

Identifying Recoverable Fire-Dependent Systems in the Mio District of the Huron-Manistee National Forest



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We collectively acknowledge that Michigan State University occupies the ancestral, traditional, and contemporary Lands of the Anishinaabeg – Three Fires Confederacy of Ojibwe, Odawa, and Potawatomi peoples. In particular, the University resides on Land ceded in the 1819 Treaty of Saginaw. We recognize, support, and advocate for the sovereignty of Michigan's twelve federally recognized Indian nations, for historic Indigenous communities in Michigan, for Indigenous individuals and communities who live here now, and for those who were forcibly removed from their Homelands. By offering this Land Acknowledgement, we affirm Indigenous sovereignty and will work to hold Michigan State University more accountable to the needs of American Indian and Indigenous peoples.

As ecologists, we further acknowledge that Indigenous peoples and their cultural practices were and are integral to the healthy, functioning natural ecosystems that we strive to understand and conserve. The definition of natural communities presented in this report recognizes this fact.

Cover: Mio Prairie is a previously documented dry sand prairie where United States Forest Service fire stewardship extends into the surrounding landscape. This project builds on that foundation by identifying additional remnants and opportunities for recovery. All photos by T. J. Bassett unless otherwise indicated.

EXECUTIVE SUMMARY

Fire is inextricably linked to the ecological and cultural history of the Grayling Outwash Plain in the northern Lower Peninsula of Michigan, particularly the pine-dominated ecosystems that characterize the Mio District of the Huron-Manistee National Forest (HMNF). Fire-dependent systems are threatened by widespread fire exclusion over the past century or more. The Mio District remains a fire-dependent landscape with great potential to restore connectivity among fire-dependent ecosystems. Recoverable fire-dependent systems (RFDS) retain characteristic native species composition, ecosystem structure, and other ecological legacies that provide a foundation for biodiversity conservation and recovery. Using these RFDS as cores of landscape-scale planning can guide ongoing fire stewardship within the Mio District.

We identified RFDS by developing a prioritized list of survey targets using a GIS-based fire needs assessment model indicating potential fire-dependent ecosystems, aerial imagery interpretation, and manager consultation. Survey priorities focused on documenting natural community element occurrences (EOs), or high-quality examples of representative ecosystem types. The prescribed fire needs assessment model identified 66% of the Mio District as high, very high, or highest fire need. Targeted surveys guided by this prioritization increased the documented acreage of fire-dependent natural community EOs in the Mio District by more than eight-fold. We documented 20 new natural community EOs of 6 fire-dependent natural community types totaling 1,981 acres, including bog (1), dry northern forest (5), dry-mesic northern forest (4), intermittent wetland (1), oak-pine barrens (1), and pine barrens (8); updated one EO each of four natural community types, dry northern forest, dry sand prairie, dry-mesic northern forest, and oak-pine barrens. We also identified 3,194 acres of RFDS that do not currently meet EO criteria but retain potential for recovery with the application of fire and other stewardship. Altogether, 3.5% (7,778 acres) of the Mio District is either a current fire-dependent conservation target (EO and/or existing management area) or a newly-identified restorable RFDS, that together can serve as dynamic cores for framing stewardship of the Mio District's fire-dependent landscape.

We emphasize the importance of frequent low-intensity fire, applied at large scales across ecotonal boundaries, and centered on the RFDS we identified as “dynamic cores”. This management approach can enhance the integrity of these cores and facilitate the expansion of high-quality natural communities into the surrounding landscape. Much of the Mio District and surrounding landscape is managed for the Kirtland's warbler (*Setophaga kirtlandii*), primarily through the establishment of dense plantations of jack pine (*Pinus banksiana*) rather than with fire. Where they replace recoverable systems, dense plantations can reduce the integrity of pine barrens and related ecosystems, diminish habitat for other species of concern, and can contribute to greater crown-fire risk. We recommend avoiding conversion of the most recoverable portions of the landscape to plantation and increasing the use of fire where it can contribute to Kirtland's warbler habitat objectives, and seek opportunities to manage simultaneously for pine barrens and Kirtland's warbler.

The work reported here takes place in the context of multiple efforts to document recoverable fire-dependent ecosystems and establish baseline data across the northern Lower Peninsula and the eastern Upper Peninsula. Management and monitoring efforts are being implemented by multiple regional partners, both independently and in the context of collaborations such as the Northern Pine Plains Partnership and the Northern Michigan Regional Fire Collaborative. Together, these efforts provide a foundation for conservation planning at the ecoregional scale across ownership boundaries.

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This project was also greatly enhanced by the expertise, input, and guidance of Huron-Manistee National Forest staff, including Dana Meder, Phil Huber, Brian Stearns, Jillian Pritchett, and Rich Corner.

This report draws on the work and contributions of many Michigan Natural Features Inventory scientists. We relied on foundational work by former MNFI scientists Denny Albert, Pat Comer, Mike Kost, Mike Penskar, and Bradford Slaughter. Connor Wojtowicz assisted with field surveys and logistical support. Katelyn Brolick, Sarah Carter, Deb Richardson, Rebecca Rogers, Kraig Korroch, and Mike Monfils provided administrative support. Courtney Ross and Nicole Smith provided GIS, modeling, and technical support.

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INTRODUCTION

Background

Fire-dependent ecosystems are threatened in Michigan and worldwide by altered fire regimes, in addition to threats that impact all ecosystems like human development, invasive species, and conversion for agriculture (Vitousek et al 1997, Foley et al. 2005). Historically, landscape-scale Indigenous cultural burning and lightning-set fires shaped the distribution and functioning of these ecosystems, reducing colonization by trees and shrubs, maintaining open canopy structure, fostering regeneration of fire-dependent species, and increasing biodiversity (Stewart 2009). Fire-dependent landscapes in Michigan changed dramatically following the removal of Indigenous Peoples throughout the 19th century and both the cessation of Indigenous cultural burning and the institution of wildfire suppression. In the absence of frequent fire over the past century or more, many prairies, savannas, and forests of pine and oak have converted to closed-canopy forests dominated by shade-tolerant native and invasive species, resulting in significant reductions in species and habitat diversity (Comer et al. 1995, Nowacki and Abrams 2008, Te et al. 2019). Remnants of fire-dependent ecosystems exist today, but they persist in isolated fragments and in many landscapes are poorly documented. Evaluating and mapping these ecosystems is necessary to provide a foundation for management centered on reincorporating fire at a landscape scale while increasing connectivity between these fragments and the rest of the landscape.

The Mio District of the Huron-Manistee National Forest (HMNF) in the northern Lower Peninsula of Michigan occupies a fire-dependent landscape with great potential to restore connectivity between fire-dependent ecosystems (Figure 1).



Mio Prairie is a previously documented dry sand prairie where Forest Service fire stewardship extends into the surrounding landscape. This project builds on that foundation by identifying additional remnants and opportunities for recovery. Photo by J. M. Lincoln

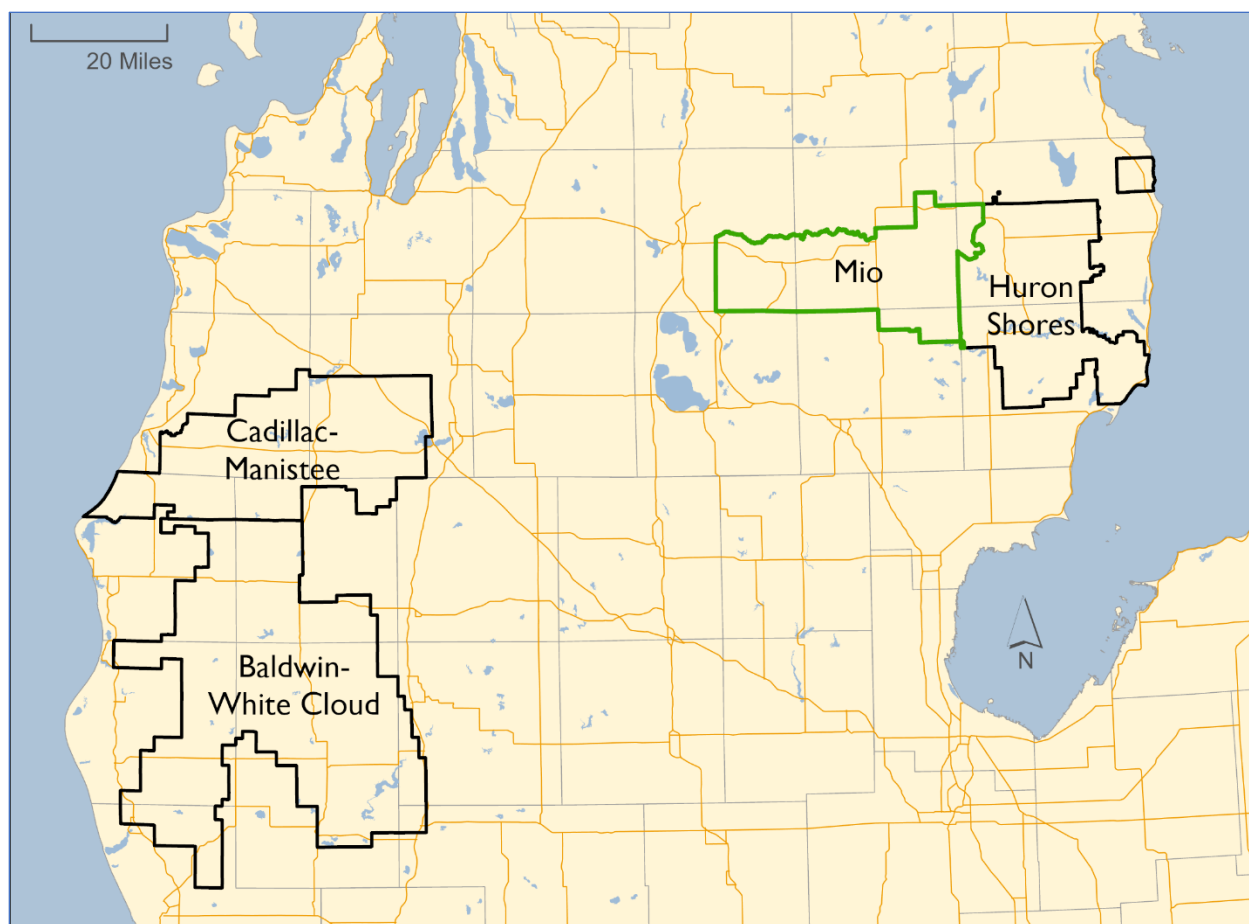


Figure 1. The Baldwin-White Cloud, Cadillac-Manistee, Huron Shores and Mio Districts of the Huron-Manistee National Forest in the northern Lower Peninsula of Michigan with the Mio District highlighted in green.

To provide the foundation for managing fire-dependent ecosystems at the landscape scale in the Mio District, Michigan Natural Features Inventory (MNFI) conducted surveys to identify, evaluate, and map recoverable fire-dependent systems (RFDS), or fire-dependent ecosystems with restoration potential. RFDS include the highest-quality examples of natural communities. A natural community is defined as an “assemblage of interacting plants, animals, and other organisms that repeatedly occurs under similar environmental conditions across the landscape and is predominantly structured by natural processes” (Cohen et al. 2015, 2025). Historically, Indigenous cultures were an integral part of the development of natural communities across the Great Lakes region with many natural community types maintained by Indigenous stewardship, especially cultural fire (Cohen et al. 2025). Natural communities with exemplary ecological integrity are mapped as benchmark examples in the Michigan Natural Heritage Database as element occurrences (EOs) – an area of land or water where an element of biodiversity including natural communities and rare species currently or historically occurred (NatureServe 2002, MNFI 2026).

Natural community EOs exhibit strong continuity with the historic landscape in terms of composition, structure, and ecological processes and receive minimal impact from modern

anthropogenic disturbances such as timber harvests, hydrological alteration, and fire suppression. RFDS also include systems that have been altered by fire suppression and other anthropogenic disturbances and presently do not meet EO criteria. Nonetheless, RFDS continue to support important concentrations of characteristic species and are potentially restorable to a condition that satisfies EO criteria (Gann et al. 2026). Identifying and prioritizing sites across this spectrum of RFDS provides an opportunity to stabilize, expand, and reconnect declining fire-dependent landscapes while they remain restorable. Recovery is most promising where characteristic ground flora, ecosystem structure, and connections to intact natural communities persist (Pile Knapp et al. 2024).



Luzerne Barrens (EOID 27654), a pine barrens occurrence within the footprint of the 2006 Hughes Lake Fire. Steep hillsides like these escaped conversion to dense jack pine plantation and retain characteristic barrens vegetation, including indicator species largely absent from the adjacent former plantation. Such remnants preserve ecological legacies that can anchor stewardship across the broader fire-dependent landscape. Photo by J.M. Lincoln

Landscape context

The northern Lower Peninsula of Michigan where the Mio District occurs was historically dominated by fire-dependent natural communities, and the contemporary landscape is relatively unfragmented by anthropogenic development and retains many aspects of its historical character. The landforms, climate, soils, and vegetation of the Mio District support a very fire-prone landscape. Albert (1995) sub-divided Michigan into ecoregions based on glacial landforms, soils, climate, and characteristic ecosystems. The Mio District occurs within the Highplains subsection, a high plateau formed primarily from sandy glacial outwash, especially the Grayling Outwash Plain sub-subsection within which the Mio District is largely contained (Figure 2). Nested within the predominant outwash features, there are areas of steep slopes associated with ice-contact topography, glacial drainages, and local areas of fine-textured end moraine (Figure 3). Soils in the uplands are very strongly to very slightly acidic (pH of 4.5-6.5) sands and loamy sands, generally with a very shallow (1-5 cm) O-horizon. The droughty soils and cold-air drainages slow encroachment of trees and shrubs and maintain fine grassy fuels that favor fire-dependent natural communities.

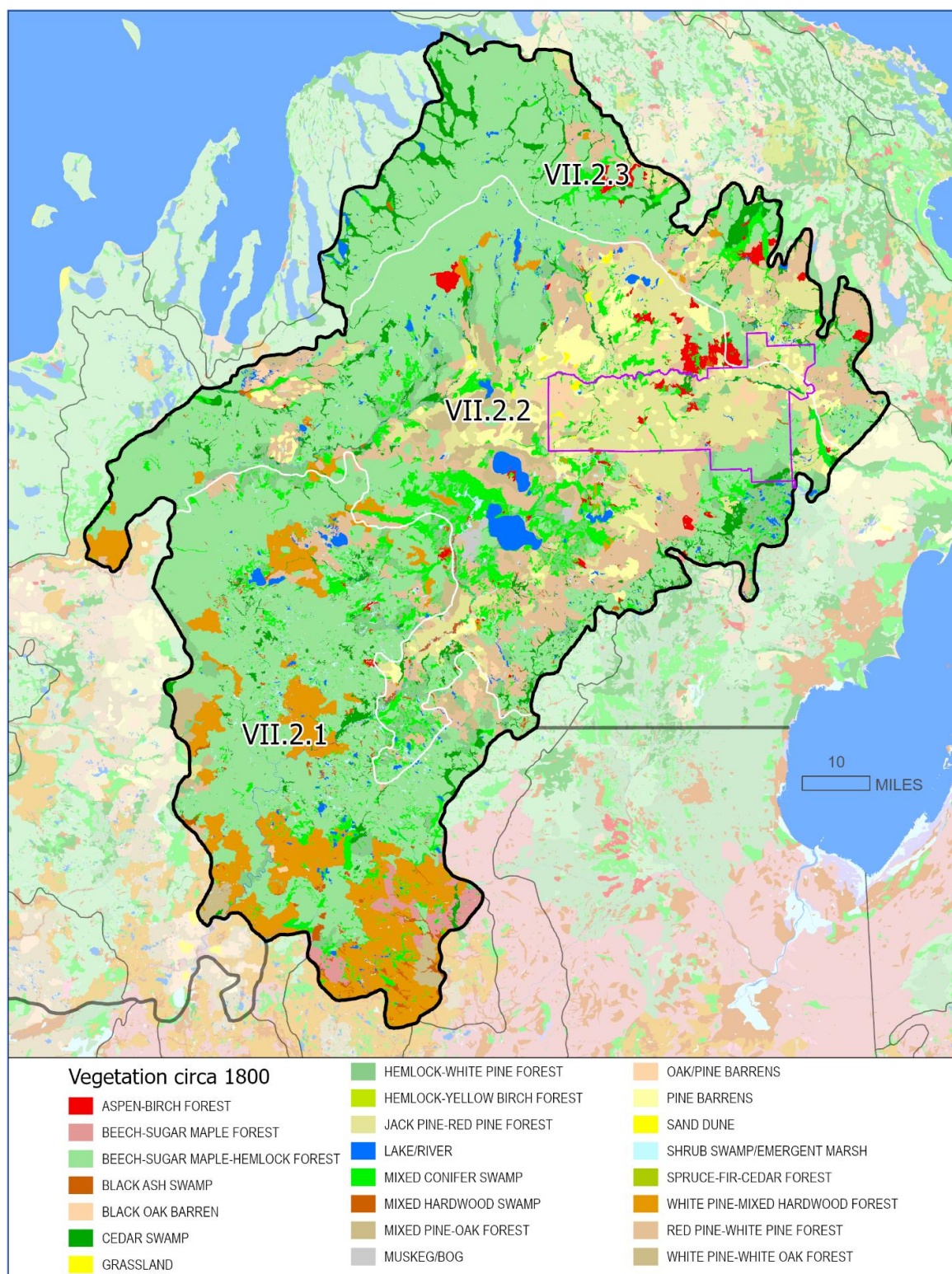


Figure 2. The circa 1800 vegetation of the Mio District (purple outline) and surrounding areas. Overlaid boundaries show Albert's (1995) ecological landscape classification, which groups areas with similar landforms, soils, climate, and vegetation. The Highplains Subsection (VII.2; black outline) includes the Cadillac (VII.2.1), Grayling Outwash Plain (VII.2.2), and Vanderbilt Moraines (VII.2.3) sub-subsections.

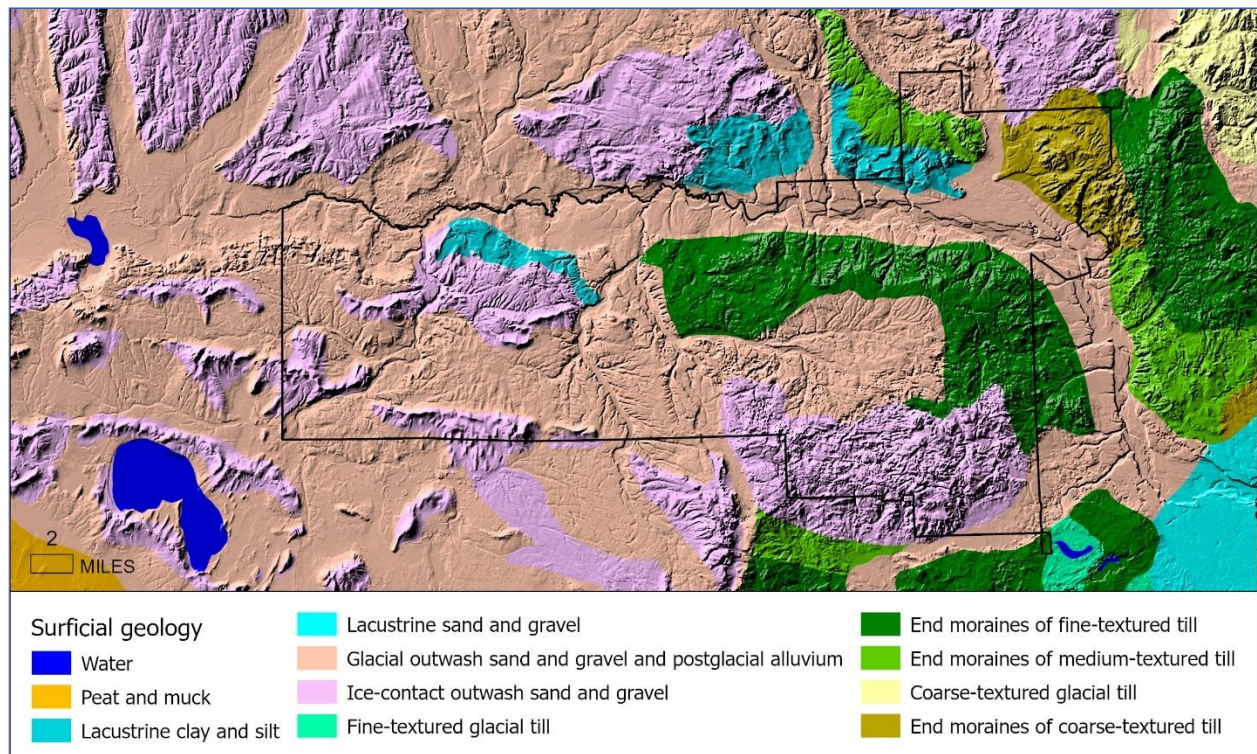


Figure 3. Glacial landforms (surficial geology) of the Mio District. Glacial deposits influence landform, soil texture, drainage, and moisture conditions, helping pattern vegetation and the distribution of fire-dependent natural communities across the Mio District.

General Land Office (GLO) surveys mapped vegetation and other features along a square-mile grid across Michigan from 1816 to 1856, documenting tree species composition, tree size, and general land conditions (General Land Office 1890). MNFI ecologists interpreted these records to reconstruct historic vegetation patterns (Comer et al. 1995). Fire-dependent ecosystems covered an estimated 79% of the landscape occupied by the Mio District. A shifting mosaic of these fire-dependent natural communities occurred across the Mio District and formed a complex and dynamic landscape. A significant component of the landscape was characterized by dry forests dominated by jack, red, and white pine (*Pinus banksiana*, *P. resinosa*, and *P. strobus*) (Figure 2; Table C1). Forests in the contemporary landscape that occur on the driest soils and are dominated by red and jack pine are classified as dry northern forest (Cohen et al. 2015, 2025). Forests on slightly more mesic soils, dominated by white pine and often co-dominated by red pine and red oak (*Quercus rubra*), are classified as dry-mesic northern forest. Fire-dependent savannas occupied only 12% of the Mio District. Pine barrens are a savanna occurring on the driest soils and characterized by a sparse, patchy canopy of jack, red, and occasionally white pine, and a ground layer dominated by sedges, grasses, and low shrubs. Oak-pine barrens are similar to pine barrens, but occur on marginally richer soils, and northern pin oak (*Quercus ellipsoidalis*) and locally white oak (*Q. alba*) are co-dominant in the canopy. However, interpretations of the GLO surveys provide only a coarse-scale reconstruction of historical vegetation and likely underrepresent small or heterogeneous fire-dependent natural communities such as barrens (Comer et al. 1995). Areas with the open

canopy structure of barrens were likely lumped in with larger forest tracts or missed entirely by the scale of sampling. Furthermore, European colonization disrupted Indigenous communities across the Great Lakes region before the GLO surveys of the 1830s (McDonnell 2015). The associated decline in cultural burning likely allowed some open fire-dependent systems to convert to forest before they were mapped.



Historic photograph from the Grayling area, late nineteenth century. The open, heterogeneous structure of large red pine above patches of jack pine is consistent with General Land Office surveyor descriptions from portions of the historic pine barrens landscape. This fine-scale variation is difficult to resolve from the GLO's square-mile sampling grid and is likely underrepresented in reconstructions of circa 1800 vegetation.

Historical vegetation has been modified by anthropogenic land use including fire suppression and silviculture. Following European colonization, widespread timber harvest and subsequent fire suppression contributed to the drastic decline in fire-dependent natural communities. Michigan prairie, savanna, and barrens remnants have been reduced to less than 1% of their past extent (Comer et al. 1995). Plantation forestry is prominent in the Mio District, including both red pine plantations for timber production and jack pine plantations to provide habitat for the recently federally de-listed Kirtland's warbler (*Setophaga kirtlandii*, State Threatened). The widespread institution of densely planted "opposing wave" or "weave" plantations in the 1970s was largely responsible for bringing the Kirtland's warbler back from the brink of extinction, but may not maximize Kirtland's warbler occupancy and provides limited or no habitat for many other conservation priorities (Machusko et al. 2024). Both the furrowing of soil used to facilitate establishment of closely planted jack pine and the dense closed-canopied conditions that result have diminished the abundance of many barrens plant species (e.g., Tucker et al. 2016, Tucker and Kashian 2018). Despite these landscape-scale modifications, much of the Mio District remains dominated by forests and barrens of oak and pine with scattered grassland openings

and bears a much closer resemblance to historical vegetation than other regions of Michigan. For example, a comparison of circa 1800 land cover to contemporary land cover (Office for Coastal Management 2016) shows that at a coarse scale 64% of forest, grassland, and wetland cover is unchanged in the Mio District, compared to 38% for Michigan as a whole (Table 1). However, the capacity for these systems to function as a shifting mosaic has been restricted by forestry and fire suppression. The shifting mosaic no longer functions at the scale of the Grayling Outwash Plain and fire-dependent natural communities have been degraded, isolated, and relegated to landscape positions that help slow conversion to closed-canopy forest through drought and late-season frosts.

Table 1. Land cover change in the Mio District vs. all of Michigan, circa 1800 to 2016. Historical vegetation reconstructed from General Land Office survey notes (Comer et al. 1995) was compared with contemporary land cover from 2016 (Office for Coastal Management). “Unchanged” indicates that an area remained within the same broad class: upland forest, forested wetland, open wetland, or grassland, although composition, vegetation structure, or ecological condition may have changed.

Circa 1800 to Current Land Cover	Mio		Michigan	
	Acres	Percent	Acres	Percent
Unchanged Upland Forest	147,038	58%	8,344,585	29%
Unchanged Open Wetland	220	0.1%	154,693	1%
Unchanged Grassland	7,456	3%	134,981	0.5%
Unchanged Forested Wetland	8,186	3%	2,372,900	8%
Dune to Degraded (2 miles GL shoreline)	NA	NA	10,515	0.04%
Other (changed)	89,871	36%	18,169,138	62%
Total Acres	252,771		29,186,812	



Jack pine “weave” plantation in the Mio District, appearing in a checkerboard pattern. Weave plantations were supported Kirtland’s warbler recovery. Dense plantings and soil furrows contrast can diminish ecological integrity where they replace recoverable fire-dependent pine barrens and the characteristic patchy canopy and intact ground-layer.

Fire frequency across the Mio District has been dramatically reduced since the 19th century, although it is not clear to what degree other aspects of the fire regime have changed, such as intensity, severity, and seasonality (Cleland et al. 2004, Parks et al. 2025). Recent evidence suggests that historic fires occurred at a wide range of intensity, severity, and seasonality, including frequent low-intensity fires (Simard and Blank 1982, Jolly et al. 2016, Stambaugh et al. 2024). Historical fire return interval estimates range from 9 to 55 years (Simard and Blank 1982, Cleland et al. 2004, Stambaugh et al. 2024), and several historic and contemporary fires were thousands of acres in size (Simard and Blank 1982). Indigenous cultural traditions tell of near-annual burns in some places, such as those lit to increase blueberry production (Kimmerer and Lake 2001). In many landscapes, the incidence of fire also affected patterns of grazing by ungulates like elk (*Cervus canadensis*) and bison (*Bison bison*), with this fire-grazing interaction driving a shifting mosaic of species composition and ecosystem structure (Cleland 1966, Fuhlendorf and Engle 2004, Te et al. 2019). The prevalence of forests, savannas, and prairies fluctuated across these landscapes through time, shaped by this fire-grazing interaction in concert with the effects of gradients in soil moisture, aspect, slope and other abiotic factors. While silviculture and other mechanical treatments have replaced fire as the primary disturbance regime, fire continues to shape the Mio District. For example, there have been at least nine wildfires in the Mio District since 1996, impacting 21,383 acres (Figure 4; Appendix C, Table C2). Contemporary wildfires and many prescribed fires tend to be high-severity “stand-replacing” fires, in part due to the accumulation of fuels as a result of decades of fire suppression lower than needed fire frequency.

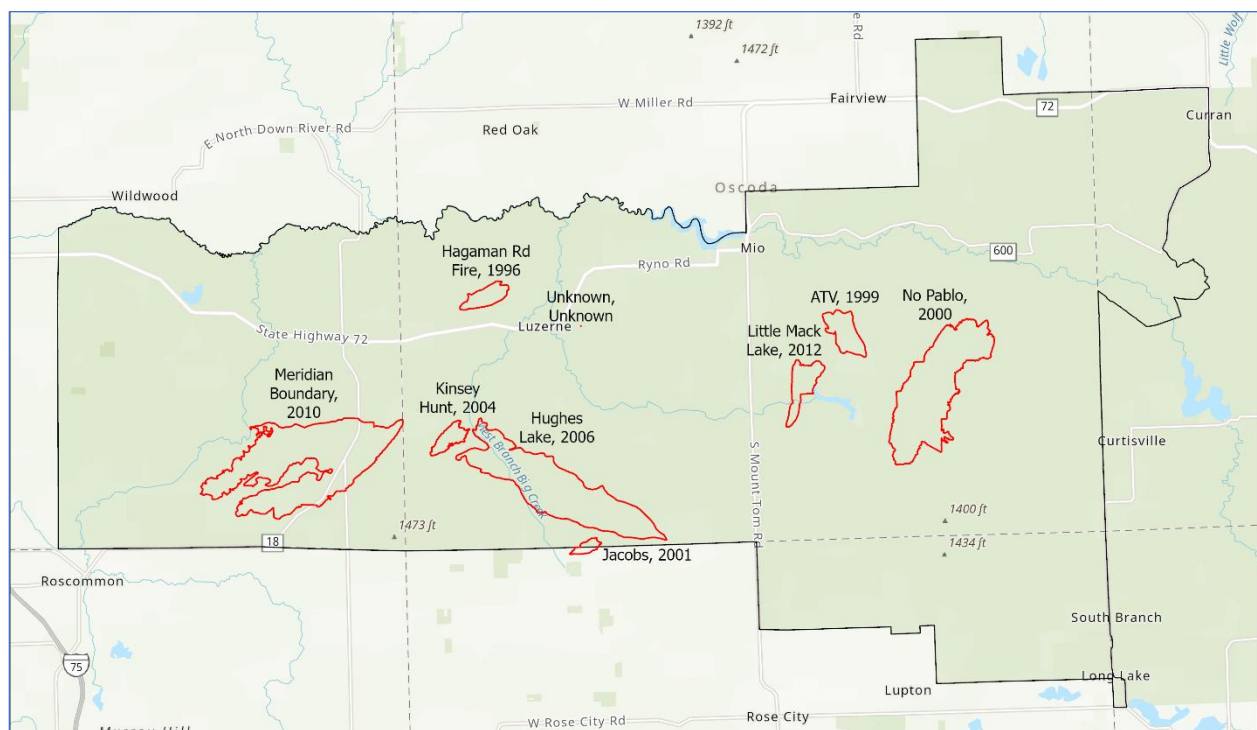


Figure 4. Footprints of eight named wildfires (red outlines) in the Mio District (black outline), between 1996 and 2012, plus one unnamed fire. These footprints were useful for understanding the contemporary influence of fire on the landscape and served as focal areas for identifying potential RFDS.

Project objectives

The Mio District is ideal for increasing connectivity between RFDS and between RFDS and the surrounding landscape, through reintroducing landscape-scale fire and other stewardship approaches. Our primary objectives with this project are to identify previously undocumented fire-dependent EOs and other RFDS, and to develop recommendations for protecting RFDS and extending stewardship into surrounding landscapes. While the historical shifting mosaic no longer operates at its former scale, RFDS can serve as 'dynamic cores' for managing fire-dependent ecosystems in portions of the landscape that can support something approaching a shifting mosaic. Rather than treating these surviving examples as isolated conservation targets, this dynamic core approach uses their characteristic composition and structure to guide stewardship beyond their boundaries (Lincoln et al. 2022, 2026). Extending fire and related stewardship outward from these cores can expand fire-dependent ecosystems, reconnect remnants, and facilitate the fluctuation of prairie, barrens, and forest boundaries through time (Pile Knapp et al. 2024).



Managed opening adjacent to South Branch Woods dry northern forest (EOID 27662).

Applying relatively frequent, low-intensity prescribed fire across both the forest and adjacent opening would maintain mature pine and native ground flora, limit woody encroachment, and allow open and forested conditions to shift through time. This approach treats high-quality forests, as well as barrens, as dynamic cores rather than an isolated conservation target. Photo by J.M. Lincoln.

METHODS

We identified RFDS by first developing a prioritized list of survey targets, by analyzing the results of a GIS-based model indicating potential fire-dependent ecosystems, combined with aerial imagery interpretation and manager consultation. We then conducted field surveys in areas identified as priorities and evaluated the ecological integrity of the natural communities observed in the field using Natural Heritage Methodology (NatureServe 2002; Faber-Langendoen et al. 2008, 2015).

Identifying survey targets

We identified survey targets by first applying a GIS-based multicriteria decision analysis model (hereafter, fire needs model) to indicate stands with high potential to support fire-dependent ecosystems (Appendix A, Figure A1). MNFI originally developed the prescribed fire needs assessment model for lands administered by Michigan's Department of Natural Resources (DNR) (Cohen et al. 2021). The foundational unit of that original model is stand-level Michigan Forest Inventory (MiFI) data describing canopy and subcanopy species composition, stand age, and other ecological attributes (MDNR 2024). Each stand was also cross-walked to a natural community used to infer additional attributes associated with each community (Cohen et al. 2021, 2025). These stand-level data were then combined with inputs from multiple physiographic and vegetation spatial data layers at multiple spatial scales for a total of 13 inputs overall and given a score on the scale of the source data for that layer. Finally, a weighting factor was applied to each of the 13 inputs based on their importance for indicating prescribed fire needs, and the sums of these weighted scores were then standardized as a fire needs score on scale from 0, or "no fire needs", to 5, or "highest fire needs." We adapted the original fire needs model by inputting the stand-level USFS field-sampled vegetation (FSVeg) dataset for the Mio District (USDA 2024), cross-walking each FSVeg stand to a natural community, and combining those inputs with the same additional inputs used in the original fire needs model (also see Lincoln et al. 2022, 2026). Examples of attributes that resulted in higher fire needs score include stands cross-walked to fire-dependent natural communities, occurring in fire prone landforms (e.g., sandy glacial outwash), and supporting rare, fire-dependent species.

