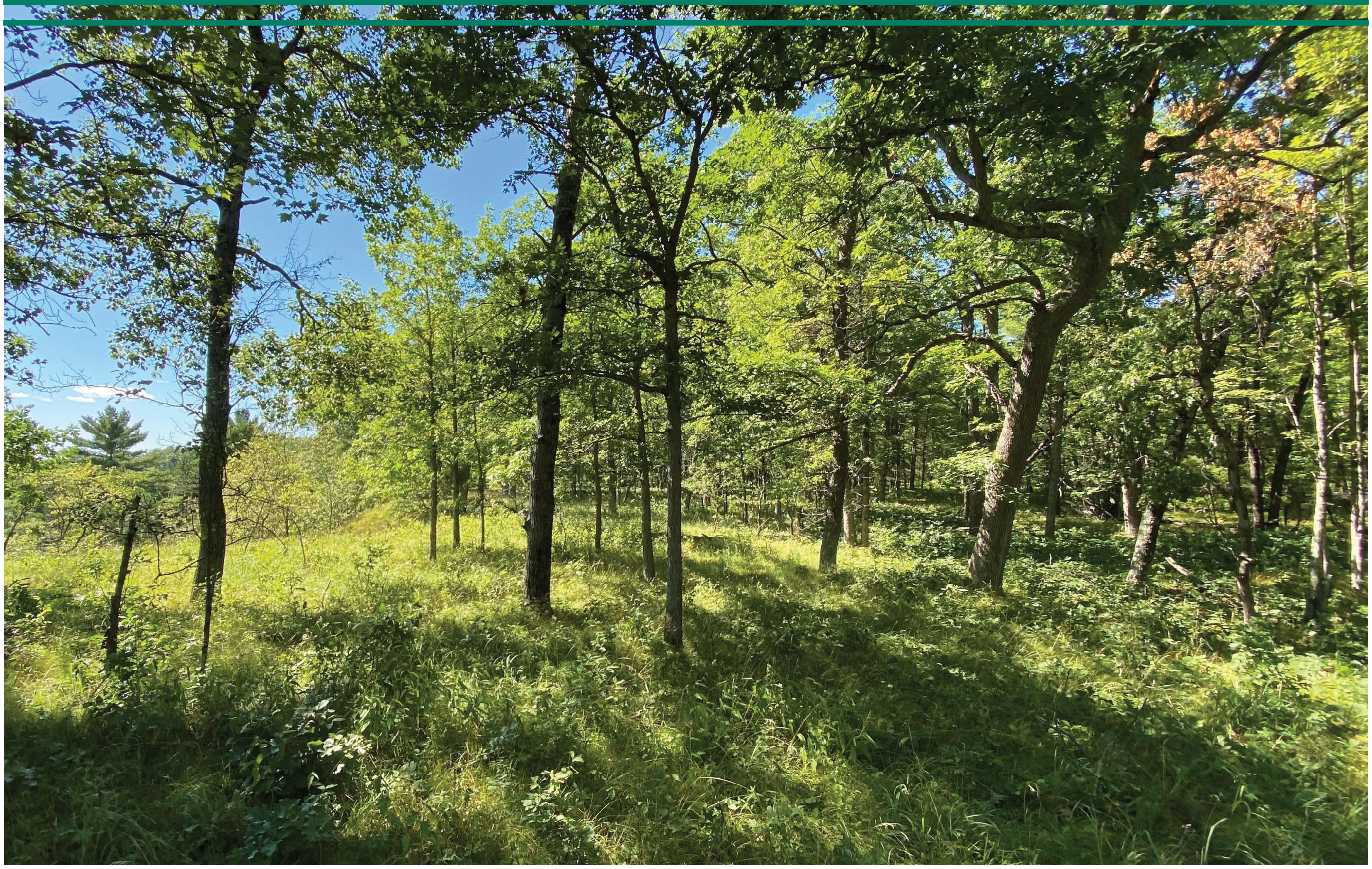
Identifying Recoverable, Fire-Dependent Systems in The Cadillac-Manistee District of the Huron-Manistee National Forest



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Michigan Natural Features Inventory and Huron-Manistee National Forest staff on a site visit to an oak-pine barrens. Photo by Joshua G. Cohen.

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Cover Photo: Pine River Oak-Pine Barrens. Photo by Jesse M. Lincoln, 2022. All pictures by Jesse M. Lincoln unless otherwise noted.

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Introduction

There are several types of fire-dependent natural communities in Michigan. In the past, lightning- and human-set fires frequently spread over large areas of the landscape, helping to reduce colonization by trees and shrubs, fostering regeneration of fire-dependent species, and maintaining the open structure of these fire-dependent ecosystems. In the absence of frequent fires, prairies, barrens, and savannas have converted to closed-canopy forests dominated by shade-tolerant native and invasive species. The conversion of prairie, barrens, and savanna ecosystems to closed-canopy forest typically has resulted in significant reductions in species and habitat diversity (Cohen et al. 2021).

The Huron-Manistee National Forests (HMNF) consists of about 1 million acres divided into four districts in the Northern Lower Peninsula of Michigan. The Cadillac-Manistee District oversees approximately 250,000 acres in the northwestern portion of the Lower Peninsula. Managers of the district are responsible for promoting native biodiversity and protecting high-quality examples of natural communities. The HMNF partnered with the Michigan Department of Natural Resources (DNR) and Michigan Natural Features Inventory (MNFI) to identify examples of recoverable, fire-dependent systems (RFDS) within the Cadillac-Manistee District during the 2022 field season. We define RFDS as remnant patches of fire-dependent natural communities with concentrations of indicator species and the potential for recovery to a level of substantial conservation value with stewardship intervention. These natural communities and many of the species associated with them are considered fire-dependent, in that their long-term persistence is contingent on regular and recurring fire.

MNFI is Michigan's natural heritage program and maintains a geospatial database of populations of rare and declining plants and animals and benchmark ecosystems. There have been numerous high-quality natural communities documented in the Cadillac-Manistee District, including bog, northern hardwood swamp, rich conifer swamp, northern wet meadow, floodplain forest, hardwood conifer swamp, mesic northern forest, dry-mesic northern forest, emergent marsh, and intermittent wetland (MNFI 2022). But there was only one documented dry sand prairie and no high-quality examples of barrens or other prairie community types documented from the district prior to the 2022 surveys.

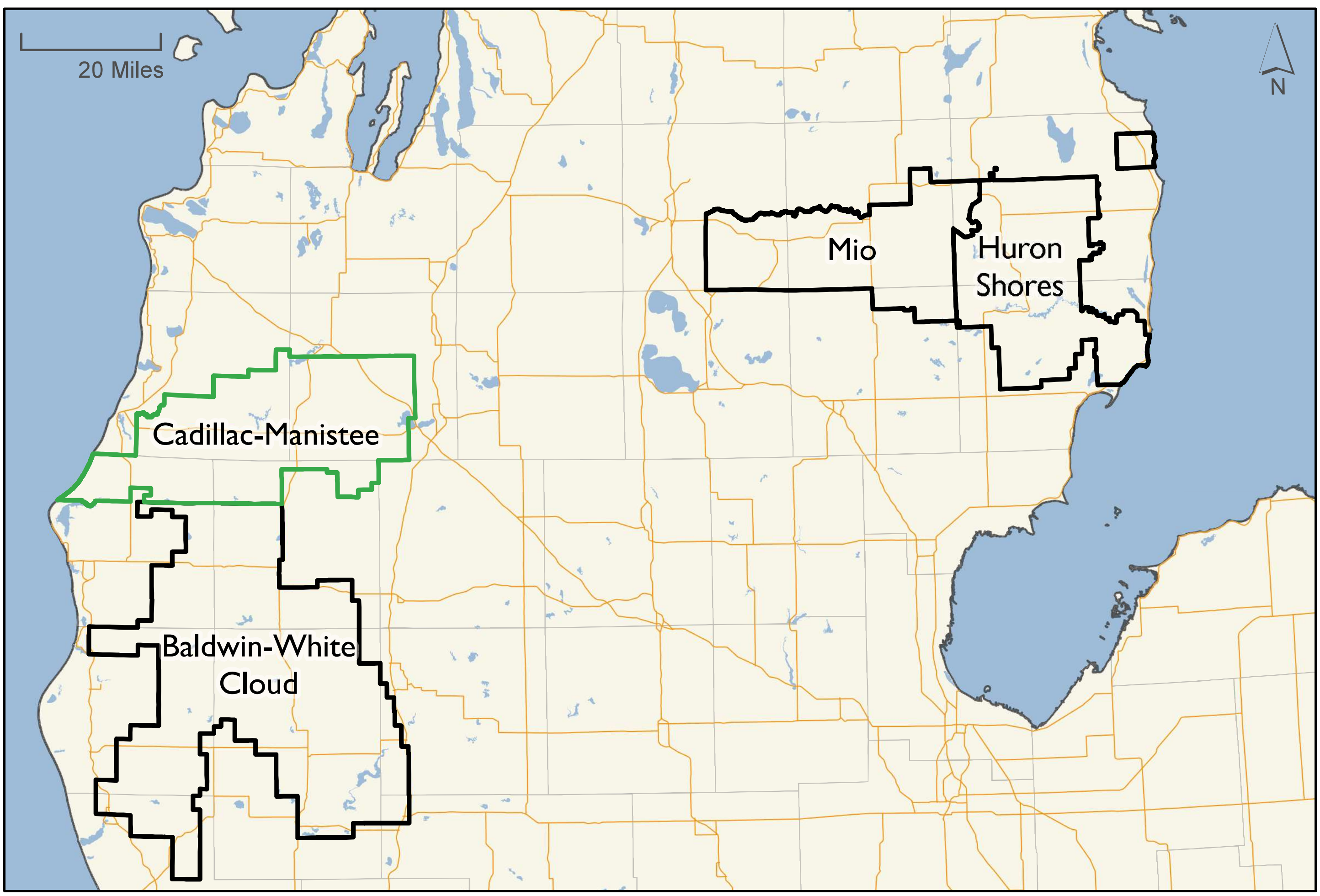

Figure 1. The Huron-Manistee National Forest with The Cadillac-Manistee District highlighted.

MNFI has developed a prescribed fire needs assessment model for Department of Natural Resources (DNR) land in Michigan. The model uses a range of factors to determine approximate intervals for applying prescribed fire to particular areas. The model was adapted for the Cadillac-Manistee District and used to direct targeted field surveys for the purpose of finding RFDS. This report provides a brief description of MNFI's modeling efforts and highlights the areas identified by the model and subsequent ground survey efforts as RFDS. In addition, we provide detailed information about the fire-based ecological stewardship of these important conservation targets. The goal of this project is to identify and evaluate the best examples of fire-dependent natural communities in the Cadillac-Manistee District using MNFI's prescribed fire needs assessment model and expert interpretation.

The natural communities identified in the district were surveyed and specific stewardship recommendations were developed to help District managers protect and sustain the best examples of recoverable, fire-dependent systems in the District. We believe this approach is the best chance to recognize, prioritize, and stabilize the remaining cores of prairie and barrens remnants to create a more diverse and resilient landscape that prevents continuing loss of rare natural communities and the species that rely on them.

Pine barrens are characterized by widely spaced trees and diverse herbaceous vegetation.

The Cadillac-Manistee District features extensive natural cover including this hillside prairie along the Pine River. Photo by Tyler J. Bassett.

Landscape Context

Michigan has been sub-divided into ecoregions based on glacial features, climate, and characteristic ecosystems (Albert 1995). This classification system provides a framework for understanding the distribution patterns of species, natural communities, natural disturbance regimes, and anthropogenic activities. The classification is structured with three levels, from broad landscape regions called Sections, down to smaller Subsections and Sub-subsections. The Cadillac-Manistee District occurs within the Northern Lacustrine-Influenced Lower Michigan Section and the Newaygo Outwash Subsection (Albert 1995). The Newaygo Outwash Subsection is characterized by extensive sandy outwash plains. These sandy plains are features of deep sands deposited by outwash events from melting glaciers. As a result of the sandy deposits, many areas throughout the region have excessively- and well-drained soils that support fire-dependent natural communities (Albert 1995). The Subsection also forms a cold air drainage from the adjacent high plains and therefore late-season frosts are relatively prevalent.

Figure 2. LiDAR imagery is especially useful for understanding the complex post-glacial landforms of the area.

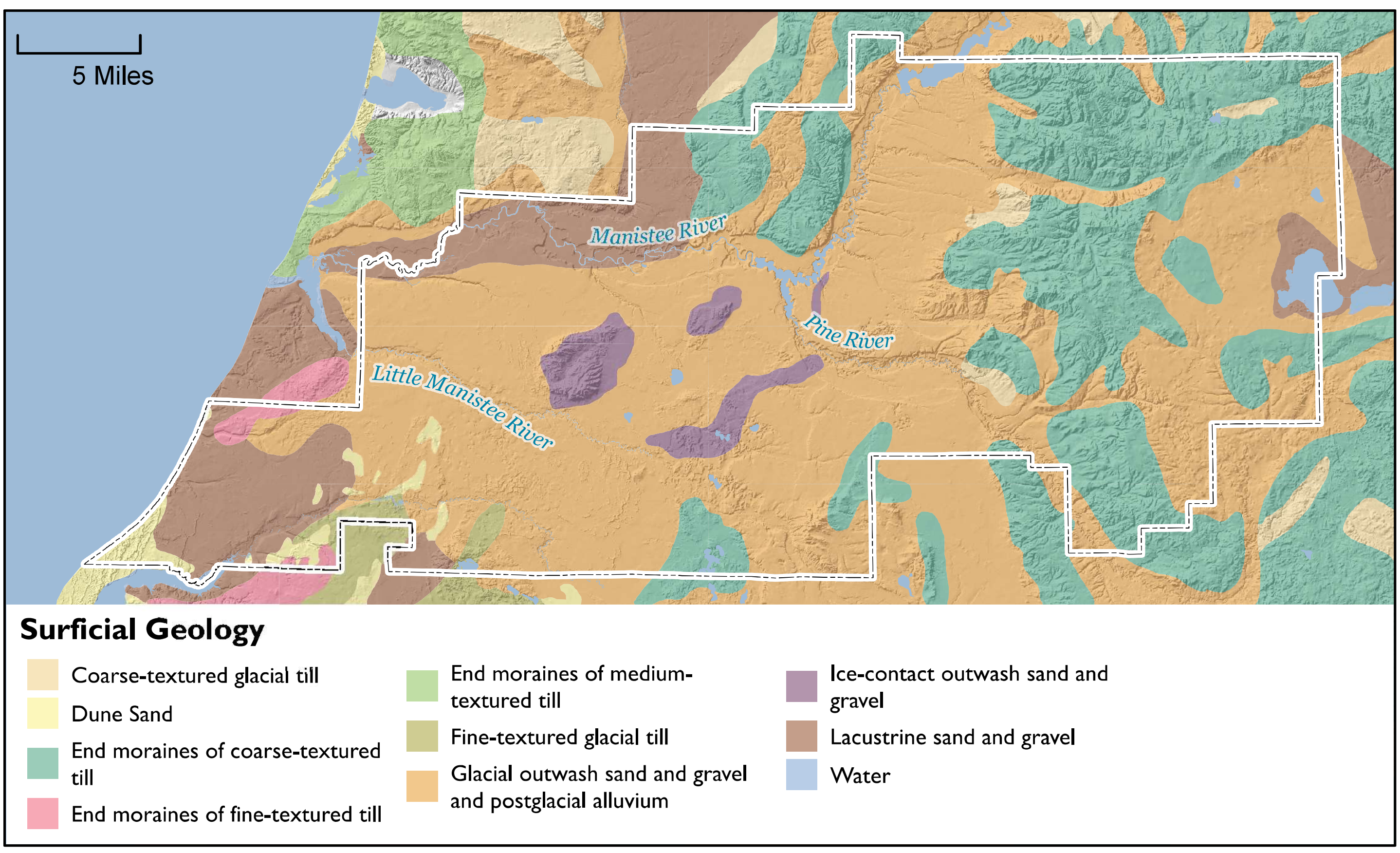

Figure 3. Surficial geology of the Cadillac-Manistee District.

Interpretations of the General Land Office (GLO) surveyor notes by MNFI ecologists indicated that the Cadillac-Manistee District and surrounding area contained several distinct vegetation assemblages (Comer et al. 1995; Figure 4). The GLO survey notes of eastern Manistee County were recorded in 1839 by John Brink (Michigan Library and Historical Center, accessed December 2022). The surveys record information on tree species composition, tree size, and general condition of the lands in the area. The district was predominantly forested at the time of the surveys in 1830s, with an estimated 84% of the District supporting upland forested ecosystems. The predominant forested cover types included beech-sugar maple-hemlock forest (34.4%), white pine-red pine forest (24.3%), white pine-mixed hardwood forest (13.2%), jack pine-red pine forest (7.1), and hemlock-white pine forest (4.7%). Pine barrens covered an estimated 3.6% and oak-pine barrens about 0.1% of the District. (Comer 1995) The remainder of the covertypes and their abundance are detailed in Table 1.

Table 1. Abundance of historic cover types based on notes from GLO surveys conducted in 1839.

