weigh and scale weight.

To obtain more precise fuel moistures, samples are collected per fuel type in air-tight tins. The tins are labeled and tabulated as to their contents. The tins and contents are weighed, and oven dried at 100°C for 24 hours and weighed again. The moisture is then calculated.

7.10.2 Weather Parameters

Temperature, wind and relative humidity are recorded every hour during the burn. Weather may be obtained from a nearby weather station or a field observer using a sling psychrometer or a digital weather meter.

7.10.3 Fire Behavior

Fire behavior measurements include flame length, flame zone depth, and rate of spread.

7.11 MECHANICAL TREATMENTS

Mechanical treatments are monitored using the Overstory/Large Tree and/or Canopy protocols listed under Oak Savannas. Given that treatments take several years to complete and often do not impact the plot area, monitoring is not done after each treatment, but when the entire unit or sufficiently large area is completed.

8.0 DATA SHEETS

All project level monitoring forms are on file with the Great Lakes Fire Effects office.

9.0 DATA MANAGEMENT AND ANALYSIS

9.1 STANDARD DATA

Data are managed by the GRLA Fire Ecology Program. All non-photographic plot data are entered in the FFI (FEAT Fire-Mon Integrated) database. These data files are stored and backed up by the USGS on their server. Copies of the database are uploaded to IRMA. Original hard copies of all data as well as descriptions and directions to the plots are kept at the INDU Fire Effects Office. A geographical information systems (GIS) data layer of the plot locations is maintained by the GRLA Fire Ecology Program.

Data analysis will take place once sufficient treatments are completed to show a reasonable difference in one or more of the vegetation layers. In general, data analysis will be used to determine whether objectives are being met or if unwanted results are occurring. Goals, burn prescriptions, and other management techniques will be reviewed and adjusted as necessary. Results may also be used to assist in modifying protocols.

9.2 PHOTOS

Plot photos are taken with a digital camera and these digital files are stored on the INDU network drive. Canopy photos are analyzed using Gap Light Analyzer software. These data are then exported to a spreadsheet and stored in association with other electronic fire effects data.

9.3 QUALITY CONTROL

Plant identification errors are mitigated through training, plant photos, and reading plots during peak phenology.

Data quality will be ensured through proper crew training to guarantee consistency in data collection and entry procedures. Before leaving a plot, all data sheets are checked by the lead crewmember for accuracy and completeness. Data entry errors will be minimized through cross-checks with the original forms, and data analysis and manipulation.

Plot protocols are reviewed periodically to call attention to procedural errors or inconsistencies. A program review by the regional and/or eco-region fire ecologist may take place every 5 years or as needed to maintain consistency of data collection and analysis, and to re-assess program requirements.

9.4 NAMING CONVENTION

The naming convention for PLM plots is as follows until the site is burned: the first visit is PRE; subsequent visits are labelled as PRE followed by the year interval from the previous read, e.g. d PREyr05. Treated plots follow the same convention except PRE is omitted and is replaced with the number of treatments. For example, 02yr05 signifies the 5-year read after the second burn.

10.0 RESPONSIBLE PARTIES

This Fire Effects Monitoring Plan was written by Scott Weyenberg, Fire Ecologist for the Great Lakes Eco-region.

Administrative duties will be assigned as follows:

- Great Lakes Eco-Region Fire Ecologist – program management, plan revision and data analysis.
- Lead Fire Monitor – crew lead, data management, park liaison.
- Fire Effects Monitoring Crew– data collection and data entry.
- Midwest Region Fire Ecologist – program reviews.

11.0 FUNDING

Funding for all monitoring activities comes from the national fire program. The GRLA Fire Ecology program employs two permanent seasonal fire effects monitors and one full time permanent lead monitor.

12.0 ADAPTIVE MANAGEMENT

To achieve objectives, monitoring results should serve as feedback to fire and resource management staff so appropriate adjustments can be made to prescribed fire prescriptions. However, care should be taken to avoid making hasty management decisions based on only a few years' data. Effective long-term fire management will require a comprehensive understanding of the various interactions between vegetation and fire, which can only be obtained from long-term monitoring and analysis.

The Ecological Models and Reference sections of this plan may serve as summary of current knowledge, which can guide management decisions. However, the information summarized for tallgrass prairie and oak savanna come from only a small portion of the available literature.