We established survey priorities by ranking stands based on their potential to support RFDS. Ranking was based on the fire needs score from the fire needs model, evaluation of spatial data and existing natural community and rare species EOs, and recommendations from managers and biologists with local knowledge. The Mio District consists of 8,227 stands in 291 compartments covering 223,729 acres (USDA 2024). The dataset available to MNFI at the time used for modeling contained only 7,296 stands (87%) covering 195,103 acres (87%). The fire needs model identified over one-half of the Mio District (57% of stands and 66% of acres) as high, very high, or highest fire needs, more potential RFDS than could be targeted during surveys. As a result, we relied strongly on other resources to narrow down a list of priorities. We prioritized surveys based on the conservation value of natural communities, among other considerations. Global and subnational (i.e., state-level) conservation ranks (G-rank and S-rank) are used to assess the conservation value of each element of biodiversity, including natural communities (Masters et al. 2012). Conservation ranks range from critically imperiled (G1 and S1) to secure (G5 and S5), and may include additional ranks (e.g., GU, or globally unrankable) (Appendix B, Tables B1-2).

Primary survey targets were pine and oak-pine barrens and dry and dry-mesic northern forest, but secondary priorities included additional fire-dependent natural communities when they were encountered opportunistically, including bog, dry sand prairie, intermittent wetland, northern wet

meadow, northern fen, and poor fen (Cohen et al. 2015, 2025). Pine barrens and oak-pine barrens were high priorities for surveys due to their conservation rank, reliance on frequent fire, and high biodiversity including many rare species. Both communities are globally vulnerable (G3) and imperiled in Michigan (S2) and were historically prominent on the landscape (12% of circa 1800 landcover) (Table C1; Comer et al. 1995, Cohen et al. 2025). Barrens were characterized by heterogenous canopy structure and a variable light environment. Fire exclusion and the subsequent woody encroachment can rapidly degrade these natural communities by eliminating the open physiognomy, homogenizing the floristic composition, and simplifying the vegetative structure (Comer et al. 2010). Typical of other savannas and open forests, the heterogeneity of light and soil productivity in barrens supports very diverse plant communities (Leach and Givnish 1999, Pavlovic et al. 2006, Hanberry et al. 2020). To identify likely pine and oak-pine barrens remnants, we evaluated both contemporary and historical aerial imagery for their characteristic heterogenous canopy structure and investigated the footprint of historical fires that may have enhanced or generated barrens composition and structure (Figure 4). Both dry and dry-mesic northern forest are vulnerable in Michigan (S3). Dry northern forest is possibly vulnerable globally (G3?) and dry-mesic northern forest is apparently secure globally (G4). To identify high-quality dry and dry-mesic northern forests, we reviewed FSVeg data for stand ages over 100 and notes that indicated “potential old growth” (USDA 2024). Additionally, we analyzed aerial imagery for stands with high canopy closure and variable tree heights including evidence of “supercanopy” red and white pine trees that characterize high-quality, mature pine and oak-pine forests. Old-growth red pine is one of the rarest forest types in the Great Lakes Region with only 0.2% of the historic extent remaining (Frelich 1995). Given the regional rarity of this forest type, we especially focused our surveys on documenting older natural red pine forest. Finally, we also prioritized surveys in several management areas that Mio District biologists have been managing as openings for wildlife or wildfire mitigation and evaluated them as potential RFDS.

Field surveys

We conducted qualitative meander surveys between June 10 and September 20, 2024 and between June 16 and October 17, 2025, to evaluate potential RFDS. We evaluated the size, condition, and landscape context of each survey target based on Natural Heritage methodology (NatureServe 2002; Faber-Langendoen et al. 2008, 2015). For each high-quality natural community (EO), we delineated boundaries and evaluated condition by collecting data on canopy composition, structure, and age; woody plant species composition and structure of other vertical strata; ground layer plant species composition, relative abundance, richness, and evenness; evidence of natural processes, largely fire history, abundance of wood ant (*Formica* sp.) mounds, and other animal use; and threats and anthropogenic disturbances, including invasive species, furrowing, and off-road vehicle (ORV) use. Size and landscape context were largely evaluated later via desktop analysis, but additional notes were taken in the field to facilitate desktop analysis, including buffers and transitions with adjacent land cover; notable landscape features that demarcate boundaries; and notable disturbances in adjacent land cover such as natural gas derricks, intensive silviculture, and ORV use.

For each restorable RFDS (not EOs), we evaluated condition using the same methodology as for EOs. Instead of explicitly delineating restorable natural community boundaries, we compiled a list of stands that could be incorporated into landscape-scale conservation management, including prescribed fires targeting natural community EOs and other conservation targets. Our intent is also that groups of these stands be considered for management that may increase their ecological integrity to increase support for biodiversity (Appendix D, Table D1).

Finally, several stands in the Mio District are currently under management by USFS, managed to support wildlife and other biodiversity. While not an original goal of this project, we evaluated the condition of these stands at the request of Mio District biologists, to place existing management areas in the same context as potential RFDS evaluated during our surveys. We classified each existing management area as RFDS (natural community EO, not EO but restorable) or non-RFDS (degraded, plantation, other) according to the rubric in Table 2. In *degraded* sites, characteristic ground flora and ecosystem structure, or both, were lacking. Also, connections to intact natural communities were limited. *Plantation* sites were similar to degraded sites, and in addition had a history of furrowing for plantation forestry that degraded soil structure and amplified negative impacts to composition and structure. We classified sites as “other” when they were not fire-dependent systems, which could include mesophytic forests dominated by quaking or big-tooth aspen (*Populus tremuloides* or *P. grandidentata*), red maple (*Acer rubrum*), or sugar maple (*A. saccharum*).

Table 2. Rubric for evaluating potential RFDS within stands currently under management by USFS for wildlife and other biodiversity. Only classes EO and Restorable are considered RFDS. We used this rubric to place these stands in a similar context to newly documented RFDS. See Appendix, Tables D1 and D2 for stand-scale evaluation.

Class	Description
EO	High-quality natural community (primarily pine or oak-pine barrens, or dry sand prairie), documented by MNFI prior to or during 2024-2025 surveys
Restorable	Natural communities that possess some but not all attributes of an EO, that could be restored to EO-quality within a reasonable time frame (e.g., 5-10 years) through a combination of prescribed fire and mechanical thinning
Degraded	Natural communities that possess some but not all attributes of an EO, that are unlikely to be restored to EO-quality within a reasonable time frame (e.g., 5-10 years) through fire and thinning, due to degrading anthropogenic history
Plantation	Sites lacking most or all EO attributes due to a history of furrowed or non-furrowed plantation of red, white, or jack pine, including weave plantation for KW habitat
Other	Cover types that do not represent a fire-dependent MNFI natural community
NA	Stands that we were not able to survey during 2024-2025 due to time constraints

Barrens and forest indicator species

It can be difficult in the Grayling Outwash Plain to differentiate between barrens and forest natural communities that originated from natural processes like frequent fire from those that originated from a mix of natural and anthropogenic processes (Lincoln et al. 2024a). The landscape remains dominated by the same suite of ‘matrix’ species that dominated the historical landscape, and the historical range of ecosystem structure is represented in the contemporary landscape (Comer et al. 1995; Table 1). Red, white, and jack pine, and northern pin, red, and white oak dominate tree canopies today as they did historically. Graminoid species like Pennsylvania sedge (*Carex pensylvanica*), poverty grass (*Danthonia spicata*), and hair grass (*Avenella flexuosa*) still dominate ground layers, along with low shrub species like low sweet blueberry (*Vaccinium angustifolium*), sweet fern (*Comptonia peregrina*), and sand cherry (*Prunus pumila*) (Appendix C, Table C3). Wildfire and prescribed fire continue to influence composition and structure, even in sites with a history of silviculture, tillage, and other contemporary anthropogenic land use. Because matrix vegetation and fire remain persistent, distinguishing RFDS that exhibit relatively unbroken continuity with the historic landscape from sites with intensive anthropogenic disturbance histories can be challenging.

We developed lists of ground layer plant species that we believe are indicative of temporal continuity with high-quality barrens and forests and useful for differentiating high-quality barrens and forests from degraded sites (Table 3). The abundance and evenness of these species was used to assess the condition of potential RFDS and to classify sites as barrens vs. forest natural community types. Our approach is similar to wetland indices that differentiate obligate wetland species (occurs in a wetland with 99% probability) from obligate upland species (occurs in an upland with 99% probability) and includes facultative species (occurs with equal probability in a wetland or upland) (Reed 1988, Herman et al. 2001). Similarly, we differentiate obligate barrens species (occurs in a barrens with 99% probability) from obligate forest species (occurs in a forest with 99% probability), and from facultative (i.e., matrix) species (occurs with equal probability in a barrens or forest) (Appendix C, Table C3).

Table 3. Plant species strongly indicative of high-quality barrens vs. forest in the Mio District. These species are largely restricted to high-quality barrens or forest natural communities. C = coefficient of conservatism, W = wetland coefficient.

Scientific Name	Common Name	C	W	Physiognomy
Barrens indicators				
<i>Agoseris glauca</i>	Pale agoseris	9	3	Forb
<i>Anemone cylindrica</i>	Thimbleweed	6	5	Forb
<i>Bromus kalmii</i>	Prairie brome	8	0	Grass
<i>Helianthus occidentalis</i>	Western sunflower	8	3	Forb
<i>Koeleria macrantha</i>	June grass	9	5	Grass
<i>Liatris cylindracea</i>	Cylindrical blazing-star	5	5	Forb
<i>Liatris scariosa</i>	Northern blazing-star	5	5	Forb
<i>Lilium philadelphicum</i>	Wood lily	5	0	Forb
<i>Lithospermum canescens</i>	Hoary puccoon	10	5	Forb
<i>Lithospermum caroliniense</i>	Hairy puccoon	10	5	Forb
<i>Sibbaldiopsis tridentata</i>	Three-toothed cinquefoil	10	3	Forb
<i>Solidago ptarmicoides</i>	Upland white goldenrod	10	3	Forb
<i>Spiranthes lacera</i>	Slender ladies'-tresses	10	0	Forb
<i>Taenidia integerrima</i>	Yellow-pimpernel	8	5	Forb
<i>Viola pedata</i>	Birdfoot violet	9	5	Forb
<i>Viola sagittata</i>	Arrow-leaved violet	8	0	Forb
Forest indicators				
<i>Aralia nudicaulis</i>	Wild sarsparilla	5	3	Forb
<i>Asclepias exaltata</i>	Poke milkweed	6	5	Forb
<i>Brachyelytrum aristosum</i>	Northern shorthusk	7	5	Grass
<i>Chimaphila umbellata</i>	Pipsissewa	8	5	Shrub
<i>Diervilla lonicera</i>	Bush-honeysuckle	4	5	Shrub
<i>Dryopteris carthusiana</i>	Spinulose woodfern	5	-3	Fern
<i>Dryopteris intermedia</i>	Evergreen woodfern	5	0	Fern
<i>Epigaea repens</i>	Trailing-arbutus	7	3	Shrub
<i>Eurybia macrophylla</i>	Big-leaved aster	4	5	Forb
<i>Gaultheria procumbens</i>	Wintergreen	5	3	Shrub
<i>Hamamelis virginiana</i>	Witch-hazel	5	3	Shrub
<i>Linnaea borealis</i>	Twinflower	6	0	Forb
<i>Maianthemum canadense</i>	Canada mayflower	4	3	Forb
<i>Mitchella repens</i>	Partridge-berry	5	3	Forb
<i>Trientalis borealis</i>	Star-flower	5	0	Forb

Data analysis

We evaluated the ecological integrity and viability of each high-quality natural community by determining an EO rank based on Natural Heritage methodology, which combines individual ranks for size, condition, and landscape context based on data-driven expert judgement (MNF 1988; NatureServe 2002; Faber-Langendoen et al. 2008, 2015). EO ranks range from A (Excellent estimated viability/ecological integrity) to D (Poor estimated viability/ecological integrity) (Appendix B, Table B3). The utility of EO ranks includes comparing relative integrity or viability between occurrences of the same natural community type, tracking change of integrity of an occurrence over time, and assessing the status of a natural community type overall by examining the distribution of EO ranks for that type.

For each high-quality natural community, we determined the mean coefficient of conservatism (C-value) and Floristic Quality Index (FQI) with the Universal Floristic Quality Assessment Calculator (Reznicek et al. 2014, Freyman et al. 2016). These metrics of ecological integrity provide a somewhat objective benchmark for comparing natural community occurrences of the same type. An expert consensus has assigned each vascular plant species occurring in Michigan an a priori C-value that ranges from 0 to 10 on a scale of increasing conservatism or fidelity to high-quality natural communities (Reznicek et al. 2014). Plant species with a C-value of 7 to 10 are considered highly conservative, a C-value of 4 to 6 indicates moderate conservatism and a C-value of 1 to 3 indicates low or no conservatism (e.g., ruderal species) (Herman et al. 2001). Non-native species have a C-value of 0, as they have no fidelity to high-quality natural communities. We calculated FQI for each natural community occurrence as: $FQI = \bar{C} \times \sqrt{n}$, where $\bar{C}$ = mean C-value and n = species richness. Michigan sites with an FQI of 35 or greater possess sufficient conservatism and richness that they are considered floristically important from a statewide perspective (Herman et al. 2001).

RESULTS

The prescribed fire needs assessment model identified 4,827 stands covering 128,804 acres (66% of modeled Mio District) as high, very high, or highest fire need (31,058 acres [16%] as highest; 65,847 acres [34%] as very high; 31,898 acres [16%] as high) (Table 4; Figure 5). Based on model results and other sources of information we prioritized approximately 500 stands across over 100 compartments for survey and visited the majority of prioritized stands. We documented 20 new natural community EOs of 6 fire-dependent natural community types totaling 1,982 acres (Figure 6, Table 5). This represents a nearly four-fold increase in fire-dependent EOs (from 7 to 27) in the Mio District, and a more than eight-fold increase in coverage (from 265 to 2,247 acres) (MNFI 2026). Newly documented natural communities included bog (1), dry northern forest (5), dry-mesic northern forest (4), intermittent wetland (1), oak-pine barrens (1), and pine barrens (8).

Table 4. Fire needs model results for Mio District.

	Stands			Acres	
Highest	997	14%	31,058	16%	
Very High	2627	30%	65,847	34%	
High	1203	17%	31,898	16%	
Moderate	167	2%	4,161	22%	
Low	1	0.01%	19	0.01%	
None	2301	32%	62,119	32%	
Total:	7296		195,103		

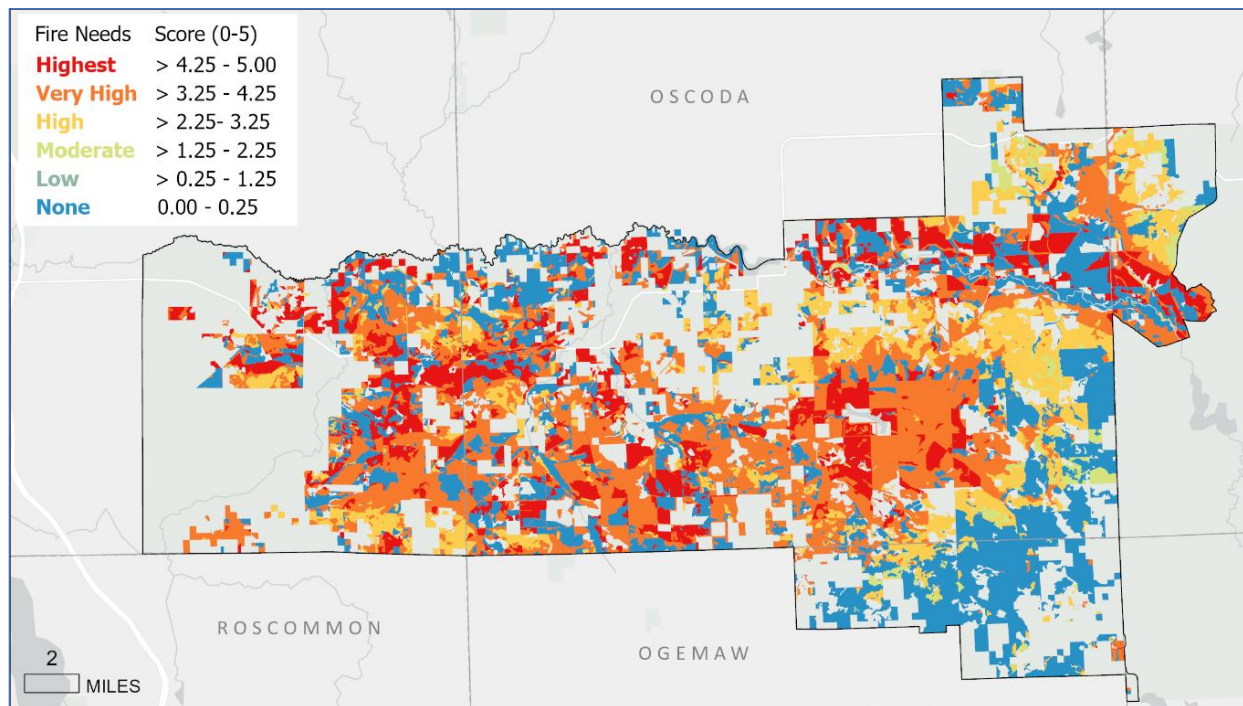


Figure 5. Fire needs model results for Mio District.

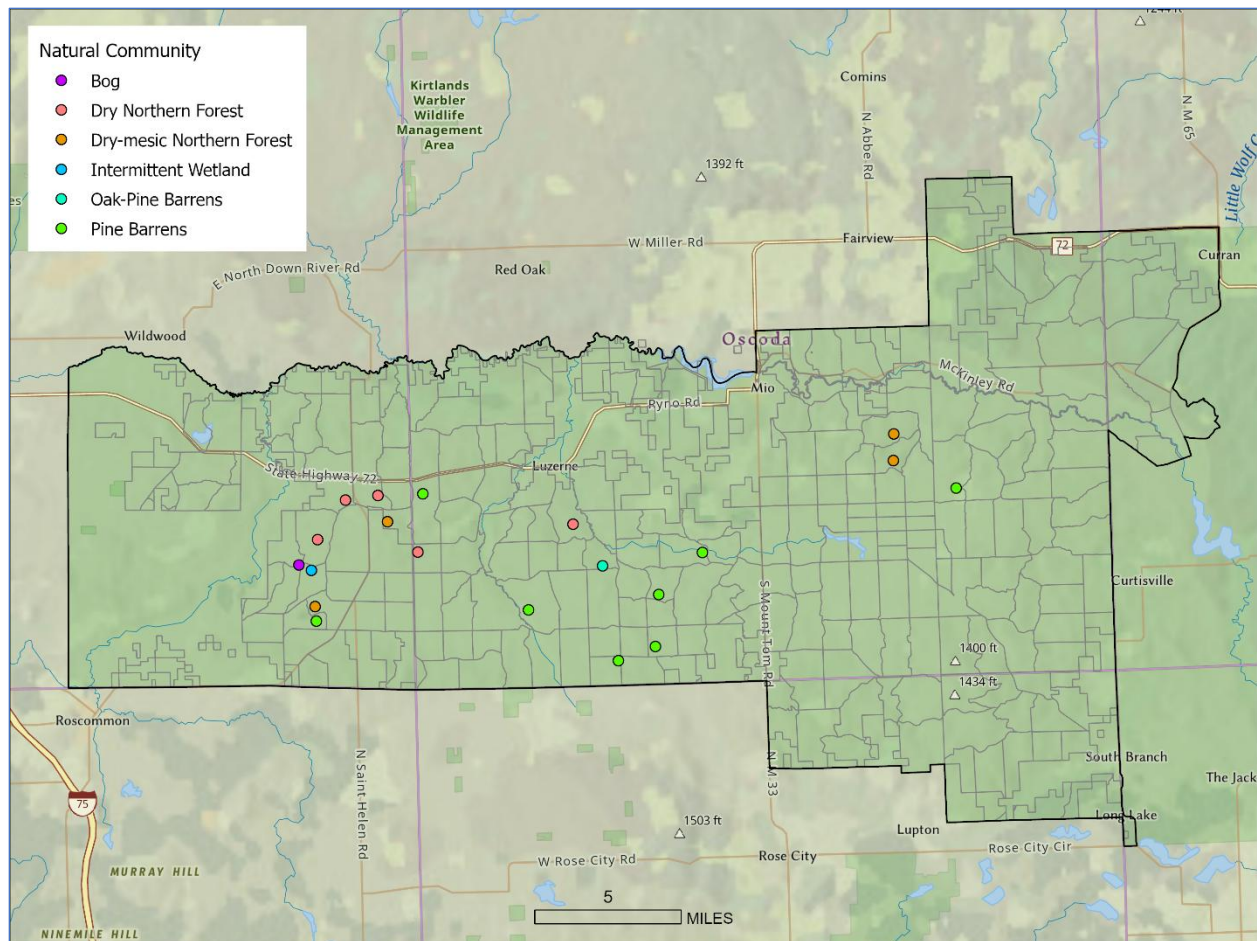


Figure 6. Newly documented fire-dependent natural community EOs in the Mio District.

The five new dry northern forest EOs we documented ranged in size from 11 to 554 acres and totaled 841 acres, increasing the total area of dry northern forest EOs in Michigan by 16% to 5,925 acres (Table 5). The four new dry-mesic northern forest EOs we documented ranged in size from 31 to 84 acres and totaled 222 acres, increasing the total area of dry-mesic northern forest in Michigan by 2% to 12,678 acres. The eight new pine barrens we documented ranged in size from 13 to 261 acres and totaled 861 acres, increasing the statewide total by 17% to 5,920 acres. Finally, the single new 27-acre oak-pine barrens EO we documented increased the area of oak-pine barrens in Michigan by 1% to 3,598 acres, the 14-acre bog EO increased the area of bog in Michigan by 0.1% to 12,388 acres, and the 17-acre intermittent wetland increased the area of intermittent wetland in Michigan by 1% to 1,900 acres. We also updated records for one EO each of four natural community types, dry northern forest, dry sand prairie, dry-mesic northern forest, and oak-pine barrens (Table 6). In each case, we revised the EO boundaries and prepared an updated plant species lists and associated FQI.

Table 5. Newly documented fire-dependent EOs in the Mio District, by natural community type. Global (G) and state (S) ranks: 1 = critically imperiled; 2 = imperiled; 3 = vulnerable; 4 = apparently secure; and 5 = secure (see Appendix C). EO ranks integrate condition, size, and landscape context: A = excellent; B = good; C = fair; and D = poor (see Appendix C). The *Results* section groups nearby sites by geography and shared stewardship context as project areas; corresponding project area and page numbers are provided for each EO.

EOID	Site Name	Rank	Acres	Compartments	Stands	Project Area	Page
<i>Bog (G3G5/S4)</i>							
28007	Brush Road	C	14	56	2	Hughes Lake Fire	50
<i>Dry northern forest (G3/S3)</i>							
28006	Claudia Trail	B	554	57	13-16, 25, 27, 30, 33	McMasters West	24
27662	South Branch Woods	BC	145	60; 70	5,6,9; 3,16	McMasters East	30
28009	River Lake Road	BC	93	59	10-12, 26	McMasters West	26
28170	Meridian 490	CD	38	92	8, 10	McMasters East	31
28157	East Branch Pines	D	11	118	21	Luzerne Region	65
<i>Dry-mesic northern forest (G4/S3)</i>							
28185	Eldorado Pines	C	84	82	6,7	McMasters East	33
28457	Hickey Creek Pines	C	31	55	9	Meridian Boundary Fire	47
26825	Cline's Oaks and Pines	BC	68	227	31	Bull Gap Moraine	70
28158	Bull Gap Pines	CD	39	224	7, 8	Bull Gap Moraine	72
<i>Intermittent wetland (G2/S3)</i>							
28008	Brush Road	C	17	56	2	Meridian Boundary Fire	50
<i>Oak-pine barrens (G3/S2)</i>							
28153	Merrit Prairie	CD	28	129	27	Luzerne Region	66
<i>Pine barrens (G3/S2)</i>							
27708	Meridian-Markle	C	261	88	12, 13, 16, 42, 43	McMasters East	35
28018	Loli Tract	C	179	151	19	Mio Prairie Expansion	41
27654	Luzerne Barrens	C	141	123	13, 27, 34, 40, 45, 48	Hughes Lake Fire	53
28179	Hickey Creek Barrens	C	100	54	10	Meridian Boundary Fire	48
27504	East Branch Big Creek	C	50	158; 159	13; 29, 35	East Branch Region	76
28069	Hughes Lake	C	13	126	1	Hughes Lake Fire	56
28160	Briggs Gravel Pit	CD	90	147	20, 25	Mio Prairie Expansion	43
28458	Bull Gap Barrens	CD	27	707	40, 4	No Pablo Fire	61

Table 6. Existing fire-dependent EOs in the Mio District. Global (G) and state (S) ranks: 1 = critically imperiled; 2 = imperiled; 3 = vulnerable; 4 = apparently secure; and 5 = secure (See Appendix C). EO ranks integrate condition, size, and landscape context: A = excellent; B = good; C = fair; and D = poor (see Appendix C).

EOID	Site Name	<u>Rank</u>		<u>Acres</u>		Compartment	Stands	<u>Survey Date</u>	
		New	Old	New	Old			New	Old
Bog (G3G5/S4)									
7168	Section 24 Bog	-	A	-	78.34	69	24, 26, 37, 30	no survey	09/10/1992
Dry northern forest (G3/S3)									
5690	O'Brien Lake	CD	BC	20.53	48.68	702	27, 28, 44	10/16/2025	09/02/1991
Dry sand prairie (G3/S2)									
11050	Mio Prairie	AB	AB	32.96	27.69	149	4	09/11/2025	09/18/1992
Dry-mesic northern forest (G4/S3)									
8810	Blockhouse Creek	C	C	25.26	32.10	656	29-31	10/16/2025	09/17/1992
Intermittent wetland (G2/S3)									
3274	Hunters Lake	-	B	-	27.69	75	10	no survey	09/11/1992
Northern fen (G3/S3)									
27342	Cathedral Pines	-	CD	-	3.37	231	28, 29	no survey	08/22/2023
Oak-pine barrens (G3/S2)									
13567	Section 16	D	C	76.59	124.00	147	2, 5, 8, 13	08/15/2024	10/20/1994

Beyond EO-quality natural communities, we identified 74 stands in 26 compartments covering 3,194 acres as restorable RFDS (Appendix D, Table D1). This total includes some stands that are already being managed for wildlife and other biodiversity by USFS. Of the 62 stands (3,617 acres) being managed by USFS, we evaluated 87% (54) of the stands and 93% (3,394 acres) of the area (Figure 7; Tables 7, D2). We determined that 34 of these stands totaling 1,855 acres (51% of existing management areas) are RFDS (Table 2; Appendix D, Tables D1, D2), including 5 EOs covering 591 acres (EOIDs 11050, 27708, 28018, 28158, 28160; Tables 5, 6). Altogether, 3% (6,207 acres) of the Mio District is either a current fire-dependent conservation target (EO and/or existing management area) or a newly-identified restorable RFDS, that we are recommending as a dynamic core for framing management of the fire-dependent landscape of the Mio District.

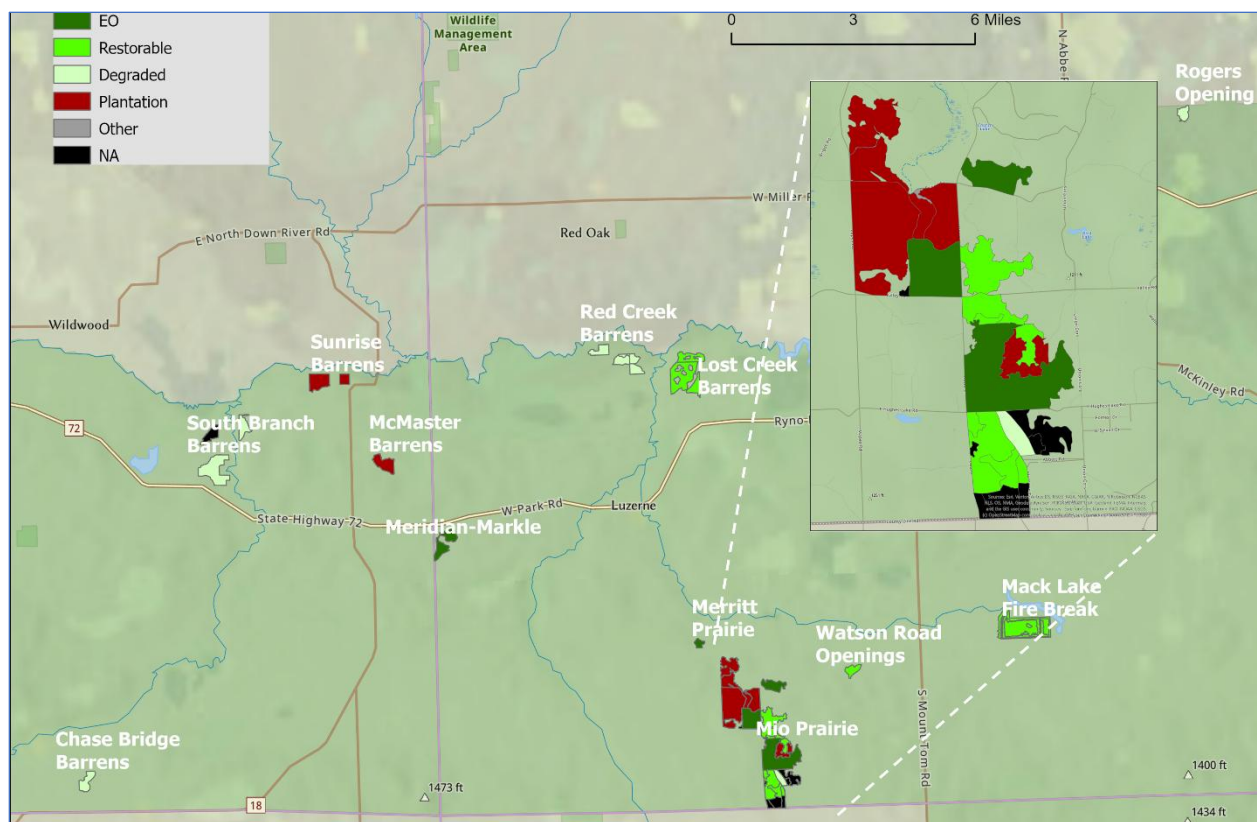
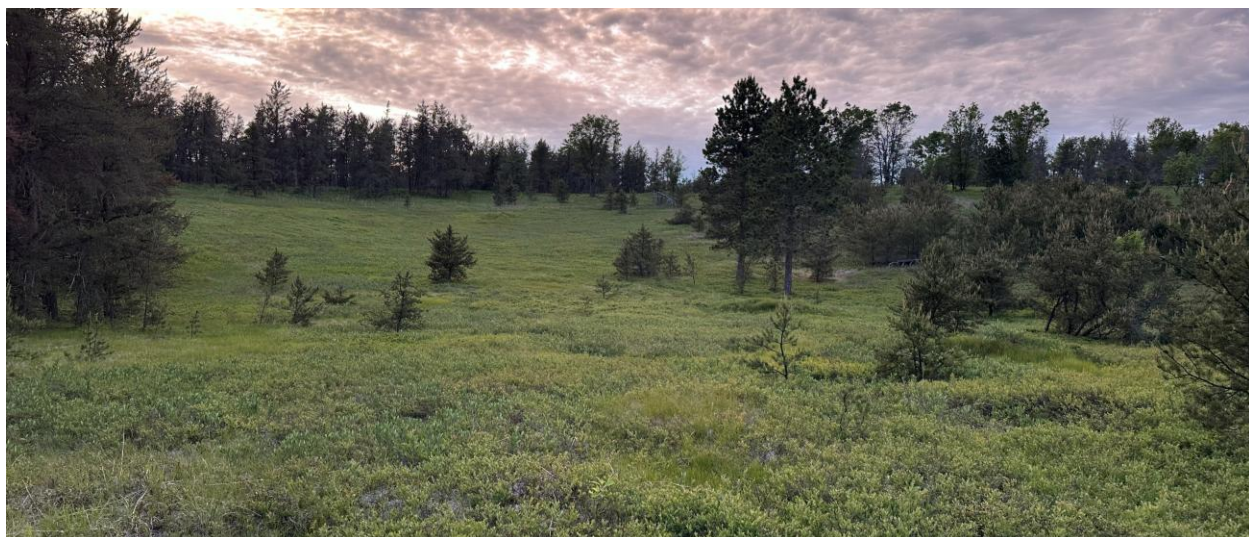


Figure 7. Existing management areas in the Mio District, classified in descending order of quality as RFDS (EOs, restorable) or non-RFDS (degraded, plantation, other) (Tables 2, 7; Appendix D, Table D2). Stands classified as NA were not surveyed due to time constraints.



Meridian-Markle pine barrens (EOID 27708), a natural community EO within an existing USFS management area. Prescribed fire and forestry mowing have maintained a heterogeneous landscape of low-shrub openings and scattered pine, while adjacent fire-suppressed barrens retain potential for recovery. Photo by J. M. Lincoln.

Table 7. Summary results for existing management areas in the Mio District. See Appendix D, Table D2 for stand-level results.

Class	Description	Total Stands	Acres	Pct	Example
EO	High-quality natural community (dry or dry-mesic northern forest, pine or oak-pine barrens, or dry sand prairie), documented by MNFI prior to or during 2024-2025 surveys	6	659	18%	Mio Prairie: Dry sand prairie (Comp 149, Stand 4); Merrit Prairie: Oak-pine barrens (Comp 127, Stand 27)
Restorable	Natural communities that possess some but not all attributes of an EO, that could be restored to EO-quality within a reasonable time frame (e.g., 5-10 years) through a combination of prescribed fire and mechanical thinning	28	1195	33%	Lost Creek Barrens (Comp 134, Stands 4,8; Comp 135, Stand 6); Watson Road Opening (Comp 156, Stand 36), Mack Lake Fire Breaks (Comp 205, Stands 2-4, 6, 8, 12, 16-18)*
Degraded	Natural communities that possess some but not all attributes of an EO, that are unlikely to be restored to EO-quality within a reasonable time frame (e.g., 5-10 years) through fire and thinning, due to plantation or other anthropogenic history	10	633	18%	Red Creek Barrens (Comp 111, Stands 10, 11, 17; Comp 112, Stands 6, 14); Chase Bridge Barrens (Comp 12, Stand 5)
Other	Cover types that do not represent an MNFI natural community [a single aspen stand]	1	3	0.1%	A small aspen clone in Comp 149, Stand 12
Plantation	Sites lacking most or all EO attributes due to a history of furrowed or non-furrowed plantation of red, white, or jack pine, including weave plantation for KW habitat	9	903	25%	Sunrise Barrens (Comp 65, Stands 2, 4); McMaster Barrens (Comp 63, Stand 18)
NA	Stands that we were not able to survey during 2024-2025	8	223	6%	Various mostly small stands
Total:		62	3617		

New natural community descriptions

The bulk of this section contains descriptions of natural community EOs identified through our model-directed survey efforts. We describe these EOs in the context of project areas to encourage consideration of management at the scale of landscapes rather than stands. For each project area, we describe the landscape features that justify grouping EOs together and provide a general picture of the immediate landscape context. Some project areas are defined by a specific landform, such as a geologic feature or wildfire, while others are defined solely based on the spatial proximity of two or more EOs.