Circa-1800 Cover Type	% Cover
BEECH-SUGAR MAPLE-HEMLOCK FOREST	34.4
WHITE PINE-RED PINE FOREST	24.3
WHITE PINE-MIXED HARDWOOD FOREST	13.2
JACK PINE-RED PINE FOREST	7.1
HEMLOCK-WHITE PINE FOREST	4.7
PINE BARRENS	3.6
MIXED CONIFER SWAMP	3.5
CEDAR SWAMP	3.0
WHITE PINE-WHITE OAK FOREST	2.4
MIXED HARDWOOD SWAMP	2.1
LAKE/RIVER	0.6
BLACK ASH SWAMP	0.4
SHRUB SWAMP/EMERGENT MARSH	0.4
SAND DUNE	0.0
OAK/PINE BARRENS	0.1
MUSKEG/BOG	< 0.1
ASPEN-BIRCH FOREST	< 0.1
HEMLOCK-YELLOW BIRCH FOREST	< 0.1

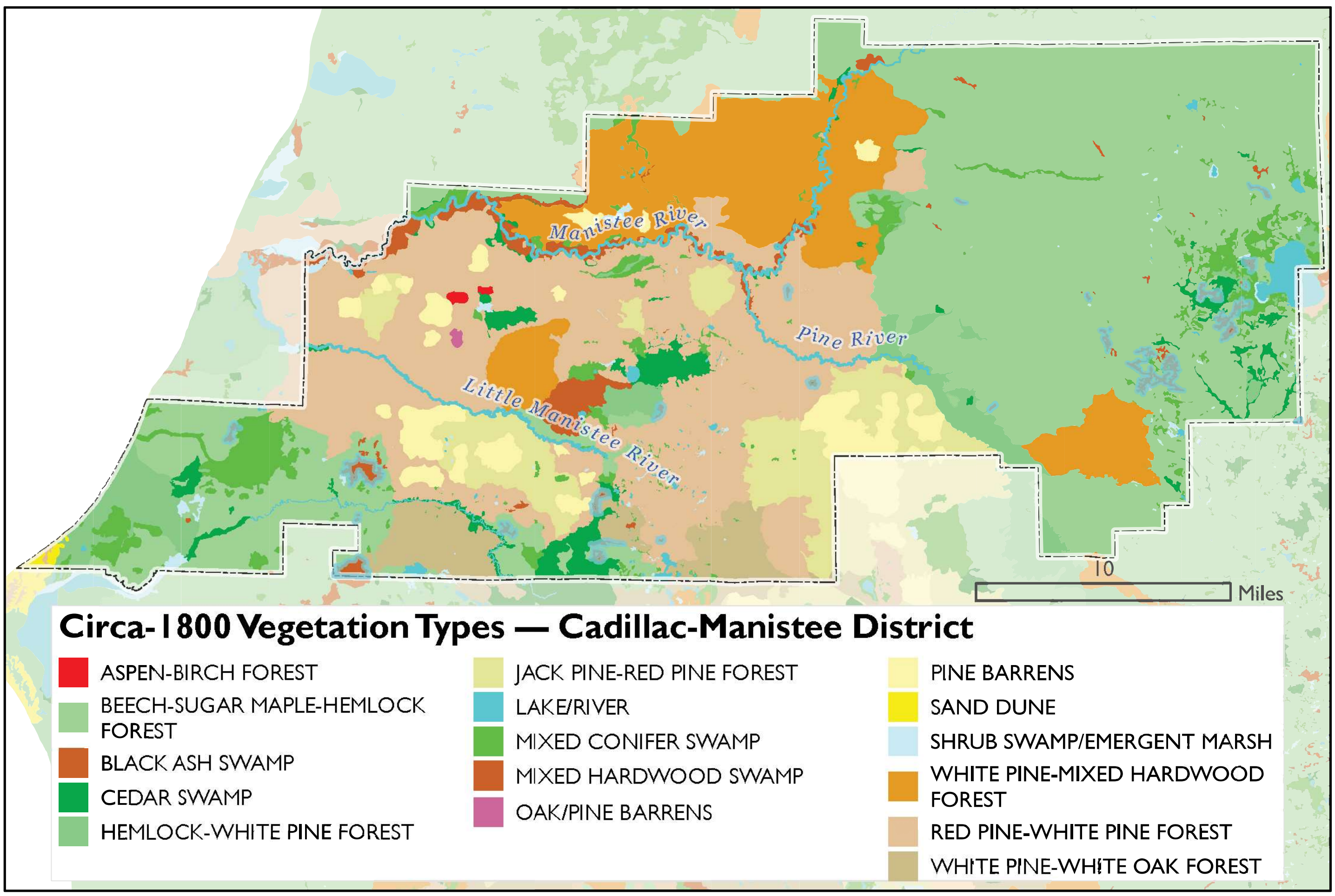

Figure 4. Vegetation of the Cadillac-Manistee District circa 1800 (Comer 1995).

The GLO surveys were a coarse-scale assessment. Some small-scale expressions of natural communities such as dry sand prairie in frost pockets, hillside prairie along rivers, and barrens were often not captured in the GLO notes. The broader region was occupied by Indigenous Peoples for thousands of years and fire was likely used to manage the vegetation across the region. With the removal of Indigenous People and the cessation of cultural fire, it is likely that many open fire-dependent systems quickly converted to forest by the time of the GLO surveys in the 1830s.

Barrens and prairies were once part of a heterogenous landscape where distribution of natural communities partially shifted over time, depending on landforms and patterns of disturbance. This shifting mosaic of fire-dependent natural communities created a complex and dynamic landscape. 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).

The shifting mosaic model no longer applies to the landscape 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. Because of these complex land-use histories, changes in disturbance regimes, and degrading aspects of modern land use, the remaining examples of these natural communities can be difficult to locate and identify.

Despite being relatively minor components of the landscape and persisting in a somewhat degraded state, barrens and prairie remnants continue to support high biodiversity and are especially valuable targets for biodiversity conservation. Protecting and managing representative natural communities is critical to biodiversity conservation because native organisms are best adapted to environmental and biotic forces with which they have survived and evolved over millennia (Cohen et al. 2015). Biodiversity is most easily and effectively protected by preventing high-quality sites from degrading. This project is ultimately aimed at directing restoration efforts to the best examples of RFDS on the district.

The hillsides along the Pine River support several areas with barrens structure and concentrations of characteristic vegetation. The structure and composition of the barrens could be improved and expanded with prescribed fire.

Methods

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 Cadillac-Manistee 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, 2020). 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 Cadillac-Manistee 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,

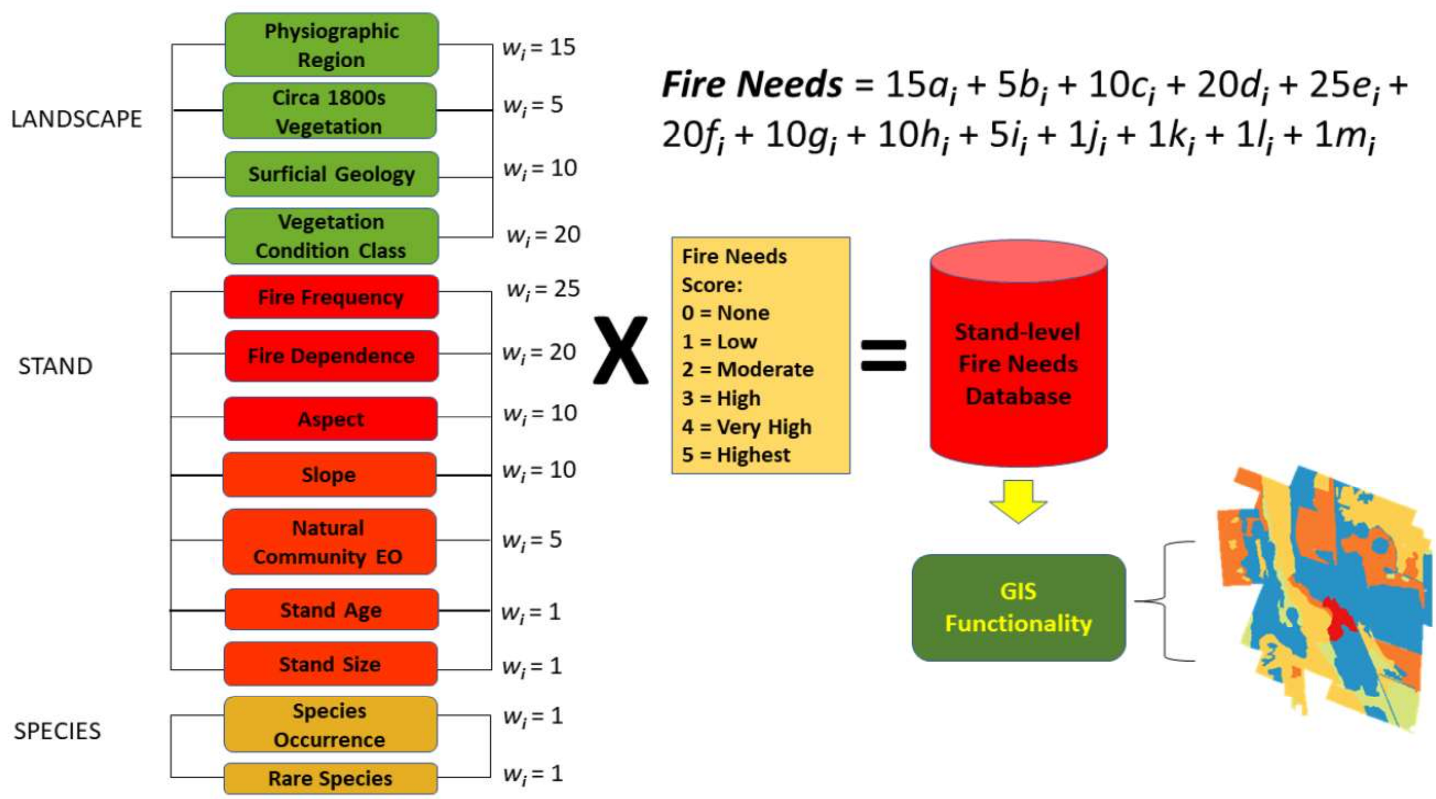

Figure 5. Conceptual framework of the Prescribed Fire Needs Assessment Model. This model gauges each stand's ecological need for prescribed fire based on an array of spatial variables and the presence of fire-dependent and fire-sensitive species. For each stand, multiple input variables at multiple scales 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).

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 5). 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 5 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.

Once there was an output (Figure 6), we assessed areas with concentrations of stands with high-fire scores. We consulted with HMNF staff and analyzed topography and texture of aerial imagery helped identify priority areas to survey. A list of target compartments was generated and given to the district to comment on. After comments from the district, a final list of priority survey areas was developed (Table 2, Page 10).

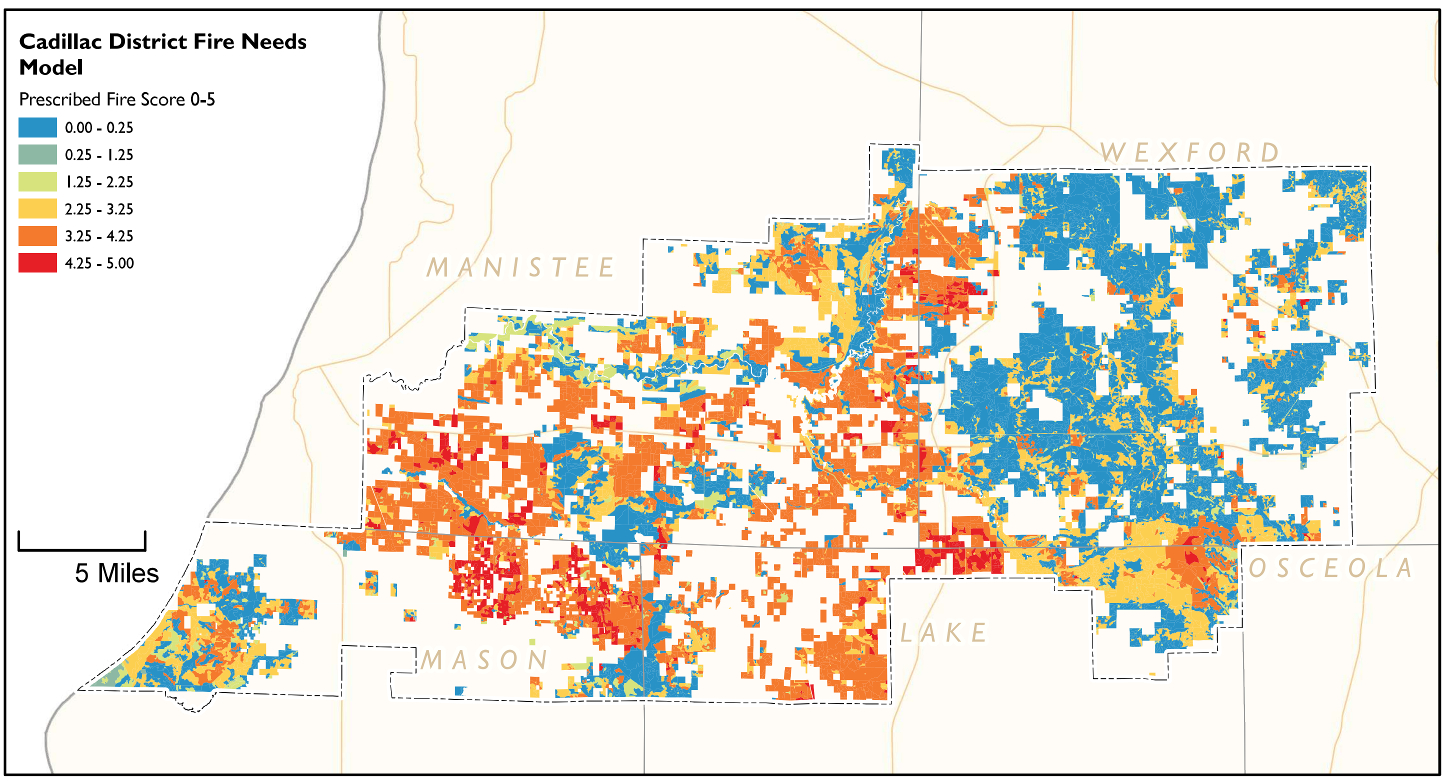

Figure 6. Output of the prescribed fire needs assessment model.

Surveys

We conducted targeted surveys for natural communities in portions of 14 compartments identified as priorities by the MNFI's prescribed fire needs assessment model and interpretation of aerial imagery and topographic maps. 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. They are predominantly structured by natural processes rather than modern anthropogenic disturbances such as timber harvest, hydrological alteration, and fire suppression (Kost et al. 2007, Cohen et al. 2015, Cohen et al. 2020). Historically, Indigenous peoples were an integral part of Michigan's natural communities with many natural community types being maintained by Indigenous management practices such as prescribed fire.

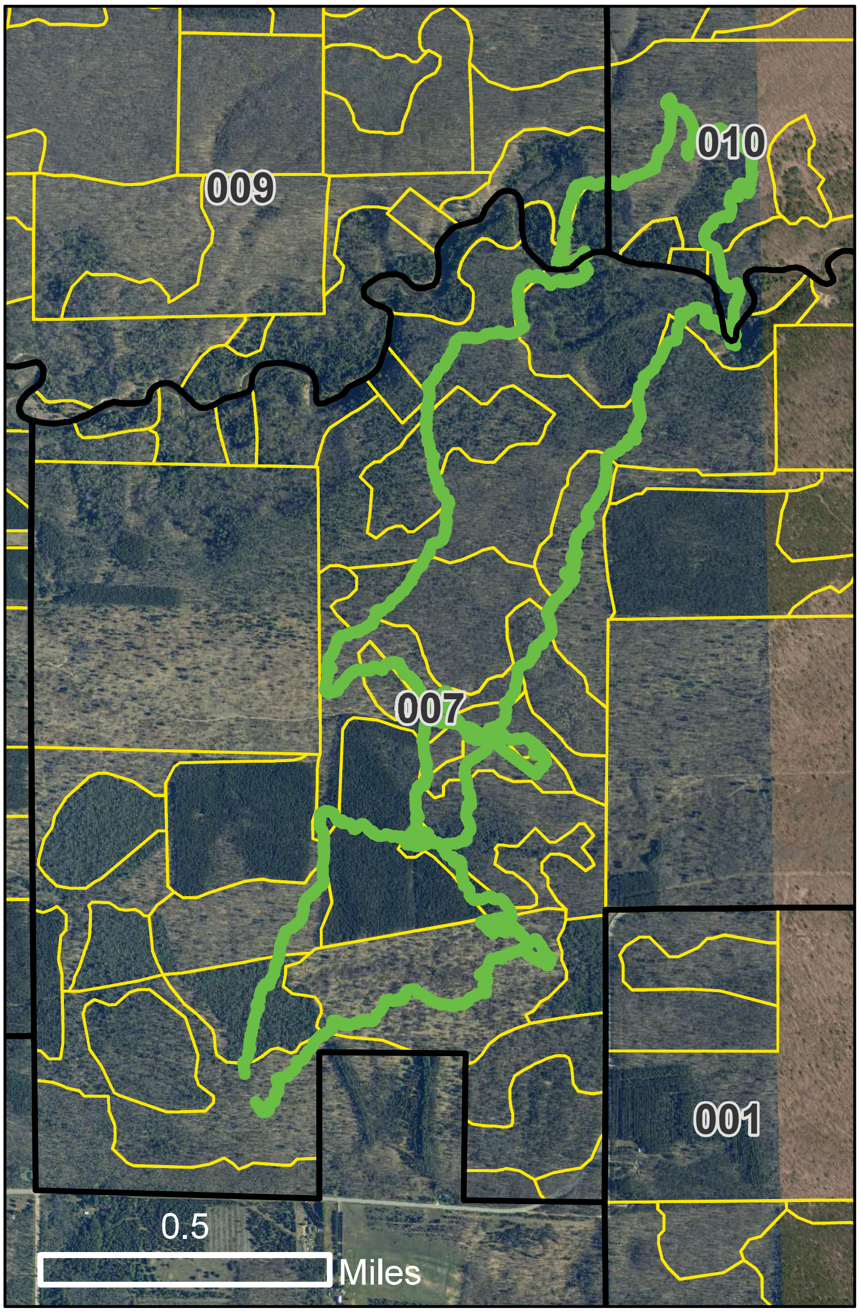

Figure 7. Example of a survey route (green) through Compartments 7 and 10.

Throughout this report, a documented occurrence of a high-quality natural community at a specific location is referred to as an "element occurrence" (EO). The areas prioritized for natural community surveys were evaluated employing MNFI methodology, which considers three factors to assess a natural community's ecological integrity or quality: size, landscape context, and condition (Faber-Langendoen et al. 2008, 2015). If a site meets defined requirements for these three criteria (MNFI 1988), it is categorized as a high-quality example of that specific natural community type, entered into MNFI's database as an EO, and given a rank of A to D – excellent to poor – based on how well it meets the above criteria. To assess natural community size and landscape context, a combination of field surveys, aerial photographic interpretation, and Geographic Information System (GIS) analysis was employed.

Ecological field surveys were conducted over 14 days during 2022. These surveys occurred in several compartments of the Cadillac-Manistee District of the Huron Manistee National Forest during June, July, August, and early September. Qualitative meander surveys were conducted to assess the natural community classification, ecological boundaries, and ranking of the communities (example of survey route in Figure 7). Vegetative structure and composition, soils, landscape and abiotic context, threats, management needs, and restoration opportunities were all assessed. Surveyors carefully documented and framed threats to ecological integrity of natural communities to develop management recommendations that will serve to protect the high-quality examples of natural communities on the landscape and the rare taxa therein. Ecological evaluations are important for facilitating site-level decisions about prioritizing management objectives to conserve native biodiversity, evaluating the success of restoration actions, and informing landscape-level planning efforts.

Methods employed during this survey followed the methodology developed during the initial evaluation of ecological reference areas on state forest land by MNFI ecologists (Cohen et al. 2008; Cohen et al. 2009).

These ecological field surveys involved:

- compiling comprehensive plant species lists to be summarized in a floristic quality index and noting abundance of representative species
- describing site-specific structural attributes and ecological processes
- visually estimating canopy coverage
- measuring tree diameter at breast height (dbh) of representative canopy trees and aging canopy dominants
- analyzing soils
- noting current and historical anthropogenic disturbances
- evaluating potential threats to ecological integrity
- taking digital photos
- surveying adjacent lands to assess landscape context
- ground-truthing distinct signatures of historic images and recent satellite imagery
- evaluating the natural community classification and mapped ecological boundaries
- determining the ecological integrity of mapped high-quality natural communities by assigning or updating element occurrence ranks
- updating EO data for rare plants
- noting management needs for stewardship

For each high-quality natural community, floristic data were compiled into the Universal Floristic Quality Assessment Calculator (Reznicek et al. 2014, Freyman et al. 2016) to determine the Floristic Quality Index (FQI) for each natural community element occurrence. The floristic quality assessment is derived from a mean coefficient of conservatism and floristic quality index. Each native species is assigned a coefficient of conservatism, a value of 0 to 10 based on probability of its occurrence in a natural versus degraded habitat. Species restricted to a specialized or undisturbed habitat are assigned a value of 10, implying the species has extremely strong fidelity to a specific habitat. Native species that are not particular or indicative of natural conditions are assigned a low value of 0 or 1.