Status reports and results summaries concern progress toward or away from specified objectives and goals and are submitted to Trail staff and appropriate GRLFMZ personnel. Annual reports contain information concerning the program in general and are submitted to the regional and national ecologists. The annual report is intended to highlight program changes, successes, failures and future plans. Results summaries are intended to provide information on the status of a particular monitoring type or site. All analyses are at the discretion of the ecologist, but in general they will focus on current conditions, identifying trends and determining whether objectives are being met. When appropriate, suggestions will be made to help program managers realize their objectives.

13.0 CONSULTATION AND COORDINATION

The GRLA Fire Effects staff coordinates and consults regularly with other parks, fire management staff and other Midwest Region Fire Ecologists. People available for consultation regarding fire effects monitoring at IATR are:

- Katie Frauen, Trail Manager
- Regan Little, Biological Technician
- Erin Yeoman, Acting Fire Ecologist for the Midwest Region
- Scott Weyenberg, Fire Ecologist for the Great Lakes Eco-region

14.0 PEER REVIEW

Peer and technical reviews for this plan were provided by:

Erin Yeoman, Acting Regional Fire Ecologist
National Park Service, Midwest Region
Omaha, NE

Jamie Ladner, Fire Ecologist
National Park Service
Missouri & Iowa Fire Management Zone
Van Buren, MO

Katie Frauen, Trail Manager
National Park Service
Ice Age Trail National Scenic Trail
Cross Plains WI