We conclude the discussion of each project area with some recommendations for abating threats and managing for biodiversity, which consistently include prescribed fire. The general approach to fire we are advocating varies depending on the landforms and natural communities

in each project area, but follows the same general goal – restoring a critical landscape-scale process and landscape-scale connectivity for plant and animal species across the spectrum of fire-dependent ecosystems. Here, we provide detailed context and justification for prescribed fire recommendations, and keep individual recommendations in each project area brief. We mostly suggest frequent, low-intensity and -severity burns. Low-intensity burns encourage regeneration of pines, especially jack and red, while avoiding excessive mortality of mature canopy jack and red pine. We also encourage large burn units that are not restricted to EO boundaries, for example using roads and other existing boundaries as fire lines. Large burn units that span ecosystem boundaries encourage gradual ecotones across canopy closure gradients that mimic the heterogeneity of the shifting mosaic and increase habitat diversity at the landscape scale through that heterogeneity. Finally, estimated historical fire frequency across the northern lower peninsula ranged from at least as frequent as every 5 to 40 years but was certainly variable across the region (Loope and Anderton 1999, Drobyshev et al. 2008, Kipfmüller et al. 2017, Stambaugh et al. 2024). In returning fire to the landscape, we generally recommend more frequent fire initially to stimulate pine recruitment and ground layer plant species diversity. After these initial goals are achieved, fires can become less frequent, with the goal shifting to preventing mesophication (i.e., a shift to a mesophytic system; Nowacki and Abrams 2008) by limiting recruitment of oak, maple, and fir. Fire in barrens and prairie systems should be more frequent over the long-term than in forests, to maintain open conditions by reducing woody encroachment. Fire regimes driven by other goals, such as Indigenous cultural burning for berry production and other objectives, may have different frequencies and intensities.



Low-intensity prescribed fire in a mature natural red pine stand in Minnesota. Low-intensity burns, which the Mio District currently conducts, retain mature trees and ground-layer legacies while reducing accumulating surface and ladder fuels. Extending this approach across the project areas identified here would reconnect fire-dependent ecosystems at a landscape scale. Photo by Lane Johnson, College of Food, Agricultural and Natural Resource Sciences, University of Minnesota.

McMasters West

The McMasters West project area includes two dry northern forest EOs that occur in gently rolling glacial outwash immediately south of M-72 and west of M-18 (Table 5; Figure 8). Importantly, this project area includes the largest dry northern forest documented in Michigan, Claudia Trail (EOID 28006; Table 5). Aside from a 367-acre fair to poor occurrence (EO Rank = CD) in Iosco County, 554-acre Claudia Trail is the only dry northern forest greater than 200 acres in the Lower Peninsula (MNFI 2026). Poor to excellent occurrences (EO Rank = D to A) ranging from 243 to 491 acres occur in Luce, Marquette, Delta, Schoolcraft, and Keweenaw Counties in the Upper Peninsula. This project area includes several small, high-quality wetlands, including spruce and hardwood swamps and seepages draining into the South Branch of the Au Sable River. This project area includes a mix of young and mature pine and oak-pine stands and red and jack pine plantation, and occasional young aspen stands in lower, mesic landscape positions. A few restorable stands in Compartments 57 and 59 span the gap between the two documented EOs (Appendix D, Table D1). Two additional EOs, Brush Road bog and intermittent wetland (EOID 28007 and 28008), are adjacent to the southern boundary of Claudia Trail dry northern forest but in the scar of the Meridian Boundary Fire of 2010 that defines a separate project area discussed below.



Claudia Trail dry northern forest (EOID 28006), Michigan's largest documented occurrence of this natural community type. Claudia Trail is consistently dominated by red pine (*Pinus resinosa*) but encompasses much of the natural variation of the type.

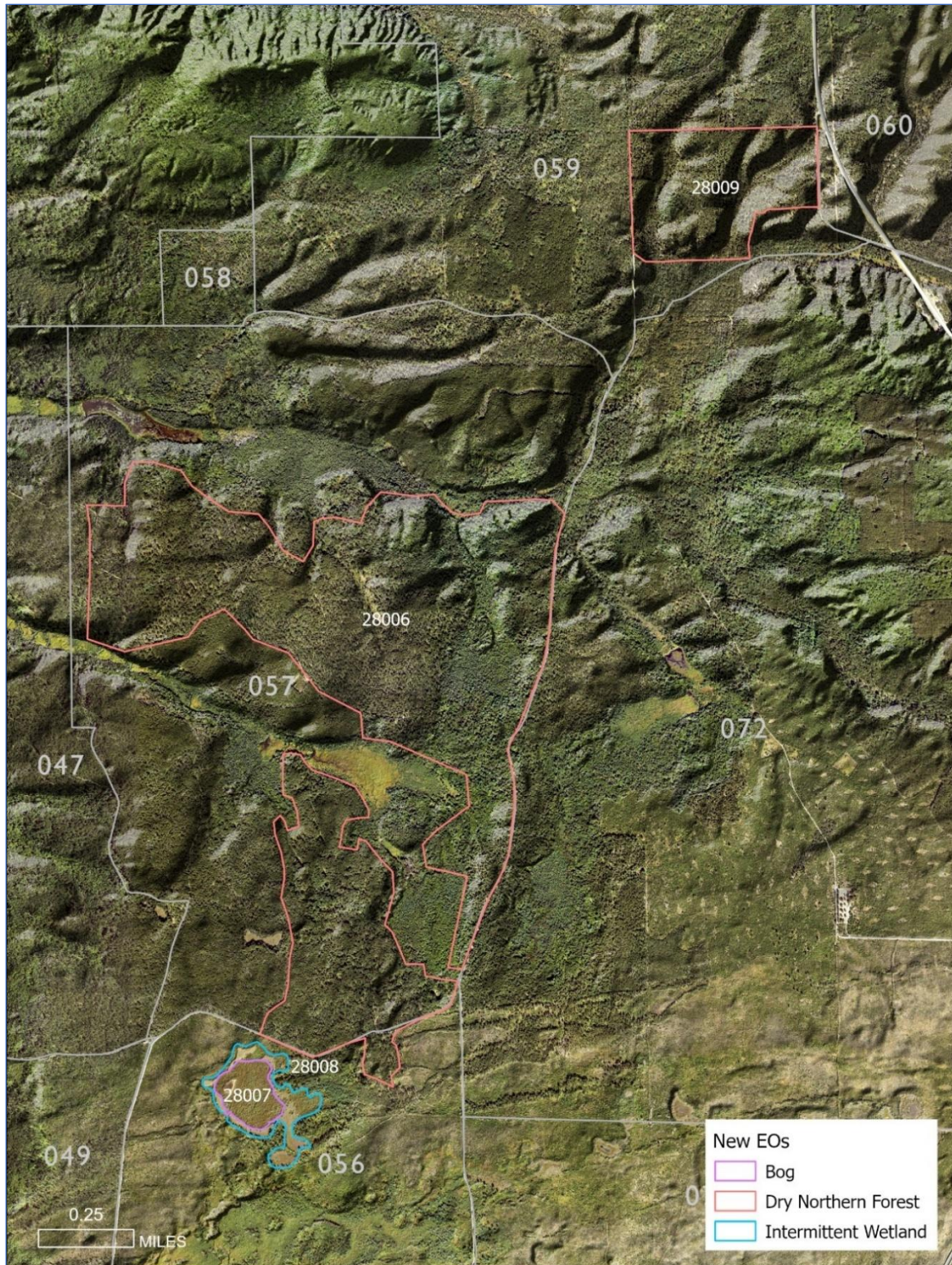


Figure 8. McMasters West project area in the Mio District, including Claudia Trail (EOID 28006) and River Lake Road (EOID 28009) dry northern forests. Brush Road bog and intermittent wetland to south (28007, 28008) included in Meridian Boundary fire project area. Compartments outlined and numbered in white.

Claudia Trail

Dry Northern Forest (EOID 28006)

EO Rank: B; 554 acres

FQI: 33.6; Mean C: 4.6; Species richness: 52 (51 native)

Compartment: 57

Claudia Trail dry northern forest occurs in lightly undulating glacial outwash surrounded by ice-contact features and drainages to the South Branch of the Au Sauble River. Ecosystem structure and species composition vary according to soil texture, landscape position, and proximity to wetlands. The canopy, with cover mostly 90-100% and occasional patches as low as 70%, is consistently dominated or (locally) co-dominated by red pine (*Pinus resinosa*), ranging in age from 80 to as old as 150, with an estimated 90% of the canopy around 120 years old. Overall, white pine (*P. strobus*) is the most frequent species in the regeneration class from the tall shrub to subcanopy strata, and locally abundant to dominant, including under a dense red pine canopy. Red pine and northern pin oak (*Quercus ellipsoidalis*) are occasional to locally common in both the subcanopy and tall shrub strata, while northern pin oak and white oak (*Q. alba*) seedlings are locally abundant. Low sweet blueberry (*Vaccinium angustifolium*) dominated the ground layer, with wintergreen (*Gaultheria procumbens*) frequent and locally dominant. Pennsylvania sedge (*Carex pensylvanica*) is a consistent member of the ground layer plant community, and frequently dominant, particularly in patches with greater light availability where low sweet blueberry is sparse. Feather mosses, and to a lesser extent reindeer lichen (*Cladonia* spp.), are also frequently locally dominant. Bracken fern (*Pteridium aquilinum*) is also abundant throughout. Other frequently encountered species included Canada mayflower (*Maianthemum canadense*), northern shorthusk (*Brachyelytrum aristostum*), rough-leaved ricegrass (*Oryzopsis asperifolia*), and starflower (*Trientalis borealis* [synonym = *Lysimachia b.*]).

Conditions ranged from inclusions of dry-mesic northern forest along the most shaded north-facing slopes to overgrown pine barrens in the sandiest areas with the most sun exposure. The most dry-mesic inclusions occurred along the northern boundary of the EO and along the margin of Sauger Creek in the east-central portion of the EO, and in these locations the canopy is co-dominated by white pine (*P. strobus*), balsam fir (*Abies balsamea*) regeneration is sometimes locally dense, and the ground layer community included species like barren-strawberry (*Geum fragarioides*), gay-wings (*Polygaloides paucifolia*), glaucous honeysuckle (*Lonicera dioica*), and partridgeberry (*Mitchella repens*). The most xeric portions are in the northwestern lobe of the EO, where jack pine (*P. banksiana*) is co-dominant in the canopy, and species like hairy goldenrod (*Solidago hispida*), rattlesnake-weed (*Hieracium venosum*), and huckleberry (*Gaylussacia baccata*) characterized the ground layer.

Old pine stumps were observed throughout, often with fire char, but evidence of recent fire is lacking. The 2010 Meridian Boundary wildfire covers the southern boundary, impacting only ~ 7 acres of this dry northern forest. Pine regeneration is high considering apparent fire exclusion, as is plant diversity, although the large size and extent of heterogeneity likely explain the latter. There are local areas of mesophication, either dense red maple, balsam fir, or bigtooth aspen poles and saplings, but these are rare. Coarse woody debris and tip-up mounds are occasional.

There are two small peatland inclusions, a 10-acre poor conifer swamp in the northeast supporting a sparse canopy of black spruce (*Picea mariana*) over a tag alder (*Alnus incana*) thicket and a dense mat of sphagnum moss (*Sphagnum* spp.), and a small boggy seepage wetland (<1 acre) in the northwest with localized pockets of sheep-laurel (*Kalmia angustifolia*) and leatherleaf (*Chamaedaphne calyculata*) over sphagnum moss.



Claudia Trail dry northern forest (E0ID 28006), showing dry-mesic extreme co-dominated by red and white pine (*Pinus resinosa* and *P. strobus*) (above), and dry extreme co-dominated by red and jack pine (*P. banksiana*) (below).



River Lake Road

Dry Northern Forest (EOID 28009)

EO Rank: BC; 93 acres

FQI: 27.5; Mean C: 4.1; Species richness: 45 (36 native)

Compartment: 59

River Lake Road dry northern forest occurs along three parallel ridges separated by narrow frost pocket swales on a disintegrating margin of an ice-contact feature adjacent to a broad drainage channel. The canopy ranges from 70 to 100% and is comprised of three roughly 5-acre near-monocultures of red pine (*Pinus resinosa*), nested within a matrix of 80-year-old, 15 to 25 cm DBH jack pine (*P. banksiana*) and 25 to 50 cm DBH red pine with a scattered supercanopy of older red pine. The canopy or supercanopy of red pine is dominated by mature trees (~120 years), 33 to 54 cm DBH, and includes those approaching old growth (up to 170 years). The red pine monocultures are largely found on flattish ridge tops and steep slopes while jack pine locally dominates in bisecting frost pockets and drainage channels. Mortality of canopy jack pine and possible canopy thinning has created small openings. In one mild slope along a drainage, some canopy red pine appears to have been planted. The subcanopy structure is largely open and sparse at 10% cover, dominated by saplings and small trees of jack pine, with occasional red pine and Northern pin oak (*Quercus ellipsoidalis*). Both red pine regeneration and ground layer plant species diversity are low, presumably due to fire suppression and the accumulation of pine needles and duff.

The ground layer (90% vegetative cover) is dominated by low sweet blueberry (*Vaccinium angustifolium*), and locally by feather mosses and pine needle litter. Reindeer lichen (*Cladonia* spp.) is frequently locally abundant, and huckleberry (*Gaylussacia baccata*) infrequently so. Rice grass (*Piptatherum pungens*), hair grass (*Avenella flexuosa*), and Pennsylvania sedge (*Carex pensylvanica*) are occasional to frequent, but generally sparse when encountered. A two-track bisects the EO diagonally and is a source of weedy non-natives, including sparse populations of invasive non-native species like spotted knapweed (*Centaurea stoebe*), quack grass (*Elymus repens*), orange hawkweed (*Hieracium aurantiacum*), and Kentucky bluegrass (*Poa pratensis*), as well as innocuous non-native species like Queen-Anne's lace (*Daucus carota*) and ox-eye daisy (*Leucanthemum vulgare*). Associated soil disturbance in one canopy opening also supports a few individuals of conservative barrens species such as Gillman's goldenrod (*Solidago simplex* var. *simplex* [synonym = *S. glutinosa*]), balsam ragwort (*Packera paupercula*), and rough fescue (*Festuca altaica*, Special Concern). This site has no apparent recent fire history. Despite a close proximity to Claudia Trail dry northern forest (~ 1 km) and a similar canopy age, River Lake Road dry northern forest is mapped separately due to the significant portions with 80-year-old jack pine canopy and apparent underplanting.



River Lake Road dry northern forest (EOID 28009). Note dense accumulation of pine needles with especially sparse understory.

Management Recommendations

We encourage managers to reintroduce prescribed fire, avoid timber harvests, and prevent ORV access. The goals of prescribed fire in both EOs includes stimulating regeneration of red pine, limiting invasive species, and increasing ground layer diversity. In particular, low-severity fires should aim to reduce the depth of pine needles and duff to increase microsites for recruitment of ground layer plant species while managing the risk of extensive canopy tree mortality. Three or more fires may be necessary to generate a robust regeneration class of pines. Fires should include as large of a proportion of both EOs as possible in burn units, include portions of surrounding stands as feasible and safe, occur at a frequency of once every 5 to 40 or 50 years, and be more frequent initially to stimulate pine recruitment.

We recommend avoiding timber harvests within the EOs, and limiting logging in areas adjacent to EOs to winter months to reduce soil disturbance. Avoid clearcuts in the landscape surrounding the EOs, to maintain habitat connectivity for forest-obligate plant and animal species. Timber management in the surrounding landscape should target oak, maple, and fir. Finally, consider blocking off two-tracks that bisect the EOs, and taking other measures to prevent ORV access.

McMasters East

The McMasters East project area includes two dry northern forest EOs, one dry-mesic northern forest EO, and one pine barrens EO and occurs on undulating and pitted topography of an ice-contact feature immediately south of M-72 and east of M-18 (Table 5; Figure 9). It is bisected by a narrow glacial drainage now occupied by Markle Road. The surrounding landcover is mostly degraded but also includes some high-quality, dry northern forest and pine barrens. The west and south boundary of Eldorado Pines dry-mesic northern forest (EOID 28185) and the west boundary of Meridian 490 dry northern forest (EOID 28170) abut private property. Additionally, a few restorable stands in Compartment 70 could increase connectivity between South Branch Woods dry northern forest (EOID 27662) and Meridian-Markle Barrens (EOID 27708) (Appendix D, Table D1).



The McMasters East project area includes South Branch Woods dry northern forest (EOID 27662). This forest supports uneven-aged red pine, including scattered trees more than 180 years old. Extending prescribed fire from adjacent managed openings into the forest would retain mature pine while promoting ground-layer diversity and red pine recruitment.

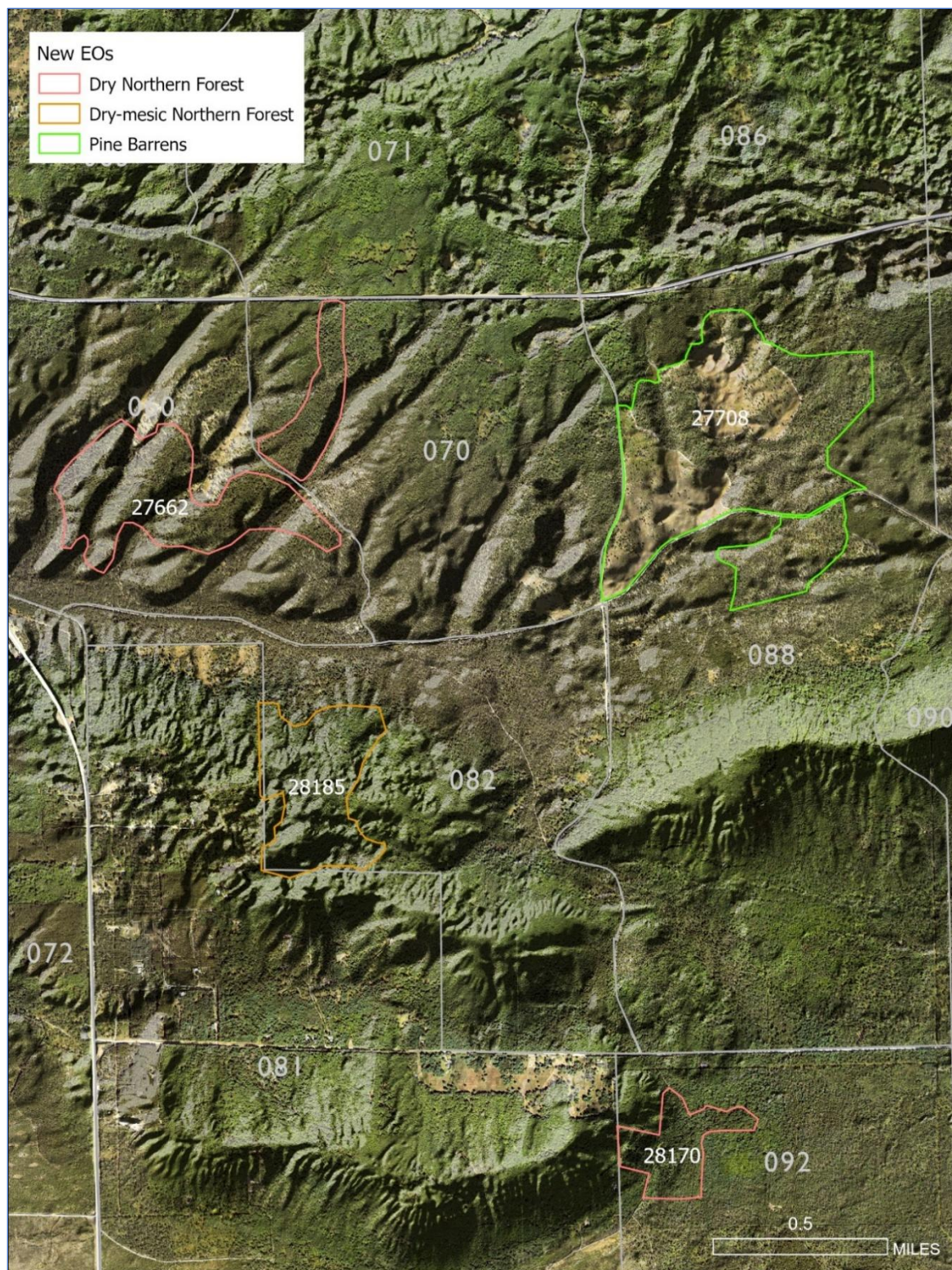


Figure 9. McMasters East project area in the Mio District, including South Branch Woods (EOID 27662) and Meridian 490 (EOID 28170) dry northern forest, Eldorado Pines dry-mesic northern forest (EOID 28185), and Meridian-Markle pine barrens (EOID 27708). Compartments outlined and numbered in white.

South Branch Woods

Dry Northern Forest (EOID 27662)

EO Rank: BC; 145 acres

FQI: 25.5; Mean C: 5.0; Species richness: 26 (26 native)

Compartments: 60, 70

South Branch Woods is an uneven-aged dry northern forest dominated by red pine (*Pinus resinosa*). Canopy closure is generally 95 to 100%, with scattered openings supporting 50 to 75% cover. Most canopy trees belong to a 90- to 110-year-old cohort and range from 40 to 70 cm DBH, but approximately 10% of the canopy represents 180-year-old cohort. Jack pine (*P. banksiana*), northern pin oak (*Quercus ellipsoidalis*), and white pine (*P. strobus*) occur occasionally in the canopy. The subcanopy ranges from sparse to locally dense and includes red pine, white pine, jack pine, northern pin oak, and white oak (*Q. alba*). A 3-cm-DBH red pine was 75 years old, indicating limited red pine recruitment beneath the closed canopy.

The low-shrub layer is patchy to dense and dominated by low sweet blueberry (*Vaccinium angustifolium*) and huckleberry (*Gaylussacia baccata*), with wintergreen (*Gaultheria procumbens*), sweet fern (*Comptonia peregrina*), sand cherry (*Prunus pumila*), serviceberry (*Amelanchier interior*), and tree seedlings. The sparse, ground layer includes Pennsylvania sedge (*Carex pensylvanica*), rough-leaved rice-grass (*Oryzopsis asperifolia*), hair grass (*Avenella flexuosa*), spreading dogbane (*Apocynum androsaemifolium*), cow-wheat (*Melampyrum lineare*), and abundant bracken fern (*Pteridium aquilinum*). Deep moss, reindeer lichens, needle duff, and matted organic material are abundant. There is no evidence of recent logging. Standing and downed coarse woody debris including cavities, and material in multiple stages of decay are signs of mature forest development. Its large size, old red pine, multiple age classes, and continued development of mature-forest structure are tempered by prolonged fire exclusion, high canopy closure, low ground-layer diversity, and limited red pine recruitment.



South Branch Woods dry northern forest (EOID 27662). A limited number of small canopy gaps support ground layer plant diversity and pine regeneration. Photo by J. M. Lincoln.

Meridian 490

Dry Northern Forest (EOID 28170)

EO Rank: CD; 38 acres

FQI: 19.1; Mean C: 4.5; Species richness: 18 (18 native)

Compartment: 92

Meridian 490 forest occurs in undulating glacial outwash adjacent to the margin of a large ice-contact feature. The uneven-aged canopy (80-90% closure) is dominated by 40 to 65 cm DBH red pine (*Pinus resinosa*), particularly in the core of the EO, with other canopy species more prominent along the edges. White pine (*P. strobus*) is frequent in the canopy and ranges from ca. 27 to 81 cm DBH. The canopy ranges in age from an estimated 60 to 125 years. The dominant age is roughly 100 years, and a red pine estimated at 100-years-old showed a canopy release after ~ 30 years. The younger cohort, at 60-years-old, was likely recruited after a thinning around 1965. Several oak species were scattered throughout the EO, including 30 to 45 cm DBH white oak (*Quercus alba*), 20 to 50 cm DBH northern pin oak (*Q. ellipsoidalis*), and 45 to 60 cm DBH red oak (*Q. rubra*). Evidence of fire-suppression leading to mesophication is abundant. Red maple (*Acer rubrum*) is abundant in all strata, including scattered 20 to 35 cm DBH trees in the canopy. Red maple is occasional but locally dominant in the subcanopy, frequent in the tall shrub layer, and red maple seedlings were occasional in the ground layer as well. Red pine regeneration is notably absent. Big-toothed aspen (*Populus grandidentata*) is present but rare in the canopy, around 35 to 40 cm DBH. White pine was also well-represented in other strata, occasional in the subcanopy and particularly abundant in the tall shrub layer, and frequent as a seedling in the ground layer. Regeneration of white oak was occasional in the tall shrub layer while Northern pin oak seedlings were occasional in the ground layer.

The ground layer was sparse (20-30% cover), suppressed by a mix of pine and maple leaf litter. Low sweet blueberry (*Vaccinium angustifolium*) was abundant, wintergreen (*Gaultheria procumbens*) and bracken fern (*Pteridium aquilinum*) were frequent, and Pennsylvania sedge (*Carex pensylvanica*) was locally dominant. The ground layer plant community was depauperate, with patches of low shrubs including trailing arbutus (*Epigaea repens*) and huckleberry (*Gaylussacia baccata*), and forest herbs including rough-leaved rice-grass (*Oryzopsis asperifolia*), northern shorthusk (*Brachyelytrum aristosum*), and false-melic (*Schizachne purpurascens*), as well as feather mosses. Despite the abundance of species typical of dry-mesic northern forest in the canopy (e.g., white pine, oak species), the highly acidic sands with little organic matter or loamy profile and overall dominance by red pine suggest this is a mesophied dry northern forest.

A popular ORV trail runs through the center of this EO, although no non-native species were observed. Coarse woody debris was abundant, mostly branches of white pine and red maple that likely fell during the ice storms of the previous two winters. No stumps were observed. A large area to the southwest is planned to be clearcut for Kirtland's warbler (*Setophaga kirtlandii*) habitat, and a fuel break is planned along and inside the western boundary adjacent to a private inholding.



Meridian 490 dry northern forest (E01D 28170) with supercanopy red pine (*Pinus resinosa*) in the background. Dense accumulation of red maple (*Acer rubrum*) saplings and leaf litter in the foreground are indications of prolonged fire-suppression and mesophication.

Eldorado Pines

Dry-mesic Northern Forest (EOID 28185)

EO Rank: C; 84 acres

FQI: 24.5; Mean C: 4.8; Species richness: 26 (26 native)

Compartment: 82

Eldorado Pines occurs in gently undulating to hilly terrain within a series of kettles and ridges in ice-contact topography. The dense canopy (90% closure) is relatively young but uneven-aged (ca. 85-120) and dominated by 35 to 80 cm DBH white pine (*Pinus strobus*), with 30 to 55 cm DBH red pine (*P. resinosa*) subdominant on more xeric aspects such as ridge tops, otherwise forming a sparse subcanopy. White pine was estimated to be between 85 and 110 years old and red pine was estimated to be between 93 and 190 years old. The rings of the oldest red pine indicated a canopy release event circa 1925 to 1935, consistent with a thinning leading to the current dominant canopy age of 90 to 100 years. Red oak (*Quercus rubra*) is an important canopy associate, ranging in DBH from 40 to 60 cm DBH, and estimated at roughly 100 years old. White oak (*Q. alba*) ranged between 20 to 45 cm DBH and was estimated at roughly 120 years old. Bigtooth aspen (*Populus grandidentata*) is infrequent but locally common, range from at 35 to 60 cm DBH and are estimated at roughly 95 years old. Red maple (*Acer rubrum*) is rare in the canopy but mature, at 50 cm DBH. A few snags and downed debris of paper birch (*Betula papyrifera*) were observed. Effects of fire-suppression, specifically the early stages of mesophication in the form of red maple abundance, are evident in every stratum below the canopy. The subcanopy (10-40% cover) is dominated by white pine with occasional red oak and red maple including locally dense stump sprouts. The tall shrub layer is dominated by white pine regeneration (1-5 m tall), which is locally dense, although red maple is frequent in this stratum. Red maple is common to abundant in all strata except the canopy. Among non-canopy-tree species, witch hazel (*Hamamelis virginiana*) occurs occasionally in the tall shrub layer.

Ground layer cover is generally sparse (5-30% cover), dominated by red maple and white pine litter. Among low shrubs, wintergreen (*Gaultheria procumbens*) is abundant, and huckleberry (*Gaylussacia baccata*) is common. Seedlings of white pine and red oak are rare and red maple is common. Among herbaceous species, feather mosses are common and other ground layer plant species are typically rare, except Pennsylvania sedge (*Carex pensylvanica*) and bracken fern (*Pteridium aquilinum*). Gay-wings (*Polygaloides paucifolia*), rough-leaved rice-grass (*Oryzopsis asperifolia*), and false-melic (*Schizachne purpurascens*) are occasional to locally common. The forest contains species indicative of both dry conditions such as pipsissewa (*Chimaphila umbellata*) and dry-mesic conditions such as twinflower (*Linnaea borealis*), round-lobed hepatica (*Hepatica americana*), and Solomon-seal (*Polygonatum biflorum*). This is probably due to the high sand content in the soil, which is mediated by northern and eastern aspects to include more dry-mesic components.

This EO is bisected by at least 3 logging roads and one 2-track. Evidence of recent logging is minimal, mostly in the form of red maple stump sprouts, although other cut stumps are occasional. Coarse woody debris is frequent (15-40 cm in diameter), and mostly in the least decayed classes, including many recently fallen branches.



Eldorado Pines (EOID 28158) dry-mesic northern forest. Red and white pine (*Pinus resinosa* and *P. strobus*) dominate the canopy and locally dense red maple (*Acer rubrum*) saplings and leaf litter are prominent in lower strata(above); locally dense white pine regeneration (below).



Meridian-Markle

Pine Barrens (EOID 27708)

EO Rank: C; 261 acres

FQI: 35.3; Mean C: 4.9; Species richness: 52(50 native)

Compartment: 88

Meridian-Makle pine barrens occurs in largely level to slightly undulating ground atop an ice-contact feature. Canopy structure in this barrens is strongly bimodal, comprised of two intensively-managed openings, one in the north and one in the southwest of the EO, with a sparse canopy (10-20%) dominated by red pine (*Pinus resinosa*) and northern pin oak (*Quercus ellipsoidalis*). These openings are separated by and adjacent to fire-suppressed barrens currently structured as an open-canopied (~50% cover) jack pine (*P. banksiana*) forest. An additional patch of fire-suppressed barrens (60% cover), more transitional to dry northern forest, occurs to the south across Markle Road. We first describe the heavily managed openings, then describe the fire-suppressed barrens.

The openings are being maintained with fire and forestry mowers. Widely-spaced, 35 to 50 cm DBH and 55 to 115 year-old red pine and 15 to 45 cm DBH 80 to 85 year-old Northern pin oak co-dominate the sparse canopy. Several large-diameter Northern pin oak, and fewer red pine, have major fire damage to the lower trunk. The subcanopy is absent but a tall shrub layer of mostly oak grubs is prominent. Jack pine, mostly 15 to 25 cm DBH and 45 to 50 years old, is occasional, and locally common in the northern extent of the northern opening. Stump sprouts of Northern pin oak are dominant to abundant and being managed through fire and forestry mowing, while jack pine regeneration is uncommon and red pine regeneration was not observed. Sweet fern (*Comptonia peregrina*) is common and sand cherry (*Prunus pumila*), bearberry (*Arctostaphylos uva-ursi*), and low sweet blueberry (*Vaccinium angustifolium*) are abundant in the ground layer, with the latter frequently locally dominant. Common species in the ground layer (80-90% vegetative cover overall), which had extensive but local patches of bare soil, include reindeer lichen (*Cladonia* sp.), haircap moss (*Polytrichum* sp.), rattlesnake weed (*Hieracium venosum*), and locally, Pennsylvania sedge (*Carex pensylvanica*). There are several highly conservative species, including western sunflower (*Helianthus occidentalis*), June grass (*Koeleria macrantha*), northern blazing star (*Liatris scariosa*), three-toothed cinquefoil (*Sibbaldiopsis tridentata*), Canada hawkweed (*Hieracium kalmii*), and dwarf blazing star (*Liatris cylindracea*). A small population of few-flowered nut rush (*Scleria pauciflora*, State Endangered) was observed on the margin of the sandy two-track that borders the openings.

The bisecting fire-suppressed barrens is characterized by a scattered canopy of 30 to 80% closure and is strongly dominated by 15 to 40 cm DBH jack pine. Jack pine ranges in age from an estimated 60 to 120 years old. There are patches with abundant standing dead and fallen jack pine in various states of decay. Both 25 to 60 cm DBH red pine and 25 to 50 cm DBH Northern pin oak are subdominant. A Northern pin oak was estimated at 130-years-old. A red pine tree was estimated at around 110 years old – tree-ring analysis revealed slow growth during the first 60 years, likely correlated with closed-canopied conditions, and fast growth over the past 50 years, suggesting a canopy thinning around 1975. About one-half of the standing oak stems are dead, however toward the east the canopy is denser and living Northern pin oak are more common in the canopy with most of the jack pine > 35 cm standing dead. Canopy structure is mostly open and park-like with an open understory but with local areas of jack pine regeneration, especially in the east. Overall, the subcanopy is thin (20% cover), with all three canopy species occasional, and black cherry (*Prunus serotina*) and white oak (*Q. alba*) rare. Low sweet blueberry is abundant, huckleberry is locally dominant, and sand cherry is



Meridian-Markle pine barrens (EOID 27708). Open-canopied portions are managed with forestry mowers and prescribed fire (above), while areas with denser canopy or fire-suppressed barrens have restoration potential (below).



common in the low shrub layer (60% cover), which also included bearberry, wintergreen (*Gaultheria procumbens*), trailing arbutus (*Epigaea repens*), and shadbush serviceberry (*Amelanchier spicata*). Among seedlings, Northern pin oak are occasional and black cherry and red maple are rare. Among herbaceous species, Pennsylvania sedge is dominant and bracken fern (*Pteridium aquilinum*) is occasional and locally abundant. Reindeer lichen and feather mosses are common. Shade-tolerant species like false-melic (*Schizachne purpurascens*) and rice-grass (*Piptatherum pungens*) are occasional and species that differentiate barrens from forests like prairie brome (*Bromus kalmii*) and little bluestem (*Schizachyrium scoparium*) are present but generally rare, emphasizing extended fire exclusion.