The coefficient of conservatism is determined by experts on the flora of a region, and so may vary for a given plant species from region to region. From the total list of plant species for an area, a mean C value is calculated and then multiplied by the square root of the total number of plant species to calculate the FQI. 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). FQI scores greater than 50 indicate exceptional sites with extremely high conservation value (Herman et al. 2001). Mean C values may represent a less biased indicator of relative conservation value and are provided with conservation metrics in the Appendices (Matthews et al. 2015; Slaughter et al. 2015). Species lists for each natural community element occurrence are also provided in the Appendices.

Table 2. Areas prioritized by MNFI's methodology.

Focal Compartment	Additional Target Compartments	Model Supports?	MNFI Prioritization Tier	HMNF Prioritization Tier	HMNF Prioritization Area?	Additional Notes
392	388, 389, 390	Yes	1	1	Yes	dry sand prairie, barrens texture
334	338, 391	Yes	1	1	Yes	survey north of intermittent wetland, focus on sw of 391
332	333, 337	Yes	1	1	Partially	good topography in western 332
373		yes	1	1	Yes	north of wetland
323	326	Yes	1	1	Yes	existing project areas
325	324, 322	Yes	1	2	Yes	good topography/texture
7	9	Yes	1	1	Yes	oak pine barrens matrix (7); dry sand prairie (9)
321*	314	Mostly	2	2	No	excellent topography coastal plain marsh records pipeline for easy survey
327		Minimally	2	2	No	existing intermittent wetland EO many prairie species in description Evaluate as wet mesic sand prairie
50*	1, 2, 154	Yes	2	2	Yes	barrens texture throughout assess from road then explore as needed
303*	304, 301	Yes	2	2	Partially	

* denotes areas that were not surveyed in 2022

Results

We documented 16 new natural communities and updated records on 2 previously documented natural communities in 10 of the 14 surveyed compartments. During the 2022 survey efforts, we documented new EOs for 6 different natural community types, including hillside prairies (2), wet-mesic sand prairies (3), oak-pine barrens (5), pine barrens (2), dry sand prairies (3), and a bog (1). We also updated records for 2 previously documented intermittent wetlands (Table 3).

One of the areas prioritized for surveys had a minimal component of recoverable, fire-dependent systems (RFDS). Compartment 325 (Priority Area 6) was surveyed and found to have minimal barrens composition and no remnant natural communities were identified. We do not recommend focused stewardship actions within this compartment. The extensive natural cover seemed to be part of a fire-adapted landscape, but none of the openings had more than a few indicator species and these species occurred at low densities, even in areas where previous stewardship work had occurred. We provide management recommendations for several additional areas where the District has been conducting barrens restoration in the Table 6 (Page 48).

The Pine River Hillside Prairie in Compartment 9 and Yonkers Prairie (wet-mesic sand prairie) in Compartment 327 are the highest priority conservation targets identified during the survey efforts of 2022. Several additional potential stewardship areas for improving RFDS were identified. The following results section presents the potential stewardship areas identified through our modeling and survey efforts. We have arranged the order of the potential stewardship areas by conservation priority, starting with the areas we believe most valuable for the conservation of unique natural communities and biodiversity. Our ranking order for stewardship actions prioritizes the rarity of system (S-rank), condition of the natural communities in the project area, and landscape context. We provide detailed site descriptions of each area with relevant management recommendations. Ultimately, the prioritization of restoration and implementation of management actions depends on several factors within the Forest Service and the recommendations below are intended to support those internal agency processes. Detailed compartment maps and species lists for each natural community are included in the Appendices.

The Pine River Hillside Prairie was first documented during the surveys of 2022. It is recommended as a top conservation priority for the District.

Table 3. A list of natural community EOs, organized by potential stewardship areas. All were documented during this study except for Yonkers Prairie and Black Lake Marsh, which were first described in 1987. Overall Ranks are as follows: A - Excellent condition; B - Good condition; C- Fair condition; D - Poor condition. Definitions of S-ranks are provided in Appendix 1.

Site Name	Community Type	EOID	Overall Rank	Size (ac)	FQI	Number of Plant Species	Compartment (s)	Stand(s)
Pine River Corridor								
Pine River Hillside Prairie	Hillside Prairie (S1)	26243	B	9	46.3	134	9	21, 22, 24 34, 37, 38
Pine River Oak-Pine Barrens	Oak-Pine Barrens (S2/S3)	26324	C	28	38.7	79	9 10	17, 22, 37, 38, 34, 68 9
Pine Bowl Dry Sand Prairie	Dry Sand Prairie (S3)	25433	D	1	26.9	43	9	31
Yonkers Prairie								
Yonkers Prairie*	Wet-Mesic Sand Prairie (S1/S2)	10967	B	79	53.7	149	327 328	29, 43, 46, 14 8, 9, 11, 12
Hoxeyville								
Hoxeyville Oak-Pine Barrens	Oak-Pine Barrens (S2/S3)	26325	BC	101	38	95	7	2, 9, 25 27, 28
Steinberg-Little River								
Steinberg Pine Barrens	Pine Barrens (S2/S3)	26332	C	76	35.2	56	389 390	3 11
Little River Oak-Pine Barrens	Oak-Pine Barrens (S2/S3)	26327	CD	37	30.5	44	392	12, 21
Little River Dry Sand Prairie	Dry Sand Prairie (S3)	26334	C	5.5	30.2	35	392	17, 18
Koenig								
Koenig Dry Sand Prairie	Dry Sand Prairie (S3)	26335	C	8.2	34.9	60	332	8, 9
Pine Creek								
Udell Prairie	Wet-Mesic Sand Prairie (S1/S2)	26339	C	5	37.7	67	373	69
Hart Oak-Pine Barrens	Oak-Pine Barrens (S2/S3)	26326	C	19	30.1	47	373	67
Black Lake								
Hoague Pine Barrens	Pine Barrens (S2/S3)	26333	CD	26	31.6	37	338	6
Black Lake Intermittent Marsh*	Intermittent Wetland	5835	D	4.4	20.2	13	334	38
Black Lake Prairie	Wet-Mesic Sand Prairie (S1/S2)	26338	CD	3.2	18.4	26	334	38
Black Lake Oak-Pine Barrens	Oak-Pine Barrens (S2/S3)	26328	D	8.9	32.1	38	334	37
North Country Prairie								
North Country Prairie	Wet-Mesic Sand Prairie (S1/S2)	26340	C	37.4	26.5	27	323 324	35 10

** Previously documented EO*

EOs Not Included in Proposed Project Areas

Little Man Meadow	Northern Wet Meadow (S4)	26337	C	11.2	19.4	26	395	3
Nighthawk Hillside	Hillside Prairie (S1)	26336	D	0.217	24.3	32	395	1
Hasenbank Bog	Bog (S4)	26341	BC	5.9	33.3	22	332	40

Yonkers Prairie is recommended as another top conservation priority for the District.

The Pine River Corridor

Compartments 9 and 10 along the north side of the Pine River is our highest priority potential stewardship area for the restoration of fire-dependent systems in the Cadillac-Manistee District. Stands of interest in Compartment 9 are 17, 22, 24, 34, 37, 38, 68, and Stand 9 in Compartment 10. We documented three natural communities in the area: hillside prairie, oak-pine barrens, and dry sand prairie. Most notably, the Pine River Hillside Prairie is the first example of this community type in the Manistee River watershed and is one of the best examples of the community type in the state. Prior to these surveys, there were 11 documented hillside prairies in the state, and many are relatively degraded and haven't been revisited in recent decades as several occur on private property (Table 4).

The hillside prairie occurs as series of 10 openings along the steep slopes of the Pine River. The openings feature concentrations of characteristic barrens and prairie vegetation. The herbaceous layer of the openings is variable and especially diverse compared to the surrounding broad, level tablelands at the top of the slopes. Graminoids are more dominant than forbs and include little bluestem, poverty grass, big bluestem, and prairie brome. Common forbs include yarrow, wormwood, butterfly-weed, hoary puccoon, sand coreopsis, northern bedstraw, woodland sunflower, long-leaved bluets, veiny pea, and northern blazing-star. A 20-inch diameter red pine at the edge of the prairie in Stand 37 had 180 rings counted. Pockets of oak-pine barrens occur adjacent to the hillside prairie where the steep slopes transition flatter areas with sparse canopy and concentrations of diverse vegetation.

The Pine River Hillside Prairie, Oak-Pine Barrens, and Dry Sand Prairie occur in an area designated as a Wild and Scenic River. The condition of the hillside prairie openings is variable with extensive zones of high species diversity and high species evenness and other areas seriously degraded by ongoing anthropogenic disturbance. Two especially disturbed areas of hillside prairie occur in Stands 34 and 24 along the river and have extensive zones of exposed sand due to people climbing the steep slopes.

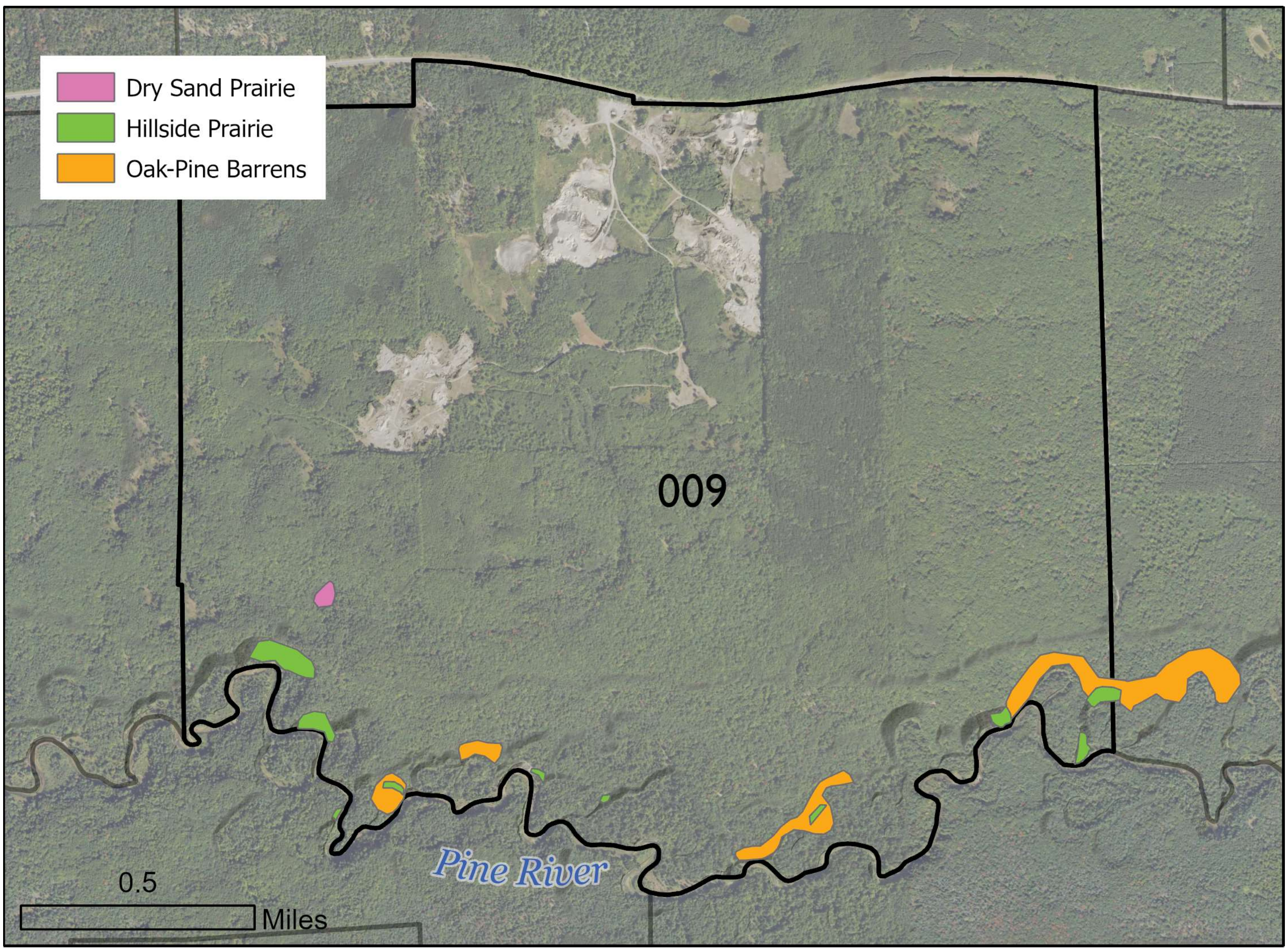

Figure 8. Natural communities in Compartment 9, the Pine River Corridor.

Table 4. All documented hillside prairies in Michigan, organized by overall rank and size. Two hillside prairies were documented in the Cadillac-Manistee District during the 2022 field season, one along the Little Manistee River, the other in Compartment 9, along the Pine River. The Pine River Hillside Prairie and surrounding oak-pine barrens is a top stewardship priority due to the rarity of the community type, the good condition of this occurrence, the size of the prairie, the excellent landscape context, and the fact that so many other hillside prairies have been degraded in recent decades.

Site Name	Rank	Size (ac)	County	Watershed	Location	Last Visited	Protected Status	EOID
Pine River Hillside Prairie	**B**	**9.0**	**Manistee**	**Pine/Manistee**	**Huron Manistee National Forest, Cadillac District**	**2022**	**Yes, USFS**	**26243**
Pine Hill	B	3.1	Kent	Thornapple/Grand	Private Residence, recently developed	1984	No	9635
Fenwick Hillside Prairie	B	2.1	Montcalm	Flat/Grand	Flat River State Game Area	2015	Yes, WLD	19983
Harwood Lake	B	1.7	Barry	Thornapple/Grand	Private Residence	2002	No	870
Highland Cemetary	B	1.3	Washtenaw	Huron	Huron	1984	Unclear	7314
Grand River Drive	BC	1.9	Kent	Grand	Private Residence, recently developed	1984	No	10237
Pemene Falls	BC	1.2	Menominee	Menominee	Wisconsin Public Service Company	2007	No	5050
Thornapple River Bluffs	C	14.8	Kent	Thornapple/Grand	Private Residence, recently developed	2002	No	4497
Blythfield Country Club	C	5.8	Kent	Rogue/Grand	Golf Course	2005	No	1507
Raisin River	C	4.3	Jackson	Raisin	Private Residence	2008	No	6796
Menominee River Prairie	C	1.2	Menominee	Menominee	Menominee River State Recreation Area	2013	Yes, PRD	19737
Alaska	C	0.8	Kent	Thornapple/Grand	Private Residence, recently developed	1984	No	8470
Nighthawk Hillside	**D**	**0.2**	**Manistee**	**Little Manistee**	**Huron Manistee National Forest, Cadillac District**	**2022**	**Yes, USFS**	**26336**

A zone of hillside prairie along the Pine River.

The landscape context of this hillside prairie, excellent species composition, its overall good condition, and the rarity of the community type make this hillside prairie and surrounding barrens our top priority for further protection and stewardship efforts. The condition of the oak-pine barrens is generally good to fair but protracted fire suppression is reducing the openings, suppressing vegetation, eliminating characteristic barrens structure, and isolating patches of high-conservation value. Diversity is relatively high and typically representative of the community type, though deer herbivory is likely decreasing herbaceous composition. Invasive species are not at problematic levels in the barrens.

Management Recommendations

Our management recommendations in order of priority are to provide signs to keep people off the slopes to help protect the site from further anthropogenic disturbance, close roads to minimize access to areas where camping activities may facilitate erosion, treatment of invasive species where reasonable, and incorporation of the hillside prairie in a larger burn unit that would also include the adjacent oak-pine barrens to expand the ecotone between these two natural communities, and continue to maintain the broader landscape as a Wild and Scenic River.

The westernmost openings (Stands 24 and 34) are being impacted by ongoing anthropogenic activities that are exacerbating natural erosion. Signs could be posted at the base of the slopes so canoers avoid the most sensitive areas. In addition, signage at the top of the slopes may help prevent campers from impacting the slopes and closing two-tracks would limit access to the most sensitive hillsides.

Many of the invasive species will be difficult to treat. Woody invasive species such as autumn olive and oriental bittersweet could be treated using a cut-stem approach. Other invasives such as spotted knapweed and sweet clover could be spot treated in some areas but other places are so steep that climbing gear and ropes will likely be necessary.

We recommend including the hillside prairie, oak-pine barrens, dry sand prairie, and surrounding forest in frequent prescribed burns. This work could be focused in Compartment 9 in Stands 22, 23, 37, 38, 64, 68, and in Stand 9 of Compartment 10. The open conditions of the hillside prairie are maintained by slope, aspect, and drought and it does not need to be directly targeted with fire. However, fire is critical for preventing continued loss of barrens structure and composition in areas adjacent to

Stand 34 of Compartment 9 is the westernmost polygon of Pine River Hillside Prairie. Though hillside prairies are naturally disturbance-prone communities, the erosion along the river is being exacerbated by recreationalists.

the hillside prairie and fires for barrens restoration should be allowed to creep onto the hillsides when possible. Ideally burns would occur at a frequency of 1 to 3 burns per decade. The higher frequency is ideal for promoting open conditions during initial restoration. Historically, fire likely regularly happened in the fall and this timing should be a goal when feasible. We recommend including as large of an area as possible, avoiding creating burn breaks within or near the slopes prone to erosion, and burning under conditions that promote patchiness as a way of maximizing refugia for wildlife within the site.

Where woody encroachment is eliminating barrens structure, managers could mechanically reduce understory trees and saplings, namely maple, black oak, and black cherry; especially to control any vigorous response to fire and accelerate recovery of barrens structure and composition. We recommend promoting barrens structure in adjacent areas where herbaceous composition responds positively to fire. If thinning takes place to accelerate barrens structure, we suggest it take place after implementation of the prescribed fire so that mortality of sensitive individuals will reveal more resilient canopy trees to retain. During the thinning process, protect large, old, open-grown oaks as well as red and white pine in the canopy. Red and white pine were likely much more prevalent historically, based on GLO notes.

In general, we do not recommend managers supplement the species composition of mapped EOs by planting additional species. However, some of the most severely eroded areas may not be able to recover without such intervention. If recovering areas of exposed soil is desired, we urge managers to use locally sourced seeds or plants of local genotypes as much as possible. Ideally, the seeds would come from nearby remnants.