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16.0 APPENDICIES

APPENDIX A. PLOT LOCATIONS

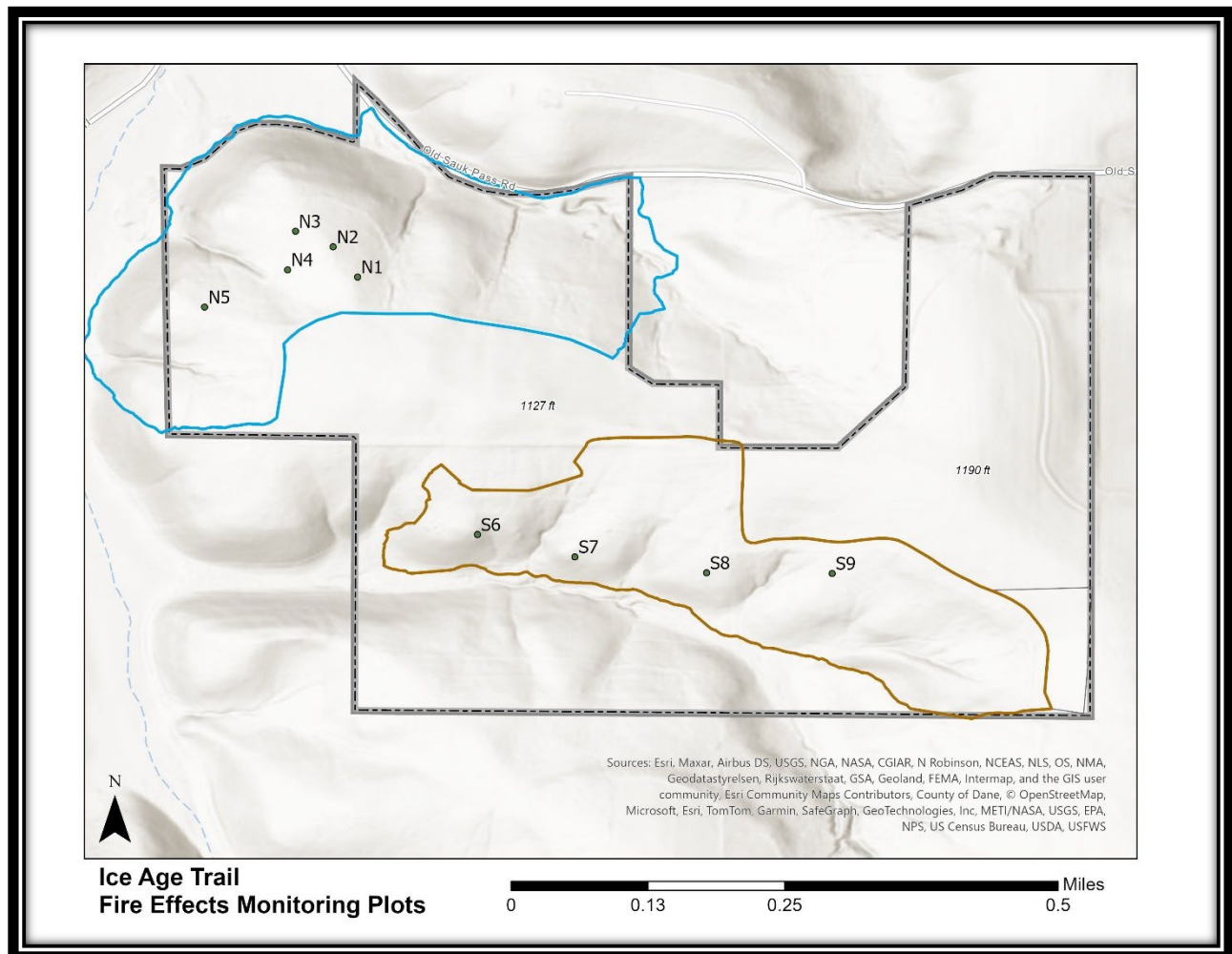


Figure 6. Ice Age Trail fire effect monitoring plot locations.

Table 3. Ice Age Trail fire effects monitoring plot coordinates.
Datum - North American 1983 Zone 16N

Plot	Latitude	Longitude	Easting	Northing
N1	43.0808	-89.6206	286676	4773121
N2	43.0812	-89.6209	286651	4773166
N3	43.0814	-89.6214	286611	4773190
N4	43.0809	-89.6215	286601	4773134
N5	43.0804	-89.6226	286510	4773082
S6	43.0774	-89.6190	286793	4772739
S7	43.0771	-89.6177	286897	4772703
S8	43.0769	-89.616	287038	4772675
S9	43.0769	-89.6143	287173	4772670

APPENDIX B. PROTOCOL SUMMARY TABLE

Table 4. Project Level Monitoring protocol summary.

PROJECT LEVEL MONITORING PROTOCOLS			
Subject	Plot Size & Method	Attributes (precision)	Status
Trees (≥ 15.1 cm)	Variable Radius (10 BAF)	Tally: species, DBH (0.1")	Live & Dead
Woody Stems (4.5' tall to 5.9" DBH)	11.8' (3.6 m) Fixed radius	Tally: species & size class 1(4.5' tall – 1.9"); 2(2.0 – 3.9"); 3 (4.0 - 5.9")	Live only
Seedlings (1' – 4.5' tall)	11.8' (3.6 m) Fixed Radius Plot	Tally/species	Live only
Herbaceous Cover	30 m trans.; 1m intervals	Species ≤ 2 m tall	Annual (L/D) Perennials (Live only)
Herbaceous Frequency	6 – 1m squares; 5m intervals	Species ≤ 2 m tall	Annual (L/D) Perennials (Live only)
Canopy Openness	Hemispheric photos	NA	NA
Fuels			
1000 hour	50' Brown's transect	Diameter/log (0.1")	Sound & Rotten
100 hour	25' Brown's transect	Tally	All
10 & 1 hour	6' Brown's transect	Tally/size class	All
Litter	At 5, 10, 15, 20 & 25'	Depth (0.1")	NA

APPENDIX C. DATA SHEET EXAMPLES

C-1 PLM Datasheets

Data sheets for the standard PLM methods are compiled in a single Excel spreadsheet and include the following forms:

PLM Plot Directions

Photo Points

Tree Data Sheet

Densiometer

Sapling Data Sheet

Seedling Data Sheet

Herbaceous Frames

Point Intercept

Fuels Data Sheet

CBI Data Sheet

C-2 Fuels Datasheets

Fuels data collection forms (FMH-19) are in the FMH Handbook.

C-3 Burn Severity Assessment Datasheet

Burn Severity Assessment			
Site / Unit _____	Status _____	Date ____/____/____	
Burn Date: ____/____/____		Observers _____	
Plot # _____ Plot Location: _____			
% Plot burned: _____%		Ave Scorch Ht: _____ft	Ave Char Ht: _____ft
Severity: Substrate _____; Veg _____		Litt depth _____in	
Comments:			

Figure 7. Burn Severity Assessment datasheet.