The fire-suppressed barrens polygon to the south of Markle Road has a canopy dominated by 15 to 30 cm DBH, 85 to 135 year-old jack pine, with rare ~30 cm DBH Northern pin oak, and sparse supercanopy of 30 to 70 cm DBH, 185 to 190 year-old red pine. Jack pine is common in the subcanopy (20-30% cover) while red pine is occasional and white pine (*P. strobus*) and Northern pin oak are rare. The ground layer is dominated by mostly forest-associated species like wintergreen and bracken fern and those with a broad ecological amplitude like low sweet blueberry. Conservative barrens indicator species like balsam ragwort (*Packera paupercula*), three-toothed cinquefoil, and June grass are also present.

Wood ant (*Formica* sp.) mounds are occasional in this EO. Areas adjacent to but excluded from the EO included mature furrowed plantation, open areas with barrens structure but notable furrows and stumps, barrens structure but lacking barrens indicators, and young dry northern forest with no barrens indicators.



Forestry mower poised to continue managing woody species in Meridian-Markle barrens. Even with the consistent application of fire, woody encroachment can limit characteristic barrens structure and composition.

Management Recommendations

We encourage managers to continue using fire and apply it across a larger area, including areas of denser jack pine forest between higher quality openings. The landscape connecting South Branch Woods, Eldorado Pines, and Meridian-Markle Barrens could be managed as whole, as it contains a sufficient footprint of restorable or lightly degraded stands. Despite that connectivity, this landscape will certainly require multiple burn units. Meridian 490 Forest, on the other hand, may require its own management unit, absent the incorporation of portions of compartment 88 as a corridor connected to Meridian-Markle Barrens. Low-severity fires including the dry and dry-mesic northern forest EOs should aim to improve conditions for red pine recruitment and characteristic ground-layer vegetation by consuming duff and pine needles, while minimizing mortality of old trees. Burns including barrens openings, especially Meridian-Markle Barrens, should be of high enough intensity to stimulate regeneration of jack and possibly red pine, but of low enough severity to avoid extensive tree mortality. This approach allows the development of a patchy distribution of jack pine under a supercanopy of red pine, key attributes of the pine barrens natural community. Where feasible, burn units should encompass surrounding forest and barrens, expanding natural transitions between natural community types. Fire frequency should range from once every 3 to 25 years in barrens and every 5 to 40 years in forests.

Avoid intensive timber harvests within the EOs and avoid clearcuts in the landscape surrounding the EOs. If prescribed fire does not achieve the desired results, evaluate the implementation of mechanical treatments to reduce canopy coverage of maple, fir, and oak. Much of the area of Meridian-Markle pine barrens not managed as openings is currently (as of spring 2026) planned to be converted to red pine plantation. This conversion will certainly degrade the pine barrens natural community.

Mio Prairie Expansion

The Mio Prairie Expansion project area is centered on a broad glacial drainage channel that extends south from Luzerne. This existing project area is a long-term focus of Mio District managers, focused on Mio Prairie, one of the highest-quality dry sand prairies in Michigan (Table 6; Figure 10). We documented two new pine barrens EOs and updated Mio Prairie as well as Section 16 oak-pine barrens (Tables 5 and 6; Figure 10). A large area of stands associated with the drainage channel with Mio Prairie are being managed for open-canopied conditions in the interest of “expansion” of Mio Prairie. Red pine plantation is still prominent in that matrix, as are early-successional pine and pine-oak forests, and occasional aspen stands. This site transitions to oak-pine barrens (EOID 13567) to the north towards the Manistee-Au Sable escarpment, an ice margin position. There are two small gravel pits, including a 7-acre pit directly southeast of Mio Prairie that is being used by the regional land conservancy Huron Pines as a native plant nursery, and one in the south-central of the Briggs Gravel Pit pine barrens that is excluded from that EO. While many stands within the Mio Prairie Expansion are highly degraded due to plantation forestry, several stands are restorable (Appendix D, Table D1; Figure 7).



Several stands surrounding Mio Prairie have been cleared of trees and are being managed with fire as an expansion of the prairie. Note charred stump in foreground. Several stands like this are restorable and retain barrens indicator species such as upland white goldenrod (*Solidago ptarmicoides*) and northern blazing star (*Liatris scariosa*).

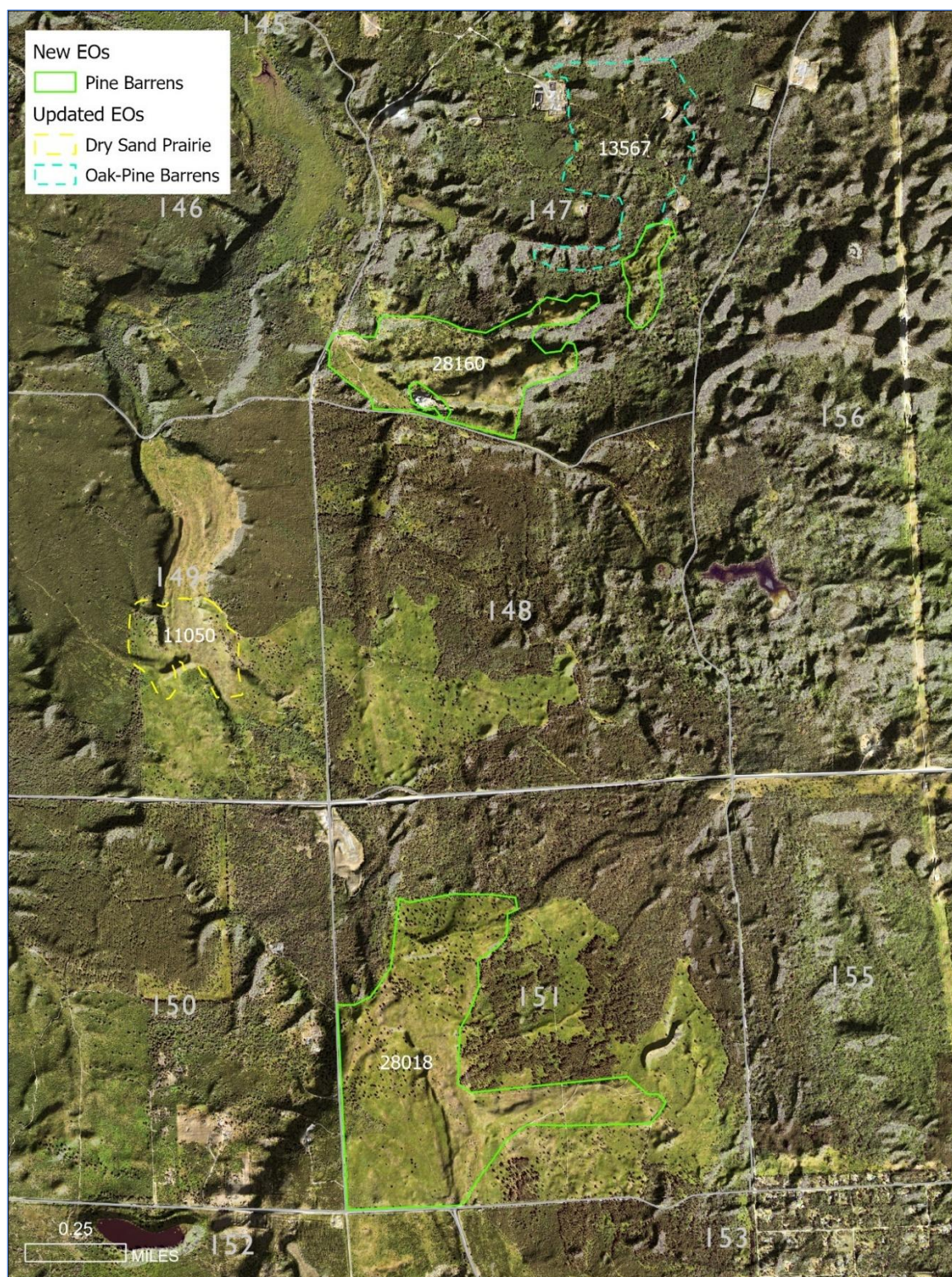


Figure 10. Mio Prairie Expansion project area in the Mio District, including new pine barrens EOs Loli Tract (EOID 28018) and Briggs Gravel Pit (28160), and updated EOs Mio Prairie dry sand prairie (EOID 11050) and Section 16 Prairie oak-pine barrens (EOID 13567). Compartments outlined and numbered in white.

Loli Tract

Pine Barrens (EOID 28108)

EO Rank: C; 179 acres

FQI: 35.3; Mean C: 4.1; Species richness: 74 (65 native)

Compartment: 151

This pine barrens occurs in a broad, north-south, glacial drainage valley in the broad Grayling outwash plain, directly southeast of Mio Prairie in the valley (Figure 10). It occupies a large proportion of an area managed with fire and forestry mowing as part of the USFS Mio Prairie expansion project (Appendix D, Table D2). Despite this history of modification, the site retains a composition indicative of ecological continuity, particularly through the presence of several conservative species characteristic of pine barrens. The canopy is sparse (~10% closure overall) and largely derived from a 1999 clear cut, and has a likely plantation history in part, with likely furrows observed in areas. Even-aged at an estimated 80 years old, the canopy is co-dominated by widely-spaced 15 to 35 cm DBH jack pine (*Pinus banksiana*) and a supercanopy of 25 to 55 cm red pine (*P. resinosa*). Northern pin oak (*Quercus ellipsoidalis*) and black cherry (*Prunus serotina*) are rare in the canopy. Of 73 rings counted on a red pine that was aged, the first 30 rings indicated fast growth with slow growth for the subsequent 43, suggesting either planting or natural regeneration into an open site circa 1950, achieving closed-canopied conditions circa 1980. The subcanopy is typically as sparse as the canopy (5-10%) but locally dense (40-80%) and primarily composed of jack pine and black cherry. Regeneration of both species is also represented in the tall shrub layer, which also included prairie willow (*Salix humilis*).

The ground layer is dense (95-100% cover) and dominated by low shrubs, especially low sweet blueberry (*Vaccinium angustifolium*). Sand cherry (*P. pumila*) and sweet fern (*Comptonia peregrina*) are abundant, shadbush serviceberry (*Amelanchier spicata*) and bearberry (*Arctostaphylos uva-ursi*) are frequent, and northern dewberry (*Rubus flagellaris*), snowberry (*Symphoricarpos albus* var. *albus*), and choke cherry (*P. virginiana*) are occasional. The herbaceous component of the ground layer is rich and very evenly distributed throughout, including many barrens indicators at high to low frequency and many weedy or invasive species at low frequency. Ground layer diversity is attributable in part to a long history of frequent fire – the southern 1/3 burned in the 2006 Hughes Lake wildfire, prescribed burns have occurred here in 2002, 2006, 2007, 2010, 2012, 2014, 2017, 2019, and 2024. Consistently observed conservative species included northern blazing star (*Liatris scariosa*), upland white goldenrod (*Solidago ptarmicoides*), June grass (*Koeleria macrantha*), and prairie brome (*Bromus kalmii*). Non-native, weedy species are likely introduced in part from a two-track that bisects the southeast portion and include invasive species like spotted knapweed (*Centaurea stoebe*) and mullein (*Verbascum thapsus*), and innocuous species like white campion (*Silene latifolia*). Local portions of the ground layer represent a “forest” signature, lacking barrens indicators, possibly due to historical red pine plantation. Soils possess an increased gravel content around 40 cm deep.



Loli Tract pine barrens (EOID 28018), with mostly an open canopy structure and notable evenness (above). Retained red pine (*Pinus resinosa*) may represent relicts of former plantation.



Briggs Gravel Pit

Pine Barrens (EOID 28160)

Element Occurrence Rank: CD; 90 acres

FQI: 34.4; Mean C: 4.2; Species richness: 67 (58 native)

Compartment: 147

This pine barrens occurs in a frost pocket and along associated slopes in the rolling topography of the Grayling outwash plain. The site is under long-term management as part of the Mio Prairie expansion, including canopy tree thinning, forestry mowing, and regular prescribed fire. As a result, the canopy is thin (5-10%) and not entirely representative of the type, but still characteristically patchy. This EO is comprised of a larger polygon centered on the USFS-managed area, and smaller frost pocket to the north that transitions into oak-pine barrens (EOID 13567). Approximately 10 to 60 cm DBH, 85-year-old northern pin oak (*Quercus ellipsoidalis*) is dominant to codominant with 20 to 35 cm DBH, 20-year-old jack pine (*Pinus banksiana*). Red pine (*P. resinosa*) forms a sparse supercanopy of 40 to 55 cm DBH trees, including a 41.1 cm individual with 50 rings. Additional tree species, particularly along forest margins, include 25 cm DBH white oak (*Q. alba*), 6 to 12 cm DBH quaking aspen (*Populus tremuloides*), and 15 to 25 cm DBH black cherry (*Prunus serotina*). The understory overall has characteristically patch structure but black cherry and other mesophytes are abundant, suggesting the need for more frequent fire. The subcanopy is very sparse, with black cherry and Northern pin oak occasional, and jack pine rare. Black cherry root sprouts and sapling recruits are dominant or at least prominent in the tall shrub layer, with prairie willow (*Salix humilis*) and northern pin oak frequent, and quaking aspen locally dominant (mostly along edges and in moist swales).

The ground layer is dominated by low sweet blueberry (*Vaccinium angustifolium*) and Pennsylvania sedge (*Carex pensylvanica*), and hair grass (*Avenella flexuosa*) and poverty grass (*Danthonia spicata*) are frequent. Sweet fern (*Comptonia peregrina*) and sand cherry (*Prunus pumila*) are also abundant, with several other low shrubs occasional to rare, and sparse seedlings of northern pin oak, quaking aspen, and jack pine. Several barrens indicators occur occasionally and include western sunflower (*Helianthus occidentalis*), northern blazing star (*Liatris scariosa*), upland white goldenrod (*Solidago ptarmicoides*), prairie brome (*Bromus kalmii*), June grass (*Koeleria macrantha*), and balsam ragwort (*Packera paupercula*). These species are individually and as a whole mostly evenly and consistently distributed throughout. The gravel pit, excluded from the EO, also includes wild wormwood (*Artemisia campestris*), thimbleweed (*Anemone cylindracea*), and wild rose (*Rosa blanda*). An ORV trail winds throughout, and along with the gravel pit is a source of invasive species, including spotted knapweed (*Centaurea stoebe*), Canada thistle (*Cirsium arvense*), orange hawkweed (*Hieracium aurantiacum*), spotted St.-John's wort (*Hypericum perforatum*), and mullein (*Verbascum thapsus*). An understory of mesophytic ground layer species is present under the several (5-10) aspen clones, including the invasive Kentucky bluegrass (*Poa pratensis*). Furrows are occasional, and an ORV trail winds throughout. Ant mounds are occasional, presumably wood ant (*Formica* sp.).



Briggs Gravel Pit pine barrens (EOID 28160) occupies broad frost pockets (above) and supports several rare plant species, including Hill's thistle (*Cirsium hillii*, Special Concern) (below).



Management Recommendations

We recommend the continued use of prescribed fire and restriction of ORV access. We encourage managers to center management in the Mio Prairie Expansion on expanding prairie in the lower elevations of the glacial drainage and pine barrens along the slopes of the drainage and the level to undulating plateaus surrounding it. We suggest lower fire-severity, particularly in pine and oak-pine barrens EOs, to encourage regeneration of patchy jack pine cover and prevent mortality of existing old (e.g., 200-year-old) red pines. With the application of fire, monitor the aspen response in Briggs Gravel Pit and Mio Prairie, especially where they are abundant on the margins in the south.

Much of the southern primary polygon of Briggs Gravel Pit is currently (as of spring 2026) planned to be converted to red pine plantation. This conversion will certainly degrade the pine barrens natural community. In the absence of conversion of Briggs Gravel Pit to plantation, we would suggest re-routing the ORV trail to avoid the pine barrens natural community.

Meridian Boundary Fire

The Meridian Boundary Fire project area occurs along a broad, flat outwash plain and is defined by the fire scar left by the 2010 Meridian Boundary Fire in the very southeastern corner of Crawford County (Figure 11). We documented one new EO each of bog, dry-mesic northern forest, intermittent wetland, and pine barrens (Table 5). There are a few restorable RFDS stands in the far northeast of this project area in compartment 81 (Appendix D, Table D1). Much of this project area is designated as 'essential' Kirtland's Warbler habitat, which if maintained as opposing wave plantations will limit connectivity between high-quality natural communities for species that are not adapted to the soil disturbance associated with plantation establishment and the closed-canopied conditions of mature plantations.

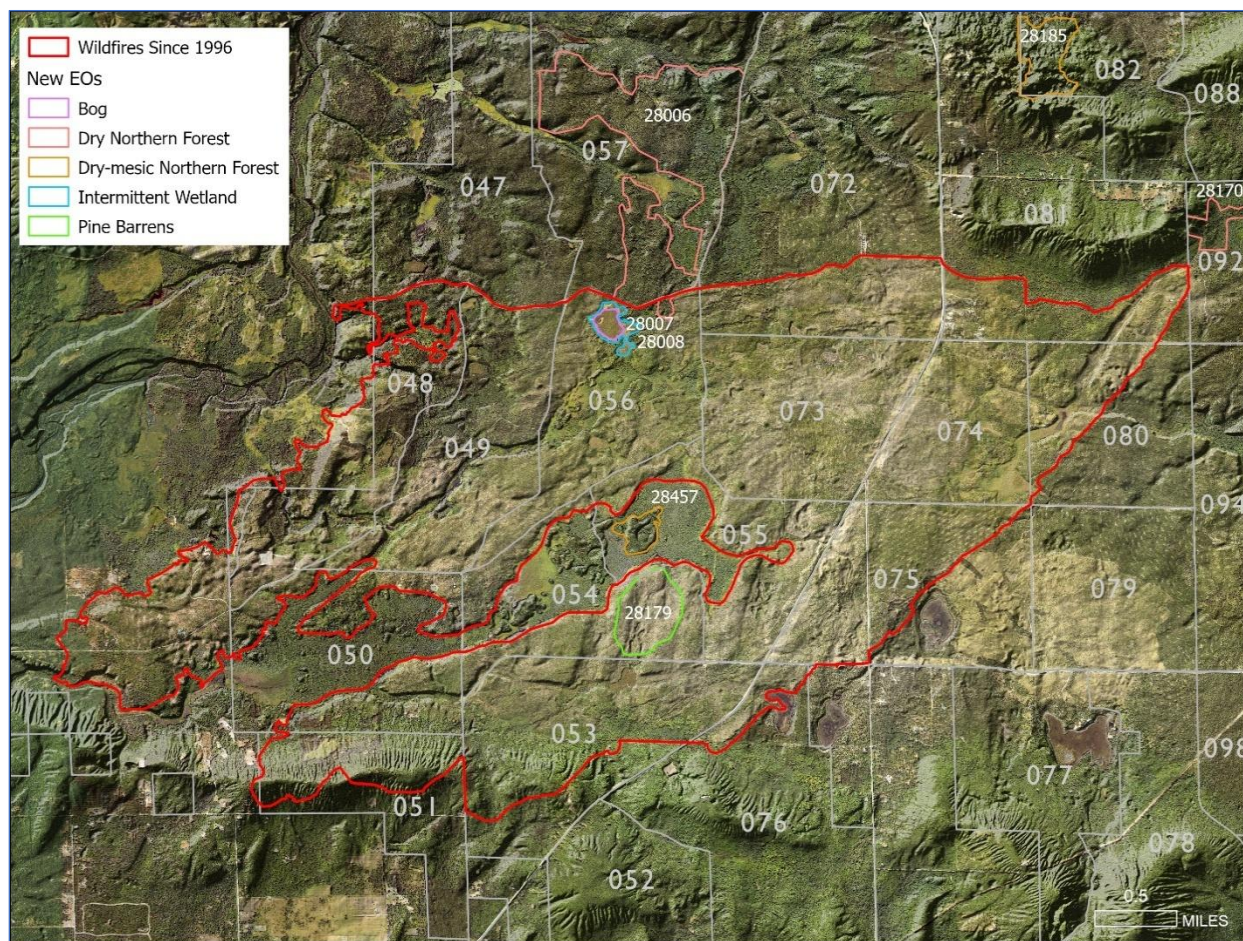


Figure 11. Meridian Boundary Fire project area in the Mio District, with Brush Road bog (EOID 28007) and intermittent wetland (EOID 28008); and Hickey Creek dry-mesic northern forest (EOID 28457) and pine barrens (EOID 28179). Compartments outlined and numbered in white.

Hickey Creek Pines

Dry-mesic Northern Forest (EOID 28457)

EO Rank: C; 31 acres

FQI: 29.4; Mean C: 5.2; Species richness: 32 (32 native)

Compartment: 55

Hickey Creek Pines is a second-growth, closed-canopy red pine forest on a flat upland rise within a large wetland complex. The canopy is dominated by red pine (*Pinus resinosa*) and white pine (*P. strobus*), with white pine locally forming a supercanopy. Most trees belong to a 100- to 120-year-old cohort and range from 40 to 70 cm DBH, although some white pine approach 80 cm. Jack pine (*P. banksiana*) occurs primarily along the margin of an adjacent high-quality poor conifer swamp. The patchy subcanopy and understory are dominated by white pine, red maple (*Acer rubrum*), and balsam fir (*Abies balsamea*), with little red pine recruitment. Dense patches of huckleberry (*Gaylussacia baccata*), low sweet blueberry (*Vaccinium angustifolium*), and velvetleaf blueberry (*V. myrtilloides*) characterize the low-shrub layer. The sparse ground layer includes Pennsylvania sedge (*Carex pensylvanica*), rough-leaved rice-grass (*Oryzopsis asperifolia*), Canada mayflower (*Maianthemum canadense*), cow-wheat (*Melampyrum lineare*), twinflower (*Linnaea borealis*), pink lady-slipper (*Cypripedium acaule*), and abundant bracken fern (*Pteridium aquilinum*).

Fire-scarred stumps remain from late 1800s or early 1900s logging, including a 72.1-cm red pine stump with scars indicating at least four separate fires. Subtle pit-and-mound topography occurs throughout, and strongly acidic sandy soils are overlain by deep duff and needle litter.



Hickey Creek Pines dry-mesic northern forest (EOID 28457). The canopy is co-dominated by white and red pine (*Pinus strobus* and *P. resinosa*) and there is considerable regeneration of white pine. Photo by J. M. Lincoln.

Hickey Creek Barrens

Pine Barrens (EOID 28179)

EO Rank: C; 100 acres

FQI: 35.2; Mean C: 5.3; Species richness: 44 (44 native)

Compartment: 54

Open areas in Hickey Creek Barrens where the Meridian Boundary Fire caused nearly complete canopy mortality now support approximately 30% cover of young jack pine (*Pinus banksiana*), established shortly after the fire. These jack pine are generally 10 to 15 cm DBH, 3 to 5 m tall, and presumably around 15 years old. Scattered standing jack pine that survived the fire compose approximately 2 to 10% of the canopy and are about 50 years old. Red pine (*P. resinosa*) is uncommon, and some near the northern boundary may have been planted before the fire. Dense patches of young jack pine are locally developing closed-canopy conditions, while stunted northern pin oak (*Quercus ellipsoidalis*) is locally abundant.

The openings support extensive low-shrub cover dominated by sand cherry (*Prunus pumila*) and low sweet blueberry (*Vaccinium angustifolium*). Round-leaved serviceberry (*Amelanchier sanguinea*), sweet fern (*Comptonia peregrina*), and bearberry (*Arctostaphylos uva-ursi*) occur throughout. Graminoids include Pennsylvania sedge (*Carex pensylvanica*), little bluestem (*Schizachyrium scoparium*), poverty grass (*Danthonia spicata*), northern rice-grass (*Piptatherum pungens*), big bluestem (*Andropogon gerardii*), and panic grasses. Forbs are consistently present at low abundance and include rattlesnake-weed (*Hieracium venosum*), long-leaved bluets (*Houstonia longifolia*), harebell (*Campanula rotundifolia*), blazing-stars (*Liatris scariosa* and *L. cylindracea*), smooth aster (*Symphyotrichum laeve*), violets (*Viola* spp.), and goldenrods (*Solidago* spp.). Hill's thistle (*Cirsium hillii*, Special Concern) is locally abundant.

The occurrence is largely free of invasive species, although several non-native species occur along the road forming its southern boundary and could spread through ORV disturbance. Shallow furrows near the northern boundary indicate former red pine plantation management, but characteristic barrens vegetation persists. The site supports abundant coarse woody debris and scattered wood ant (*Formica* sp.) mounds. Despite localized canopy closure and past plantation impacts, the occurrence retains characteristic pine barrens structure and diverse native vegetation.



Hickey Creek Barrens (EOID 28179), characterized by locally dense jack pine (*Pinus banksiana*) regeneration (background, above) and coarse woody debris from the Meridian Boundary Fire (foreground, above). A sparse supercanopy of red pine (*P. resinosa*) survived the fire (below). Photos by J. M. Lincoln.



Brush Road

Bog (EOID 28007)

EO Rank: C; 14 acres

FQI: 35.0; Mean C: 6.1; Species richness: 33 (33 native)

Compartment: 56

Intermittent Wetland (EOID 28008)

EO Rank: C; 17 acres

FQI: 31.8; Mean C: 5.8; Species richness: 30 (30 native)

Compartment: 56

Brush Road bog and intermittent wetland are situated in a small kettlehole on a mostly level to slightly undulating plateau in the Grayling outwash plain, between several small to large ice-contact features and associated glacial drainages. Vegetation zonation is well-defined and inclusive of both bog and intermittent wetland, so these two natural communities are discussed together here. The center of the kettlehole supports a bog mat that occurs on deep, fibric-hemic peat. The bog grades into intermittent wetland that occurs on shallow peat (< 50 cm) over moist sands (EOID 28008). These wetlands occur at the northern margin of the 2010 Meridian Boundary wildfire.

The sparse canopy (<5% cover) of this small bog is composed of scattered and stunted 5-35 cm DBH 140-year-old tamarack (*Larix laricina*) and 30 cm DBH jack pines (*Pinus banksiana*) snags, presumably consumed in the 2010 wildfire. There are also occasional 2 to 5 cm DBH saplings of both tamarack and jack pine, especially along margins of the bog mat associated with the tall shrubs wild raisin (*Viburnum cassinoides*) and tag alder (*Alnus incana*). The ground layer is strongly dominated by leatherleaf (*Chamaedaphne calyculata*), with other low shrubs including slender willow (*Salix petiolaris*), bog birch (*Betula pumila*), Labrador tea (*Rhododendron groenlandica*), and pale-laurel (*Kalmia polifolia*) occurring occasionally throughout or locally common. Forbs and graminoids are generally uncommon, except in an emergent zone in middle with sweet-scented water lily (*Nymphaea odorata*), three-way sedge (*Dulichium arundinaceum*), arrow grass (*Scheuchzeria palustris*), and wiregrass sedge (*Carex lasiocarpa*), and otherwise concentrated along the margins of the bog at the transition to intermittent wetland. Few-seeded sedge (*C. oligosperma*), twig-rush (*Cladium mariscoides*), and wiregrass sedge are found throughout interspersed with the dense leatherleaf. Soils in the bog are fibric peat to 5 cm under partially decomposed sphagnum moss (*Sphagnum* sp.), and hemic peat mixed with small amounts of sapric peat to 100 + cm, pH 4.5.

Dominance by graminoid species sharply differentiates the intermittent wetland from the leatherleaf-dominated bog, especially wiregrass sedge, and locally blue-joint grass (*Calamagrostis canadensis*) and twig-rush. Other representative graminoids include little yellow sedge (*C. cryptolepis*), bulrush (*Scirpus atrovirens*), beak-rush (*Rhynchospora capitellata*), and golden-seeded spike-rush (*Eleocharis elliptica*). Forbs are generally sparse to occasional, including northern blue flag (*Iris versicolor*), marsh skullcap (*Scutellaria galericulata*), and lance-leaved violet (*Viola lanceolata*). Most shrubs and small trees are restricted to the margins in areas transitional to xeric uplands or the bog mat in the center. A band of leatherleaf dominated the outer margin, with a few fire-charred jack pine snags. Small local depressions in the intermittent wetland occurred with seasonal standing water. ORV tracks are noted in portions, but are not widespread. Soils in the intermittent wetland are fibric peat to 3 cm, pH 4.5; sapric peat to 30-40 cm, pH 4.5; moist brown sand to 100+ cm, pH 5.5 (pH 6.5 at greater depths). On the outer margins soils are moist acidic sands lacking a peat layer.

Management Recommendations

Given both the range of natural community types and the prevalence of opposing wave plantations in this project area, management recommendations differ widely based on natural community type. Overall, we encourage reintroduction of low-severity prescribed fire and restriction of ORV access. Given the recent wildfire, no targeted burns are needed to limit woody encroachment throughout the project area. We recommend avoiding establishment or expansion of the warbler weave within Hickey Creek Barrens and adjacent recoverable habitat. We recommend including Hickey Creek Barrens and as much of the surrounding Meridian Boundary Fire project area as practicable within a relatively frequent prescribed fire regime, generally on a 5–10-year return interval. Much of the barrens is approaching a stage where continued succession due to fire exclusion will reduce habitat suitability. Low-intensity burns with patchy mixed-severity effects would help maintain open structure and heterogeneous vegetation while periodically renewing conditions suitable for Kirtland's warbler.

Threats to Hickey Creek Woods are minimal because the forest is isolated from most threats by occurring within a large wetland complex. Despite its landscape position in a wetland, we noted several fire-scarred stumps showing evidence of at least 4 fires. Given the lack of recent fire, we recommend applying low-severity prescribed fires once every 5 to 20 years to stimulate pine regeneration, then decrease fire frequency gradually. Burns should use the surrounding wetland as a natural control line and emphasize limited canopy mortality. We recommend avoiding mechanical treatments and unnecessary soil disturbance, especially because equipment access via surrounding wetlands is difficult and may be particularly disruptive. The primary threat to Brush Road Bog and Intermittent Wetland is hydrological modification, so we recommend avoiding ditching and other soil disturbances within these EOs. These wetlands should be included in prescribed fires conducted in the surrounding landscape.



Brush Road bog (EOID 28007) and intermittent wetland (EOID 28008). The bog is dominated by leatherleaf (*Chamaedaphne calyculata*; background); the intermittent wetland dominated by wiregrass sedge (*Carex lasiocarpa*; foreground).

Hughes Lake Fire

The Hughes Lake Fire project area is defined by the scar created by the 2006 Hughes Lake fire that extends across a gently rolling outwash plain in very southwestern Oscoda County. Much of the Hughes Lake Fire scar is composed of stands designated as 'essential' Kirtland's Warbler habitat. We documented two new pine barrens EOs in this project area (Table 5; Figure 12). There are a few restorable stands in compartment 152 in the far southeast of the fire scar where it overlaps the Mio Prairie Expansion project area (Appendix D, Table D1).

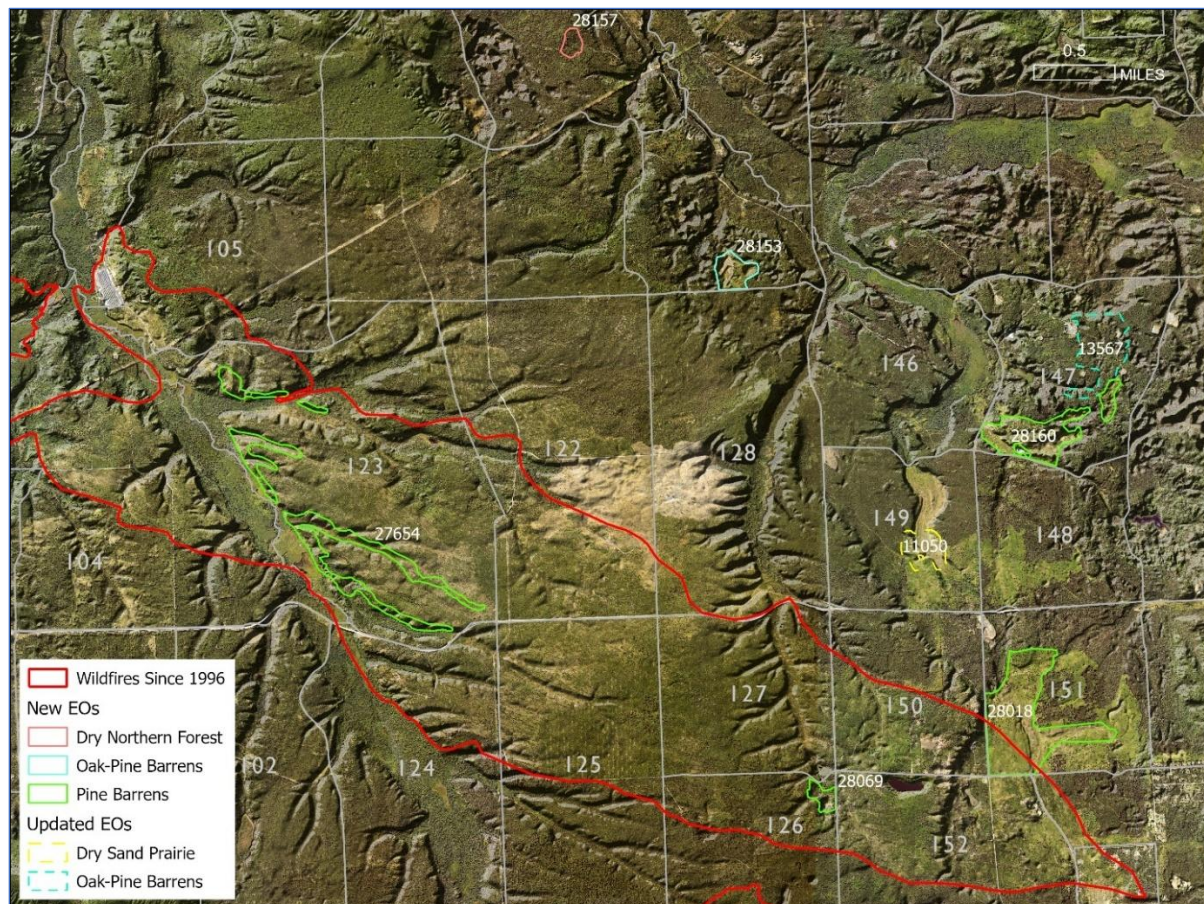


Figure 12. Hughes Lake Fire project area in the Mio District, including Luzerne (EOID 27654) and Hughes Lake pine barrens (EOID 28069). Additional EOs represented here are described in the Mio Prairie Expansion project area (EOID 11050, 13567, 28018, and 28160) and the Luzerne Region project area (EOID 28153). Compartments outlined and numbered in white.