Barrens structure and composition persists in many places at the top of the hillside prairie. These areas should be prioritized in prescribed burns with the goal of expanding barrens. Protect old, open-grown trees during mechanical treatments.

Yonkers Prairie

Yonkers Prairie is a wetland in Compartment 327 and was first described by MNFI ecologists in 1988 as an intermittent wetland (and originally named Yonkers Meadow). Several rare species were documented at that time and the site is a candidate Research Natural Area. This area was not a top priority for our survey of fire-dependent natural communities, in part because the GLO notes describe the area as beech-maple forest and it was in the MNFI database as an intermittent wetland. This area was therefore a low priority target for the 2022 surveys.

While this site was not initially targeted for surveys, the MNFI site description listed some species with an affinity for prairie habitat. As a result Yonkers Prairie was included in the 2022 surveys. Following the 2022 surveys, the site was reclassified from intermittent wetland to wet-mesic sand prairie – much rarer and more diverse than intermittent wetland. Michigan's natural community classification system has been continually refined since 1988 and the wet-mesic sand prairie was not a recognized community type when Yonkers Prairie was first surveyed in the 1980s.

Yonkers Prairie is the second largest wet-mesic sand prairie in the state and one of the most diverse. Graminoids dominate the openings with characteristic grasses including hair grass (*Deschampsia cespitosa*), big bluestem, little bluestem, switchgrass, Canada bluejoint, and prairie cord grass. Common sedges and rushes include *Carex pellita*, *Carex vesicaria*, *Carex stricta*, golden-seeded spike rush, Canadian rush, and Greene's rush. Forbs include pale spiked lobelia, wild blue flag, bushy aster, rough-leaved goldenrod, and small sundrops among many others.

Numerous rare species have been documented in Yonkers Prairie, including the northernmost record for tall green milkweed (State Threatened; a new county record was documented in 2022), Engelmann's spike-rush (State Special Concern), Vasey's rush (State Threatened; observed in 2022), and short-fruited rush (State Threatened; observed in 2022). Additionally, there were several crayfish burrows throughout the site and the prairie has potential to support the Federally Threatened massasauga rattlesnake.

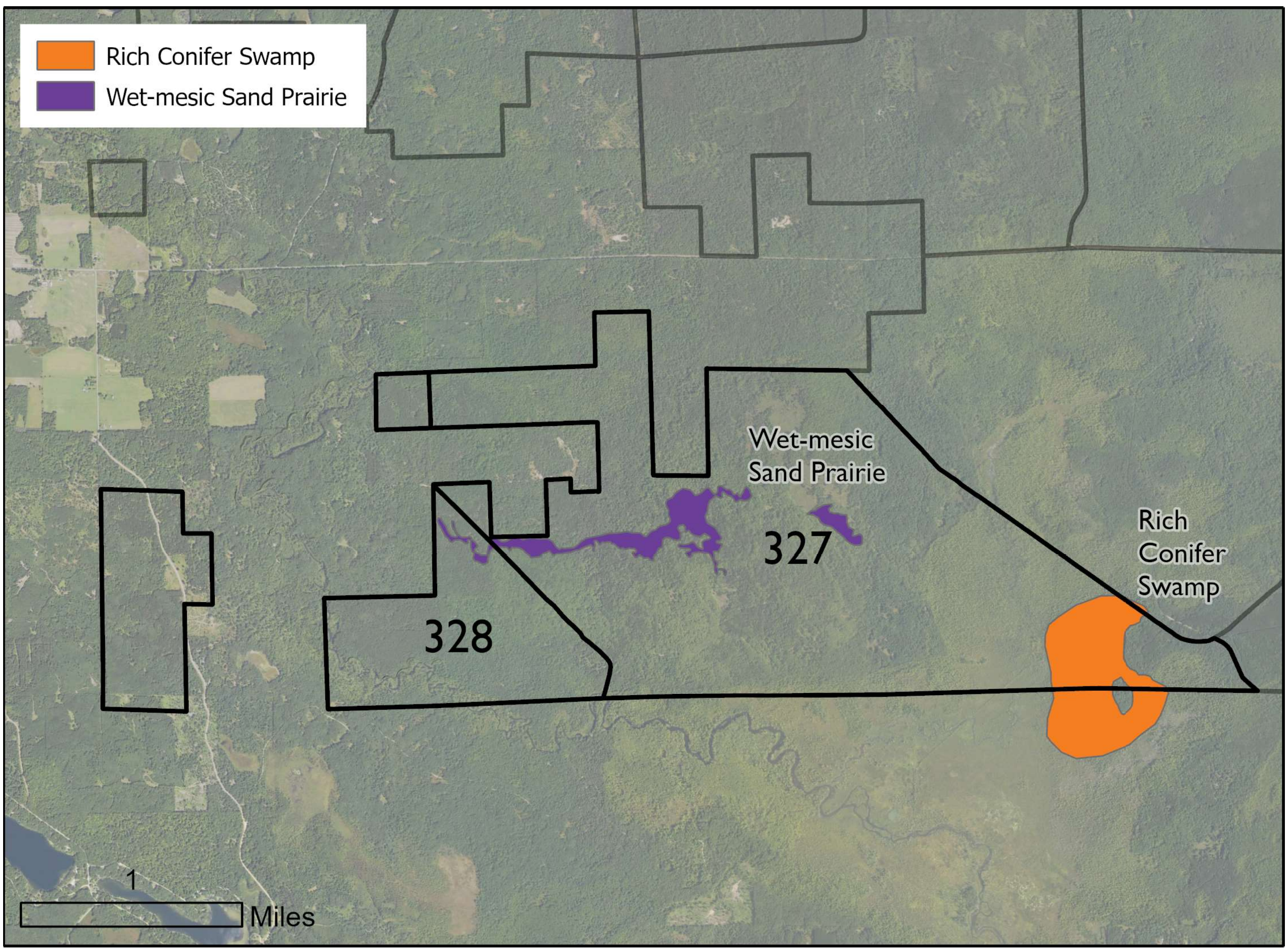

Figure 9. Natural communities in Compartment 327, the Yonkers Prairie Area.

Juncus vaseyi (Left, State Threatened) has been documented in Yonkers Prairie and is similar to *Juncus greenei* (Right), which is not rare.

Tall green milkweed (*Asclepias hirtella*, State Threatened) was documented from Yonkers Prairie in 2022. This is the first time the species has been found in Mason County.

Yonkers Prairie features an especially diverse assemblage of native vegetation.

Management Recommendations

The rarity of the community type, the concentration of rare species, and the threats from roads, ditches, and incipient infestations of non-native species make this another top priority for protection and stewardship. The top management priorities for Yonkers Prairie are to treat reed canary grass along roads, close two-tracks and trails to provide protection from off-road vehicle damage, repair ditches along two-tracks that alter hydrology, include large zones of surrounding landscape in prescribed burns, and reduce trees at the margins by hand felling and treating aspen with herbicide.

There is notable encroachment of woody species in portions of the prairie. This is facilitated by the clonal nature of quaking aspen which may pose the greatest threat to the prairie system. Without action soon, the site may reach a tipping point where aspen rapidly expands causing a dramatic shift in composition and reducing the recoverability of the prairie. Aspen responds positively to fire and the site should be monitored for rapid growth and spread of sprouts following a fire. Treating aspen with wetland approved herbicide is recommended regardless of the application of fire.

We recommend the inclusion of the prairie and surrounding forest in regular prescribed burns. Burn breaks should be avoided at the ecotone where the wetland transitions into the uplands. Ecotones tends to support high floristic diversity but are unfortunately frequently targeted for plow lines and burn breaks. Ideally the prairie vegetation would spread into the surrounding uplands which might express a barrens structure and composition with the return of repeated fires. Heavy equipment and mop-up work should be excluded from the prairie.

Initially, burns could occur at a frequency of 1 to 2 burns per decade with careful evaluation of the prairie's response. Historically, because of high water levels in late winter and early spring, fire likely regularly happened in the fall and this timing should be a goal when feasible. We recommend including as large of an area as possible within the burn unit and avoiding the creation of burn breaks within or near the sensitive, wet soils.

We recommend promoting barrens structure in the uplands adjacent to the prairie where barrens composition responds to fire. If thinning of surrounding uplands takes place, protect large, old white oaks, natural red pine, and white pine in the process. Burn as big of an area as possible and burn under conditions that promote patchiness as a way of maximizing refugia to wildlife.

Uplands surrounding Yonkers Prairie often have old, open-grown white oaks with abundant huckleberry, indicating a fire-adapted landscape. We recommend including these areas in prescribed burns.

We suggest managers close the two-tracks that bisect the prairie, reduce access, and repair hydrology where feasible. Once closed, these two-track features could be used as burn breaks.

Hoxeyville

Hoxeyville Oak-Pine Barrens is in Compartment 7, Stands 9, 27, 28, 25, and 2. This is the largest oak-pine barrens that has been identified in the District and is currently mapped as three separate polygons, though additional habitat likely occurs in the western portions of the Compartment. This is an area where the District has been conducting barrens management. Stand 9 had mechanical treatment of saplings that were becoming dense following a prescribed burn.

This large oak-pine barrens occurs along small drainages on the outwash plain associated with the Manistee River. The system has fair to good landscape context that is characterized by natural cover with some neighboring private residences and other fragmentation from small roads and two-tracks. The condition of the oak-pine barrens is generally good to fair but fire suppression is reducing the openings, suppressing vegetation, eliminating characteristic barrens structure, and isolating patches of high-conservation value.

Some of the mapped zones have a nearly closed canopy, but areas typically have 30 to 70% canopy coverage with black oak, white oak, white pine, and jack pine as canopy dominants. Canopy trees typically range in diameter from 10 to 22 inches and are around 100 years old. The subcanopy is typically between 20 to 30% coverage and is characterized by white oak, black oak, white pine, and jack pine. The shrub layer is generally sparse with coverage ranging from 10 to 25%. Low sweet blueberry, prairie willow, chokecherry, bearberry, sweetfern, sand cherry, and shadbush serviceberry are common to locally abundant in the shrub layer. Low sweet blueberry forms extensive colonies that are locally dominant.

The herbaceous layer is much more diverse than adjacent closed-canopy forest. Within the barrens graminoids are much more dominant than forbs. The combination of deer herbivory and lack of fire is causing a dense, uniform thatch of Pennsylvania sedge and hair grass (*Avenella flexuosa*). The dominance of these graminoids and the thatch are competitively excluding other species in many areas. The highest quality areas feature an increase in graminoid diversity including, big bluestem, little bluestem, poverty grass, June grass, false melic, ticklegrass, prairie brome, slender wheatgrass, and several panic grasses. Forbs are much less abundant than graminoids and include common frostweed, hairy bedstraw, racemed milkwort, early goldenrod, cow-wheat, northern blazing star, smooth aster, and butterfly-milkweed. Invasive species occur at low densities throughout the area but are at highest densities along roads and trails.

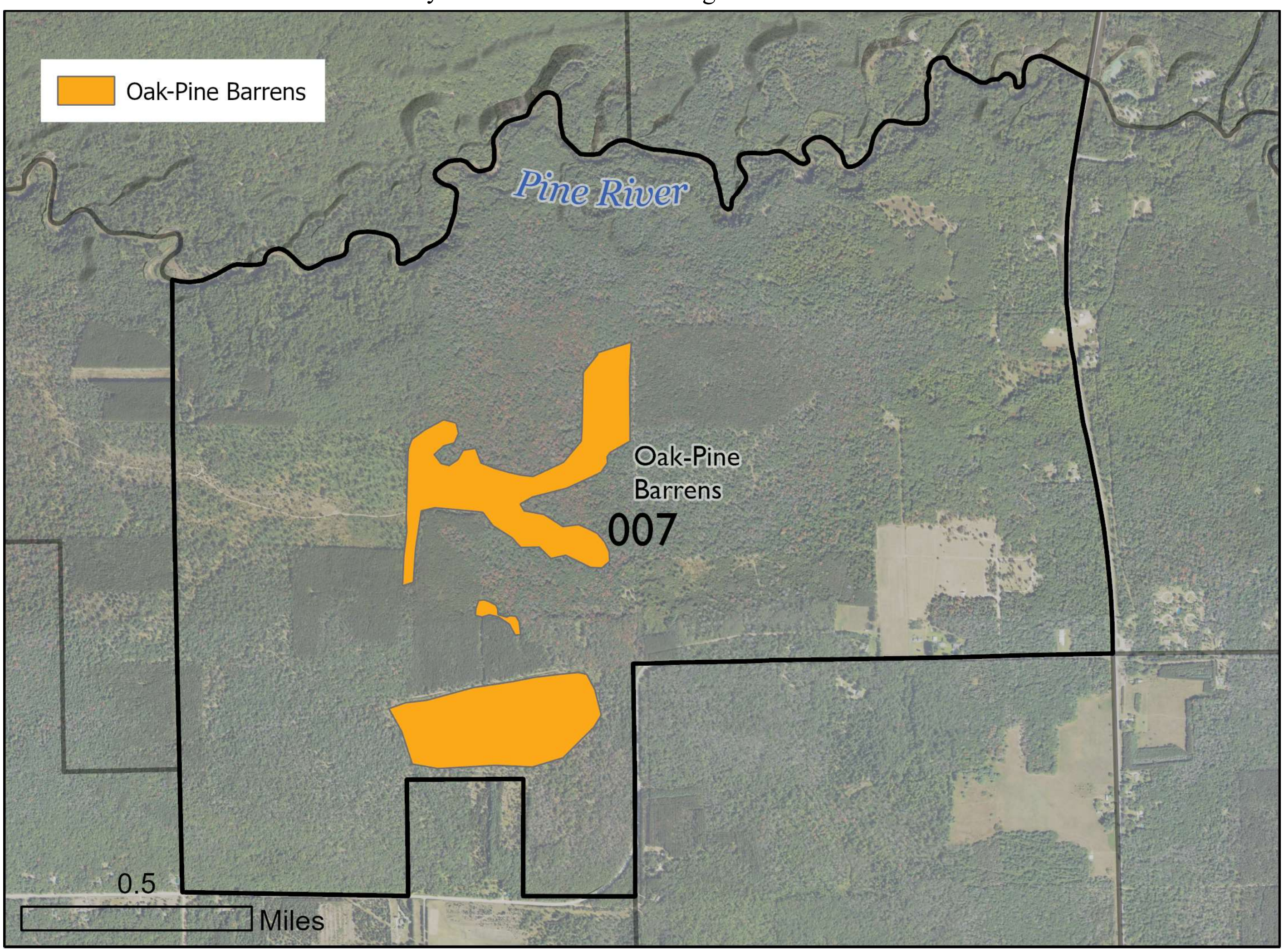

Figure 10. Natural communities in Compartment 7, the Hoxeyville Area.

Hoxeyville Oak-Pine Barrens is the largest documented example of the community type in the District.

Management Recommendations

The overall recommendation for the Hoxeyville Oak-Pine Barrens is to expand the size of the barrens and increase connectivity between existing managed patches. There is ongoing management work already being undertaken in this area and we encourage managers to continue the work. Mechanical treatments to reverse the transition to forest are being applied to some of the open areas to reduce understory cherry and oak saplings. Ideally this work would be done in conjunction with fire in the future. There is some ORV activity and erosion associated with the two-track that bisects the northernmost polygon.

We recommend continuing to prioritize the management of Hoxeyville Oak-Pine Barrens. We recommend the following restoration actions: applying prescribed burns; closing roads to minimize risk from ORVs; reducing black cherry and black oak saplings where appropriate; treating invasive species; and thinning surrounding forests, particularly pine plantations, to expand and connect barrens habitat.

Ideally burns on the surrounding landscape would occur at a frequency of 3 burns per decade. This high frequency is ideal for initial restoration of oak-pine barrens that require establishing open conditions but the frequency could be reduced once target structure is achieved. Historically, fire likely regularly happened in the late fall and this timing should be a goal when feasible. We recommend managers burn under conditions that promote patchiness as a way of maximizing refugia for fire-sensitive species within the site. We recommend including as large of an area as possible and avoiding creating burn breaks in the highest quality areas, around drainages where there tends to be concentrations of characteristic vegetation, or along ecotones between forest and open barrens.

We suggest managers continue to mechanically reduce understory black oaks and black cherry, especially where dense regeneration of oaks is eliminating barrens structure and composition. Removal of red pine, white oak, and jack pine from the understory should be avoided. These are more resilient to high-frequency fire return interval and the pines were likely more prevalent historically. In addition, native shrub species that are generally low in abundance should be avoided during mechanical treatments. We recommend promoting barrens structure in surrounding forests to facilitate connectivity between high value patches, especially where composition responds positively to fire. The pine plantation in Stand 6 would ideally be thinned to expand openings and connect areas of high-quality barrens. This could be partially thinned before the initial fire, retaining healthy white oaks in the canopy. If thinning of natural forests takes place to accelerate barrens structure, we suggest it take place after the initial fire so that mortality of sensitive individuals will reveal more resilient canopy trees to retain. During the thinning process, protect large, old white oaks, red pine, and white pine as they were all likely much more prevalent historically.

Many areas of the barrens opening are characterized by low diversity and a dominance of Pennsylvania sedge, hair grass, and poverty grass. This is likely due to several factors, including natural prevalence of these species, impacts of fire suppression, and selective herbivory from deer, which favor forbs. This area likely supported elk historically and these large herbivores graze more extensively on graminoids than deer. The return of elk to the landscape might facilitate barrens recovery through disruption of the graminoid thatch through grazing and by browsing on woody regrowth that makes maintaining open savanna conditions difficult.

Many areas of Hoxeyville Oak-Pine Barrens have excellent structure and composition, despite locally dense thickets of oak saplings.

Steinberg-Little River

Steinberg Pine Barrens occurs as two polygons in Compartment 390 (Stand 11), and Compartment 389 (Stand 3). This large pine barrens has fair landscape context with some adjacent private inholdings and other fragmentation from small roads and two-tracks. The eastern polygon (Stand 3) was burned recently and an adjacent pine stand was thinned to approximate barrens structure. Many barrens indicator species persist in the thinned area and it should continue to be included with prescribed burns and mechanical treatments to reduce woody regrowth, especially black cherry and black oak. The condition of the pine barrens is generally good to fair but encroachment from black cherry and other tree saplings is reducing the openings and eliminating herbaceous vegetation and characteristic barrens structure. Diversity within the pine barrens is substantially higher than the surrounding forest and typically representative of the community type.

The canopy is characterized by a sparse canopy of jack pine, black oak, white pine, black cherry, and red pine as typical canopy dominants. The shrub layer is typically 5 to 20% coverage with low sweet blueberry forming extensive colonies that are locally dominant. The highest quality areas typically feature a prevalence of sand cherry, bearberry, and shadbush serviceberry. The herbaceous layer is much more diverse than adjacent closed-canopy forest and graminoids are much more dominant than forbs. Pennsylvania sedge, hair grass, and Kentucky bluegrass are often the most dominant graminoids, forming a dense thatch over many areas to the exclusion of other species.