Luzerne Barrens

Pine Barrens (EOID 27654)

EO Rank: C; 141 acres

FQI: 43.2; Mean C: 4.8; Species richness: 102 (92 native)

Compartment: 123

Luzerne Barrens is large at 142 acres, and comprises four polygons embedded in burned-over opposing wave plantation directly east of the West Branch of Big Creek. The occurrence occupies irregular slopes, cold-air drainages, and other areas that largely escaped conversion to jack pine (*Pinus banksiana*) plantation. Structure, composition, and condition vary widely throughout this pine barrens, which has widely spaced, mixed-age red pine (*P. resinosa*) throughout but patches that grade into oak-pine barrens, dry sand prairie, and dry northern forest. The red pine canopy ranges from approximately 20 to 50% cover and includes trees estimated to be 80 to 250 years old. Canopy trees are typically about 40 cm DBH, although several ranged from 60 to 77 cm DBH. An old red pine stump showed evidence of at least eight fires over 101 years, with intervals ranging from 6 to 26 years. The subcanopy and understory provide approximately 20% cover and consist primarily of 3- to 5-m-tall jack pine, northern pin oak (*Quercus ellipsoidalis*), and black cherry (*Prunus serotina*). Low shrubs provided 30 to 40% cover and are dominated by sweet-fern (*Comptonia peregrina*), with low sweet blueberry (*Vaccinium angustifolium*), sand cherry (*P. pumila*), and snowberry (*Symphoricarpos albus*).

Ground-layer composition varies with slope position. Lower slopes above an adjacent poor conifer swamp support velvetleaf blueberry (*Vaccinium myrtilloides*), northern shorthusk (*Brachyelytrum aristosum*), Canada mayflower (*Maianthemum canadense*), starflower (*Trientalis borealis*), fringed brome (*Bromus ciliatus*), and broad-leaved panic grass (*Dichanthelium latifolium*). Upper slopes support prairie brome (*Bromus kalmii*), June grass (*Koeleria macrantha*), slim-leaved panic grass (*Dichanthelium linearifolium*), low bindweed (*Calystegia spithamea*), and hoary puccoon (*Lithospermum canescens*). Other characteristic species include bluegrass (*Poa saltuensis*), wintergreen (*Gaultheria procumbens*), harebell (*Campanula rotundifolia*), birdfoot violet (*Viola pedata*), sand violet (*V. adunca*), Canada frostweed (*Crocianthemum canadense*), Hill's thistle (*Cirsium hillii*, Special Concern), and bearberry (*Arctostaphylos uva-ursi*).

Condition varies considerably, with many sources of degradation, including local areas with plantation history, bisecting roads, a history of ORV disturbance, and the presence of invasive species. The highest-quality areas retain diverse ground-layer vegetation, abundant coarse woody debris, widespread badger activity, and numerous large wood ant (*Formica* sp.) mounds. Small areas, particularly those supporting old-growth red pine, retain excellent composition and structure, while extensive portions support dense postfire regeneration of jack pine, quaking aspen (*Populus tremuloides*), Hills oak, and black cherry. Adjacent plantations killed by the Hughes Lake Fire generally have low plant diversity but retain native vegetation and recovery potential.



Luzerne pine barrens (EOID 27654), restricted to steep slopes (see darker rows of trees, which are red pines [*Pinus resinosa*]) in an area converted to opposing wave plantation then burned in the Hughes Lake Fire (above). Standing dead snags and fallen coarse woody debris are abundant, in the wake of the Hughes Lake Fire (below). Photos by J. M. Lincoln.





Old red pine (*Pinus resinosa*) stumps, harvested in the late 1800s or early 1900s, can be used to reconstruct fire-histories going back centuries. Shown here, a section of stump sampled from Luzerne Barrens, with fire scars annotated with estimated number of years between fires. Fire scars indicate fires at least every 10-25 years. Photo by J. M. Lincoln.

Hughes Lake

Pine Barrens (EOID 28069)

EO Rank: C; 13 acres

FQI: 31.8; Mean C: 4.8; Species richness: 44 (40 native)

Compartment: 126

Hughes Lake pine barrens occurs in a deep frost pocket and on associated slopes. To the west, this EO grades into mesophied dry northern forest with a canopy dominated by red pine (*Pinus resinosa*). The Hughes Lake wildfire stimulated an abundance of young northern pin oak (*Quercus ellipsoidalis*) and jack pine (*P. banksiana*) regeneration. That fire was not stand-replacing in this location, although fire severity increased farther along the path of the fire to the northwest (see *Luzerne Barrens*, EOID 27654). A sparse canopy (10-20% closure) of 15 to 30 cm DBH, 90 year-old jack pine is overtopped by a similarly sparse supercanopy (5-10% closure) of 20 to 60 cm DB, 80- to 150-year-old red pine. Black cherry (*Prunus serotina*) is rare in the canopy and generally small (< 20 cm DBH). Northern pin oak is absent from the canopy, possibly consumed during the Hughes Lake fire, but locally dominates the young, small-diameter (~ 30 cm) regeneration subcanopy class and occurs frequently throughout the EO in this stratum. Jack pine is also frequent in the subcanopy while black cherry and red pine are occasional. Regeneration of jack pine is frequent in the tall shrub layer while red pine, Northern pin oak, and black cherry are occasional.

The ground layer is dominated by Pennsylvania sedge (*Carex pensylvanica*) and hair grass (*Avenella flexuosa*) is frequent. There are occasional patches of bare sand, frequently colonized by reindeer lichen (*Cladonia* sp.). Low shrubs are prevalent in the ground layer, with bearberry (*Arctostaphylos uva-ursi*), sand cherry (*P. pumila*), and low sweet blueberry (*Vaccinium angustifolium*) frequent and sweet fern (*Comptonia peregrina*) occasional. Several conservative forbs and graminoids are observed throughout, but typically at low abundance, including hairy puccoon (*Lithospermum carolinense*), June grass (*Koeleria macrantha*), prairie brome (*Bromus kalmii*), western sunflower (*Helianthus occidentalis*), northern blazing star (*Liatris scariosa*), dwarf blazing star (*L. cylindracea*), and upland white goldenrod (*Solidago ptarmicoides*). An ORV trail runs along the north and west edges of the EO, and a fire line runs down one slope of the frost pocket. Both of these linear disturbances are sources of invasive propagules. Noted invasive species include spotted knapweed (*Centaurea stoebe*), spotted St.-John's wort (*Hypericum perforatum*), goat's beard (*Tragopogon dubius*), and mullein (*Verbascum thapsus*). According to stand data (i.e., FSVeg; USDA 2024), portions of stand 1 were disked in 1996, although it is not clear whether that applies to the portion of stand 1 occupied by this EO.



Hughes Lake pine barrens (EOID 28069) occupies a deep frost pocket and grades into dry northern forest to the west (background, above). An ORV trails runs adjacent to the eastern and northern boundary, and is a source of invasive species (below).



Management Recommendations

We encourage reintroduction of low-severity fire and rerouting of ORV trails. In general, incorporate adjacent portions of plantation burned during the Hughes Lake Fire into management of both EOs, rather than wholesale conversion to opposing wave plantations. We recommend applying recurrent, low-severity prescribed fire, generally at intervals of 3 to 25 years and adjusted according to vegetation response. Burns should encompass as much of the occurrence and adjacent recoverable habitat as safely practicable, using existing roads as control lines.

Avoid mechanical canopy reduction within the highest-quality polygons, particularly areas supporting old-growth red pine. Some surrounding areas may require mechanical treatment before fire can be safely applied, but treatments should be limited to what is necessary and designed to minimize soil disturbance. Retain old trees, structural variation, and transitions among community types. Prevent reestablishment or expansion of jack pine or red pine plantation within the EOs and adjacent recoverable habitat. Finally, close or reroute ORV trails at least in both EOs, as they may reduce ground layer plant diversity and facilitate invasive species spread.

No Pablo Fire

The No Pablo Fire project area is defined by the scar of the 2000 No Pablo Fire, occurring west of Mack Lake in southeastern Oscoda County in a gently rolling outwash plain. We documented one pine barrens EO in this project area, which is dominated by opposing wave plantations (Table 5; Figure 13). According to aerial imagery interpretation, potentially restorable pine barrens are distributed among areas designated as 'essential' Kirtland's warbler habitat, although we did not conduct extensive surveys throughout No Pablo Fire scar. Outside of Bull Gap Barrens, we only surveyed compartment 216, stand 9, and compartment 215, stands 1 and 3, which were degraded by plantation forestry and mostly lacked representative barrens composition and structure.



Open, pine-dominated vegetation within the footprint of the 2000 No Pablo Fire. Although portions of the footprint of the No Pablo fire retain a barrens-like structure, this and similar sites supported few barrens indicator species and did not meet EO criteria. The scarcity of characteristic species may reflect plantation conversion before the fire.

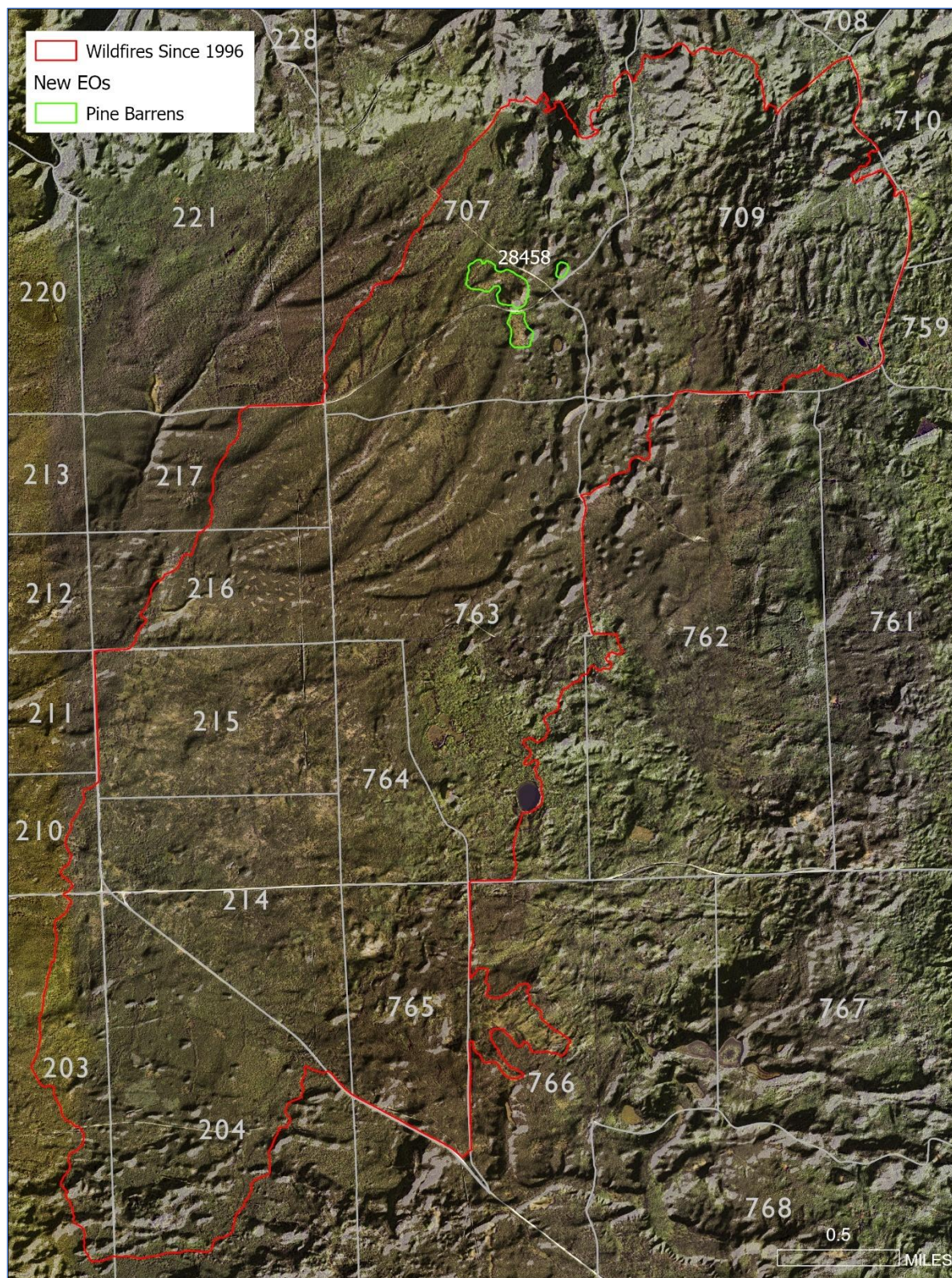


Figure 13. No Pablo Fire project area in the Mio District, with Bull Gap Barrens (EOID 28458). Compartments outlined and numbered in white.

Bull Gap Barrens

Pine Barrens (EOID 28458)

EO Rank: CD; 27 acres

FQI: 32.5; Mean C: 4.3; Species richness: 57 (51 native)

Compartment: 707

Bull Gap Barrens occurs as three polygons separated by unpaved roads. Open areas support approximately 20% canopy cover of jack pine (*Pinus banksiana*), primarily a 20- to 25-year-old cohort that likely regenerated following the No Pablo wildfire. Dense jack pine thickets with closed-canopy conditions occur locally. Stunted northern pin oak (*Quercus ellipsoidalis*) and black cherry (*Prunus serotina*) are infrequent, while quaking aspen (*Populus tremuloides*) occurs in clumps on ridges bordering depressions. A severe ice storm in 2025 left numerous trees contorted and contributed abundant coarse woody debris.

The openings support extensive low-shrub cover dominated by sand cherry (*Prunus pumila*) and low sweet blueberry (*Vaccinium angustifolium*), with round-leaved serviceberry (*Amelanchier sanguinea*), sweet fern (*Comptonia peregrina*), and locally dominant bearberry (*Arctostaphylos uva-ursi*). Graminoids dominate the herbaceous layer and include Pennsylvania sedge (*Carex pensylvanica*), little bluestem (*Schizachyrium scoparium*), poverty grass (*Danthonia spicata*), big bluestem (*Andropogon gerardii*), northern rice-grass (*Piptatherum pungens*), and panic grass (*Dichanthelium depauperatum*). Forbs occur consistently at low abundance and include rattlesnake-weed (*Hieracium venosum*), three-toothed cinquefoil (*Sibbaldiopsis tridentata*), harebell (*Campanula rotundifolia*), balsam ragwort (*Packera paupercula*), blazing-stars (*Liatris scariosa* and *L. cylindracea*), smooth aster (*Symphotrichum laeve*), pussytoes (*Antennaria howellii*), and sand violet (*Viola adunca*). Hill's thistle (*Cirsium hillii*, Special Concern) and rough fescue (*Festuca altaica*, Special Concern) are locally abundant.

Invasive species occur at low density and primarily near roads, although non-native hawkweeds and common mullein (*Verbascum thapsus*) are locally abundant and could spread through soil disturbance associated with ORV use. Localized soil disturbance may be associated with suppression of the No Pablo Fire and forestry in adjacent plantations. Despite roads, localized disturbance, and dense jack pine thickets, the occurrence retains characteristic open pine barrens structure, diverse native vegetation, and abundant coarse woody debris.

Management Recommendations

We recommend reintroduction of prescribed fire and reductions in ORV use. In areas impacted by ice storm damage, we recommend waiting to implement prescribed fire until after the recent jack pine coarse woody debris has decomposed. These treatments should be limited to what is necessary to ensure fire safety and designed to minimize soil disturbance. The initial burn prescription should be patchy, targeting short flame lengths and limited (<10%) canopy mortality. Burns should encompass as much of the occurrence and surrounding recoverable habitat as safely practicable, using existing roads as control lines.

Avoid mechanical canopy reduction, and avoid establishment or expansion of jack pine plantation within the occurrence and adjacent recoverable habitat. Restrict ORV use within and adjacent to the EO, to limit damage to ecological integrity through, particularly through the spread of invasive species.



Bull Gap Barrens (EOID 28458), characterized by large open-canopied areas with scattered jack pine (*Pinus banksiana*) and locally dense jack pine patches (background). Photo by J. M. Lincoln.

Luzerne Region

The Luzerne Region project area occurs directly south of Luzerne along the western margin of the drainage channel that characterizes the Mio Prairie Expansion, and occurs north of that project area (Figure 14). The East Branch of Big Creek occupies the glacial drainage in this project area, which contains several large private inholdings, particularly in areas adjacent to the East Branch of Big Creek. We documented one dry northern forest EO, as well as one oak-pine barrens EO in an existing USFS management area (Tables 5, 7). The immediate surroundings of Merritt Prairie oak-pine barrens (EOID 28153) in compartment 129 include up to 250 to 300 acres of recoverable (fire-suppressed) oak-pine barrens between Merritt and Galloway Roads, although some is on private land (Appendix D, Table D1). We did not conduct extensive surveys in the area between the two EOs, so the opportunities for connectivity are uncertain.



Merritt Prairie oak-pine barrens (EOID 28153), a long-term managed opening in deep frost pockets of the Grayling Outwash Plain. Repeated fire and mechanical treatments have maintained a sparse oak-pine canopy and a diverse ground layer of sedges, grasses, and low shrubs. Photo by J. M. Lincoln.



Figure 14. Luzerne Region project area in the Mio District, with Merrit Prairie oak-pine barrens (EOID 28153) and East Branch Pines dry northern forest (EOID 28157). Compartments outlined and numbered in white.

East Branch Pines

Dry Northern Forest (EOID 28157)

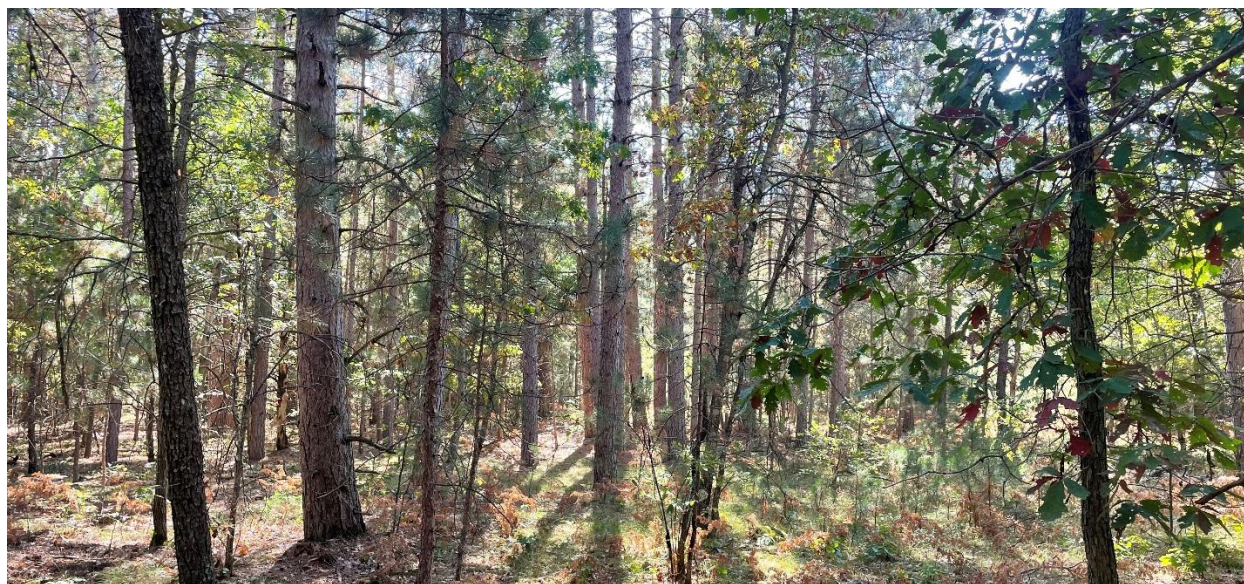
EO Rank: D; 11 acres

FQI: 23.7; Mean C: 3.9; Species richness: 37 (33 native)

Compartment: 118

East Branch Pines occurs in a generally level portion of the large Grayling outwash plain. The canopy is dominated by 29 to 55 cm DBH red pine (*Pinus resinosa*), with an 80- and 120-year-old cohort. Most of the oldest trees are concentrated north of a bisecting two-track. Jack pine (*P. banksiana*) and northern pin oak (*Quercus ellipsoidalis*) are uncommon in the canopy, although many additional standing dead jack pine stems were present. Big-toothed aspen (*Populus grandidentata*) is invading from some of the margins. Black cherry (*Prunus serotina*) and white pine (*P. strobus*) are extremely rare in the canopy. The regeneration class (saplings and poles) is largely white pine (*P. strobus*) and northern pin oak, suggesting prolonged fire suppression. The subcanopy is dense in portions, represented by a roughly equal mix of red and white pine and northern pin oak. Red pine is absent from lower strata, and instead white pine saplings are locally abundant in the tall shrub layer and seedlings occasional in the ground layer, with northern pin oak occasional in both layers. Black cherry regeneration is uncommon, mostly as saplings concentrated in the tall shrub layer.

The ground layer is moderately sparse (40-50% cover), with large shady patches dense with pine needles and with local patches of Pennsylvania sedge (*Carex pensylvanica*) with high light availability. Bracken fern (*Pteridium aquilinum*) is abundant over expanses of feather mosses and reindeer lichen (*Cladonia* sp.). Low sweet blueberry (*Vaccinium angustifolium*) is frequent to dominant while Pennsylvania sedge is locally dominant and sweet fern (*Comptonia peregrina*) and poverty grass (*Danthonia spicata*) are occasional. Barrens species like hairy goldenrod (*Solidago hispida*) and big bluestem (*Andropogon gerardii*) are rare in small canopy gaps. Some non-native weedy species occur only along the edge of the east-west two-track bisecting the EO, including redtop (*Agrostis gigantea*), orange hawkweed (*Hieracium aurantiacum*), spotted St.-John's wort (*Hypericum perforatum*), and sheep sorrel (*Rumex acetosella*).



East Branch Pines dry northern forest (EOID 28157), showing signs of mesophication with dense leaf litter in the ground layer.

Merrit Prairie

Oak-pine Barrens (EOID 28153)

EO Rank: CD; 28 acres

FQI: 34.4; Mean C: 4.4; Species richness: 61 (55 native)

Compartment: 129

Merrit Prairie oak-pine barrens occurs in two deep frost pockets and along associated slopes in the rolling topography of the Grayling outwash plain. The site is under long-term management as a warm-season grass opening, including canopy tree thinning, forestry mowing, and regular prescribed fire. Northern pin oak (*Quercus ellipsoidalis*) dominated the sparse (10%) canopy with trees between approximately 30 and 50 cm DBH and estimated at 100-years-old. A small number of 25 to 45 cm DBH red pines (*Pinus resinosa*) are also scattered throughout the site, including one that was aged at around 65 years old. There are occasional clumps of smaller (and presumably younger, although none are aged) 20 to 30 cm DBH jack pine (*P. banksiana*) under the tall canopy or supercanopy of northern pin oak and red pine. Canopy structure originated from mechanical clearing and has been maintained by high-severity fire leading to mortality of small-diameter pines. There is a robust regeneration class, with 30% cover overall mostly concentrated in clumps of stump-sprouting Northern pin oak, with sparse scattered jack pine and black cherry (*Prunus serotina*) occurring at similar densities. Seedlings of black cherry are occasional, and Northern pin oak and jack pine are less frequent. Alleghany plum (*Prunus umbellata*, Special Concern) occurs in and (mostly) adjacent to this barrens.

The dense (nearly 100% cover except along trails and two-tracks) ground layer is dominated in large swaths by Pennsylvania sedge (*Carex pensylvanica*), with sand cherry (*P. pumila*) and low sweet blueberry (*Vaccinium angustifolium*) abundant and either locally dominant or codominant with Pennsylvania sedge, and sweet fern (*Comptonia peregrina*) common. Cover of low shrubs is about 40% and herbaceous cover is about 80%. The low shrub layer is diverse with 17 species, with prairie willow (*Salix humilis*), snowberry (*Symphoricarpos albus* var. *albus*), choke cherry (*P. virginiana*), gray dogwood (*Cornus foemina*), shadbush serviceberry (*Amelanchier spicata*), bearberry (*Arctostaphylos uva-ursi*), northern dewberry (*Rubus flagellaris*), fragrant sumac (*Rhus aromatica*), and wintergreen (*Gaultheria procumbens*) occurring as occasional to uncommon. In addition to Pennsylvania sedge, big bluestem (*Andropogon gerardii*) and poverty grass (*Danthonia spicata*) are common. Several species are observed occasionally, including characteristic barrens species prairie brome (*Bromus kalmii*), slender wheatgrass (*Elymus trachycaulus*), Indian grass (*Sorghastrum nutans*), three-toothed cinquefoil (*Sibbaldiopsis tridentata*), and dwarf blazing star (*Liatris cylindracea*), as well as species that occur more broadly in the forest-barrens matrix like harebell (*Campanula rotundifolia*), hairy goldenrod (*Solidago hispida*), smooth blue aster (*Symphyotrichum leave*), false-melic (*Schizachne purpurascens*), and hair grass (*Avenella flexuosa*). Additional conservative barrens indicators are relatively rare, including northern blazing star (*Liatris scariosa*), upland white goldenrod (*S. ptarmicoides*), western sunflower (*Helianthus occidentalis*), and June grass (*Koeleria macrantha*). Several weedy or invasive species non-native species are present, all relatively rare and clearly associated with a well-used ORV trail that cuts through the center of the western frost pocket, including spotted St.-John's wort (*Hypericum perforatum*), mullein (*Verbascum thaspium*), orange hawkweed (*Hieracium aurantiacum*), spotted knapweed (*Centaurea stoebe*), Kentucky bluegrass (*Poa pratensis*), and sheep sorrel (*Rumex acetosella*).



Merrit Prairie oak-pine barrens (EOID 28153) straddles two deep frost pockets. A popular ORV bisects these openings. Several restorable stands surround the EO.

Management Recommendations

We encourage the continued use of prescribed fire, but recommend the application of low-severity fire, and reduction in ORV impacts. We recommend a management approach that increases canopy structural complexity in Merrit Prairie and maintains red pine canopy dominance in East Branch Pines. Reducing fire intensity in Merrit Prairie should encourage recruitment of jack pine to canopy and avoid mortality of existing canopy trees. Reintroducing fire to East Branch Pines will be necessary to increase recruitment of red pine saplings. We recommend including surrounding stands in all burns, especially in the stands surrounding Merrit Prairie, which includes highly restorable barrens. Although we did not conduct surveys adjacent to East Branch Pines, including surrounding stands in fires should hypothetically increase red pine recruitment and may expand the size of this small dry northern forest EO. Preventing ORV access across this area is a priority and will help decrease the negative impacts of non-native species.

Bull Gap Moraine

The Bull Gap Moraine project area occurs in steep terrain associated with an end moraine along the Manistee-Au Sable Escarpment. We documented two new dry-mesic northern forest EOs (Table 5; Figure 15). Surrounding stands support a mix of young (circa 75-90 or younger) but maturing forests dominated variously by aspen (*Populus* spp.), white and red oak (*Quercus alba* and *Q. rubra*), or white or red pine (*Pinus strobus* or *P. resinosa*). The popular ORV attraction, Bull Gap Hill Climb, occurs near Bull Gap Pines, and likely increases the abundance of invasive species in the project area.



The Bull Gap Hill Climb, a potential source of invasive species to the project area.

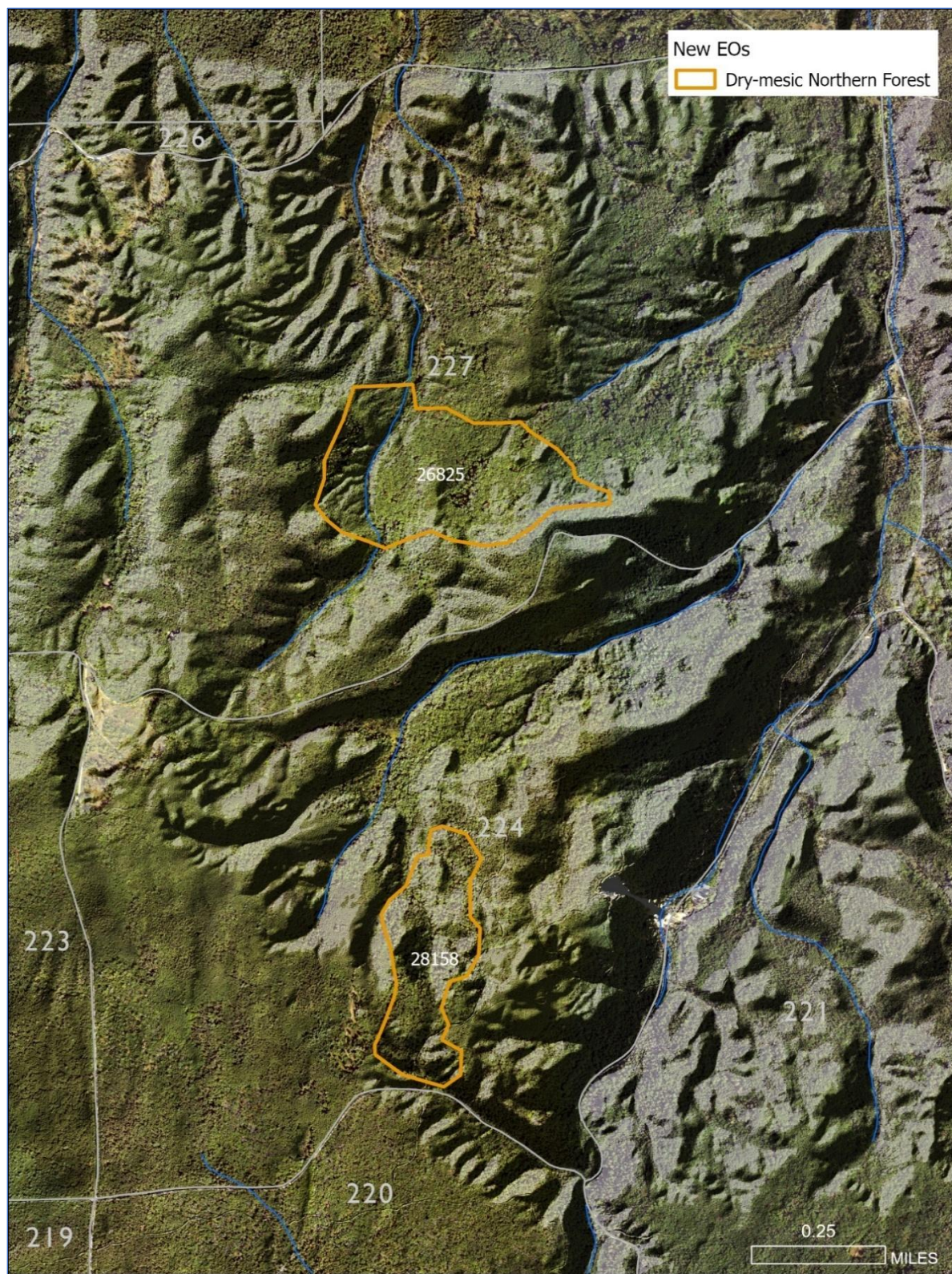


Figure 15. Bull Gap Moraine project area in the Mio District, with Cline's Oaks and Pines (EOID 26825) and Bull Gap Pines (EOID 28158) dry-mesic northern forest. Compartments outlined and numbered in white.

Cline's Oaks and Pines

Dry-mesic Northern Forest (EOID 26285)

EO Rank: BC; 68 acres

FQI: 33.2; Mean C: 4.9; Species richness: 46 (45 native)

Compartment: 227

Cline's Oaks and Pines occurs in an apparent ice-block depression along the margin of the Manistee-Au Sable Escarpment, on an end moraine extending roughly from Luzerne to Curtisville along the Au Sable River. The canopy (80-90% closure) is dominated by large-diameter oaks and pines and is uneven-aged, estimated between 120- and 170-years-old. Red oak (*Quercus rubra*) is the canopy dominant, ranging from 35 to 80 cm DBH and estimated to be 130- to 145-years-old. White oak (*Q. alba*) is frequent in the canopy, ranging from 30 to 65 cm DBH and an estimated to be 155- to 170-years-old. White pine (*Pinus strobus*) is common in the canopy, ranging from approximately 45 to 85 cm DBH and estimated to be 120- to 125-years-old. Red pine (*P. resinosa*), at 35 to 55 cm DBH and estimated to be 150-years-old, and red maple (*Acer rubrum*), at 30 to 45 cm DBH, are uncommon in the canopy. Frequent old pine stumps suggest that white and possible red pine were historically co-dominant but were thinned. Multiple age classes of red maple are abundant in the subcanopy, and red maple seedlings are common in the ground layer, indicating mesophication due to prolonged fire exclusion. White pine is also common in many age classes but less common than red maple in strata below the canopy. Witch hazel (*Hamamelis virginiana*) is occasional in the tall shrub layer. Seedlings of a few species occurred uncommonly, including white ash (*Fraxinus americana*), ironwood (*Ostrya virginiana*), and white pine, while white oak seedlings are occasional. The lack of advance regeneration of canopy species other than red maple and white pine may indicate excessive deer browse, in addition to fire exclusion.

The ground layer plant community is generally sparse at 30 to 40% cover, with large swaths dominated by oak leaf litter. Bracken fern (*Pteridium aquilinum*) and wintergreen (*Gaultheria procumbens*) are both abundant in the ground layer, and hog-peanut (*Amphicarpaea bracteata*) is locally common. Patches of huckleberry (*Gaylussacia baccata*) and low sweet blueberry (*Vaccinium angustifolium*) are occasional, as are rough-leaved rice-grass (*Oryzopsis asperifolia*) and starflower (*Trientalis borealis* [synonym = *Lysimachia b.*]). Most other species are rare to uncommon. A single non-native species, Kentucky bluegrass (*Poa pratensis*), is uncommon. Despite the evidence of historical logging and lack of decaying coarse woody debris, there are indications of developing old growth conditions in this forest. In addition to a canopy dominated by old, large-diameter canopy trees, pit-mound topography is abundant throughout.



Cline's Oaks and Pines dry-mesic northern forest (EOID 26825), dominated by oaks (*Quercus* spp.) but red pine (*Pinus resinosa*) is abundant in the canopy. Red maple (*Acer rubrum*) is prevalent in regeneration classes.

Bull Gap Pines

Dry-mesic Northern Forest (EOID 28158)

EO Rank: CD; 39 acres

FQI: 19.5; Mean C: 4.6; Species richness: 18 (18 native)

Compartment: 224

Bull Gap Pines occurs in depressions and steep slopes on an end moraine feature associated with the Manistee-Au Sable Escarpment that runs roughly from Luzerne to Curtisville. The canopy is dominated by 30 to 60 cm DBH, 95- to 155-year-old red pine (*Pinus resinosa*), often as a supercanopy, with 40 to 55 cm, roughly 105-year-old DBH red oak (*Quercus rubra*) subordinate to locally co-dominant. White pine (*P. strobus*), white oak (*Q. alba*), and northern pin oak (*Q. ellipsoidalis*) are roughly equally occasional to uncommon in the canopy, while bigtooth aspen (*Populus grandidentata*) and red maple (*Acer rubrum*) are rare but locally common. The dominant canopy age is approximately 100 years, with a frequent super canopy of 150 or more years. Occasional concentrations of the oldest canopy trees (red pine, mostly) occur, especially along stand boundaries. There are locally frequent, old cut white pine stumps, suggesting that the historic importance of this species in the canopy was reduced by a thinning. Both red and white pine are also absent from the subcanopy, indicating prolonged fire suppression. White and red oak are occasional in the subcanopy and red maple and bigtooth aspen are locally dominant, often co-occurring. Where locally dominant in the subcanopy, both species are also dominant in the tall shrub layer. The co-occurrence of these species is apparently due to resprouts or suckering in canopy gaps created by thinning. A red pine supercanopy is consistently associated with locations where apparent thinning was observed. Witch hazel (*Hamamelis virginiana*) is frequent in the tall shrub layer, and advance regeneration of white pine and red oak are occasional. Pines are absent from the seedling class, but white and red oak are locally abundant and red maple is occasional.

Vascular plant species richness is low in the ground layer. The low shrub component comprised the majority biomass. Huckleberry (*Gaylussacia baccata*) is abundant and wintergreen (*Gaultheria procumbens*) and low sweet blueberry (*Vaccinium angustifolium*) are frequent. Among herbaceous species, only bracken fern (*Pteridium aquilinum*) is frequent, and Pennsylvania sedge (*Carex pensylvanica*) is occasional and locally abundant. Canada mayflower (*Maianthemum canadense*), rough-leaved rice-grass (*Oryzopsis asperifolia*), starflower (*Trientalis borealis* [synonym = *Lysimachia b.*]), and poke milkweed (*Asclepias exaltata*) are rare.

Fire exclusion is likely limiting diversity and oak and pine regeneration. There is evidence of light recent logging, including both hardwood (perhaps oak) stumps and maple resprouts. The Bull Gap Hill Climb, a popular ORV attraction, is adjacent to, but not visibly impacting the EO.



Bull Gap dry-mesic northern forest (EOID 28158) has a canopy dominated by red pine (*Pinus resinosa*), that characterize the natural community. There are also several highly mesophilic patches with extensive regeneration of red maple (*Acer rubrum*), an indicator of fire suppression.

Management Recommendations

We recommend reintroducing prescribed fire to stimulate regeneration of oaks and pines, limit invasive species, and increase ground layer diversity. Fires should include as large of a proportion of both EOs as possible in burn units, include portions of surrounding stands as feasible and safe, occur at a frequency of once every 5 to 40 years, and be more frequent initially to stimulate oak and pine recruitment.

We recommend avoiding timber harvests throughout the project area, and limiting logging to single tree selection in winter to encourage regeneration. We recommend avoiding timber management in these dry-mesic northern forest EOs. Cline's Oaks and Pines is planned for a timber cut ("oak thinning"), as of spring 2026. The removal of most oaks from the canopy will reduce canopy diversity and reduce canopy closure enough to degrade the ground layer and subcanopy conditions. Specifically, increased light availability and temperatures will increase stress for many species. The extent of disturbance associated with the Bull Gap Hill Climb is a likely source of invasive species propagules for the entire project area. To limit this impact, avoid routing ORV trails within EOs, and ideally re-route them away from the EOs as much as possible.

East Branch Region

The East Branch Region occurs in a narrow outwash channel roughly 10 km south of Mio, and directly northeast of the Mio Prairie Expansion project area. We documented one pine barrens EO in this project area (Table 5; Figure 16). The existing management area Watson Barrens is restorable and occurs to the south of this project area (Figure 7). Management to increase connectivity between East Branch Big Creek pine barrens and Watson Barrens would increase connectivity for species associated with pine barrens.



East Branch Big Creek project area, where open shrub-grassland vegetation grades into scattered oak and pine. This heterogeneous structure illustrates the fire-dependent conditions that management can maintain and expand across the region. Photo by J. M. Lincoln.

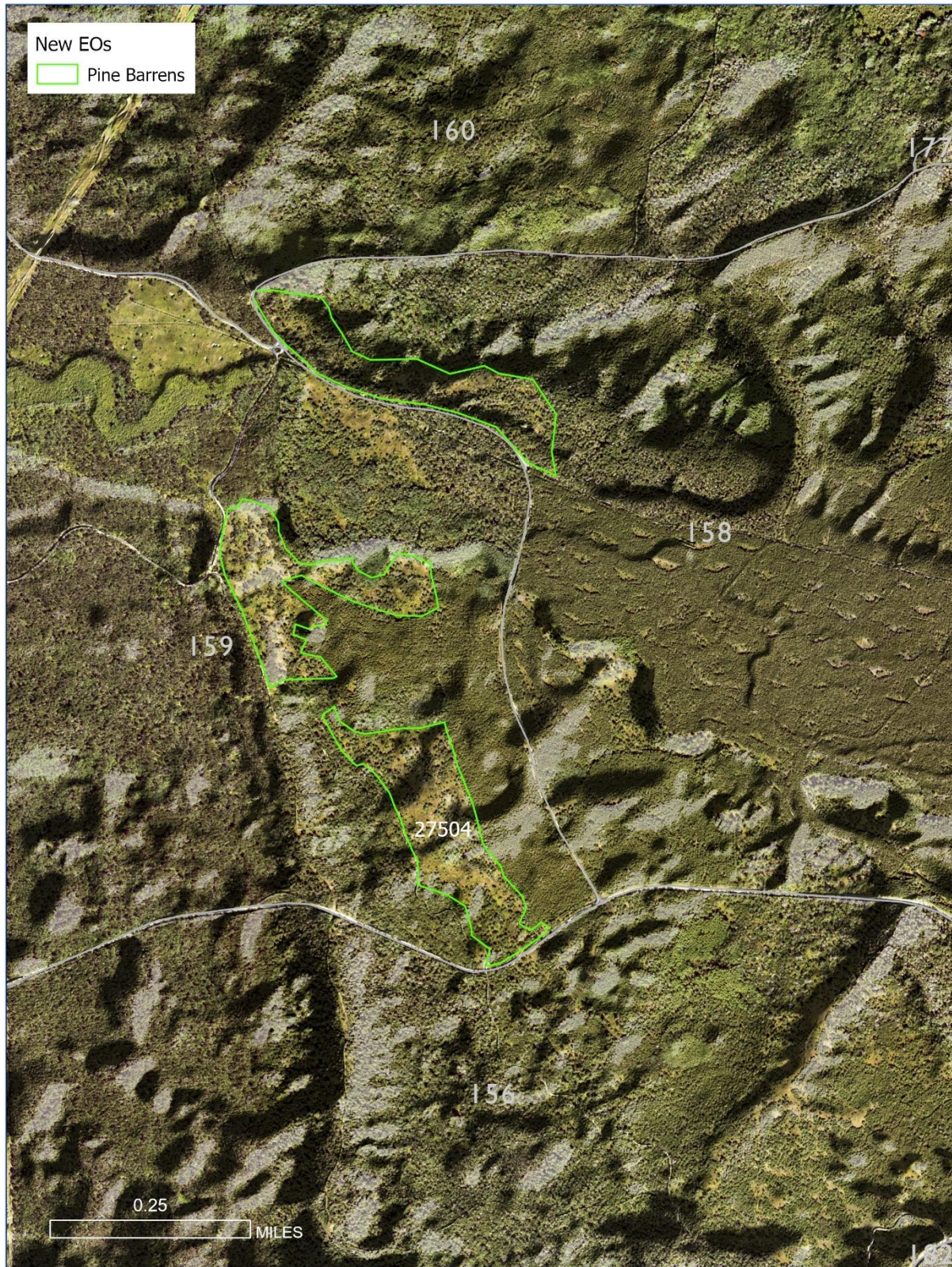


Figure 16. East Branch Region project area in the Mio District, with East Branch Big Creek pine barrens (EOID 27504). Compartments outlined and numbered in white.

East Branch Big Creek

Pine Barrens (EOD 27504)

EO Rank: C; 50 acres

FQI: 40.4; Mean C: 4.7; Species richness: 74 (68 native)

Compartments: 158, 159

This pine barrens occurs in a series of frost pockets and drainages in a glacial outwash channel adjacent to end moraine, and on the south-facing slope of the moraine. The EO occurs in three polygons, split in part by the East Branch of Big Creek, two polygons to the south and one to the north of the creek along Watson Road. The site is hilly with a mix of openings and areas of dense jack pine (*Pinus banksiana*), with variable structure. The structurally heterogeneous canopy (30% closure overall) is strongly dominated by mostly even-aged 15 to 40 cm DBH jack pine estimated at 40 to 50 years old, although at least two older cohorts are present, estimated at 80 to 85 and 115 to 125 years old, respectively. Northern pin oak (*Quercus ellipsoidalis*) is occasional in the canopy and ranges between 40 and 50 cm DBH. Oaks are locally abundant in the south polygon. Quaking aspen (*Populus tremuloides*) is also invading from the margins of the south polygon, although the species is rare overall in the canopy, as are black cherry (*Prunus serotina*) and red pine (*P. resinosa*). Many black cherry are cut or top-killed and are root-sprouting. Choke cherry (*P. virginiana*) is also locally aggressive in the tall shrub layer. Seedlings of quaking aspen, jack pine, black cherry, and red pine were noted as uncommon.

The ground layer is dense (95% cover). The low shrub layer is dominated by sand cherry (*P. pumila*) and low sweet blueberry (*Vaccinium angustifolium*), while bearberry (*Arctostaphylos uva-ursi*) and sweet fern (*Comptonia peregrina*) are common. Reindeer lichen (*Cladonia* sp.) and Pennsylvania sedge (*Carex pensylvanica*) are abundant, especially in openings, and bracken fern (*Pteridium aquilinum*) is abundant along forested edges and under invading quaking aspen. Prairie willow (*Salix humilis*) is locally common throughout. Ground layer diversity is high but somewhat patchy, with areas of high diversity interspersed within low diversity patches dominated by species including Pennsylvania sedge and low sweet blueberry. Barrens species that are widespread in the landscape are mostly common, including hairy goldenrod (*Solidago hispida*), smooth blue aster (*Symphyotrichum laeve*), big bluestem (*Andropogon gerardii*), poverty grass (*Danthonia spicata*), and hair-grass (*Avenella flexuosa*). Evenness in the ground layer increases from the south to the north of the EO, so that overall there is high evenness and frequency of barrens indicators. Several barrens indicator species are occasional to locally common, including prairie brome (*Bromus kalmii*), June grass (*Koeleria macrantha*), upland white goldenrod (*S. ptarmicoides*), and northern blazing star (*Liatriis scariosa*). Gillman's goldenrod (*S. simplex* var. *simplex*; [synonym = *S. glutinosa*]), three-toothed cinquefoil (*Sibbaldiopsis tridentata*), hairy puccoon (*Lithospermum carolinense*), and prairie cinquefoil (*Drymocallis arguta*) were observed less frequently. Hill's thistle (*Cirsium hillii*, Special Concern) and rough fescue (*Festuca altaica*, Special Concern) are both sparse. The first collections of both green milkweed (*Asclepias viridiflora*) and clasping milkweed (*A. amplexicaulis*) from Oscoda County were collected in this EO. Both species occur primarily in the southern lower peninsula in Michigan. A maintained ORV trail forms the western boundary of the southern two polygons and is a source of non-native species. Invasive species are rare, though, and include spotted knapweed (*Centaurea stoebe*), orange hawkweed (*Hieracium aurantiacum*), spotted St-John's wort (*Hypericum perforatum*), Morrow's honeysuckle (*Lonicera morrowii*), and Kentucky bluegrass (*Poa pratensis*).

Soils are very sandy, and somewhat gravelly, especially along the edge of end moraine in the northern polygon. Wood ant (*Formica* sp.) mounds are occasional to locally abundant. There are also irregular lumpy soil disturbances in the south polygon that appeared more likely to be

anthropogenic than originating from old ant mounds. Old pine stumps are occasional, roughly 35 cm DBH, suggesting historical plantation. Subtle furrows were occasionally observed as well, supporting this conjecture. Areas adjacent to the southern two polygons were planted to red pine plantation sometime after 1998 (plantation absent from 1998 imagery, present in recent imagery). Evidence for recent fire history is lacking, although stand notes indicate “BURNED IN ZIMOWSKI FIRE” (USDA 2024).



East Branch Big Creek pine barrens (EOID 27504), supporting representative barrens canopy structure and multiple age classes of jack pine (*Pinus banksiana*).

Management Recommendations

We encourage the reintroduction of fire and limiting ORV use. The reintroduction of low-severity prescribed fire should be implemented to maintain composition and structure. Monitoring should be implemented to evaluate aspen response, especially where it is abundant on the margins in the south. We recommend fires every 3 to 5 years over the next decade or two to stimulate pine regeneration and increase ground layer diversity. Once the site has been conditioned by fire, the frequency of fire can be gradually increased to once every 25 years.

We recommend eliminating ORV access to limit soil disturbance and the introduction of invasive species. Prevent access to ORVs. An ORV trail runs adjacent to the western boundary of the southern two polygons. Consider re-routing this trail away from this EO.

Updated natural community descriptions

We also updated boundaries and descriptions for four natural community EOs in the Mio District (Table 6). These communities were initially mapped on paper prior to the introduction of GIS, so previous boundaries were approximate.

We remapped Mio Prairie dry sand prairie primarily based on the presence of highly conservative forb and graminoid species and increased its size from 27.69 to 32.96 acres. Much of the rolling plains surrounding the glacial drainage and adjacent slopes where this dry sand prairie is found should be managed as pine barrens. Characteristic pine barrens ground layer species are present in many areas, particularly to the southwest of Mio Prairie, but pine barrens canopy structure is lacking (see Management Recommendations under Mio Prairie Expansion project area, above). Scattered red and jack pine (*Pinus resinosa* and *P. banksiana*) occur throughout Mio Prairie, including several “legacy” red pine trees aged at near 200-years-old. The ground layer is characterized by extremely high richness and evenness, and limited abundance of non-native species. Of 78 species recorded, only 5 are non-native, including spotted knapweed (*Centaurea stoebe*), orange hawkweed (*Hieracium aurantiacum*), spotted St.-John’s wort (*Hypericum perforatum*), Kentucky bluegrass (*Poa pratensis*), and goat’s beard (*Tragopogon dubius*). Among the 75 native species recorded, 19 were highly conservative (C-value 7-10).



Mio Prairie (EOID 11050), one of the highest quality dry sand prairies in Michigan. Note persistence, old, large-diameter red pine (*Pinus resinosa*). Photo by J. M. Lincoln.



Mio Prairie exhibits a ground layer with high richness and evenness. No one species is the overall dominant. Photo by J. M. Lincoln.

The nearby Section 16 oak-pine barrens was remapped to be smaller, from 124.00 to 76.59 acres (Table 6). Areas excluded from this oak-pine barrens contained closed-canopied quaking aspen (*Populus tremuloides*) and northern pin oak (*Quercus ellipsoidalis*) with an extremely mesophied understory, and a small portion in the southeast that was remapped as pine barrens and included within Briggs Gravel Pit Barrens (EOID 28160). Future surveys may eliminate additional areas impacted by natural gas derricks, particularly in the northern portions of this EO where surveys were not conducted in 2024-2025. This oak-pine barrens occurs along a relatively flat plateau with small frost pockets in the rolling topography of the Grayling outwash plain. The canopy is relatively dense (~70% cover, often 100%), diverse with 7 species, and heterogenous, with small open-canopied patches and otherwise dominated in patches by red pine, northern pin oak, and quaking aspen. Northern pin oak, ranging from 25 to 50 cm DBH, and red pine, ranging from 50 to 60 cm DBH, are the most frequent dominants. Red pine ranges from ca 70- to 160-years-old. Quaking and big-tooth aspen (*P. grandidentata*) are around 40-years-old, suggesting recent invasion. Jack pine (*Pinus banksiana*) is occasional to locally abundant but concentrated in the southern portion. White oak (*Quercus alba*) and white pine (*Pinus strobus*) are uncommon. The subcanopy includes quaking aspen, red and jack pine, black cherry (*Prunus serotina*), and white oak.

The shrub layer is very diverse, including 22 spp (15 shrubs, 7 tree seedlings). In the low shrub component of the ground layer, wintergreen (*Gaultheria procumbens*) is frequent, while low sweet blueberry (*Vaccinium angustifolium*) and northern dewberry (*Rubus flagellaris*) are common and fragrant sumac (*Rhus aromatica*) is locally dominant. Among herbaceous species, evidence of mesophication due to aspen is notable. Non-native species orange hawkweed (*Hieracium aurantiacum*) and Kentucky bluegrass (*Poa pratensis*) are locally common to abundant and Pennsylvania sedge (*Carex pensylvanica*) is common. Some portions are dense with bracken fern (*Pteridium aquilinum*), particularly in and adjacent to aspen clones.



We remapped portions of Section 16 oak-pine barrens (E01D 13567) that were dominated by quaking aspen (*Populus tremuloides*) (above). Much of the remainder is dominated by red pine (*Pinus resinosa*), with canopy closure due to fire exclusion (below).



Blockhouse Creek dry-mesic northern forest and O'Brien Lake dry northern forest were both remapped based on the consistent presence of old (> 100 years, often approaching 150 years) white and red pine (*Pinus strobus* and *P. resinosa*). Blockhouse Creek dry-mesic northern forest occurs in far eastern Oscoda County north of the Au Sable River along its tributary Blockhouse Creek, west of Hardy Grade Road and north of Old State Road (CR 600) (Figure 17). Formerly 32.19 acres, we remapped it at 25.26 acres by removing a tag alder (*Alnus incana*) thicket in the center and some areas dominated by young (circa 50-years-old) red maple (*Acer rubrum*) canopy on margins, and restricting mapping to large-diameter red and white pines and the white oak slope in the northwest.

Blockhouse Creek dry-mesic northern forest occurs at the east end of the Mio Plateau in an outwash channel between two bands of end moraine. The uneven-aged canopy (95% cover) is dominated by white pine (*Pinus strobus*) ranging from 35 to 105 cm DBH. An 84.5 cm white pine had a ring count of 156 indicating germination around 1860 in closed-canopied conditions, followed by a thinning event around 1915, and subsequent canopy closure. Red pine (*Pinus resinosa*) is frequent in the canopy ranging from 35 to 65 cm DBH. A 36.7-cm and 64.8-cm DBH red pine had 59 and 114 rings, respectively. The canopy is diverse, including in decreasing frequency – red maple (*Acer rubrum*), white oak (*Quercus alba*), northern pin oak (*Quercus ellipsoidalis*), and balsam fir (*Abies balsamea*). Oaks were mostly restricted to an east-facing slope in the west of the EO, where a 37.5-cm DBH white oak has 121 rings. There are several ca 25 to 30 cm jack pine (*Pinus banksiana*) snags, due to recent mortality, but no living stems in canopy. White pine is frequent in the subcanopy (10-20% cover) and balsam fir is locally dominant, especially near Blockhouse Creek. White oak and red maple is occasional and black spruce (*Picea mariana*) is rare. The tall shrub layer ranges from sparse (10%) to dense (90%), and 30% on average. Balsam fir is locally dominant and advance regeneration of white pine is frequent. Beaked hazelnut (*Corylus cornuta*) and white oak are rare.

The ground layer is characterized by a very diverse low shrub component (22 species), following the transition from swamp edge to the dry hillside. Low sweet blueberry (*Vaccinium angustifolia*) is abundant and wintergreen (*Gaultheria procumbens*) is frequent. Seedlings of white pine, red maple, and northern pin oak are occasional. The herbaceous component is often sparse due to dense leaf and needle litter and less diverse (16 species). Stiff clubmoss (*Spinulum annontinum*) is locally dominant and Pennsylvania sedge (*Carex pensylvanica*) is frequent but absent from areas with a dense white pine and balsam fir understory. Additional representative species include gold-thread (*Coptis trifolia*), bracken fern (*Pteridium aquilinum*), lady fern (*Athyrium filix-femina*), rough-leaved rice-grass (*Oryzopsis asperifolia*), and northern shorthusk (*Brachyelytrum aristosum*). All classes of coarse woody debris were frequent, including downed trees. Pit and mound features were prominent.

O'Brien dry northern forest occurs on the slopes west of O'Brien Lake in western Alcona County near the Oscoda County line (Figure 17). Formerly 48.68 acres, we remapped it to 20.53 acres. We excluded the north half of stand 27 and all of stand 28, which was characterized by a circa 70-year-old canopy of red pine and jack pine (*Pinus banksiana*), including some apparent plantation, with frequent but not dominant supercanopy red pines. Notes from Stand 27 include, "PLANTED TO RP 1967, LEAVE SCATTERED MAST TREES" (USDA 2024). Furrows are apparent throughout much of excluded area, with occasional young stumps indicating a thinning. The north half of stand 28 had barrens structure and a consistently young canopy.



We remapped Blockhouse Creek dry-mesic northern forest (EOID 8810) (left) and O'Brien Lake dry northern forest (EOID 5690) (right). This remapping includes large-diameter red and white pine (*Pinus resinosa* and *P. strobus*) (left) and excludes small diameter canopy trees and plantation furrows (right).

O'Brien dry northern forest occurs on the east end of the Mio Plateau on a slope above a kettlehole lake (O'Brien Lake) in an outwash channel between two bands of end moraine. The canopy is dominated by large-diameter red pine (*Pinus resinosa*), approximately 60 cm DBH and 120-years-old, with occasional 25 to 75 cm DBH white pine (*Pinus strobus*) and 25 to 40 cm DBH jack pine (*Pinus banksiana*). Balsam fir (*Abies balsamea*) is rare in canopy, mostly on slopes above Au Sable River. The subcanopy includes occasional jack, white, and red pine, and northern pin oak. White pine regeneration is frequent in the tall shrub layer, suggesting fire exclusion, while red pine and northern pin oak are occasional and black cherry (*Prunus serotina*) is rare. The ground layer is dominated by low shrubs with low sweet blueberry (*Vaccinium angustifolium*) abundant and wintergreen (*Gaultheria procumbens*) frequent. Huckleberry (*Gaylussica baccata*) and fragrant sumac (*Rhus aromatica*) are locally dominant and abundant, respectively. Seedlings of black cherry and northern pin oak are occasional, with pines are absent from the seedling layer. Pennsylvania sedge (*Carex pensylvanica*) and feather mosses are abundant in the ground layer and bracken fern (*Pteridium aquilinum*) is locally dominant. Other common species include rough-leaved rice-grass (*Oryzopsis asperifolia*), reindeer lichen (*Cladonia* sp.), northern shorthusk (*Brachyelytrum aristosum*), and false-melic (*Schizachne purpurascens*).

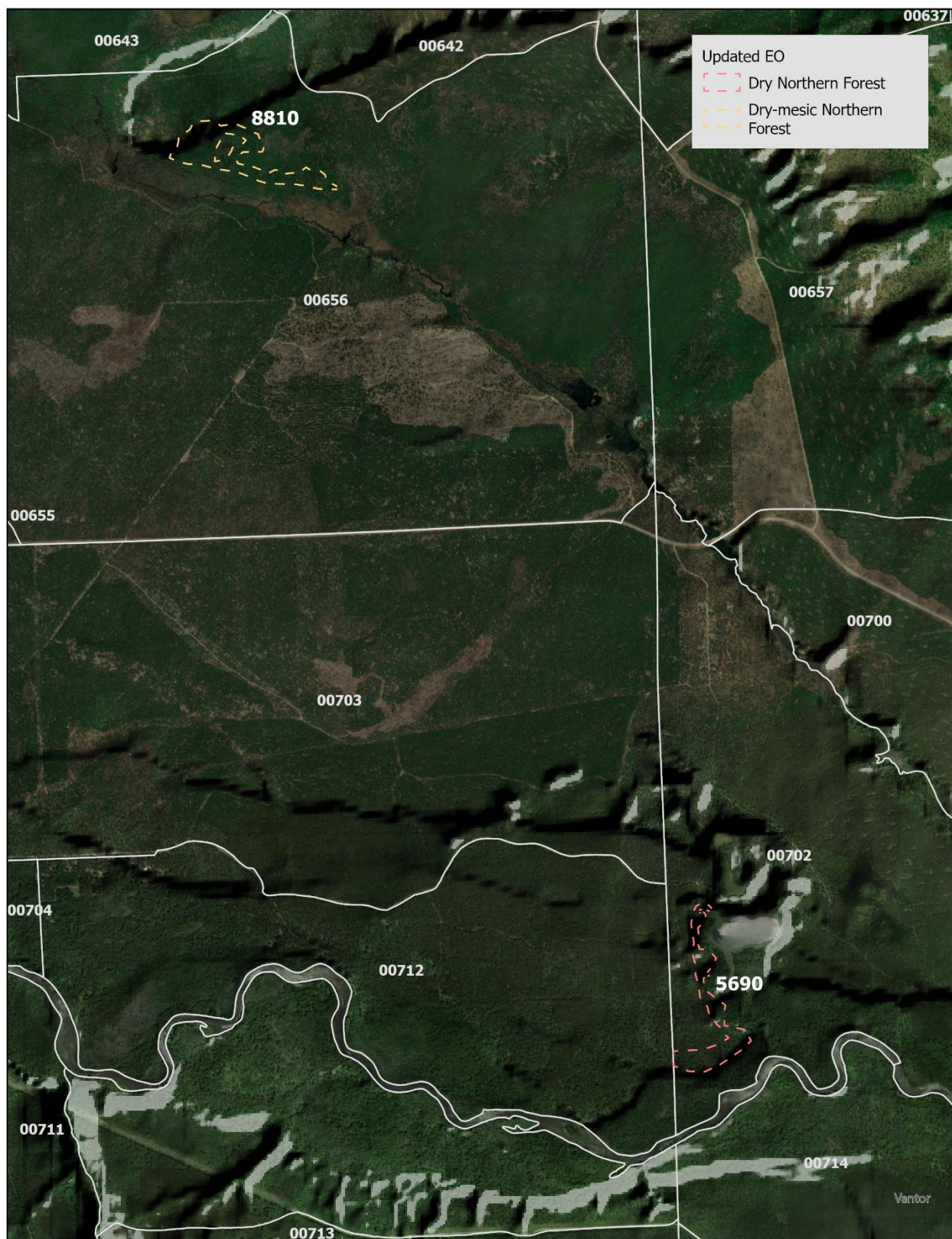


Figure 17. Blockhouse Creek dry-mesic northern forest (EOID 8810) and O'Brien dry northern forest (EOID 5690). Compartments outlined and numbered in white.

Existing management areas

Areas currently being managed by USFS as barrens or prairies and for wildlife habitat range from high-quality EOs with representative species composition, canopy structure, and natural processes, to highly degraded sites mostly or completely lacking these attributes (Figure 7; Table 7; Appendix D, Table D2). There are also eight stands totaling 223 acres that we did not survey due to time constraints, all but one of which were part of the Mio Prairie Expansion.

Most management areas are relatively small and isolated, comprising from one to five individual stands, with two exceptions, the Mio Prairie Expansion and the Mack Lake Firebreaks. The Mio Prairie Expansion area comprises nearly half of the existing management areas (1,728 acres; 48%) and is centered around Mio Prairie, a high-quality dry sand prairie (EOID 11050) occurring in a broad north-south-oriented glacial drainage (Figures 7, 10; Table 6). Several stands occurring along this drainage are being managed in the interest of expanding prairie and barrens habitat for several rare species with populations centered on Mio Prairie, including pale agoseris (*Agoseris glauca*, State Threatened), Kirtland's warbler (*Setophaga kirtlandii*, State Threatened), secretive locust (*Appalachia arcana*, Special Concern), and dusted skipper (*Atrytonopsis hianna*, Special Concern). The stands managed for the Mio Prairie Expansion range in quality, including natural community EOs (30%), recoverable barrens (21%), degraded barrens (2%), and highly degraded former plantations (38%).

Mack Lake Firebreak includes 446 acres of fuel breaks and adjacent overgrown pine barrens in 16 stands in compartments 179, 205, and 206, directly south and west of the Mack Lake area in Oscoda County. The entirety of this management area has the potential to be managed as recoverable pine barrens while maintaining canopy tree densities below levels that would risk crown fires in the event of a wildfire. Many characteristic pine barrens species persist here, including June grass (*Koeleria macrantha*), thimbleweed (*Anemone cylindrica*), Gillman's goldenrod (*Solidago simplex* var. *simplex* [synonym = *S. glutinosa*]), Bird's-foot violet (*Viola pedata*), northern and dwarf blazing star (*Liatris scariosa* and *L. cylindracea*), and western sunflower (*Helianthus occidentalis*).

High-quality natural community (EO)

There are six stands spanning three existing management areas over 659 acres supporting five EOs, including Mio Prairie, three new pine barrens (EOID 27708, 28018, and 28160; Figures 9 and 10), and one new oak-pine barrens (EOID 28158; Figure 14; Table 5; Appendix D, Table D2). Each of the barrens are managed as prairie-like openings with very minimal canopy tree structure. In general, we recommend managing these barrens to increase tree recruitment, especially of jack and red pine. This is particularly pertinent for the barrens areas associated with the Mio Prairie Expansion (Figure 10). While open grasslands occurred historically in the Mio District, they occurred in small openings in a matrix of forest and barrens (Comer et al. 1995) and presumably occupied larger areas in the frost pockets and cold-air glacial drainages where they are more prevalent today.

Lightly degraded - restorable natural community

There are 28 stands across 4 management areas covering 1,195 acres that we classified as restorable (Table 7; Appendix D, Table D2). These sites were degraded by clearcuts, fire suppression, and moderate soil disturbances (e.g., surface scrapes but not furrows). However, sufficient attributes of remnant pine barrens remain such that these attributes associated with high-quality natural communities may be restorable with sustained management interventions.

Importantly, representative but common barrens species like hairy goldenrod (*Solidago hispida*), smooth blue aster (*Symphyotrichum laeve*), rattlesnake weed (*Hieracium venosum*), harebell (*Campanula rotundifolia*), and small pussytoes (*Antennaria howellii*) are occasional to frequent and in the ground layer, and conservative barrens species like northern blazing star, prairie brome (*Bromus kalmii*), and western sunflower are rare if present. With the continued application of fire as a process in these stands, barrens composition and structure can be restored.

Moderately degraded natural community

We identified ten stands spanning five existing management areas covering 633 acres that were degraded barrens. These stands lacked most attributes of a barrens or prairie natural community (Table 7; Appendix D, Table D2). Representative but common barrens species are present but uncommon, and conservative barrens species are absent, and the heterogenous structure of barrens is entirely lacking. From a natural community conservation perspective, these sites are therefore a lower priority for restoration management. That said, managing these sites can in many cases serve as a buffer for higher quality natural communities or wildlife habitat, and can function to reduce wildfire risk across the landscape.

Heavily degraded - former plantations and other stands

The remainder of the stands we evaluated showed significant signs of degradation due to history of plantation forestry, or because they were converted to an open state from a forested community that historically lacked barrens composition. These stands lacked most or all of the compositional and structural attributes of a pine barrens, oak-pine barrens, or dry sand prairie natural community (Table 7; Appendix D, Table D2). As with moderately degraded stands, heavily degraded stands can serve as a buffer for higher quality natural communities or wildlife habitat, especially when managed with fire.



Some existing management areas were restored from furrowed plantations. These furrows typically disrupt soil structure, reduce plant diversity, and can persist through restoration.

DISCUSSION

Fire is inextricably linked to the ecological and cultural history of the Grayling Outwash Plain, particularly the pine-dominated ecosystems that characterize the Mio District. High-quality fire-dependent natural communities retain characteristic native species composition, ecosystem structure, and other ecological legacies that provide a foundation for biodiversity conservation and recovery. Making these remnants the cores of landscape-scale planning can guide ongoing fire stewardship within the Mio District. Targeted surveys informed by GIS modeling, spatial data interpretation, and engagement with Mio District staff increased the documented acreage of fire-dependent natural community EOs in the Mio District by more than eight-fold. Together with surrounding restorable stands, these high-quality natural communities can anchor stewardship that sustains existing biodiversity and restores fire across larger landscapes.

Our vision for conservation in the Mio District relies on connecting RFDS throughout the landscape with fire. Understanding the attributes that define RFDS are vital to that vision, so we first reflect on how certain attributes of the contemporary and historical landscape can confound efforts to distinguish between high-quality and degraded sites. From that foundation, we discuss how to transform our findings into management priorities, and further explore the role of fire as a landscape-scale ecological process, and barrens natural communities as a core restoration and management target. We conclude with discussion on the potential for collaborative management and research in the region, and suggest future work priorities that can expand the impact of the results discussed here.

Interpreting the landscape of the Mio District

A primary goal in mapping natural community EOs is to characterize the portions of the contemporary landscape that best preserve continuity with the historical landscape. Evidence of that continuity is generally found in the species composition, ecosystem structure, and ecological processes we observe, and the extent to which those observed attributes are consistent with historical data. The integrity of natural communities, however, is the result of the sum of the attributes we understand – soil characteristics, fire history, species interactions – and an unknown array of attributes we either do not understand or have not observed (Salt 1979, Ponge 2005). Mapping and managing high-quality natural communities preserves our ability to elucidate these unobserved attributes and better understand how natural communities and landscapes function.

It is important to be able to distinguish natural community EOs that exhibit high levels of continuity from degraded sites that do not. Understanding why each natural community developed where it did, how it functions, and what is responsible for its functioning, is key to guiding landscape-scale management. Once that continuity is severed, we are less likely to be able to reconnect all the pieces and the ecosystem functioning that supports biodiversity. Attempting to restore impaired ecosystems runs the risk of building functional impairment into a management approach. It can be challenging in the Mio District, and throughout the Grayling Outwash Plain, to differentiate between sites that exhibit continuity, those that have been intensively managed with silviculture and other intensive contemporary land uses, and the gradient of site histories between. This challenge is attributable to the broad-scale vegetation patterns in the Mio District being relatively unchanged compared to historical patterns (Table 1), the prevalence of deep sandy soil, extensive and frequent wildfires (Figure 4), and relatively high connectivity between similar cover types.



Mio Prairie dry sand prairie (EOLD 11050) transitions into pine barrens beneath scattered red pine (*Pinus resinosa*) that are nearly 200-years-old. These trees demonstrate continuity not only among prairie and barrens, but across time: this portion of the landscape has retained key structural and vegetation composition without interruption.