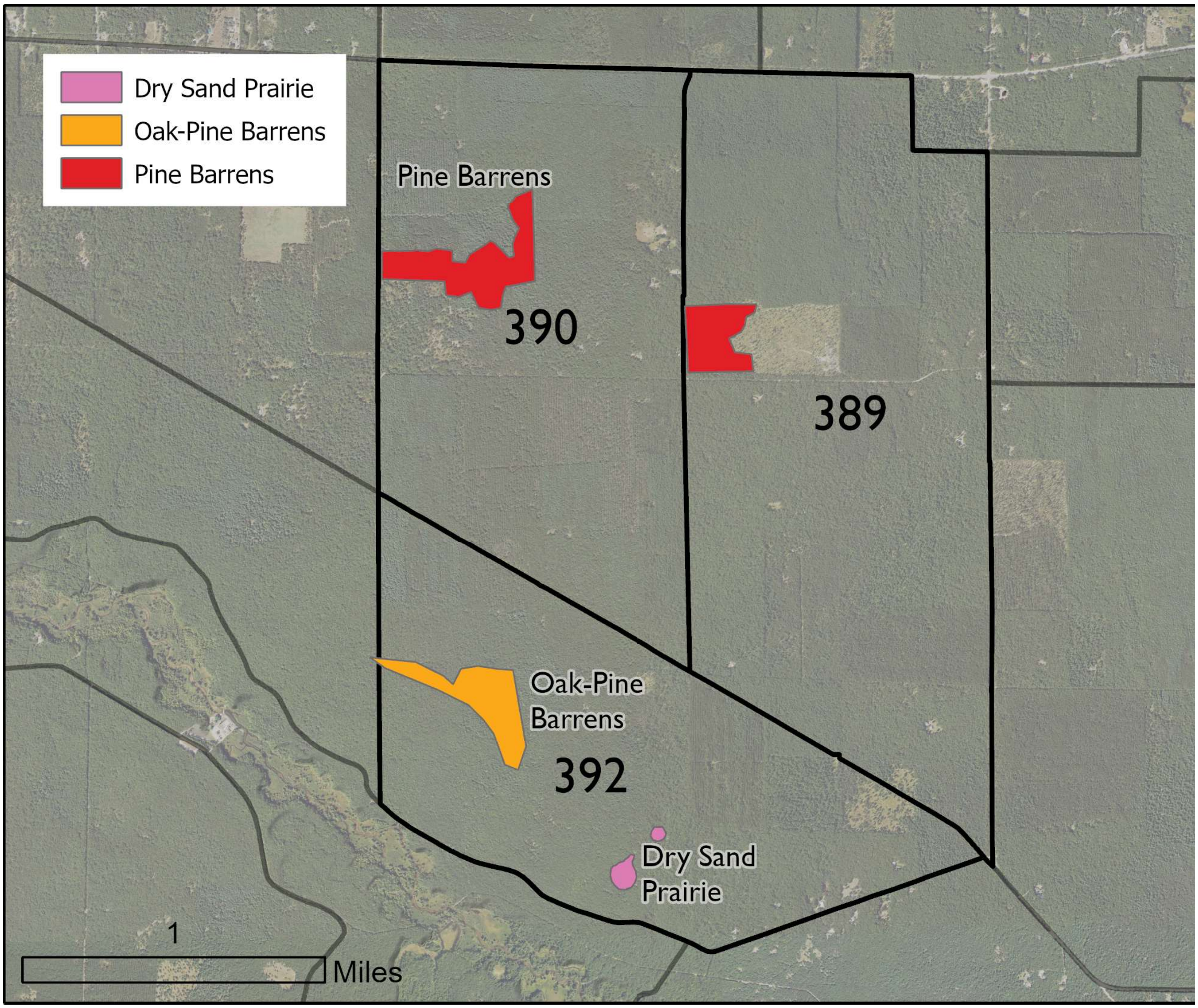

Figure 11. Natural communities in Compartments 392, 389, and 390, the Steinberg-Little River Area.

Steinberg Barrens has numerous openings dominated by native grasses, such as big and little bluestem.

Excellent barrens structure was created by thinning the forest adjacent to the Steinburg Pine Barrens (Stand 3, Compartment 389). During this process, the adjacent areas of high-quality barrens were not disturbed by equipment, which is important for the site's long-term viability as a remnant.

Other common graminoids are big bluestem, little bluestem, poverty grass, June grass, black oatgrass, and prairie brome. Forbs are less abundant than graminoids and include common frostweed, hairy bedstraw, wild strawberry, cow-wheat, cylindrical blazing-star, rattlesnake-weed, and birdfoot violet.

The Little River Oak-Pine Barrens and Little River Dry Sand Prairie occur in Compartment 392. The prairie occupies two depressions in Stands 17 and 18 and the oak-pine barrens occurs to the west in Stands 12 and 21. The condition of the prairie and barrens is generally fair but ORVs have damaged the northern opening of the prairie and portions of it have been furrowed and planted with pine. Fire suppression is causing forest to encroach at the margins of the prairie and the barrens to convert to forest. Diversity in the prairie and barrens is higher than the surrounding forest and typically representative of the community types, though not especially diverse examples.

Management Recommendations

The overall recommendation is to expand the size of the barrens and increase connectivity between existing high-quality patches of vegetation. The District has thinned areas of planted pine to expand barrens structure around Steinberg Pine Barrens in Stand 3 of Compartment 389. This effectively recreated the barrens structure and we recommend continuing to expand the openings. We encourage a similar approach to expanding the barrens area in Stand 11 of Compartment 390. The District has been reducing woody encroachment around the Little River Dry Sand Prairie in Compartment 392. We recommend continuing this approach, especially reducing dense growth of black oak and black cherry at the margins of the prairie. We suggest developing a large project area in Compartment 392 that includes the oak-pine barrens and the dry sand prairie in a single burn unit and we recommend the application of fire at a frequency of 3 burns per decade to reestablish barrens structure and composition in the areas between and around the remnants. We also recommend closing off the dry sand prairie to ORVs.

Little River Oak-Pine Barrens features a greater prevalence of oak than Steinberg Pine Barrens. The distinction is not especially important as the species composition of the herbaceous layer is similar. Little River Oak-Pine Barrens generally has a greater prevalence of Kentucky bluegrass, Pennsylvania sedge, and common St. John's-wort than many of the other RFDS.

Stand 18 is the higher quality of the two openings that comprise Little River Dry Sand Prairie. Work has been done to reduce trees and saplings at the margins of the prairie openings. This reverses the trend of woody encroachment at the margins of the prairie. We recommend managers continue to eliminate black cherry from the prairie.

A portion of the northern opening of the Little River Dry Sand Prairie (Stand 17) has been severely degraded by ORV activity. The open nature of these systems makes them inviting to this type of activity. Ideally they would be protected and offenders pursued. This site may be recoverable by planting native vegetation, though we urge managers to use local genotypes.

Koenig Prairie

Koenig Dry Sand Prairie occurs as two separate depressions in Stands 8 and 9 of Compartment 332. The openings are frost pockets dominated by graminoids within an extensive matrix of oak-pine forest. This dry sand prairie is in fair condition and in a relatively unfragmented landscape with good diversity, though Pennsylvania sedge, hair grass, and Kentucky bluegrass tend to dominate some areas. The prairie openings are bordered by natural cover, primarily of maturing oak forests that appear to be fire adapted, though more mesic than many other areas to the north which feature black oak, white oak, and a greater composition of jack pine. The forests to the southwest often have canopies of red oak, bigtooth aspen, and subcanopies dominated by red maple.

The extent of the canopy trees within the prairie is estimated to be around 5 to 10% and black cherry is the primary canopy tree in the larger northern opening with some scattered black oak. There is a large 27.1 inch open-grown white oak in the southern opening. The tall shrub layer is patchy and sparse, with black cherry saplings as the most dominant and infrequent thickets of hawthorn throughout.

Wood lily is relatively infrequent across the landscape but was locally abundant in Koenig Prairie.

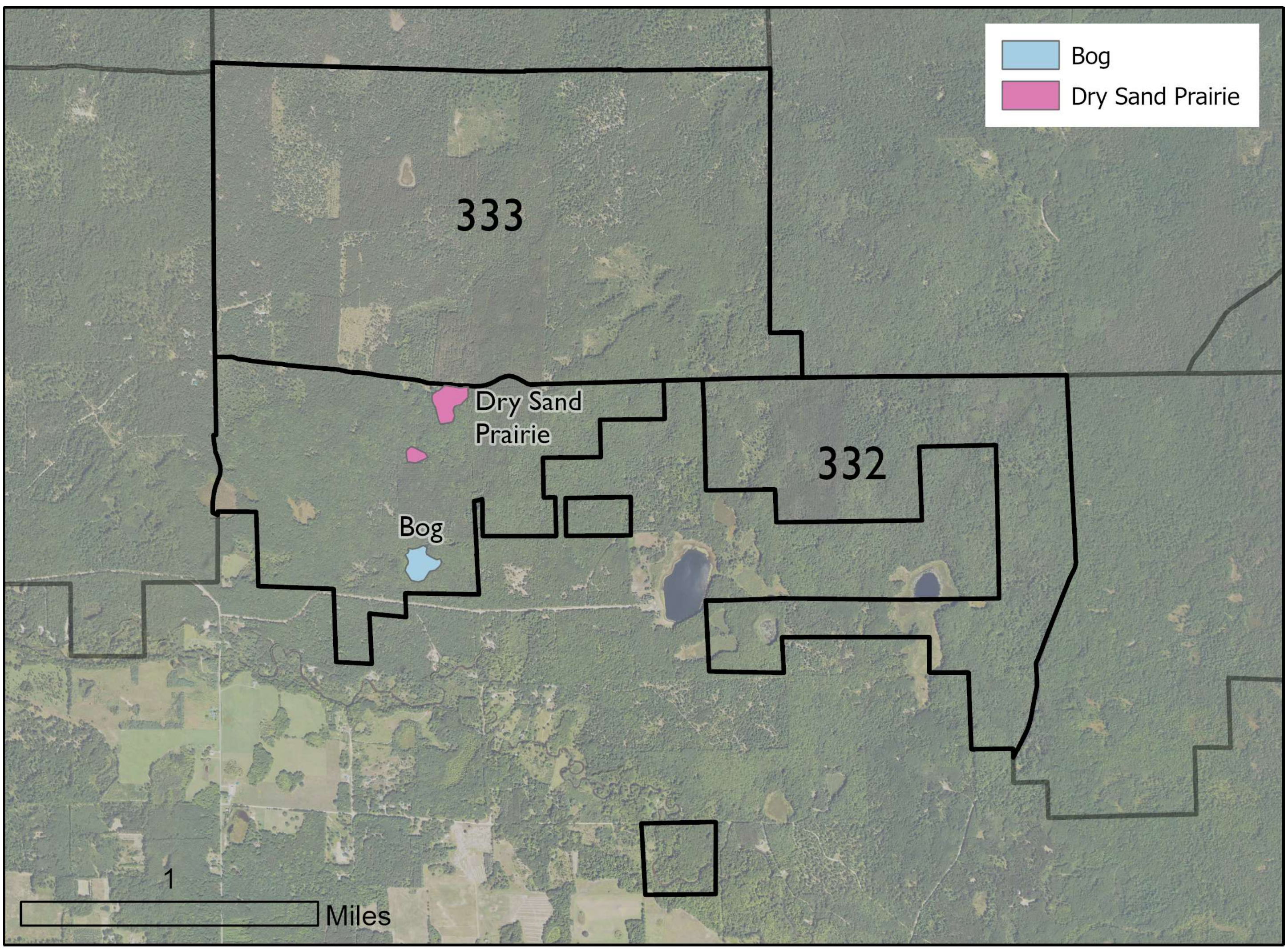

Figure 12. Natural communities in Compartments 332 and 333, the Koenig Area.

Low shrubs are locally abundant but generally at low coverage (~10%) and include sweetfern, low sweet blueberry, sand cherry, prairie willow, and shadbush serviceberry. Graminoids include Pennsylvania sedge, hair grass, little bluestem, big bluestem, Kentucky bluegrass, June grass, black oatgrass, false melic, slender wheatgrass, several panic grasses, and poverty grass. Forbs are infrequent but characteristic species include several hawkweed species, common frostweed, butterfly-weed, wood lily, and the non-natives common St. John's-wort and sheep sorrel.

Management Recommendations

The system is being degraded by ORV use, fire suppression, and invasive species. Our primary management recommendations are to close the adjacent road to protect the system from ORVs, treat invasive species where practical, establish a large project area, and include the project area in prescribed burns at a frequency of 1 to 3 burns per decades. A burn line was established at the edge of the prairie opening in Stand 8 and we suggest removing the burn line from the prairie and using roads or other existing features outside of the high-quality remnants as burn breaks. Consider establishing a large pine barrens project area to the north which would ideally include Stands 15, 18, 22, 13, 29, 10, and 8 in Compartment 333.

A burn line was installed at the edge of Koenig Prairie. We suggest managers avoid burn lines within remnants.

Koenig Prairie features a diverse herbaceous layer with a sparse canopy of black cherry.

Pine Creek-Udell

Udell Prairie occurs along a subtle, narrow drainage in Stand 61 of Compartment 373. This drainage is 6 to 8 feet below the surrounding flat topography and is 10 to 30 ft wide. The lack of fire is leading to severe encroachment of woody vegetation, though the hydroxeric nature of the drainage prevents conversion of the prairie to a closed-canopy forest. The system still features an especially diverse concentration of prairie vegetation. The narrow prairie is dominated by grasses with shrubs at the margins. Jack pine saplings throughout and canopy jack pine occur at the margins.

The ground layer is nearly continuous and dominated by big bluestem and little bluestem. Other relatively abundant grass species are switchgrass, poverty grass, prairie brome, June grass, and Canada bluejoint. Forbs are at relatively low abundance and include sand coreopsis, long-leaved bluets, wild-bergamot, and small sundrops. Shrubs were typically most abundant along the margins of the prairie with snowberry, low sweet blueberry, sweetfern, bearberry, and pasture rose as the most common. The canopy and subcanopy are typically sparse and canopy trees occurred at the margins and were shading the prairie rivulet but not growing in it. Canopy species included black oak, black cherry, jack pine, and white oak.

Small sundrops was only observed in wet-mesic sand prairies such as Udell Prairie and Yonkers Prairie.

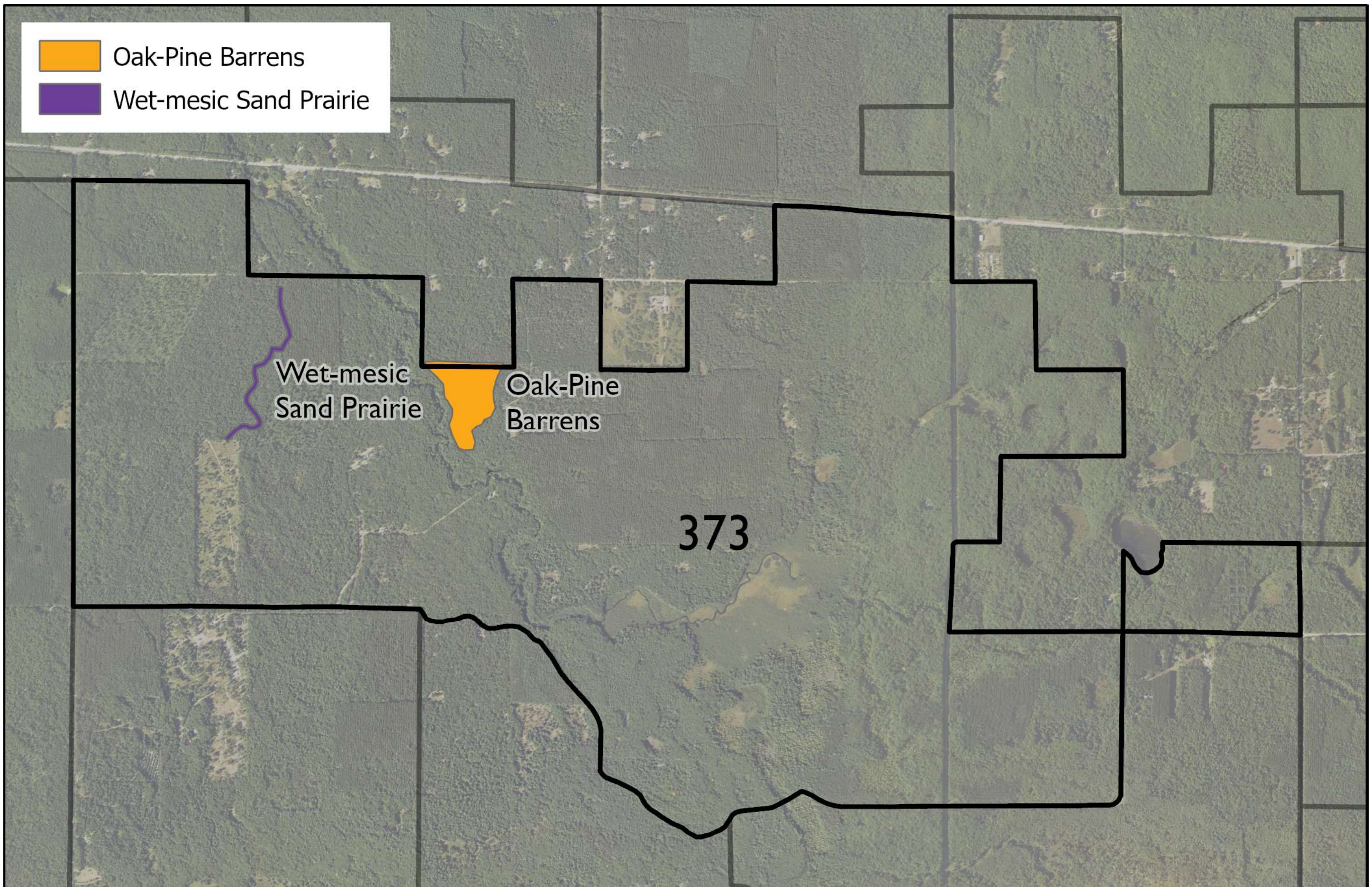

Figure 13. Natural communities in Compartment 373, the Pine Creek-Udell Area.

Udell Prairie is being reduced by woody encroachment as a result of protracted fire suppression. Ditching and alterations to hydrology has destroyed prairie in the drainage south of the remnant. A burn line was placed directly in the southern portion of the prairie. Despite these degrading actions, the system features a high degree of native biodiversity and several conservative species.

Hart Oak-Pine Barrens is a small oak-pine barrens on the flat ground above the slopes along Pine Creek in Stand 67 of Compartment 373. The system has fair landscape context that is characterized by natural cover with some nearby private inholdings and fragmentation from two-tracks. The condition of the oak-pine barrens is generally good to fair and it may have been maintained in part by past forestry operations, however fire suppression and deer herbivory are eliminating characteristic barrens structure and composition.