The deep sands of this region lead to two striking patterns. First, very little of the landscape is suitable for row-crop agriculture or conversion for productive livestock grazing, so tillage is less frequent and widespread than in other regions. In the southern Lower Peninsula with more fertile soils for example, a patch of forest with no history of tillage and a canopy greater than 120-years-old is easy to differentiate from a patch of forest that regenerated following 80 or less years of secondary succession following decades of tillage. In the Mio District, the degree of fragmentation and degradation seen in landscapes with more fertile soils is lacking, plus the differences among sites with different anthropogenic disturbance histories is more subtle. Second, small-scale linear topography indicative of soil disturbances fades quickly, making it hard to detect within a decade or two. In addition to the blurred signal of anthropogenic land uses, the fact that wildfires have continued to approximate natural processes further blurs the lines between sites with historical continuity and those with anthropogenically-derived structure. Many fire-dependent ground layer plant species are more abundant following fires, and fire stimulates regeneration of pines in heterogeneous, “natural” patches. Finally, barriers to seed dispersal are low because of the existing connectivity of similar cover types throughout the landscape. The availability of propagules that can recolonize degraded sites is therefore high (Brudvig et al. 2009). In particular, a narrow strip of vegetation along many roads often supports high plant diversity, increasing both availability of propagules and connectivity.

Transforming findings into management priorities

Before these surveys, only seven fire-dependent natural community EOs had been documented in the Mio District, each representing a different community type. Natural community EOs now encompass 1% of the 223,729 acres of the Mio District and function as the basis for

conservation planning. The eight pine barrens EOs we describe in this report are the first examples documented in the Mio District. Along with one new and one existing oak-pine barrens, there are currently 966 acres of pine and oak-pine barrens EOs that can serve as cores of management with fire and benchmarks for restoration throughout the district. Management of barrens and prairies should also be integrated into management of closed-canopied pine-dominated and pine and oak-dominated forests. There are currently 1,109 acres of dry and dry-mesic northern forest EOs, and these often occur in potential project areas where high-quality and restorable pine barrens occur (e.g., Figure 9). We also classified over 3,000 acres of the Mio District as restorable fire-dependent ecosystems (Appendix D, Table D1).

Whether to manage for forests, barrens, or prairies in the landscape surrounding EOs can be determined by interpreting the historical continuity of a site, the presence of indicator species (see Table 3; Appendix C, Table C3) combined with existing ecosystem structure. The 'dynamic cores' we have identified here support the highest levels of continuity. Historically, the Mio District supported a shifting mosaic of closed-canopied and open structure due to the interaction of fire with ungulate grazers (Fuhlendorf and Engle 2004). Today, centering fire stewardship on those cores can amplify that continuity and facilitate its expansion in the landscape, through the application of low-severity fire, which can interact with existing structure, aspect, slope, soils, and other site-level factors to restore and maintain aspects of that mosaic (Jolly et al. 2016). Importantly, avoiding high-severity fires should limit extensive canopy tree mortality and maintain the continuity of canopy structure. Particularly in barrens, heterogeneous canopy structure leads to a diversity of light environments, supporting higher ground layer plant diversity (Pavlovic et al. 2006). Furthermore, large-diameter red pine (*Pinus resinosa*) were historically an important component of the landscape and are now uncommon. Preventing their mortality preserves a vital structural component in the landscape, which requires decades to replace.



Luzerne Barrens following the 2006 Hughes Lake Fire. Dense, even-aged jack pine (*Pinus banksiana*) surround an old red pine (*P. resinosa*) snag—a remnant of canopy structure no longer evident in the present vegetation. High-severity fire can obscure the historical character of pine barrens, so surviving legacy trees, ground-layer indicators, and site context are essential for interpreting ecological continuity.

Fire as a landscape process

Fire is vital for meeting objectives related to ecological integrity and resiliency in the Mio District. Establishing a fire regime based primarily on low-intensity fires can restore and maintain heterogeneity in the Mio District and at the same time reduce wildfire risk from crown fires. Low-intensity fires, timed to coincide with high needle moisture in late summer through the dormant season, have several key effects (Jolly et al. 2016). High needle moisture limits flame length and consumes herbaceous and low shrub fuels through ground fires instead of resulting in stand-replacing crown fires. Instead of causing tree mortality, low-intensity fires “prime” canopy trees for future fires, particularly red pine, by stimulating resin production that seals the bark against subsequent injury (Hauser 2008). Low-intensity fires also burn hot enough to stimulate seed germination, recruitment, and growth in ground layer plant species, and provide sufficient heat to open serotinous jack pine cones and create seedbeds required for recruitment (Gauthier et al. 1996, Mitchell et al. 2006). Low-intensity fires also reduce ladder fuels, stimulate growth of fine herbaceous fuels that will support subsequent ground fires, and therefore reduce the risk of wildfire by reducing the chance of crown fires (Wu et al. 2023). In contrast, traditional silvicultural approaches encourage the accumulation of ladder fuels in the form of dense midstory jack pine and northern pin oak that increase the probability of crown fires. Also, the higher the density of plantation forestry in the landscape, with close spacing of trees, the higher the susceptibility to the spread of crown fires. In contrast, the application of low-intensity fire across the landscape has many benefits, maintaining a mosaic of structure and composition and increasing the resilience of the landscape to wildfire by reducing hazardous fuels in a fire-prone landscape.

The aim of the initial stage of managing barrens and forests is to restore representative canopy structure, while the long-term aim is to maintain that structure and increase and maintain the associated biodiversity. Over the long-term, replacing mechanical interventions with the use of low-intensity fire as a management tool will yield the best outcomes for biodiversity. We generally suggest a fire return interval of 5 to 25 years in barrens and 5 to 40 years in forests, the second fire occurring no less than five years after the first.

We delineated project areas (Figures 8-16) because we recommend applying prescribed burns across large project areas around RFDS using existing features like roads and rivers as burn breaks. Ecotones, including the transition area between upland and lowlands and between forest, barrens, and prairie, are generally best included within burns rather than repeatedly used as control lines. These ecotones would be included within prescribed burn boundaries to avoid damaging these especially diverse areas by establishing burn breaks. Ecotones often support high biological diversity and historically allowed fire to move across natural community boundaries (Bucher and High 2002; Morgan et al. 2020). In addition, we recommend that burn breaks and trails be kept away from high-quality openings to minimize risk of invasive species introduction and limit access for ORVs. Burning more than the identified remnants across the landscape at a landscape scale will potentially express new RFDS.



Low-severity prescribed fire in mixed oak-pine stand at Clear Lake State Park, Atlanta, MI (above). Low-severity fire maintains continuity with the most characteristic remnants of the historical landscape that persist today. If fires are too severe, for example, there is a risk of mortality of “legacy” red pine (*Pinus resinosa*) trees, some of which are over 200-years-old.



High-quality barrens and forests and the numerous species dependent on these systems assembled, persisted, and thrived under historic Indigenous influence, especially cultural burns. Therefore, the application of prescribed fire that reflects the timing and frequency of Indigenous burning will often be the most effective approach for supporting the biodiversity of the region. This will require careful evaluation of fire timing, frequency, and intensity. We recommend engaging with Tribal partners to learn about appropriate fire regimes and replicate the cultural practices around fire that promoted the persistence of fire-dependent natural communities.

Barrens as the priority for ecological stewardship

Pine and oak-pine barrens perhaps best capture the ecological character of the Grayling Outwash Plain, and provide a good organizing focus for ecosystem management in the Mio District. The heterogeneity that defines barrens natural communities reflects the response of trees and shrubs to frequent fires of varying intensities over decades, against a backdrop of environmental variation (e.g., aspect, slope, soil productivity; Tucker et al. 2016, Hanberry 2017). That same process is the driving force behind the landscape-scale heterogeneity of the Mio District, which extends to include both closed-canopied forests and open-canopied prairies.

Pine barrens and oak-pine barrens were high priorities for surveys because both are globally vulnerable (G3), imperiled in Michigan (S2), dependent on recurrent fire, and provide habitat for numerous rare species. Both communities were historically prominent in the Grayling Outwash Plain, which contained roughly one-half of Michigan's circa 1800 acreage of barrens (Comer et al. 1995). Today, the Grayling Outwash Plain supports 67% of Michigan's documented pine barrens acreage, including high-quality remnants in the Mio District and adjacent State Forest management units (Lincoln et al. 2024a, MNFI 2026). Even these high-quality remnants face threats from fire exclusion and incompatible land management. Their concentration in and around the Mio District makes this landscape particularly important for barrens conservation. Finally, barrens may have been more prevalent historically than circa 1800 maps suggest. According to Comer et al. (1995), fire-dependent forests occupied approximately 66% of the Mio District, while pine barrens, oak-pine barrens, and grasslands collectively occupied 12% (Appendix C, Table C1). These mapped proportions may not fully represent the landscape maintained under historical fire regimes. Disruption of Indigenous communities likely reduced the frequency and extent of cultural burning before GLO surveys reached the region in the late 1830s (General Land Office 1890, McDonnell 2015), potentially allowing canopy density to increase in some barrens before they were surveyed and be interpreted as forests. Areas mapped as forest also likely included patches of woodland with relatively high canopy closure but sparse midstories, allowing sufficient light to support barrens-associated ground vegetation. Finally, small pine barrens were likely overlooked by the mapping scale and occurred within areas mapped as forests, especially in small frost pockets and similar landscape features that slow the growth of trees. Thus, the predominance of forested cover on these maps may conceal a more heterogeneous landscape of forest, woodland, and barrens openings.

Pine and oak-pine barrens are fire-dependent savannas that develop on drought-prone landscapes where recurrent fire, excessively drained soils, and growing-season frosts limit forest development. These interacting processes historically produced large, spatially heterogeneous landscapes with multiple age classes of jack pine and red pine, along with northern pin oak, white pine, and occasionally white oak. The resulting savanna mosaic ranged from non-forested openings to groves of dense trees, generally supporting canopy cover of 5 to 60%. This structural complexity influenced fuel continuity and fire behavior while creating the diverse habitats characteristic of pine barrens. Many characteristic barrens plants depend on fire-associated conditions or cues for flowering, germination, resprouting, and recruitment.

Open-canopy conditions support rich assemblages of grasses, flowering plants, and shrubs that sustain diverse wildlife, including rare insects and birds such as Kirtland's warbler.

The structural heterogeneity that defines barrens natural communities has important implications for management. On the contemporary landscape, silviculture has replaced the fire as the primary determinant of structure, both to support forestry and to protect against high-severity, stand-replacing wildfires that are more common in dense jack pine stands in particular. However, relying on silviculture alone to replicate a pattern of heterogeneity generated by the interplay of fires of varying intensity and multiple environmental gradients has limitations. For example, silviculture alone does not yield the continuously distributed fine fuels (grasses and sedges, and pine needles) that carry low-intensity ground fires, especially when techniques like scarification are used to expose continuous bare soil to reduce competition with tree seedlings (Mitchell et al. 2006). Recurrent fire is essential to sustaining the processes that maintain these communities.



Pine barrens maintained with regular prescribed fire, showing sparse red pine (*Pinus resinosa*) of multiple age classes, patches of jack pine (*P. banksiana*) regeneration, and herbaceous openings. Recurrent fire sustains the fine fuels and variable light environments that maintain this structural complexity across the site. Photo by J.M. Lincoln.

Placing barrens natural communities at the center of management priorities does not mean that management for closed-canopied forests and open-canopied grasslands is not justified in sites with the potential to support those conditions. In this report, we have described sites that currently support high-quality forests and open grasslands and recommended management approaches that maintain and expand them. Rather, it guards against the tendency to manage *primarily* for forests and open grasslands and ensures the maintenance of canopy heterogeneity and species composition that historically defined the character of the Grayling Outwash Plain. Restoring that heterogeneity will require the application of frequent, low-intensity fire likely in combination with other management approaches such as canopy thinning and mastication of ladder fuels.

Managing for both barrens and the Kirtland's warbler

The pine barrens natural community and the ecology of the Kirtland's warbler have a shared history, but a divergent present. The Kirtland's warbler adapted its nesting behavior to the landscape of the Grayling Outwash Plain as that landscape was developing with frequent fire, the same process that gave rise to the pine barrens natural community. In the contemporary landscape, the extent of pine barrens natural community and abundance of associated plant species have been reduced by Kirtland's warbler management. Single-species management is frequently effective for the conservation of the focal species, but can negatively impact other species of concern and the ecosystems they depend upon (Caro and O'Doherty 1999, Jenkins et al. 2021). While expansion of jack pine plantations has supported recovery of the Kirtland's warbler, broad suites of other species associated with pine barrens are now in decline (Huber et al. 1996, Tucker et al. 2016, Tucker and Kashain 2018, Lincoln et al. 2024a). Conversion to plantation eliminates the structural complexity and simplifies the characteristic vegetation that define pine barrens, both locally and at the landscape scale. We urge managers to carefully evaluate sites prior to establishing plantations to avoid converting the most recoverable portions of the landscape, particularly undocumented pine barrens.



Dense jack pine weave plantation established for Kirtland's warbler habitat. Uniformly and closely planted trees replace the irregular canopy, mixed age classes, and diverse ground layer characteristic of pine barrens. The resulting continuity of low branches and dense live fuels also increases the potential for crown fire relative to an open, heterogeneous barrens landscape.

Expansion of dense, even-aged jack pine plantations has simplified portions of the fire-dependent landscape and increased the density of ladder and canopy fuels. Where these conditions are concentrated, they can increase the potential for crown fire and constrain opportunities to apply prescribed fire. Increasing the use of low-severity fire around recoverable systems would reduce fuel density, restore native ground-layer vegetation, and create a more varied mosaic of open, shrubby, and young pine conditions that can support multiple conservation objectives. This density and associated risk necessitate intensive fire suppression to protect life and property, including the installation of broad fuel breaks adjacent to many plantations and active fire suppression in the event of wildfires and escaped prescribed fires. As a result, fire is excluded from much of this fire-dependent landscape. In contrast, increasing the use of fire for manage fuels relative to the reliance on silviculture would both increase the incidence of fire-dependent barrens and other natural communities and decrease fire risk across the landscape. Fire could also play a meaningful role for generating and sustaining Kirtland's warbler habitat.



The density of jack pine (*Pinus banksiana*) plantations is a fire risk, as seen in many wildfires, including the 2023 Wilderness Trail Fire that burned 2,400 acres in Crawford County (left), including a large proportion of jack pine planted for Kirtland's warbler (*Setophaga kirtlandii*) habitat. This risk extends to prescribed fires, such as the 2021 Brittle Fire (right) that escaped and burned around 6,000 acres in the Huron Shores District in Iosco County.

Recent surveys by MNFI have identified numerous previously undocumented pine barrens and broader portions of those landscapes that retain the capacity for recovery (e.g., Lincoln et al. 2022, 2024a, 2026). This work provides an opportunity to more closely align pine barrens stewardship with Kirtland's warbler management through the strategic application of prescribed fire. Repeated, low-severity prescribed fire across broad, connected areas can maintain and expand pine barrens while creating a shifting mosaic of vegetation structure that includes dense young jack pine habitat that can support nesting habitat for the Kirtland's warbler. By highlighting RFDS as dynamic cores here and elsewhere in the Grayling Outwash Plain (e.g., Lincoln et al. 2024a), we are emphasizing where pine barrens stewardship, Kirtland's warbler habitat objectives, and wildfire risk reduction can be pursued together.

Concurrent work and opportunities for collaboration

The work reported here takes place in the context of multiple efforts to document recoverable fire-dependent ecosystems and establish baseline data across the northern Lower Peninsula and the eastern Upper Peninsula. These efforts increase opportunities for connectivity and resilience of habitats and ecosystems at a broader regional scale. MNFI has completed multiple recent projects, for Camp Grayling, DNR-FRD, USFS, USFWS, and Huron Pines mostly or partially within the Grayling Outwash Plain from 2021 through 2025. In addition, MNFI is conducting similar work in the eastern Upper Peninsula and northeastern Lower Peninsula on State Forest lands for the Sustainable Forestry Initiative in coordination with DNR-FRD and DNR-WLD (Lincoln et al. 2025). Including the work described here, MNFI has documented 164 EOs of fire-dependent natural communities, increasing the footprint of high-quality RFDS across northern Michigan by 18%, and providing management recommendations for new and existing EOs as well as alternative approaches for management using low-severity fire (Lincoln and Cohen 2022; Lincoln et al. 2023, 2024a,b, 2025 a,b, 2026; Schilke et al. 2024). Additional projects include collecting baseline data to track the effects of management (with fire and other tools) on ecosystem structure, composition, and rare plant species (Bassett and Lincoln 2024, Bassett et al. 2024, 2026), monitoring bird populations (e.g., Monfils et al. 2023, Branch et al. 2026), and surveys for rare insects (Cuthrell et al. 2021, Rowe et al. 2023) and snakes (Lee 2022).

Altogether, this work provides a rich template for making conservation decisions at the ecoregional level across ownership boundaries. To this end, synergistic efforts across land ownership are being catalyzed by the Northern Pine Plains Partnership (NPPP), a multi-stakeholder collaborative effort formed in 2021 to “improve ecological outcomes through the cohesive co-management of the jack pine ecosystem.” The NPPP is supported by several state agencies (DMVA [Camp Grayling], DNR [FRD, PRD, WLD]), federal agencies (USFS, USFWS, Smithsonian Institute), university partners (Michigan State University [including MNFI], University of Michigan, Wayne State University), and private land trusts (American Bird Conservancy, Great Traverse Regional Land Conservancy, Huron Pines, Little Traverse Conservancy). Each of these partner organizations has historically and continues to contribute research, management, and policy in the Grayling Outwash Plain and surrounding areas that supports and increases the resilience of biodiversity across the region. In addition to the NPPP, the Northern Michigan Fire Collaborative is working to increase capacity to apply prescribed fire across the region.

Future work

Many opportunities remain to enhance and expand upon this diversity of efforts to support the reintroduction of fire to fire-dependent landscapes across northern Michigan. Here, we highlight opportunities for both additional surveys to document high-quality ecosystems, and opportunities for research and monitoring that can increase the understanding of fire effects and guide conservation planning centered on fire.

Much of the Mio District is a fire-dependent landscape (e.g., 66% with high, very high, or highest fire needs; Table 4). While we surveyed the majority of our survey targets in 2024-2025, there were several areas that we did not survey due to time constraints, or were not selected as targets. In doing this surveys, the authors developed a refined sense of how to detect potential RFDS, and additional surveys may result in documenting new RFDS. In addition, we recommend surveys to:

- Identify RFDS in the Huron Shores and Baldwin-White Cloud Districts. As of this report, RFDS have been identified in the Mio and Cadillac-Manistee Districts (Lincoln et al. 2026). Completing surveys in the other two districts would provide a foundation for HMNF managers to conduct Forest-wide conservation planning for the application of fire;
- Target other systems to expand the footprint of high-quality natural communities in the Mio District and other Districts of the HMNF. For example, there are a lot of stands that potentially support “old-growth” forests. Mapping high-quality forests throughout the Mio District and the rest of HMNF; and
- Identify RFDS in the Hiawatha National Forest. While not as prevalent as in HMNF, many examples of pine barrens, dry northern forest, and other fire-dependent ecosystems occur in the Hiawatha, and likely many remain to be documented.

Monitoring is critical for evaluating the effectiveness of stewardship. We have developed barrens vegetation monitoring protocol and recommend implementation of longitudinal monitoring of these restoration projects to track the success of fire management (Bassett and Lincoln 2024). This protocol is also in the process of being adapted for use by the NPPP to build a dataset tracking fire effects across ownership boundaries. With this in mind, we recommend:

- Implementation of vegetation monitoring in areas currently under management with fire in the Mio District, and areas planned for management in the future; and
- Development of detailed management plans for project areas highlighted in this report.

CONCLUSIONS

The Mio District is overwhelmingly a fire-dependent landscape, and biodiversity management would be improved by prioritizing where the application of fire would be most beneficial. We identified recoverable, fire-dependent systems across the Mio District, including evaluating 20 new and updating 4 existing fire-dependent natural communities, as well as several other RFDS that are restorable with fire and other management. We recommend that these RFDS serve as dynamic cores for management with low-intensity fire to increase ecological integrity within sites, and expand and connect high-quality sites across the landscape. This reintroduction and expansion of fire is necessary to both increase and maintain biodiversity, mitigate wildfire risk across the landscape, and enhance fire resiliency at the landscape scale.



We recommend the widespread application of low-intensity fire in the Mio District. This approach can increase the abundance of barrens indicator species like wood lily (*Lilium philadelphicum*) and stimulate the patchy regeneration of jack pine (*Pinus resinosa*) that generates characteristically heterogenous canopy structure.

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APPENDIX A: MODEL DEVELOPMENT

Model Background and Natural Community Crosswalk

The prescribed fire needs assessment model is more thoroughly described in Cohen et al. (2021). MNFI originally developed the model for state lands in Michigan administered by Michigan's Department of Natural Resources (DNR). The model described here was modified for the Mio District. Vegetative cover of lands within the Huron-Manistee National Forest is tracked through a stands database. The foundational unit of our model are these stands. For each stand, we generated an intersection with numerous spatial data layers including datasets with information on physiographic region, landform, circa-1800 vegetation, slope, aspect, departure from historical fire regime, and occurrences of high-quality natural communities or ecosystems. We used information gleaned from this intersection as well as stand-level data to "crosswalk" or assign a natural community type to as many stands as possible. Anthropogenic systems (e.g., developed, cropland, plantations, roads, ruderal systems, and grassland plantings) were not crosswalked to a natural community type.

Over the course of four decades, MNFI has developed a classification of natural community types in Michigan (Cohen et al. 2015, Cohen et al. 2025). Part of this classification includes a detailed discussion of each natural community type's vegetative composition and structure, soil texture and soil moisture, hydrology, and natural disturbance regime. The classification typically includes information on fire dependence and fire return interval drawn from literature review and ecological inference. Fire return interval is the time in years between two successive fires in a designated area and can be used to estimate fire frequency range. We use fire frequency range throughout to convey the range of time between fire events typical of a given natural community type irrespective of area.

Variable Selection and Data Preparation

Through literature review, evaluation of available spatial data layers, and discussion with natural resource managers and ecological experts, we identified potential variables critical for determining a site's proclivity to support a fire-dependent ecosystem or need for prescribed fire. In selecting these variables, we tried to incorporate factors that contribute to a site's past, current, and future relationship with fire. Because multiple variables interact at different scales in determining the characteristics of a site's fire regime, we identified critical variables for our model at the following three spatial scales: landscape, stand, and species.

Landscape

Landscape-scale variables included physiographic region, surficial geology or landform, historic vegetation, and departure from historic disturbance regime. Physiographic regions are classified by large scale abiotic factors, such as climate and underlying bedrock, which, along with surficial geology, influence the patterning of ecosystems across landscapes. We used Schaetzl et al. (2013) for physiographic regions and Farrand and Bell (1982) for surficial geology. The data layer of surficial geology that we used includes descriptions of the glacial and post-glacial landforms as well as modifiers that convey information about soil texture properties of those landforms. Vegetation circa 1800 has been mapped in Michigan following interpretation of the original land surveyors' notes (Comer et al. 1995). This spatial database of historic land cover provides useful information about how fire-prone and fire-sensitive ecosystems were patterned across Michigan. The historical legacy of ecosystems and species influences current distribution of ecosystems and their need for fire disturbance. To incorporate departure from historic fire

regime we used LANDFIRE's Vegetation Condition Class or VCC, which gauges how far removed an area is from its historic fire return interval (LANDFIRE 2008).

Stand

Stand-level variables included fire frequency range, fire dependence, aspect, slope, age, size, and presence of exemplary ecosystems or natural community element occurrences. For each stand crosswalked to a natural community type we determined the scale of fire dependence (i.e., extremely fire dependent, very fire dependent, fire dependent, fire neutral, fire sensitive, very fire sensitive, and extremely fire sensitive), fire frequency (i.e., extremely frequent, very frequent, somewhat frequent, frequent, infrequent, somewhat infrequent, very infrequent, extremely infrequent), and fire frequency range (e.g., 1-5 years, 10-20 years, 200-500 years, and >1000 years). We also assigned a level of certainty for the fire frequency range (i.e., low, medium, and high). Fire frequency ranges were derived from the literature, but in cases where there was no reference for a natural community type, we relied on expert inference and evaluated similar natural community types to assign a fire frequency range.

For natural community types with broad fire frequency ranges, such as wetland ecosystems, we modified the fire frequency range depending on the landscape context of the natural community. For example, wet meadows occurring in a fire-prone landscape were assigned a higher fire frequency range (e.g., 10-100 years) than prairie fens nested in less combustible landscapes (e.g., 100-200 years). In terms of aspect, westerly and southerly aspects are more prone to fire than easterly and northern aspects. We used 30-meter digital elevation model (DEM) data to incorporate slope and aspect into the model. In terms of slope, flatter areas are more fire prone than areas of rugged topography. The stand database was used to derive the age and size variables. For forested systems, stand age and size-class can be used as predictors of need for fire, since certain forest types such as oak and pine forests depend on fire disturbance to foster regeneration. Within fire-dependent forested systems, there is a greater need for fire in mature systems compared to regenerating ones. For the size-class variable, we assumed there is a greater need for fire in forested stands categorized as "sawtimber" compared to "poletimber" and "seedling/sapling". Finally, stands that have higher ecological integrity have a higher need for fire from a conservation perspective and were therefore integrated into the model using documented examples of high-quality natural communities from MNFI's Natural Heritage Database (i.e., natural community element occurrences).

Species

We ran an intersection of Mio District stands with MNFI's rare species element occurrences and generated a list of known rare species occurrences that intersect with stands. For each of these species we researched whether or not the species is fire tolerant or fire dependent, and if the habitat the species depends on is fire dependent. We evaluated a total of 461 rare animal and plant species.

Variable Scoring

The input variables included both categorical and numerical data. For example, classes within the surficial geology layer include "end moraines of fine-textured till" and "ice-contact outwash sand and gravel," and classes attributed to the aspect variable include "south," "southwest," and "west." The variables that have numerical data are attributed with different numbering systems with different ranges. For example, for the slope variable, the data is broken into mean slope classes (e.g., ≥ 0 and ≤ 6 ; ≥ 7 and ≤ 9 ; ≥ 21 and ≤ 30), and the fire frequency range variable

included 14 different classes (e.g., 1-5 years; 5-20 years; 50-100 years; 500-100 years; > 1000 years). To combine the input variables into the same analysis, we reclassified each variable to the same relative evaluation scale to allow for comparison across variables. Scores for most variables were scaled equally within 6 integers and ranged between 0 and 5, in order of increasing ecological need for prescribed fire (i.e., 0 = No Fire Needs or None, 1 = Low, 2 = Moderate, 3 = High, 4 = Very High, 5 = Highest).

We developed detailed scoring rules for each input variable. For example, for natural community types with a fire frequency range of 1 to 5 years, we developed the following rule: "IF Fire Frequency Range = 1-5 Years, THEN +5." Additional examples of rules include: "IF Surficial Geology = Ice-contact outwash sand and gravel, THEN +5"; "IF Aspect = West, THEN +5"; and "IF stand is classified as 'fire dependent' and Mean Slope ≥ 0 AND ≤ 6 , THEN +5".

GIS-Based Multicriteria Decision Analysis

To synthesize the data contributed by our multiple input variables into one prescribed fire needs score, we used GIS-based multicriteria decision analysis, which combines spatially referenced data and multi-attribute criteria in a problem-solving environment. This integrated analysis allows users to apply weights to input variables and combine them into a single output. We assigned weights to variables to infer relative importance to prescribed fire needs. Weighting was determined by expert opinion and not empirical statistical analysis. Weights were derived following discussions with natural resource managers and fire ecology experts and literature review on the factors that influence fire disturbance regimes and the response of landscapes, ecosystems, and species to fire. We multiplied each reclassified score by the assigned weighting factor. Assigned variable weights include x25 for Fire Frequency Range, x20 for VCC, x20 for Fire Dependence, x15 for Physiographic Region, x10 for Surficial Geology, x10 for Aspect, x10 for Slope, x10 for Size Class, x5 for Circa- 1800 Vegetation, and x5 for Natural Community Element Occurrence (Figure A1). The remaining variables received a weight of one (x1), which is equivalent to no weight. For each stand, the prescribed fire needs score was calculated by summing the weighted scores for each variable, and then rescaling the final score to a 0 to 5 range. Once again, higher scores convey a higher level of ecological need for prescribed fire. See Figure A1 for a schematic of the model architecture. To visualize the scoring, the scores were assigned colors on a blue to red color gradient with higher scores corresponding to reds and displayed within GIS.

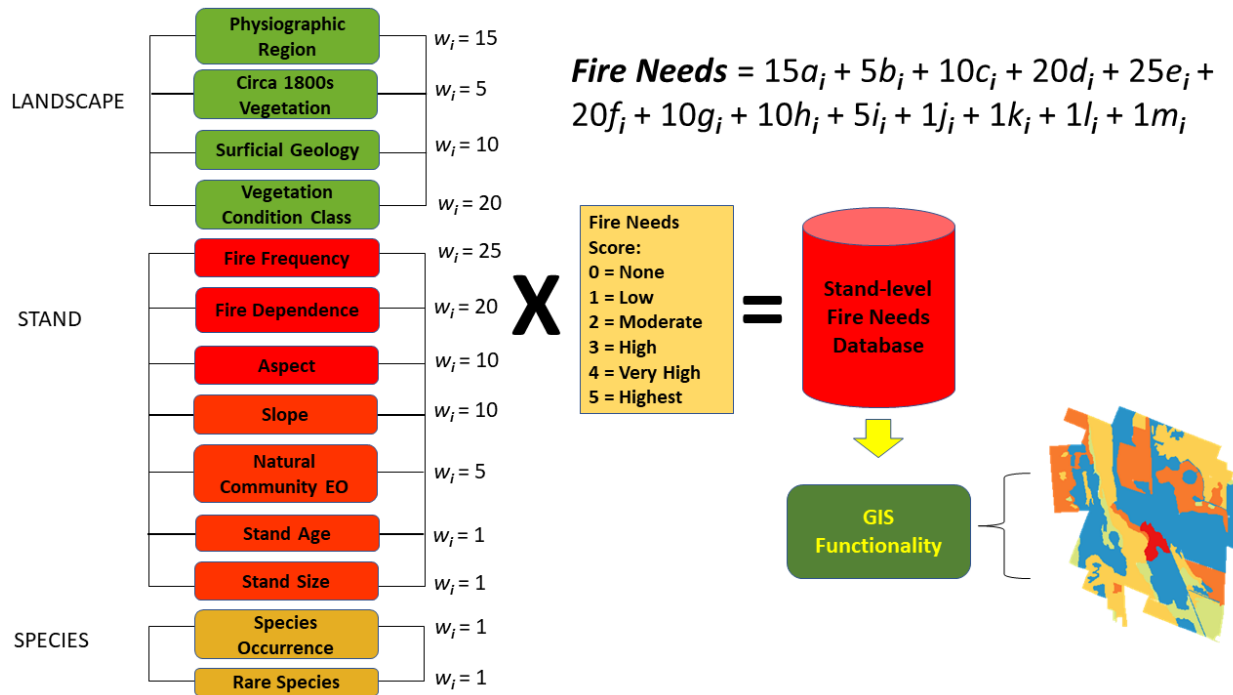


Figure A1. Overview of prescribed fire needs assessment model. This model gauges each stand's ecological need for prescribed fire based on an array of spatial variables and the presence of fire-dependent and fire-sensitive species. For each stand, multiple input variables at multiple scales were evaluated, scored, and weighted to generate an overall fire needs score. Each input variable was binned into one of three modules or submodels depending on the variable's scale (i.e., landscape, stand, and species).

APPENDIX B: CONSERVATION RANKS

Table B1. Global conservation ranks (rare species and natural communities).

Global Rank		DEFINITION
G1	Critically Imperiled	At very high risk of extinction or elimination due to extreme rarity (often 5 or fewer occurrences), very restricted range, very few populations or occurrences, very steep declines, very severe threats, or other factors.
G2	Imperiled	At high risk of extinction or elimination due to restricted range, few populations or occurrences (often 20 or fewer), steep declines, severe threats, or other factors.
G3	Vulnerable	At moderate risk of extinction or elimination due to a fairly restricted range, relatively few populations or occurrences (often 80 or fewer), recent and widespread declines, threats, or other factors.
G4	Apparently Secure	At fairly low risk of extinction or elimination due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors.
G5	Secure	At very low risk of extinction or elimination due to a very extensive range, abundant populations or occurrences, and little to no concern from declines or threats.
GH	Possibly Extinct (species) or Eliminated (communities)	Known from only historical occurrences but still some hope of rediscovery. Examples of evidence include (1) that a species has not been documented in approximately 20-40 years despite some searching and/or some evidence of significant habitat loss or degradation; (2) that a species or ecosystem has been searched for unsuccessfully, but not thoroughly enough to presume that it is extinct or eliminated throughout its range.
GX	Presumed Extinct (species) or Eliminated (natural communities)	Not located despite intensive searches and virtually no likelihood of rediscovery (species); Eliminated throughout its range, due to loss of key dominant and characteristic taxa and/or elimination of the sites and ecological processes on which the type depends (natural communities).
GU	Unrankable	Currently unrankable due to lack of information or due to substantially conflicting information about status or trends.
G?	Inexact	Incomplete data

Table B2. Subnational (State) Conservation Ranks (rare species and natural communities).

Subnational (State) Rank		DEFINITION
S1	Critically Imperiled	At very high risk of extirpation in the state because of extreme rarity (often 5 or fewer occurrences) or other factors making it especially vulnerable to extirpation, including: very restricted range, very few populations or occurrences, very steep declines, or severe threats.
S2	Imperiled	At high risk of extirpation in the state due to restricted range, few populations or occurrences (often 20 or fewer), steep declines, severe threats, or other factors.
S3	Vulnerable	At moderate risk of extirpation in the state due to a fairly restricted range, relatively few populations or occurrences (often 80 or fewer), recent and widespread declines, threats, or other factors.
S4	Apparently Secure	At a fairly low risk of extirpation in the state due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors.
S5	Secure	At very low or no risk of extirpation in the state due to a very extensive range, abundant populations or occurrences, with little to no concern from declines or threats.
SH	Possibly Extirpated	Known from only historical records but still some hope of rediscovery. There is evidence that the species or ecosystem may no longer be present in the jurisdiction, but not enough to state this with certainty. Examples of such evidence include (1) that a species has not been documented in approximately 20-40 years despite some searching and/or some evidence of significant habitat loss or degradation; (2) that a species or natural community has been searched for unsuccessfully, but not thoroughly enough to presume that it is no longer present in the jurisdiction.
SX	Presumed Extirpated	Species or ecosystem is believed to be extirpated from the state. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered. [equivalent to "Regionally Extinct" in IUCN Red List terminology]
SNR	Unranked	National or subnational conservation status not yet assessed.
S?	Inexact	Incomplete data

Table B3. Element occurrence (EO) rank definitions.

EO Rank	DEFINITION
A Excellent Viability	<p>Occurrence exhibits optimal or at least exceptionally favorable characteristics with respect to population size and/or quality and quantity of occupied habitat; and, if current conditions prevail, the occurrence is very likely to persist for the foreseeable future (i.e., at least 20-30 years) in its current condition or better. These occurrences have characteristics (e.g., size, condition, landscape context) that make them relatively invulnerable to extirpation or sustained population declines, even if they have declined somewhat relative to historical levels. For species associated with habitat patches or ephemeral or particularly dynamic habitats, occurrences warranting an A rank generally consist of metapopulations rather than single demes (unless exceptionally large and robust). Occurrences of this rank typically include at least 1,000 mature individuals but may be smaller (100s) or might require larger populations (10,000s), depending on the species and its demographic characteristics. However, occurrences can be ranked A even if population size is not known. For example, for occurrences lacking information on population size, an A rank may be appropriate under the following circumstances: the population is clearly very large but it is not known how large; the area of occupied habitat is exceptionally large; or the occurrence has excellent condition and landscape context and a long history of occurrence persistence. Occurrences with excellent estimated viability are ranked A even if one or more other occurrences have a much larger population size and/or much greater quantity of occupied habitat. In most cases, occurrences ranked A will occupy natural habitats. However, "natural" is an ambiguous concept, and occurrences in "unnatural" conditions (e.g., somewhat modified by human actions) may still be assigned a rank of A if they otherwise meet the criteria.</p>
B Good Viability	<p>Occurrence exhibits favorable characteristics with respect to population size and/or quality and quantity of occupied habitat; and, if current conditions prevail, the occurrence is likely to persist for the foreseeable future (i.e., at least 20-30 years) in its current condition or better. B-ranked occurrences have good estimated viability and, if protected, contribute importantly to maintaining or improving the conservation status of threatened or declining species. For species associated with habitat patches or ephemeral or particularly dynamic habitats, a high-quality occurrence may warrant a B rank if it consists of a single deme rather than a metapopulation (unless the single deme is exceptionally large and robust, in which case an A rank may be appropriate).</p>
C Fair Viability	<p>Occurrence characteristics (size, condition, and landscape context) are non-optimal such that occurrence persistence is uncertain under current conditions, or the occurrence does not meet A or B criteria but may persist for the foreseeable future with appropriate protection or management, or the occurrence is likely to persist but not necessarily maintain current or historical levels of population size or genetic variability. This rank may be applied to relatively low-quality occurrences with respect to size, condition, and/or landscape context if they still appear to have reasonable prospects for persistence for the foreseeable future (at least 20-30 years). Examples include very small non-degraded relict occurrences as well as some remnant occurrences of former landscape-level species such as many extant occurrences of tall-grass prairie insects. These occurrences represent the lower bound of occurrences worthy of protection.</p>

D Poor Viability	<p>If current conditions prevail, occurrence has a high risk of extirpation (because of small population size or area of occupancy, deteriorated habitat, poor conditions for reproduction, ongoing inappropriate management that is unlikely to change, or other factors). Questionably viable occurrences that could be restored to at least fair viability should not be ranked D if restoration is deemed feasible and plausible; in most such cases CD should be used. Very small occurrences that may be vulnerable to deleterious stochastic events may be ranked as follows: If the stochastic event is highly theoretical or of very low probability in the appropriate time frame (e.g., 20-30 years), then a C or CD rank may be appropriate. If a minority of other similar occurrences have disappeared as a result of, say, disease or inbreeding, then perhaps CD is best. If most of these small occurrences have been extirpated or are disappearing due to such events, then D is probably appropriate. The D rank also applies if the population is so small that there will inevitably be a year (or generation) in the near future in which by chance all adults will be the same gender.</p>
E Verified Extant	<p>Occurrence recently has been verified as still existing, but sufficient information on the factors used to estimate viability of the occurrence has not yet been obtained. Use of the E rank should be reserved for those situations in which the occurrence is thought to be extant, but an A, B, C, D, or combination rank cannot be assigned.</p>
F Failed to Find	<p>Occurrence has not been found despite a search by an experienced observer at a time and under conditions appropriate for the Element at a location where it was previously reported, but the occurrence still might be confirmed to exist at that location with additional field survey efforts. For occurrences with vague locational information, the search must include areas of appropriate habitat within the range of locational uncertainty.</p>
H Historical	<p>Recent field information verifying the continued existence of the occurrence is lacking. Examples of this rank include occurrences based only on historical collection data, or occurrences that previously were ranked A, B, C, D, or E but that are now, without field survey work, considered to be possibly extirpated due to general habitat loss or degradation of the environment in the area. H may be applied to recently verified occurrences if two or more competent subsequent efforts that should have found the species did not, or if there has been a known major disturbance since the last observation such that continued existence of the occurrence is in doubt (for example, an isolated Lepidoptera occurrence that was sprayed with Dimilin®).</p>
X Extirpated	<p>Adequate surveys by one or more experienced observers at times and under conditions appropriate for the species at the occurrence location, or other persuasive evidence, indicate that the species no longer exists there or that the habitat or environment of the occurrence has been destroyed to such an extent that it can no longer support the species.</p>

APPENDIX C: SUPPLEMENTARY BACKGROUND INFORMATION

Table C1. Circa 1800 landcover, distinguished by fire-dependent and non-fire-dependent types

Landcover	Acres	Hectares	Class	Proportion
Non-fire-dependent				
LAKE/ RIVER	905	366	Aquatic	0.38%
CEDAR SWAMP	4,703	1,903	Coniferous Lowlands	1.96%
MIXED CONIFER SWAMP	7,493	3,032	Coniferous Lowlands	3.12%
HEMLOCK-WHITE PINE FOREST	4,392	1,777	Coniferous Uplands	1.83%
BLACK ASH SWAMP	353	143	Deciduous Lowlands	0.15%
MIXED HARDWOOD SWAMP	598	242	Deciduous Lowlands	0.25%
ASPEN-BIRCH FOREST	1,975	799	Deciduous Uplands	0.82%
BEECH-SUGAR MAPLE-HEMLOCK FOREST	30,177	12,212	Deciduous Uplands	12.55%
SHRUB SWAMP/ EMERGENT MARSH	741	300	Herbaceous Lowlands	0.31%
Fire-dependent				
JACK PINE-RED PINE FOREST	143,888	58,229	Coniferous Uplands	59.84%
MIXED PINE-OAK FOREST	714	289	Coniferous Uplands	0.30%
OAK/ PINE BARRENS	8,455	3,422	Coniferous Uplands	3.52%
PINE BARRENS	20,366	8,242	Coniferous Uplands	8.47%
WHITE PINE-RED PINE FOREST	14,897	6,029	Coniferous Uplands	6.20%
MUSKEG/ BOG	424	172	Herbaceous Lowlands	0.18%
GRASSLAND	355	144	Herbaceous Uplands	0.15%
	240,436	97,301		
Total non-fire dependent:	51,337	20,775		21.35%
Total fire-dependent:	189,099	76,526		78.65%

Table C2. Wildfires in the Mio District since 1996

Year	Name	Acres	Hectares	Latitude	Longitude
1996	Hagaman Rd Fire	543.54	219.96	44.6319539°N	84.3113724°W
1999	ATV	839.91	339.90	44.6100403°N	84.0637823°W
2000	No Pablo	5,198.67	2,103.83	44.5814885°N	84.0028481°W
2001	Jacobs	196.48	79.51	44.5073312°N	84.2452065°W
2004	Kinsey Hunt	440.85	178.40	44.5624413°N	84.3384136°W
2006	Hughes Lake	5,775.94	2,337.44	44.5371747°N	84.2645713°W
2010	Meridian Boundary	7,588.02	3,070.76	44.5511871°N	84.4404462°W
2012	Little Mack Lake	799.78	323.66	44.5850040°N	84.0935611°W
Unknown	Unnamed	0.06	0.02	44.6165186°N	84.2461241°W
Total:		21,383.24	8,653.49		

Table C3. Habitat preference for plant species in the Mio District: barrens indicator (BI), typical barrens (TP), matrix (M), typical forest (TF), forest indicator (FI), and disturbance-dependent (D).

Species	Comon name	C	W	Phys	BI	TP	M	TF	FI	D
<i>Bromus kalmii</i>	Prairie brome	8	0	Herb	X					X
<i>Sibbaldiopsis tridentata</i>	Three-toothed cinquefoil	10	3	Herb	X					X
<i>Viola sagittata</i>	Arrow-leaved violet	8	0	Herb	X					X
<i>Agoseris glauca</i>	Pale agoseris	9	3	Herb	X					
<i>Anemone cylindrica</i>	Thimbleweed	6	5	Herb	X					
<i>Helianthus occidentalis</i>	Western sunflower	8	3	Herb	X					
<i>Koeleria macrantha</i>	June grass	9	5	Herb	X					
<i>Liatris cylindracea</i>	Cylindrical blazing-star	5	5	Herb	X					
<i>Liatris scariosa</i>	Northern blazing-star	5	5	Herb	X					
<i>Lilium philadelphicum</i>	Wood lily	5	0	Herb	X					
<i>Lithospermum canescens</i>	Hoary puccoon	10	5	Herb	X					
<i>Lithospermum caroliniense</i>	Hairy puccoon	10	5	Herb	X					
<i>Solidago ptarmicoides</i>	Upland white goldenrod	10	3	Herb	X					
<i>Spiranthes lacera</i>	Slender ladies'-tresses	10	0	Herb	X					
<i>Taenidia integerrima</i>	Yellow-pimpernel	8	5	Herb	X					
<i>Viola pedata</i>	Birdfoot violet	9	5	Herb	X					
<i>Arctostaphylos uva-ursi</i>	Bearberry	8	5	Woody		X				X
<i>Artemisia campestris</i>	Wild wormwood	5	5	Herb		X				X
<i>Cyperus houghtonii</i>	Smooth sand sedge	5	5	Herb		X				X
<i>Cyperus lupulinus</i>	Slender sand sedge	2	3	Herb		X				X
<i>Cyperus schweinitzii</i>	Rough sand sedge	5	3	Herb		X				X
<i>Monarda punctata</i>	Horse mint	4	5	Herb		X				X
<i>Nuttallanthus canadensis</i>	Blue toadflax	8	5	Herb		X				X
<i>Polygonum articulatum</i>	Jointweed	8	5	Herb		X				X
<i>Amelanchier sanguinea</i>	Round-leaved serviceberry	5	5	Woody		X				
<i>Amelanchier spicata</i>	Shadbush serviceberry	4	3	Woody		X				
<i>Antennaria howellii</i>	Small pussytoes	2	5	Herb		X				
<i>Antennaria parlinii</i>	Smooth pussytoes	2	5	Herb		X				
<i>Campanula rotundifolia</i>	Harebell	6	3	Herb		X				
<i>Cirsium hillii</i>	Hill's thistle	8	5	Herb		X				
<i>Comptonia peregrina</i>	Sweetfern	6	5	Woody		X				
<i>Crocanthemum canadense</i>	Common frostweed	8	5	Herb		X				
<i>Dichanthelium columbianum</i>	Panic grass	5	3	Herb		X				
<i>Dichanthelium linearifolium</i>	Slender-leaved panic grass	4	5	Herb		X				
<i>Elymus trachycaulus</i>	Slender wheatgrass	8	5	Herb		X				
<i>Festuca altaica</i>	Rough fescue	9	3	Herb		X				
<i>Festuca saximontana</i>	Fescue	6	5	Herb		X				
<i>Fragaria virginiana</i>	Wild strawberry	2	3	Herb		X				
<i>Hieracium kalmii</i>	Canada hawkweed	3	5	Herb		X				
<i>Hieracium umbellatum</i>	Northern hawkweed	7	5	Herb		X				
<i>Hieracium venosum</i>	Rattlesnake-weed	6	5	Herb		X				
<i>Packera paupercula</i>	Northern ragwort	3	0	Herb		X				
<i>Polygala polygama</i>	Racemed milkwort	9	3	Herb		X				
<i>Polytrichum</i> sp.	Hairmoss	NA	NA	Non-vascular		X				
<i>Prunus pumila</i>	Sand cherry	8	5	Woody		X				
<i>Salix humilis</i>	Prairie willow	4	3	Woody		X				
<i>Solidago hispida</i>	Hairy goldenrod	3	5	Herb		X				
<i>Solidago nemoralis</i>	Old-field goldenrod	2	5	Herb		X				
<i>Symphyotrichum laeve</i>	Smooth aster	5	3	Herb		X				
<i>Symphyotrichum urophyllum</i>	Arrow-leaved aster	2	5	Herb		X				
<i>Viola adunca</i>	Sand violet	4	3	Herb		X				

<i>Capnoides sempervirens</i>	Pink corydalis	5	5	Herb	X	X
<i>Corispermum palassii</i>	Bugseed	3	5	Herb	X	X
<i>Danthonia spicata</i>	Poverty grass	4	5	Herb	X	X
<i>Rubus flagellaris</i>	Northern dewberry	1	3	Woody	X	X
<i>Andropogon gerardii</i>	Big bluestem	5	0	Herb	X	
<i>Avenella flexuosa</i>	Hairgrass	6	5	Herb	X	
<i>Carex pennsylvanica</i>	Pennsylvania sedge	4	5	Herb	X	
<i>Cladonia</i>	Reindeer lichen	NA	NA	Non-vascular	X	
<i>Dicranum, Hypnum, Pleurozium</i>	Feather mosses	NA	NA	Non-vascular	X	
<i>Prunus virginiana</i>	Choke cherry	2	3	Woody	X	
<i>Schizachyrium scoparium</i>	Little bluestem	5	3	Herb	X	
<i>Vaccinium angustifolium</i>	Low sweet blueberry	4	3	Woody	X	
<i>Vaccinium myrtilloides</i>	Velvetleaf blueberry	4	-3	Woody	X	
<i>Amelanchier interior</i>	Serviceberry	4	5	Woody		X
<i>Anemone quinquefolia</i>	Wood anemone	5	3	Herb		X
<i>Apocynum androsaemifolium</i>	Spreading dogbane	3	5	Herb		X
<i>Dichanthelium xanthophyllum</i>	Panic grass	6	5	Herb		X
<i>Melampyrum lineare</i>	Cow-wheat	6	3	Herb		X
<i>Oryzopsis asperifolia</i>	Rough-leaved rice-grass	6	5	Herb		X
<i>Piptatherum pungens</i>	Rice-grass	9	5	Herb		X
<i>Pteridium aquilinum</i>	Bracken fern	0	3	Herb		X
<i>Schizachne purpurascens</i>	False melic	5	3	Herb		X
<i>Aralia nudicaulis</i>	Wild sarsparilla	5	3	Herb		X
<i>Asclepias exaltata</i>	Poke milkweed	6	5	Herb		X
<i>Brachyelytrum aristosum</i>	Northern shorthusk	7	5	Herb		X
<i>Chimaphila umbellata</i>	Pipsissewa	8	5	Woody		X
<i>Diervilla lonicera</i>	Bush-honeysuckle	4	5	Woody		X
<i>Dryopteris carthusiana</i>	Spinulose woodfern	5	-3	Herb		X
<i>Dryopteris intermedia</i>	Evergreen woodfern	5	0	Herb		X
<i>Epigaea repens</i>	Trailing-arbutus	7	3	Woody		X
<i>Eurybia macrophylla</i>	Big-leaved aster	4	5	Herb		X
<i>Gaultheria procumbens</i>	Wintergreen	5	3	Woody		X
<i>Hamamelis virginiana</i>	Witch-hazel	5	3	Woody		X
<i>Linnaea borealis</i>	Twinflower	6	0	Herb		X
<i>Maianthemum canadense</i>	Canada mayflower	4	3	Herb		X
<i>Mitchella repens</i>	Partridge-berry	5	3	Herb		X
<i>Trientalis borealis</i>	Star-flower	5	0	Herb		X

<u>Class</u>	<u>C</u>	<u>W</u>
Barrens Indicator	8.1	3.3
Typical Barrens Species	5.2	4.2
Matrix Species	3.9	3.1
Typical Forest Species	4.9	4.1
Forest Indicator	5.4	2.7
Disturbance-dependent	5.6	3.8

APPENDIX D: SUPPLEMENTAL RESULTS

Table D1. Restorable RFDS areas

Comp:Stand	Community	Acres	Notes	Managed
40:20, 34	Oak-pine barrens, dry northern forest	112.62	The Wakely Lake area is a broadly fire-adapted landscape centered on a large wetland complex. A pine barrens remnant occurs in Stand 20 and the unnumbered stand immediately southeast, while Stand 34 supports low-quality dry northern forest. Use Wakely Lake and the surrounding wetlands as natural control lines for landscape-scale prescribed fire, with minimal mechanical disturbance within and around the barrens remnant. Allow a natural forest buffer to develop in Stand 34, and consider natural red pine management in suitable forests elsewhere around the wetland complex.	No
57:1; 59: 3, 14, 19, 20	Dry northern forest; oak-pine barrens	203.73	These stands in the McMasters West project area form a potential core for expanding the red-pine-dominated landscape around Claudia Trail and River Lake Road dry northern forests (EOID 28006, 28009). To the north toward Comp 59, Stand 3, structure becomes more heterogenous, supporting oak-pine barrens. Similar structure occurs to the north in Comp 61.	No
61:8, 20	Pine barrens	53.44	Borderline EO with additional pockets potentially worthy of survey. A series of openings occurs along drainages and kettle depressions, with scattered old trees and localized pockets of good plant diversity. Overall composition is generally simplified, and some areas contain unusual furrows that may reflect past scarification.	No
66:37	Pine barrens	69.16	Borderline pine barrens EO with additional pockets potentially worthy of survey. Although small and bordered by areas of substantial soil disturbance, the site retains locally high plant diversity, including rough fescue, and supports green snake. The occurrence could serve as a core within a larger project area incorporating other suitable pockets in western Stand 37.	No

70:13, 14, 22, 23	Pine barrens, dry northern forest	207.98	Within the McMasters East project area. These stands form a management that could increase connectivity between multiple EOs, including South Branch Woods (EOID 27662), Meridian-Markle Barrens (EOID 27708), and Eldorado Pines (EOID 28185)	No
78:1,2	Pine barrens	82.13	This stands comprise a small, isolated pocket of restorable pine barrens. Burned during the Meridian Fire. This recoverable pine barrens features a narrow band of maturing red pine within surrounding jack pine, with localized pockets of higher plant diversity, particularly in the frost pocket and cold-air drainage in Stand 24. Although diversity is lower than in the best examples, the area retains heterogeneous structure and could likely reach EO condition following prescribed fire. Do not convert to plantation.	No
81:10, 14, 24	Pine barrens, oak-pine barrens	126.45	Parts of these restorable pine barrens are former red pine plantation, burned in the Jacobs Fire 2001. Potential core for increasing connectivity between here and the Mio Prairie Expansion and the eastern extent of the Hughes Lake Fire scar, including Hughes Lake pine barrens (EOID 28069).	No
126:19, 22, 24	Pine barrens	77.15	Within the Luzerne Region project area. These stands surround Merrit Prairie EOID 28153 and represent highly restorable, fire-suppressed oak-pine barrens. Including these stands in fires and other management in Merrit Prairie could appreciably increase the size of that EO.	No
129:14, 15, 16, 19	Oak-pine barrens	105.81		No

131:39, 40	Oak-pine barrens	79.77	Borderline oak-pine barrens EO with ongoing USFS management. The site retains good structure and consistent pockets of characteristic vegetation throughout Stand 40 and western Stand 28. Drainages in western Stands 40 and 39 support indicator species and good structure, although diversity is generally low. Stand 34 contains additional high-quality but isolated concentrations of barrens vegetation. Overall composition is simplified, and adjacent forests are low quality, but the site could serve as a core for continued openings work and broader landscape-scale prescribed fire.	No
179:17	Pine barrens	190.34	Burned in Little Mack Lake Fire 2012. Good heterogenous jack pine regeneration and many barrens indicator species in the ground layer. Continuing to manage with low-severity fire could increase value as both a natural community and as fuelbreak for Mack Lake area.	No
185:28, 29, 33, 37, 38, 40	Pine barrens, intermittent wetland, bog	251.76	Stands 29 and 30 support a mosaic of young dry northern forest and fire-suppressed pine barrens, with small, pocket wetlands in some frost pockets. Stands 33, 37, 38, and 40 have good barrens structure. There are sufficient barrens indicators in the ground layer to suggest a restorable landscape. Potentially other adjacent stands could be including that were not surveyed.	No

233:6	Pine barrens	158.69	Several isolated remnants pine barrens patches persist within a large fire-suppressed landscape that has largely converted to dry northern forest. Contains an existing USFS-managed opening that appears to have been scarified and possibly planted, also a small but high-quality dry sand prairie within a subtle drainage. Additional pockets of high plant diversity occur above the stream. Existing roads to the west and a major stream to the east provide favorable control lines for landscape-scale prescribed fire. Management could integrate pine barrens recovery with natural red pine techniques, while limiting ORV access and avoiding further conversion to jack pine plantation. Despite its isolation within a heavily altered landscape, the area is large, contains several strong ecological cores, and has excellent recovery potential.	No
646: 9, 10, 12, 17, 32	Dry sand prairie	16.38	A series of frost pockets, 1-8 acres, supporting restorable dry sand prairie with local pine barrens structure. Much of surrounding area is red pine plantation. Comp 702, Stand 32 and Comp 703, Stand 18 provide potential buffer for O'Brien dry northern forest (EOID 5690), and core for connecting natural communities in those stands to other recoverable stands in 703. Stands 4, 10, 15, 16, and 19 comprise a combination of fire-suppressed, restorable barrens and managed openings that harbor some barrens indicator species.	No
702:32; 703: 4, 10, 15, 16, 18, 19	Oak-pine barrens, pine barrens	263.09	This is Lost Creek Barrens Management Area. Canopy structure is overgrown or lacking in areas, but regeneration of jack pine and retention of red pine form a great backbone for restoration.	No
134:4, 8; 135:6	Pine barrens	333.46	Within the Mio Prairie Expansion project area. Of all the stands in the area, these are the least degraded and support the highest concentrations of barrens indicator species and/or representative structure. Including these stands in burns with increase abundance of indicator species in the project area.	Yes
148:11; 151:1, 7, 13; 152: 7, 10, 14, 22	Pine barrens, dry northern forest	370.51		Yes

156:36	Pine barrens	45.46	This is Watson Road Opening, near the East Branch Region project area. Some representative function and structure, but concentrated in retained jack pine islands and site apparently otherwise scarified or furrowed. Could function as an anchor for expanding East Branch Big Creek pine barrens (EOID 27504).	Yes
179:14, 24; 205: 2, 3, 4, 6, 8, 15, 16, 17, 18; 206: 2, 21, 22, 24	Pine barrens	446.15	Firebreaks due south of Mack Lake. Considerable representative composition and structure. Manage tree densities to avoid possibility of crown fires, but otherwise manage with low-severity fire to maintain jack pine component and diversity of forbs and graminoids.	Yes
		1998.50	new	
		1195.58	existing	
		3194.08	total	

Table D2. Existing management areas in Mio District, results of natural community evaluation.

Comp	Stand	Acres	History	Group Name	Class	Natural Community	EOID
12	5	72	Unknown	Chase Bridge Barrens	Degraded	Pine Barrens	NA
44	8	70	Red pine plantation (1970)	South Branch Barrens	Degraded	Pine Barrens	NA
45	24	212	Unknown	South Branch Barrens	Degraded	Pine Barrens	NA
111	10	49	Barrens	Red Creek Barrens	Degraded	Pine Barrens	NA
111	11	8	Unknown	Red Creek Barrens	Degraded	Pine Barrens	NA
111	17	58	Unknown	Red Creek Barrens	Degraded	Pine Barrens	NA
112	6	30	Unknown	Red Creek Barrens	Degraded	Pine Barrens	NA
112	14	44	Unknown	Red Creek Barrens	Degraded	Pine Barrens	NA
153	30	37	Burned by Hughes Lake Fire 2006 -- Updated from gps files taken by helicopter on the Hughes Lake Fire	Mio Prairie	Degraded	Pine Barrens	NA
647	29	51	FY 90 WILDLIFE OPENING-HYDROAXE CONTRACT.PLANTED FY 92 WARM SEASON GRASS 20AC WILDFIRE AREA. PBURNED FY91. -- Updated for wildlife opening contract by jcasey	Rogers Opening	Degraded	Pine Barrens	NA
88	42	65	Unknown	Meridian-Markle Barrens	EO	Pine Barrens	27708
88	43	58	Unknown	Meridian-Markle Barrens	EO	Pine Barrens	27708
129	27	25	Unknown	Merritt Prairie	EO	Oak-Pine Barrens	28158

147	20	78	ROLL CHOPPED. ALLEGHENY PLUM IN STAND. STAND HAS BEEN CLEARED FOR PRAIRIE RESTORATION. INCLUDE WITH ADJOINING STANDS AND BURN -- Updated for silvexam contract of new acquisition	Mio Prairie	EO	Pine Barrens	28160
149	4	138	Prairie. Combined stands 4, 8, 9, 10 and 19. -- Updated by phuber and leah AKA "State 80"	Mio Prairie	EO	Dry Sand Prairie	11050
151	19	295	Unknown	Mio Prairie	EO	Pine Barrens	28018
45	21	66	Unknown KW ESS. HAB. OLD DIAMETER CUT -- Updated by phuber and leah	South Branch Barrens	NA	NA	NA
149	7	3	Burned by Hughes Lake Fire 2006	Mio Prairie	NA	NA	NA
152	16	4	Some fuelbreak creation in this stand along Moccasin Trail Road	Mio Prairie	NA	NA	NA
152	26	18	PU 2 OF FOOTPRINT SALE. CULTURAL RESOURCE SITE ADJACENT TO SW CORNER OF STAND. Average of 0.7" radial growth past 10 yrs. -- Updated from gps files taken by helicopter on the Hughes Lake Fire	Mio Prairie	NA	NA	NA
152	28	16	KW ESS. HAB. JACK PINE GRASS PRAIRIE. PU 5 HOWARD SALVAGE. MISTAKENLY PLANTED TO JP SOUTH OF ROAD. MANAGE FOR KW, THEN PRAIRIE. Average dia. 1" - 3-5 Ft tall -- Updated from gps files taken by helicopter on the Hughes Lake Fire	Mio Prairie	NA	NA	NA
152	31	43		Mio Prairie	NA	NA	NA

153	3	11	PART OF HOWARD SALVAGE. -- Updated from gps files taken by helicopter on the Hughes Lake Fire KW ESS. HAB. PU 1 HOWARD SALVAGE, WILL BE KW HAB. GRAVEL LAYER 2-3 FT UNDERNEATH FALL PLANTED W/CONTAINERIZED SEEDLINGS FROM MEAD CORP. EVALUATE PRAIRIE MANAGEMENT AFTER WARBLERS LEAVE. Very thick regen 1-2" in diameter -- Updated from gps files taken by ASPEN IN KW HAB., DEFER CUTTING TO PREVENT CLONING. - - Updated from gps file from prairie_home sale	Mio Prairie	NA	NA	NA
153	31	63	from gps files taken by ASPEN IN KW HAB., DEFER CUTTING TO PREVENT CLONING. - - Updated from gps file from prairie_home sale	Mio Prairie	NA	NA	NA
149	12	3	Unknown	Mio Prairie	Other	Aspen	NA
63	18	97	Unknown	McMasters Barrens	Plantation	Former weave	NA
65	2	40	Unknown	Sunrise Barrens	Plantation	Former weave	NA
65	4	118	Unknown	Sunrise Barrens	Plantation	Former weave	NA
146	21	70	KW ESS. HAB. PLANTATION. SOME RP IN EAST ARM. KW BLOCK II. Sandpiper-PU #6 cut/remove 12/06/99. PU 3 cut/removed 01/06/00. PU #1 cut/removed 05/16/2000. PU #2 cut/removed 05/16/2000. -- updated from gps file for sandpiper sale	Mio Prairie	Plantation	Former weave	NA
146	24	98	KW ESS. HAB. DOGWOOD,CHRY, HAWTHORNE, ASP-KW BLOCK II. BUDWORM DAMAGE.PU 3 cut/removed 01/05/00. PU #5 cut/removed 01/27/00. -- Updated from gps files for sandpiper reforestation	Mio Prairie	Plantation	Former weave	NA

149	2	293	KW ESS. HAB. HEAVY BUDWORN INFEST. 1990. ALLEGHENY PLUM ALONG HOWARD ROAD. PU 1,2,3 PRAIRIE HOME SALE PU1 cut 4/6/99. PU 2 cut 3/2/00. -- Updated from gps files fro prarie home sale reforestation - stand was split due walkthrough only - verified forest type density only; ave. dbh 1-2"; height 6-12 feet; oak and patches of aspen regen present; reserve trees mostly red pine & few oak.	Mio Prairie	Plantation	Former weave	NA
149	11	91	Valley. Was part stand 11. Natural JP regen. Manage as prairie next rotation. -- Updated from gps file from prairie_home sale Opening created in 2018	Mio Prairie	Plantation	Former weave	NA
149	15	31	pathetic thinning job, not even a 1/2 a__ job, a 1/132 a__ job at best - west 1/2 is part of LOLI burn block 1, east 1/2 is part of LOLI burn block 2, part of unit 1 burned FY 12, the remainder in FY 2013. FY 2022 exam for union corners: stand has been	Mio Prairie	Plantation	Former weave	NA
151	14	65	t	Mio Prairie	Plantation	Plantation	NA
134	4	202	Unknown	Lost Creek Barrens	Recoverable	Pine Barrens	NA
134	8	55	Unknown	Lost Creek Barrens	Recoverable	Pine Barrens	NA
135	6	76	Unknown	Lost Creek Barrens	Recoverable	Pine Barrens	NA
148	11	103	ORIGINAL PRAIRIE RESTORATION AREA. BURN -- Updated for silvexam contract of new acquisition	Mio Prairie	Recoverable	Pine Barrens	NA

151	1	58	REMOVED FROM KW ESS. HAB. VARIED AGES, ASP REPRO MIXED IN W, JP 30 YRS OLD THRU STND. gravel storage area in NW corner.	Mio Prairie	Recoverable	Dry Northern Forest	NA
151	7	9	STAND IS UPLAND BRUSH OF GREYDOGWOOD- WILLOW AND ASPEN. Prairie opening. Lolipop burn unit 4. Burned 11/01. -- Updated by phuber and leah	Mio Prairie	Recoverable	Dry Northern Forest	NA
151	13	31	REMOVED FROM KW ESS. HAB. INCL. PREV. STDS. 7, 12, 13, 16, PART 8, 9. PU 4, 5, PT. 6 HUGHES LK. SALE. Average diameter 2-3" - 10-15 feet tall Burned by Hughes Lake Fire 2006 -- Updated for Blackbird Salvage Sale	Mio Prairie	Recoverable	Pine barrens	NA
152	7	110	Burned by Hughes Lake Fire 2006 KW ESS.	Mio Prairie	Recoverable	Pine barrens	NA
152	10	12		Mio Prairie	Recoverable	Pine barrens	NA
152	14	35	Burned by Hughes Lake Fire 2006.	Mio Prairie	Recoverable	Pine barrens	NA
152	22	13	Burned by Hughes Lake Fire 2006 -- Updated for Blackbird Salvage Sale Barrens Combined stands 36, 7, 41, and 38 -- GPS by plyden	Mio Prairie	Recoverable	Pine barrens	NA
156	36	45	6/30/2009	Watson Rd	Recoverable	Pine barrens	NA
179	14	34.15	New Mack Lake Fuelbreak 2008 -- Updated by GPS file from fire	Mack Lake Fire Break	Recoverable	Pine barrens	NA
179	24	9.19	Fuelbreak along Eggleston Road. created by Vortex timber sale, maintain every 3 to 5 years, was part of stand 15 -- Updated from gps file for eggleston and warbler fuelbreaks	Mack Lake Fire Break	Recoverable	Pine barrens	NA

205	2	176.83	Combined with stands 3,4,6,8,9,10,11 -- Updated from gps file for eggleson and warbler fuelbreaks	Mack Lake Fire Break	Recoverable	Pine barrens	NA
205	3	5.44	Opening updated by jchenoweth 6/2006 for Mack Lake Opening Project -- Updated by jchenoweth from doq openings	Mack Lake Fire Break	Recoverable	Pine barrens	NA
205	4	2.1	Opening updated by jchenoweth 6/2006 for Mack Lake Opening Project -- Updated by jchenoweth from doq openings	Mack Lake Fire Break	Recoverable	Pine barrens	NA
205	6	5.36	Opening updated by jchenoweth 6/2006 for Mack Lake Opening Project -- Updated by jchenoweth from doq openings	Mack Lake Fire Break	Recoverable	Pine barrens	NA
205	8	67.3	fuelbreak on south end of Mack Lake subdivision, maintained in 2006, maintain every 3 to 5 years -- Updated with GPS file for fuelbreak 2008	Mack Lake Fire Break	Recoverable	Pine barrens	NA
205	15	32.29	fuelbreak on south end of Mack Lake subdivision, maintained in 2006, maintain every 3 to 5 years -- Updated from gps file for eggleson and warbler fuelbreaks	Mack Lake Fire Break	Recoverable	Pine barrens	NA
205	16	14.41	fuelbreak along Co. Road 604, maintained in 2006, maintain every 3 to 5 years -- Updated by jchenoweth from doq openings	Mack Lake Fire Break	Recoverable	Pine barrens	NA
205	17	9.76	Fuelbreak on Eggleson Road, created by Vortex timber sale, was part of stand 2, maintain every 3 to 5 years -- Updated from gps file for eggleson and warbler fuelbreaks	Mack Lake Fire Break	Recoverable	Pine barrens	NA

205	18	4.5	Fuelbreak along Warbler road, created by Vortex timber sale, was part of stand 2, maintain every 3 to 5 years -- Updated from gps file for eggleson and warbler fuelbreaks	Mack Lake Fire Break	Recoverable	Pine barrens	NA
206	1	5.98	<Null>	Mack Lake Fire Break	Recoverable	Pine barrens	NA
206	2	18.58	fuelbreak along Co. Road 604, maintained in 2006, maintain every 3 to 5 years -- Updated by jchenoweth from doq openings	Mack Lake Fire Break	Recoverable	Pine barrens	NA
206	21	18.76	Addition to Mack Lake Fuelbreaks -- Updated with GPS for Fuelbreaks	Mack Lake Fire Break	Recoverable	Pine barrens	NA
206	22	37.63	<Null>	Mack Lake Fire Break	Recoverable	Pine barrens	NA
206	24	3.87	Fuelbreak - maintain every 3 to 5 years - created by Vortex timber sale -- Updated from gps file for eggleson and warbler fuelbreaks	Mack Lake Fire Break	Recoverable	Pine barrens	NA