The barrens features a canopy of 30 to 70% coverage with black oak, jack pine, white pine, and some red pine. as canopy dominants. Tree diameters range from 15 to 20 inches though some black oaks are over 30 inches. One white pine had a diameter of 21.0 inches. The subcanopy and understory typically range from 20 to 45% coverage and are characterized by black oak, jack pine, black cherry, and some large serviceberry (*Amelanchier interior*). The low shrub layer is generally sparse with low sweet blueberry forming thickets. Other common shrubs are sweet fern, bearberry, sand cherry, and shadbush serviceberry. New Jersey tea is relatively rare and has been browsed on by deer. The herbaceous layer is dominated by graminoids, especially Pennsylvania sedge, hair grass, Kentucky bluegrass, and little bluestem. Despite the dominance of those species in many of the openings, there is good overall evenness of graminoids with big bluestem, poverty grass, black oatgrass, false melic, and several panic grass species. Forbs are much less dominant than graminoids and include common frostweed, hairy bedstraw, smooth aster, and harebell. More disturbed zones feature poverty grass, and the non-native species sheep sorrel, Kentucky bluegrass, and common St. John's-wort. Invasive species are relatively ubiquitous though at low abundance and do not appear to be contributing to further loss of native vegetation.

Management Recommendations

The overall recommendation is to expand the size of the barrens and increase connectivity between existing patches of high-quality vegetation. We suggest creating a project area for each area. For the Udell Prairie project area, include stands 61, 60, eastern 69, 76, 11, 9, and 8. The top priorities for the Udell Prairie project area are to include large project areas zones in prescribed burns, evaluate the need for hand felling trees at the margins of the prairie, close roads to protect from ORVs, and investigate repairing ditches to the south that substantially alter hydrology.

In the Hart Oak-Pine Barrens project area, include Stands 12 and 13 in the stewardship actions. Stand 13 has young trees and poor structure but high concentrations of diverse herbaceous vegetation locally. Hart Road currently acts as a burn break to separate stands 13 and 12 from the barrens habitat in stand 67. We recommend moving the road to the east to serve as the western boundary of the project area. We also recommend applying prescribed burns to the project area, using Pine Creek as a burn break, and treating invasive species when practical.

Hart Oak-Pine Barrens has elevated graminoid diversity in places.

A small opening in eastern Stand 69 has excellent diversity and could be included in a larger restoration project with Udell Prairie.

Though the structure of Stand 13 has been impacted by timber harvest, there are numerous openings with characteristic barrens vegetation. The stand could be improved with stewardship intervention and is worthy of inclusion in a larger project area with Hart Oak-Pine Barrens.

Black Lake

Hoague Pine Barrens occurs in Stand 6 of Compartment 338. The barrens features a nearly closed canopy of jack pine-black oak forest with several small openings and diverse patches of characteristic barrens vegetation. The system has fair landscape context that is characterized by natural cover on public land with some adjacent private inholdings and other fragmentation from small roads and two-tracks. The condition of the pine barrens is generally fair to good but woody encroachment is reducing the openings and eliminating herbaceous vegetation and characteristic barrens structure. Without stewardship intervention, the site will convert to forest relatively quickly.

The Black Lake Area in Stands 38 and 37 of Compartment 334 features a very small intermittent wetland that intergrades into wet-mesic sand prairie and then to oak-pine barrens. The system has fair landscape context that is characterized by natural cover with some nearby private inholdings. The condition of the wetland is generally fair with high species diversity but it is threatened by infestations of non-native phragmites and narrow-leaf cat-tail. The barrens is small and in relatively poor condition with low diversity. Restoration work in the barrens has improved the structure of the barrens and continued stewardship and prescribed burns will continue to improve the condition of the wetland and barrens.

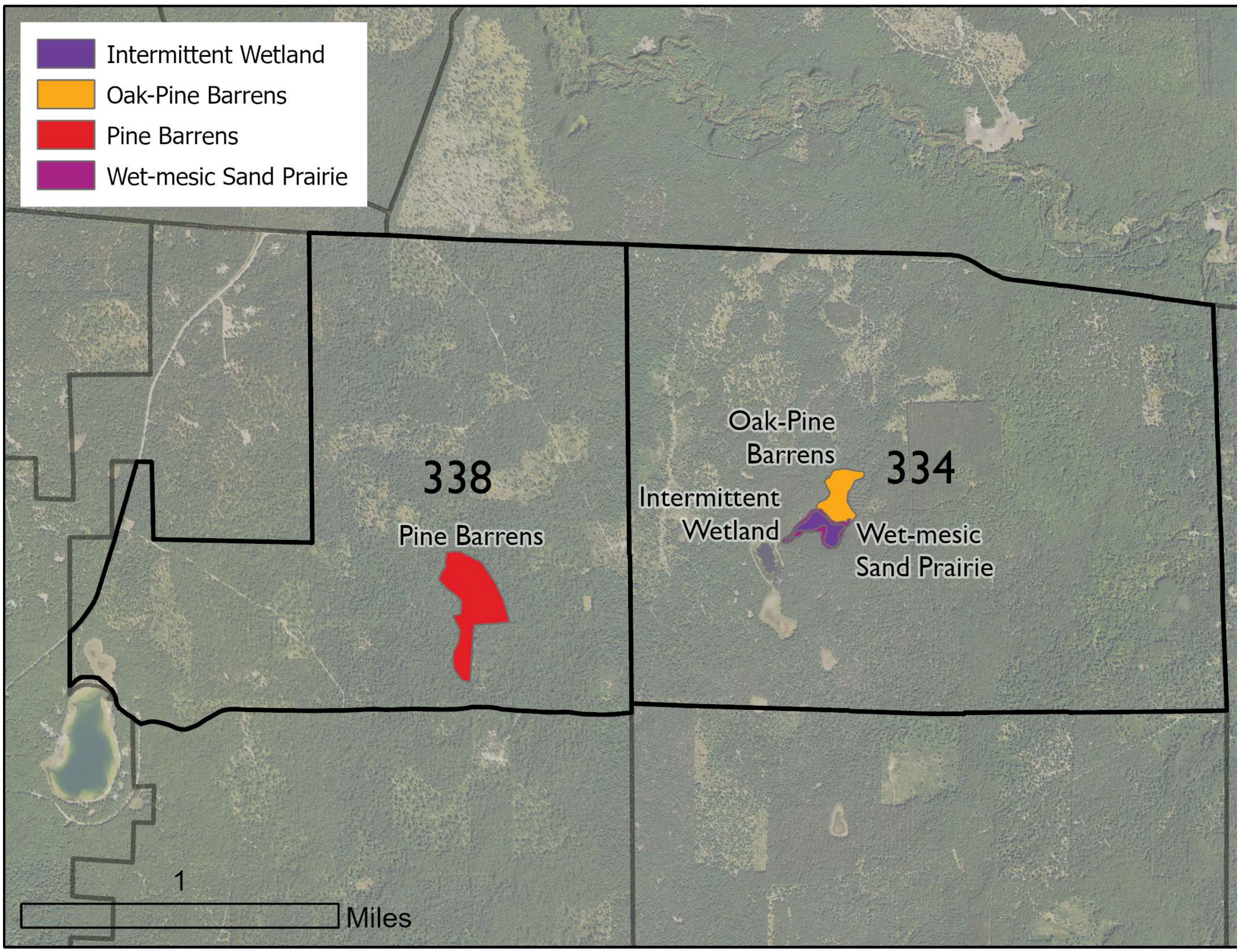

Figure 14. Natural communities in Compartments 334 and 338, the Black Lake Area.

Hoague Pine Barrens is threatened by woody encroachment due to fire suppression. The site has numerous openings that feature a high degree of plant diversity and the site is recoverable with stewardship intervention.

From left to right, the transition between the Black Lake Intermittent Wetland, Black Lake Wet-Mesic Sand Prairie, and Black Lake Oak-Pine Barrens. Such ecotones are especially diverse and should be protected from trails and burn lines.

Management Recommendations

The overall recommendation is to expand the size of the barrens and increase connectivity between existing patches of high-quality vegetation. A large project area could be established to improve and expand Hoague Pine Barrens in Stands 6, 45, 42, 44, 18, and 41 of Compartment 338. Habitat improvement work has already been implemented over large areas of Compartment 334 around Black Lake.

Our top recommendations for the Black Lake project area are to immediately treat invasive species in the wetland, thin the surrounding pine plantations to recreate barrens structure, and include the broader project area in prescribed burns at a frequency of 3 burns per decade. The furrows in the barrens may exacerbate droughty conditions and could be repaired in strategic places to mitigate water loss in the already drought-prone system.

The incipient infestation of non-native phragmites threatens the intermittent wetland and wet-mesic sand prairie. The infestation of non-native cat-tail is more advanced but still worth treating.

Ongoing efforts to create barrens structure in Compartment 334 could be expanded to include the natural communities around Black Lake. Stand 6 (above) has excellent structure and some barrens indicator species. The composition could be improved with prescribed fire and greater connectivity to the nearby natural communities.

North Country Prairie

This a very large wet-mesic sand prairie in Stand 35 of Compartment 323 and Stand 10 of Compartment 322. The prairie occupies a depression between dune ridges on a flat outwash plain. The prairie has been degraded by a road crossing, an elevated hiking trail, encroachment of jack pine, and protracted fire suppression. It is surrounded by extensive natural cover, though there are some private inholdings adjacent to the prairie. The diversity is somewhat lower than other examples of the community type, though still elevated compared to many nearby openings. There were no observed invasive species, and the road that cuts through it has had minimal observable impacts on hydrology.

The large prairie opening is dominated by graminoids including Canada bluejoint, prairie cord grass, *Carex pelleta*, ticklegrass, and beak-rush. Forbs include wild blue flag, bushy aster, hyssop hedge nettle, and lance-leaved violet. Overall, the canopy of jack pine is sparse but locally dense along the margins with up to 50% coverage. These areas of jack pine thickets were included in the mapped prairie because of the dominance of characteristic graminoids in the herbaceous layer and the recoverability of the site. The system appears to transition to intermittent wetland in the southern portion, but this area is adjacent to private property and was not surveyed in 2022.

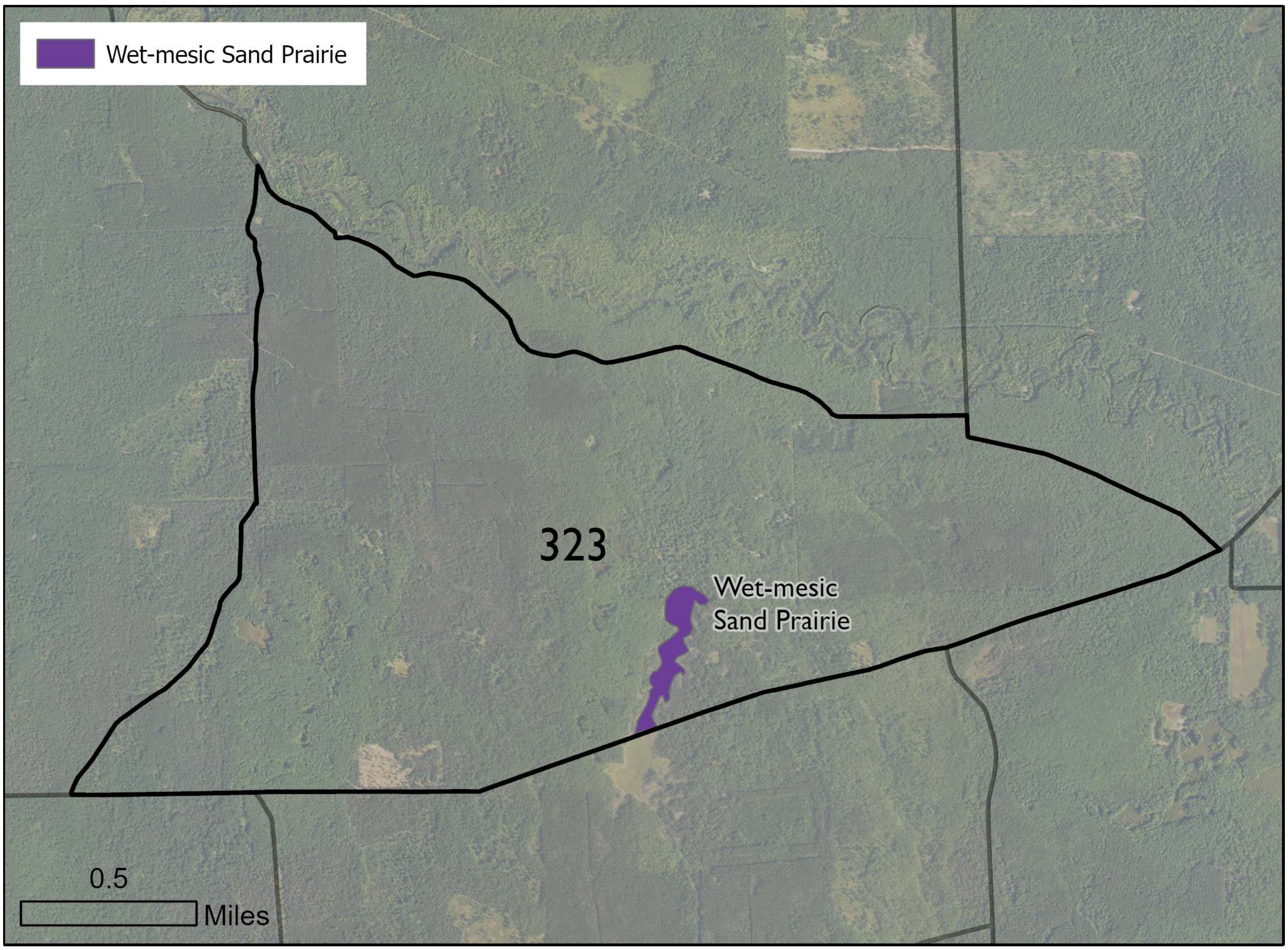

Figure 15. Natural communities of Compartment 323, the North Country Prairie Area.

Management Recommendations

The top management priorities are to move the road to protect the prairie from ORV damage, repair any ditches along the road that might alter hydrology, move the North Country Trail outside of the prairie, include the prairie within a large project area for applying prescribed burns, and investigate purchasing adjacent private land. Fire suppression and encroachment of jack pine at the margins are causing the prairie to slowly convert to forest, at least locally. The hydroxeric nature of the system will slow conversion and intervention with fire can quickly reverse the woody encroachment, particularly in the diverse margins where encroachment is most problematic.

A zone in Stand 14 of Compartment 323 has similar herbaceous vegetation characteristic of the wet-mesic sand prairie but has nearly completely converted to a jack pine forest. Most grasses in Stand 14 were not flowering and persist only in a suppressed, vegetative state due to the closed-canopy conditions. We suggest investigating establishing a large project area to include Stands 25, 14, 35, and the numerous small stands within. There is ongoing habitat work taking place in many of the smaller stands and the large prairie and barrens restoration project area would complement those efforts. Avoid establishing burn breaks at the ecotone where the wetland transitions into the uplands as this ecotone tends to have high diversity.

Where jack pine has formed thickets at the margins of North Country Prairie, characteristic herbaceous vegetation, such as prairie cord grass, still persists. This site could be substantially improved with a single burn.

North Country Prairie is dominated by graminoids. The fluctuating water table has preventing its conversion to closed-canopy jack pine forest, though the margins have been taken over by woody encroachment in the absence of fire.

Discussion

Evaluating the Model

Based on interpretations of General Land Office (GLO) surveys the Cadillac-Manistee District of the Huron-Manistee National Forest supported around 10,000 acres of barrens habitat in 1830. Prior to this project, there was only one 5.7-acre dry sand prairie documented in the 250,000-acre district. While it was clear that additional fire-dependent natural communities persisted on the landscape, there had not been concerted efforts to document and prioritize these remaining systems. Through our process of evaluating the District, we were able to identify numerous recoverable, fire-dependent systems (RFDS) that are ideal for inclusion in long-term restoration projects. Many of these areas qualify as high-quality natural communities and are types that had not been documented by MNFI in the District prior to this project. There are now 423 acres of high-quality fire-dependent prairie and barrens documented in the District and these can serve as valuable focal points for stewardship actions to recover and enhance existing natural communities.

The highest priority RFDS for proposed stewardship actions to protect prairie and barrens are in The Pine River Corridor (Compartments 9 and 10), Yonkers Prairie (327), Hoxeyville Barrens (7), Steinberg-Little River Area (389, 390, and 392), Koening Area (332 and 333), Pine Creek Corridor (373), Black Lake Area (334 and 338), and North Country Prairie (323). These sites support important examples of previously undocumented dry sand prairie, hillside prairie, oak-pine barrens, pine barrens, and wet-mesic sand prairie. Many of the potential stewardship areas have also been identified by the HMNF for barrens restoration and our sites are intended to expand and supplement the ongoing efforts by the District. Our proposed stewardship areas are ordered to protect the highest quality examples of the rarest natural community types and the largest sites. Our recommendations are that management efforts maintain ecological integrity and native biodiversity through the application of long-term stewardship actions, especially prescribed fire and control of invasive species. These efforts should be focused within natural communities that provide potential habitat for numerous rare plant and animal species.

The prescribed fire needs assessment model output was extremely useful for directing field surveys that resulted in the documentation of several fire-dependent natural communities. Arguably the two most significant conservation sites highlighted in this report – Pine River Hillside Prairie and Yonkers Prairie – did not rank especially high in our preliminary modeling effort. The GLO notes did not describe elements of prairie or barrens systems in either area. However, these fire-dependent systems historically occurred as a shifting mosaic and small-scale patches of natural communities such as dry sand prairie in frost pockets, hillside prairie along rivers, and small pockets of barrens were often not captured in the GLO notes. While those two important conservation sites were not in areas prioritized by the model, based on the number of natural communities documented in the prioritized model, the validity of the model is not in doubt. Instead, this points to the importance of experienced botanists and ecologists to recognize significant conservation sites that fall through the inevitable gaps of a model. Pairing modeling efforts with ground-truthing to identify RFDS for restoration is critical.

Hoxeyville Oak-Pine barrens has good structure but will rapidly convert to forest without stewardship intervention.

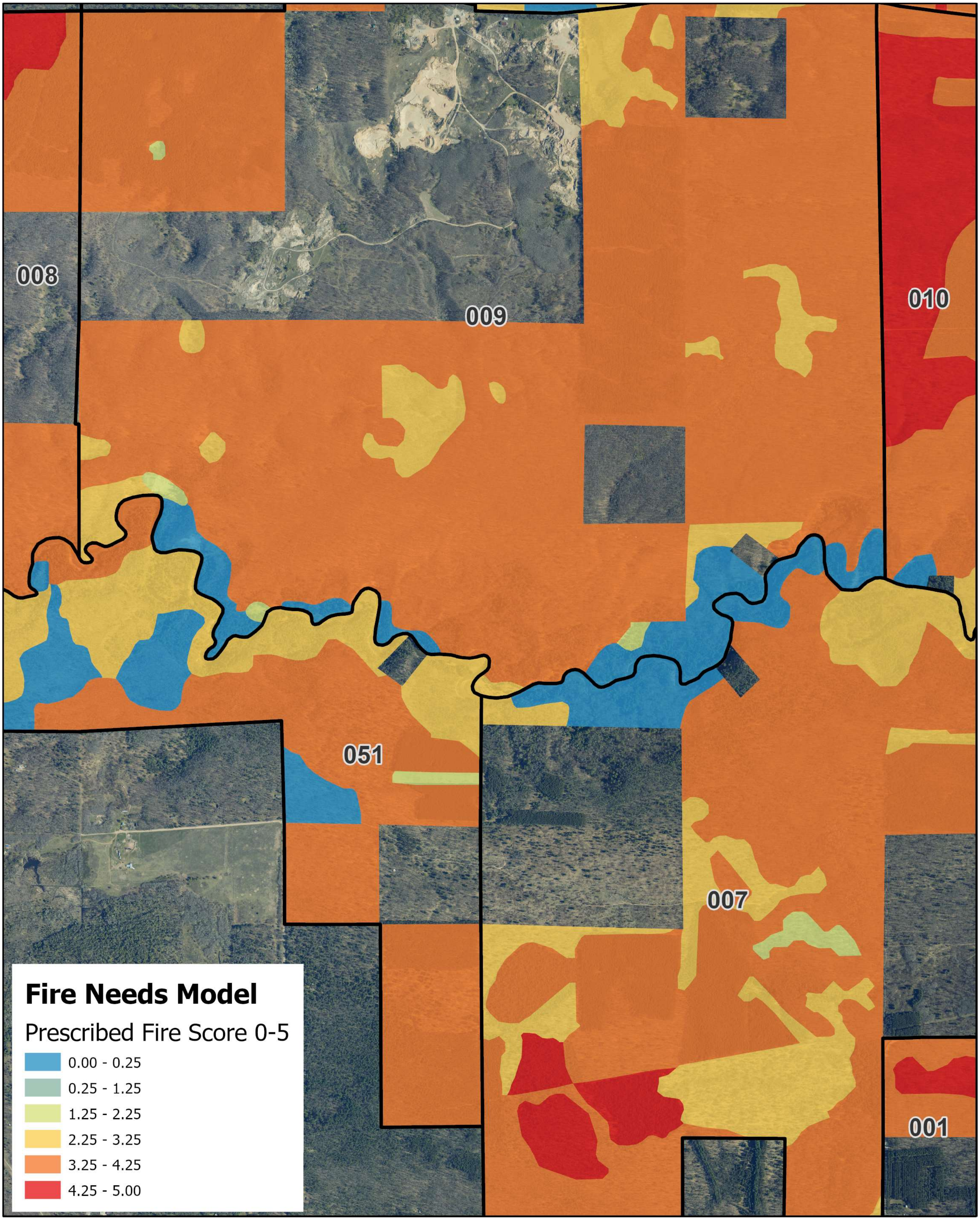

Figure 16. The prescribed fire needs assessment model output for Compartments 7 and 9 indicates a landscape with a historically high-frequency return interval of fire. This model output was extremely useful for directing field surveys that resulted in the documentation of several fire-dependent natural communities.

Another area prioritized for surveys had a minimal component of RFDS. Compartment 325 (Priority Area 6 in the original survey order) was surveyed and found to have minimal barrens composition in the eastern half of the compartment and no remnant natural communities were identified. Some previous iterations of the model applied to state lands penalized pine plantations. Plantations received lower scoring so that unnatural systems would not be overrepresented in the model output. For this iteration we allowed the signal of plantations to be amplified by the species composition, thereby giving plantations a higher fire need than was useful for this project. The justification was that pine plantations often occur on soils and landscape contexts where fire would have historically been prevalent, possibly in barrens or prairie community types. Upon surveying Compartment 325, which had numerous plantations, seemed to be part of a fire-adapted landscape, but none of the openings had more than a few indicator species and those only occurred at low densities, even in areas where previous prescribed fire and mechanical work had occurred. Therefore, to better allocate limited stewardship resources, we recommend managers do not include eastern Compartment 325 in future barrens restoration efforts. Future model outputs could automatically downgrade the scoring of plantations or display them as crosshatch so users could more easily take a stand's status as a plantation into account.

The approach of combining the prescribed fire needs assessment model and on-the-ground expert interpretation was an effective method for identifying RFDS. The results of this project will allow us to adjust future iterations of the model and strengthen its predictive abilities. With stand-level data, this approach is easily adaptable for other areas in the state and potentially across the region.

Recognizing Recoverable, Fire-Dependent Systems

RFDS in this District have an elevated graminoid diversity, increased species evenness, greater forb diversity and abundance, and more conservative species than other sites. They also had relatively low invasive species densities. RFDS were also characterized by a prevalence of the native Pennsylvania sedge (*Carex pensylvanica*) and hair grass (*Avenella flexuosa*). Hair grass is considered a relatively conservative species but, in this District, it tended to be especially aggressive in many upland community types. The prevalence of these graminoids and the similar appearance of grasses in general, gave a uniform appearance to much of the landscape. Familiarity with Michigan's flora, especially grasses and each species' degree of affinity for undisturbed habitat, was critical for recognizing remnants. Further, the superabundance of deer across the region has substantially decreased the composition of forbs (flowering plants) on the landscape. Forbs are typically useful indicators of high-quality remnants but were often absent, at very low densities, or heavily browsed as to obscure their presence, even in high-quality remnants. Therefore, the ability to perceive seemingly subtle shifts in graminoid composition and abundance was critical for identifying RFDS.

Species lists were compiled for all the surveyed RFDS. Comparison of these lists showed patterns in composition across sites, and we developed a list of the most important native species to aid in recognition of areas we identified as important RFDS in the Cadillac-Manistee District (Table 5). This list includes characteristic graminoids as well as the forbs that were characteristic in the most diverse sites. Regional botanists assign each native species a value of 0 to 10 based on probability of its occurrence in a natural versus degraded habitat.

Prairie brome is an important indicator of remnant barrens and dry sand prairie.

High-quality natural communities such as Hart Oak-Pine Barrens, have elevated graminoid diversity compared to surrounding areas.

Pennsylvania sedge is native but often dominates to the exclusion of other species.

Species restricted to a specialized or undisturbed habitat are assigned a value of 10, implying the species has extremely strong fidelity to a specific habitat. Native species that are not particular or indicative of natural conditions are assigned a low value of 0 to 2. While species with higher C values are often valuable for recognizing important sites, several species on our list with C values around 5 were consistently indicative of RFDS when they occurred at higher frequencies and in assemblages with other characteristic species.

Of the most conservative species (C > 7) we typically found in sites identified as RFDS, 38% are grasses and these tended to occur in much greater abundance than the most conservative forbs. Because of the importance of graminoid identification for recognizing valuable remnants, seasonality of surveys is important. Several key grasses – such as black oatgrass, June grass, rice-grass, native bluegrass (*Poa saltuensis*), and panic grasses (*Dichanthelium* spp.)– are cool-season grasses and are easier to identify in June and early July but are often dormant later in the season when big bluestem, little bluestem, and Indian grass are in flower or fruit. Ideally two surveys in a growing season would take place to generate a species list for each site. We recommend that future surveys of RFDS include two surveys when possible to account for the variable seasonality of indicator graminoids.

High-quality sites also frequently had areas where the non-native Kentucky bluegrass (*Poa pratensis*) was common to locally dominant. The presence of non-native *Poa* is especially challenging when evaluating the ecological integrity of sites because it can be difficult to recognize. It is a small grass and flowers early in the growing season so that by the end of the summer there is little diagnostic material. Even extensive areas of *Poa pratensis* can be difficult to perceive at certain times of the year and specimens often require a microscope for conclusive identification. Two other non-native *Poa* species occur on the landscape: *Poa nemoralis* and *Poa compressa*. A native bluegrass, (*Poa saltuensis*) has a relatively high fidelity to high-quality sites but can be difficult to distinguish from *Poa nemoralis*. The non-natives often grow intermixed with quality native vegetation and it unclear how to treat them without collateral damage or if is even worth treatment with herbicides.

The composition of non-native *Poa* on the landscape and the management implications for treatment should be better understood because they have such a strong affinity for prairies and savannas. A brief description of *Poa pratensis*, the threat it poses to natural communities, and potential management approaches is available from Illinois Nature Preserves Commission (Soleckie and Edgin 2017).

The highest quality sites had diagnostic community structure and familiarity with MNFI's classification of natural communities was also useful for identification of the highest quality and most recoverable areas. The three upland community types documented are dry sand prairie, oak-pine barrens, and pine barrens. Oak-pine barrens and pine barrens tended to have 30 to 60% canopy coverage, large open-grown trees, and were generally more diverse than dry sand prairies.

Table 5. A list of herbaceous plants that were frequently found in dry sand prairie, oak-pine barrens, and pine barrens. The species are arranged by their coefficient of conservativism (C) with the higher values indicating a fidelity to high-quality sites. These species are useful for identifying recoverable, fire-dependent systems in the Cadillac-Manistee District.

Scientific Name	Common Name	C	Physiognomy
Lithospermum canescens	hoary puccoon	10	forb
Polygala polygama	racemed milkwort	9	forb
Viola pedata	birdfoot violet	9	forb
Calystegia spithamaea	low bindweed	8	forb
Cirsium hillii	hills thistle	8	forb
Crocanthemum canadense	common frostweed	8	forb
Campanula rotundifolia	harebell	6	forb
Galium pilosum	hairy bedstraw	6	forb
Hieracium venosum	rattlesnake-weed	6	forb
Houstonia longifolia	long-leaved bluets	6	forb
Asclepias tuberosa	butterfly-weed	5	forb
Comandra umbellata	bastard-toadflax	5	forb
Hieracium gronovii	hairy hawkweed	5	forb
Liatris cylindracea	cylindrical blazing-star	5	forb
Liatris scariosa	northern blazing-star	5	forb
Symphyotrichum laeve	smooth aster	5	forb
Packera paupercula	balsam ragwort	3	forb
Monarda fistulosa	wild-bergamot	2	forb
Piptochaetium avenaceum	black oatgrass	10	grass
Koeleria macrantha	june grass	9	grass
Piptatherum pungens	rice-grass	9	grass
Bromus kalmii	prairie brome	8	grass
Elymus trachycaulus	slender wheatgrass	8	grass
Avenella flexuosa	hair grass	6	grass
Andropogon gerardii	big bluestem	5	grass
Dichanthelium columbianum	panic grass	5	grass
Poa saltuensis	bluegrass	5	grass
Schizachne purpurascens	false melic	5	grass
Schizachyrium scoparium	little bluestem	5	grass
Danthonia spicata	poverty grass; oatgrass	4	grass
Dichanthelium linearifolium	panic grass	4	grass
Carex pensylvanica	sedge	5	sedge
Arctostaphylos uva-ursi	bearberry	8	shrub
Prunus pumila	sand cherry	8	shrub
Comptonia peregrina	sweetfern	6	shrub
Amelanchier spicata	shadbush serviceberry	4	shrub

Birdfoot violet (left) and black oatgrass (right) are important indicator species with high coefficients of conservativism.

The non-native invasive Kentucky bluegrass (*Poa pratensis,* left) is subtle and often hard to detect, even when locally dominant. Northern blazing star is a native forb that frequently occurs in high-quality remnants.

The canopy composition of oak-pine and pine barrens was typically similar but sites classified as pine barrens had pine species as a majority of the canopy composition, including jack, white, and red pine. Oak-pine barrens had black and white oaks as the dominant components of the canopy. Dry sand prairies tended to occupy small depressions that function as frost pockets. The growing-season frosts within these depressions limit woody encroachment and help maintain the open structure of these prairies. Dry sand prairies tend to have canopy coverage less than 20%. Lists of herbaceous vegetation from the highest quality dry sand prairie, oak-pine barrens, and pine barrens were very similar and we conclude that the differences between dry sand prairie and barrens were primarily structural and not floristic. Differences in floral composition between natural community types may be muted by decades of fire suppression and high levels of deer herbivory.

MNFI's natural community classification was based on the best examples of Michigan's remnant natural community types. The distinctions between oak-pine barrens, pine barrens, and dry sand prairie are difficult to detect in a landscape modified by cessation of indigenous burning practices, centuries of Euro-colonization, extinction of large herbivores and keystone species, and ongoing forest management which includes timber harvest, furrowing, planting, and various other treatments. Differences in classification might subtly impact goals for future conditions, mostly around structure and composition of the canopy, but these systems historically transitioned into each other. The shifting mosaic of the historic landscape was governed by numerous interacting factors including climate, human occupancy, soil edaphic condition, and populations of large herbivores, such as elk, and potentially passenger pigeons. Therefore, the current distinction of natural community type between dry sand prairie, pine barrens, and oak-pine barrens is much less important than recognizing the fire-dependent sites retaining potential for recovery with stewardship intervention.

Steinberg Pine Barrens features a sparse canopy with a prevalence of pine species.

Hart Oak-Pine Barrens is characterized by several large, open grown black oaks, in addition to white and jack pine.

Koenig Dry Sand Prairie shows the typical prairie structure with very few canopy trees and a diverse suite of graminoids.

The Condition of the Remnants

The overwhelming abundance of Pennsylvania sedge, hair grass, and Kentucky bluegrass likely indicates severe historic disturbance, intense pressure from deer, protracted fire suppression, and potentially the loss of major grazers, like elk that would consume graminoids and disrupt the dense thatch. These factors complicate and shape any efforts to recover conservation targets. Despite the success of many restoration efforts, some treatments where conversion to barrens was an apparent goal have produced mixed results. These areas were thinned to recreate barrens structure but were lacking in the consistent diverse assemblage of herbaceous plants. Often areas that had been thinned to recreate structure, had a perceivable element of barrens vegetation but stumps and seedlings were vigorously resprouting to the detriment of herbaceous composition. In many of these areas, the structure of barrens has been restored but the floristic diversity in the herbaceous layer is lacking. While some areas that were thinned have successfully recreated a barrens structure, the removal of the canopy without previously establishing control over the understory layer can destabilize a site. The flux caused by canopy loss in an unprepared system exacerbates the loss of herbaceous composition and diminishes restoration potential. The reversal of forestation to restore barrens must include controlling the understory layer prior to major disruption of the canopy. Table 6 provides a review of several sites where the District appears to have implemented barrens restoration.

We have carefully reflected upon the nature of sites identified as RFDS and other areas where treatments appear to have not met the goals of barrens restoration. To adapt and implement the most effective management approaches, it is important to understand why some sites have characteristic vegetation and how to prevent treatments from exacerbating the loss of diverse assemblages – particularly as threats to ecological integrity become more complex and protracted. Remnant patches have diverse herbaceous composition and seem to have properties that allowed the system to resist conversion to forest. Numerous factors influence this conversion to forest, particularly droughty soils, topography that facilitated growing season frosts, or dramatic slope that inherently maintained semi-open conditions that allowed characteristic herbaceous vegetation to persist.

The restoration efforts in Compartment 395, Stand 4 were exemplary. The site selection, implementation of fire before canopy harvest, and management of the understory have resulted in a stable barrens restoration project.

Table 6. A review of some areas in which the District has implemented barrens management.

Project Area	Site Name	Notes on Positive Actions	Additional Considerations
Compartment 395 Stand 4	Little Round	•Great herbaceous diversity, ideal site selection •Excellent canopy retention •Appeared to burn prior to timber harvest •Excellent control of saplings/understory	•Consider expanding into more of Stand 4 •Continue burning at a relatively high frequency
Compartment 7	Hoxeyville	•Excellent site selection •Prescribed burns •Managed woody regrowth, primarily black cherry and black oak	•Expand burn units to include more of the barrens •Retain more trees in future thinnings (Stand 9) •Move roads outside of restoration areas •Treat invasives along roads
Compartment 389 Stand 3	Steinberg Pine Barrens	•Reduced canopy of forest adjacent to remnant pine barrens •Successfully avoided timber harvest in highest quality areas •Retained good diversity of old trees and created excellent structure •Burned prior to thinning and included remnant in burn	•May be potential to expand barrens structure into Stands 2, 5, 17, and 16 •Portions of Stand 2 seems to have barrens structure and was underplanted with pine
Compartment 392 Stands 17 and 18	Little River Dry Sand Prairie	•Thinned margins of prairie to reverse woody encroachment •Retained old white oak •Removed planted pine	•Extend project area to the northwest to include barrens area in 12 and 21 •Apply prescribed fire
Compartment 334 Numerous Stands	Black Lake	•GLO notes describe as barrens, good site selection •Very large project area •Excellent retention of trees, especially in Stand 6 •Removed planted pine in several areas •Likely historic barrens	•Ideal structure in many places, but generally low diversity •Extensive sedge/hair grass thatch, might be a good place to reintroduce elk •Continue to develop large project area •Experiment with seasonality/frequency/severity of burns •Experiment with disrupting thatch •Investigate repairing furrows on slopes near Black Lake
Compartment 338 Stands 41, 42, 43	Hoague Pine Barrens	•Nice composition/structure in portions of 41 •Good structure in several places, but intense oak regeneration in thinned areas •Removed planted pine	•Include large area in frequent prescribed burns and connect to Stand 6 with pine barrens remnant •Manage intense oak regeneration where characteristic herbaceous vegetation persists
Compartment 391 Stand 27	Six Mile South	•Good herbaceous diversity •Good site selection •Thinned canopy and retained legacy trees •Retained decent structure •Excluded deer	•Large areas of exposed sand may need to be planted with native species •Include in prescribed burns •Continue to manage understory •Consider retaining more canopy trees in when developing barrens restoration projects
Compartment 373 Stands 63, 19, 18	Hart Barrens	•Good structure and okay composition	•Consider shifting focus of barrens restoration to remnant in Stand 67 and include Stands 13 and 12 in project area
Compartment 325		•Some thinning •Some burns	•Minimal barrens pulse, not recommended as a restoration focus area

The concept of the "shifting mosaic" that characterized the landscape prior to Euro-colonization no longer describes the pattern of succession and the concept may be obfuscating modern stewardship approaches. We suggest that a slight shift in perspective may be needed to adjust stewardship of RFDS across the contemporary landscape.

Historically, barrens doubtless occurred as a shifting mosaic where the community types occurred in a matrix of forest, savanna, and prairie and expressions of the systems moved as the result of the complex interplay between Indigenous occupancy, herbivores, fire, soil conditions, and climate. Catastrophic, stand-replacing fires would have infrequently impacted areas during prolonged drought. Herbivory would have influenced successional pace and trajectory of many systems. And humans influenced patterns of herbivore grazing through careful application of fire, creating this dynamic landscape of open, roving, fire-dependent communities: the shifting mosaic.

Within such a landscape of frequent fire, mobile populations of large herbivores, and unbroken natural cover, simply reducing canopy would have enrolled an area into the shifting mosaic and pushed it towards barrens and prairie composition. However, the late stages of Euro-colonization halted the processes that governed the barrens and prairie continuum and the mosaic ceased shifting.

The barrens and prairie vegetation became fixed and then reduced by the uninterrupted successional dominance of forest. The prairie and barrens vegetation persisted only in the landscape positions with edaphic forces that prevented conversion to forest: the steep drought-prone hillsides along major rivers that occasionally sloughed and maintained hillside prairies; the hydroxeric wet-mesic sand prairies that are characterized by inundation in the early spring and drought later in the growing season; the pitted outwash depressions that facilitate growing-season frosts which maintain dry sand prairies; and the excessively drained deep sands that promote droughty conditions that allow barrens structure to persist and resist forestation. When the landscape-level processes stopped, the local variation was simplified and muted except for the areas that could resist conversion.

To better frame management approaches, we suggest shifting focus to these areas where barrens and prairie persist. We will refer to these focal areas as "dynamic cores". They are the nuclei of the recoverable, fire-dependent systems and their recognition and stewardship are critical for maintaining diverse assemblages of vegetation on the landscape.

The distinction between shifting mosaic and dynamic core is important because it places an emphasis on the careful recognition of the core zones and requires a management approach suited to recognizing, protecting, and expanding the dynamic core from a ground-up and site-specific approach. This is contrasted to the shifting mosaic approach by which a manager might recreate barrens structure in a forested area and then encourage composition to develop through fire and mechanical work: a top-down and site-unspecific approach. The key to the dynamic core concept is to have composition first, secure it through fire and mechanical work to control the understory, then reverse the momentum of canopy closure and woody encroachment to expand the core with more intense fires and forestry prescriptions. Once the core is stabilized it can be expanded: the mosaic can be shifted when the remnant is secured.

The Little River Dry Sand Prairie "dynamic core". The District has already started to develop characteristic barrens structure by thinning the forest at the margins of the prairie, reversing the momentum of woody encroachment. Continuing the process with prescribed fire will expand the quality vegetation and ideally connect to nearby cores.

The core of Udell Prairie is small and extremely diverse. The site is resisting woody encroachment through its hydroxeric nature. With stewardship intervention, particularly prescribed fire, woody encroachment in the core can be reversed and the prairie vegetation can colonize surrounding forests.

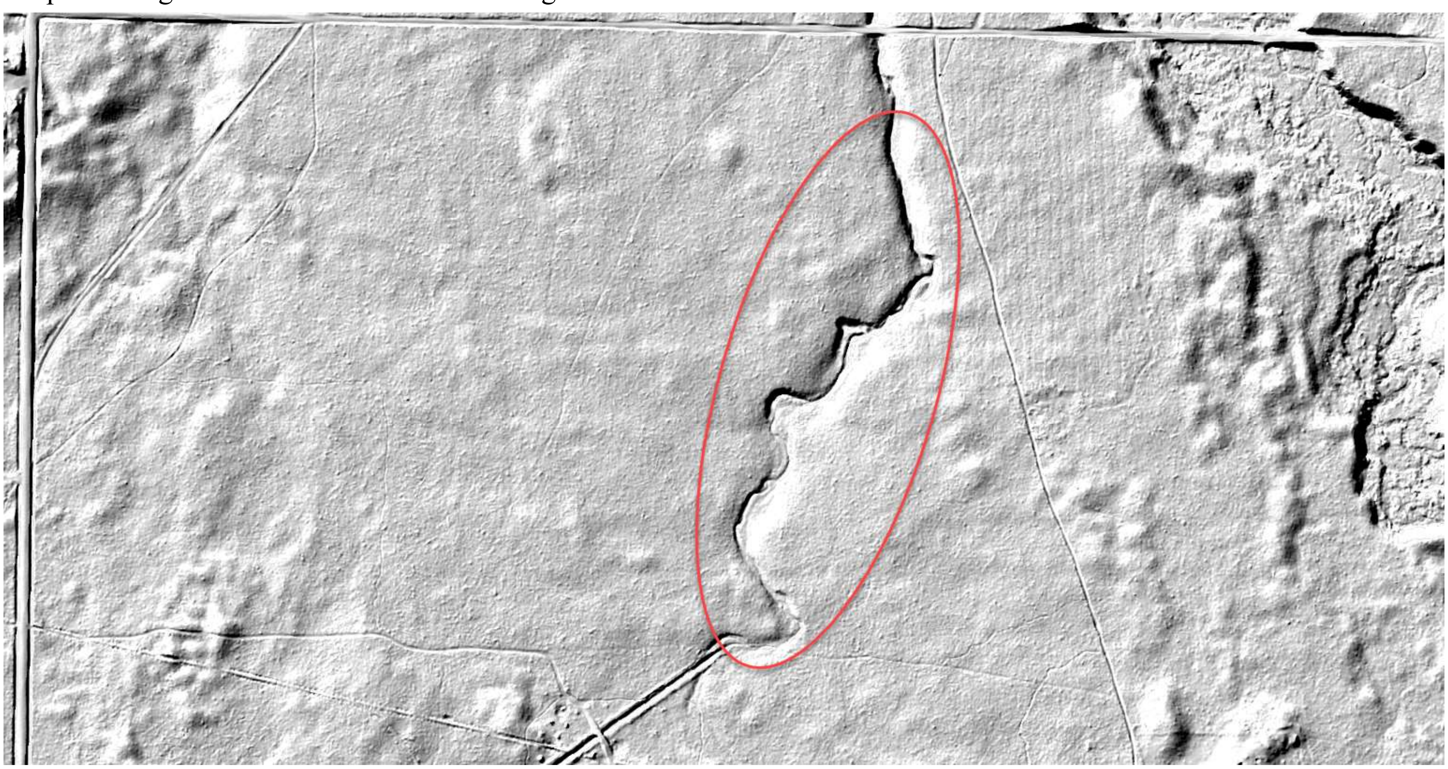

Figure 17. Udell Prairie occupies a subtle, narrow drainage on the flat outwash plain. The drainage is occasionally inundated in late winter and experiences drought in the late summer. This hydroxeric nature has allowed the diverse assemblage of prairie vegetation in this "core" to persist, despite the absence of frequent fire and the conversion of the surrounding landscape to closed-canopy forest. Without stewardship intervention its condition will continue to decline.

This "dynamic core" is also a valuable concept because it implies an impending expiration on the recoverability of these core areas. A much greater proportion of the landscape historically supported barrens and prairie composition. Systems that persisted for thousands of years have become unrecoverable over much of their former extent. It appears that once barrens and prairies succumb to reforestation, when the forbs are exhausted by herbivory, and when the graminoid composition is oversimplified, the capacity to recover the site is untenable and that core is lost. Once the core is lost, returning composition becomes a more challenging process that will require substantial time.

This change of paradigm from the "shifting mosaic" to the "dynamic core" emphasizes the urgency of this work. Without immediate and sustained intervention, these cores and the accompanying species will continue to be lost from the landscape.

Implementing Management Recommendations
Our management recommendations and prioritization must be balanced with on-the-ground knowledge. Projects depend on many factors and ultimately District managers will decide when and how resources are allocated. Broadly, the goals of the management recommendations are to promote native biodiversity by promoting ecosystem integrity. This can be accomplished on a landscape scale by identifying and protecting high-quality natural communities through the return of landscape-level prescribed fire, control of invasive species, limiting deleterious anthropogenic disturbance in sensitive areas, careful forestry prescriptions to expand and connect areas with barrens and prairie composition, and monitoring the response of systems to adjust and iteratively improve the approach.

Stand 40 of Compartment 338 was a closed-canopy forest and after thinning, had tree spacing similar to a barrens. The understory was not controlled with fire prior to thinning and the regrowth of oak saplings is so dense that it precludes the site from meaningful restoration work in the future. Any characteristic barrens vegetation that may have remained prior to the canopy alteration was undetectable.

Managers must operate at the site level to achieve this broad set of goals. There are overarching strategies, but each site is unique and requires familiarity with the composition of remnants and the overarching goals of the program. Many of these open systems are resisting conversion to a closed-canopy community and the recovery of the RFDS relies on carefully reversing the momentum away from closure, while preserving composition of each site. To best manage RFDS, we recommend identifying diverse remnants around which to develop large, long-term restoration project areas. Within these project areas, we recommend the following approach:

- Begin stewardship at the ground level by a combination of low-intensity fire, mechanical reduction of the understory, treating problematic populations of invasive species, and potentially herbiciding black oak, black cherry, and red maple saplings to begin to reduce the understory.
- Protect shrubs characteristic of barrens during understory work.
- Protect canopy structure and composition and avoid rapid shifts to the canopy which causes problematic flush of the understory saplings.
- Work to protect legacy trees ahead of the initial burn by reducing competition from neighboring inferior trees ahead of burns, eliminating ladder fuels, and removing accumulated duff from the bases of these trees.
- Avoid thinning barrens and surrounding matrix until after at least one burn to minimize destabilizing the understory. Initial fires will also kill the most fire-sensitive individual canopy trees and reduce options for retaining canopy composition. Attempt to ensure that the initial burn is a dormant season burn, ideally late fall, to limit undue stress on important trees.
- Determine the healthiest trees to retain in the canopy, prioritizing the oldest trees of typical constituents but especially favoring the retention of white oak and natural red pine which tend to be more resilient to a high-frequency return interval of fire.
- Create variable spacing of the canopy, with some areas of widely spaced trees and other zones with greater coverage.
- Do not to use high-quality areas as landings during future timber harvest and minimize soil disturbance in wetlands during mechanical work.

Ideally, many of the core areas will respond positively and additional areas in the project area will express barrens and prairie composition. It may be possible to expand and connect openings through forestry operations by gradually thinning the canopy while controlling the understory and invasive species.

An example of an old, large, open-grown white oak. This is the type of tree we recommend managers retain during barrens restoration.

The absence of fire in a system means that many individuals of a species which might otherwise be resilient to fire, will die due to initial restorative burns. This black oak with multiple fire scars at the base is likely susceptible to mortality during future fires. Many individuals will succumb to fires and it is not always obvious which individuals will be lost after the initial fires. Therefore, during barrens restoration we suggest managers minimize unintended canopy loss by thinning after the initial fire to better retain the individual trees most resilient to fire.

Several plantations appear to have been established in some areas of historic barrens. Often, the barrens structure is still perceivable with the much older, open-grown white oaks persisting along with pockets of characteristic vegetation. When incorporating plantations into barrens management areas, retain the legacy white oaks when possible.

Fire as a Landscape Process

Fire was a disturbance factor that historically shaped much of the Cadillac-Manistee District. Many natural communities in the District are fire-dependent and fire will be an integral part of maintaining prairies and barrens in the future. Historic Indigenous populations were the primary ignitors of fire and used it for myriad reasons. The systems and native biodiversity we are trying to promote assembled, persisted, and thrived under that management. Therefore, the application of prescribed fire should reflect the timing and frequency of Indigenous burning because the diversity we are trying to protect was organized under that framework. This will require careful evaluation of effectiveness of fire timing, frequency, and intensity and then assessing the need for intervention through mechanical reduction of the understory and the potential application of herbicide. Ideally, partnerships with tribes would be established to replicate the cultural practices around fire that allowed fire-dependent natural communities to persist.

We recommend applying prescribed burns across large project areas around RFDS, using existing features like roads and rivers as burn breaks. Ecotones should be included in prescribed burns, particularly along wetlands. These especially diverse areas are often the location of trails and burn breaks and are frequently excluded from burns. Burn breaks should not be installed in ecotones. In addition, we recommend that burn breaks and trails be kept away from high-quality openings to minimize risk of invasive species and limit access for ORVs. Burning more than identified remnants will potentially express new RFDS. Additionally, because deer are often attracted to recently burned areas, including more than high-quality remnants in the burn will diffuse this increased intensity of herbivory following restorative burns.

Ongoing studies of red pine stumps in the Cadillac-Manistee District suggest that burns historically occurred in the dormant seasons, either late fall or late winter. The mean fire return interval was between 4 to 36 years in one of the study areas west of Udell Hills. This study area appears to have been forested in the 1830s and nearby barrens systems might have experienced a higher frequency return interval. We recommend a high frequency of fire during initial stages of restoration, typically 3 burns per decade. Once ideal structure and improved composition have been achieved and minimal mechanical intervention is required, it is possible that a lower frequency of burns can maintain the open conditions.

We encourage attempting burns in the late fall (late September and later) for several reasons. Conducting the initial burn in the dormant season may cause less canopy tree mortality and have less of a destabilizing influence on the understory than a late spring or growing season burn. Late-season burns eliminate cover of seed predators (Anderegg et al. 2021) and remove thatch for better seed to soil contact of late-season forbs. Regardless of the seasonality of prescribed fire, these are fire-starved systems and fire at any season is likely more beneficial than continued fire suppression.

The ecotone along Black Lake transitions from intermittent wetland, to wet-mesic sand prairie, to oak-pine barrens, and forest. The ecotone should be protected and the transition zone from open system to forest broadened. This area appears to have been recently burned and we recommend managers continue applying prescribed burns here.

Openings throughout the District frequently had burn breaks at the margins. We urge managers to install breaks away from the openings to protect the ecotones which are often very diverse. Ideally projects would use existing features such as roads and streams as burn breaks to minimize disturbance to the openings whenever possible.

High fire intensity and severity can eliminate the canopy of RFDS. We suggest attempting low-intensity, high-frequency burns to retain barrens structure, at least initially. While severe, stand-replacing burns occurred historically, the landscape has not had recent widespread fire and a less intense approach might retain structure and herbaceous composition during restoration. Above, northern Stand 51, Compartment 334.

Declining Herbaceous Composition

Across the district, Pennsylvania sedge and hair grass have formed a dense thatch, including within many of the RFDS. Additionally, the landscape seems to have a dearth of forbs. Even the best remnants have minimal forb composition. Deer herbivory was obvious on many forbs and shrubs in several of the remnants. While deer do browse young woody regrowth following burns, their overwhelming preference for herbaceous vegetation during the growing season contributes to a decline in forb composition. The superabundance of deer, particularly in combination with fire suppression, is a factor driving the loss of forbs on the landscape. Timing of fire and concerted reduction in deer may help. We suggest managers investigate including deer exclosures in several project areas to allow the forb component of the RFDS to rebound during restoration.

In general, we recommend that managers do not supplement the floristic composition of mapped EOs by planting additional species. As noted above, this can reduce the site's status as a valuable reference area and makes it difficult to elucidate the community response to restoration. Restoration targets not immediately adjacent to high-quality remnants could be supplemented with additional species to improve diversity. We urge managers to use locally sourced seeds or plants as much as possible. Ideally, the seeds would come from nearby remnants. These actions should be carefully recorded so managers can understand the process that leads to future conditions.

While many of the highest quality remnants featured elevated forb composition, the most conservative species frequently had obvious signs of deer herbivory. Northern blazing star (top) and New Jersey tea (above) were frequently browsed.

Creating Resilience to Climate Change

Our management recommendations are intended to promote ecological integrity of prairie and barrens remnants persisting within the Cadillac-Manistee District. This approach is aimed at mitigating the loss of native biodiversity and will likely make the landscape more resilient to climate change.

During the 2022 surveys, black oaks in the district appeared to be especially vulnerable to climate stressors with many areas of drought-prone soils expressing substantial mortality of canopy black oaks. Comparison of current forest composition to historic GLO notes indicates that the prevalence of black oaks substantially increased following land clearing and reforestation. The species is vulnerable to oak wilt and multiple waves of spongy moth, drought, and hotter temperatures appear to be facilitating oak decline.

Increasing the extent of barrens across the District through landscape-scale fire management offers the path to a more resilient landscape by decreasing the density of trees and thereby reducing competition on individuals and a system's vulnerability to wilt. White oaks, which are less vulnerable to oak wilt, are more resilient to fire than black and northern pin oaks, particularly at the sapling stage. There is also evidence that the savanna structure favors predation of spongy moth larvae (Larsen et al. 2018). Therefore, a Cadillac-Manistee District with a lower density of black oaks on upland systems and higher incidence of low-intensity fire will increase the component of white oaks and be less susceptible to outbreaks of catastrophic disease. In fire-suppressed forests, dense undergrowth can generate high fuel loads and cause substantial risk of out-of-control wildfires. As periods of drought become more prevalent with climate change, the risk of catastrophic fires may increase in fire-suppressed systems. Reduction of understory fuel loads in fire-dependent systems through a greater application of prescribed fire will help mitigate this risk. Returning large portions of the landscape to barrens and prairie will likely improve the District's resilience to climate change, prevent the continuing loss of grassland and savanna obligates, and maintain a landscape that can contribute to the forest products industry.

Oak decline was a serious problem in Hoxeyville Oak-Pine Barrens. Increased application of prescribed fire will ideally shift composition to favor white oak and red pine and decrease canopy density, potentially making the structure and composition of the landscape more resilient to disease outbreaks.

Future work

Monitoring

Restoration is extremely complicated and developing a comprehensive and consistent monitoring methodology is critical for evaluating the effectiveness of stewardship. We suggest development of a state-wide barrens vegetation monitoring protocol that can be tailored for regions and natural communities. We recommend implementation of longitudinal monitoring of these restoration projects to ensure that management approaches aren't subtly exacerbating the loss of groups of species.

The application of prescribed fire is generally considered essential to the stewardship and restoration of fire-dependent natural communities. However, these systems evolved with fire in a different landscape context and the understanding of how this disturbance will impact modern systems in fire-suppressed landscapes is incomplete. We suggest monitoring programs include investigating shifts of Mean C values in response to fire timing and frequency and exclusion of deer.

Additional Surveys and Model Revision

We surveyed several areas of the Cadillac-Manistee District and found several RFDS and high-quality natural communities. Our model identified several additional areas that likely support RFDS and we recommend additional surveys employing the same methodology. While our method was successful for identifying important areas for conservation, the natural communities that were documented during this project could help revise the model to increase its predictive power. Additionally, as noted above, we can adjust the scoring of plantations and revise the way they are displayed in model outputs.

Natural Community Stewardship Prioritization

The process of prioritizing stewardship of natural communities is complex. For this report, we prioritized stewardship by rarity of the community type, condition of the remnant, and concentration of RFDS in a project area. This process will be more complicated if future surveys occur and additional natural communities are documented. MNFI has developed a scoring matrix for natural community element occurrences to provide a framework for the prioritization of stewardship (Cohen et al. 2022). For this scoring matrix, we developed the following three indices: an ecological integrity index, a rarity index, and an invasive index. We used the element occurrence rank to develop the ecological integrity index, with higher scores for higher-ranked element occurrences. The rarity index was developed by assigning a score for each natural community type's state rank and global rank, with higher scores assigned to rarer types. An invasive index was also developed for the matrix. For each natural community element occurrence, the sum of the scores for the ecological integrity index, rarity index, and invasive index was calculated to sort the natural community element occurrences by their stewardship prioritization score. The stewardship prioritization for fire-dependent natural community element occurrences in the Cadillac-Manistee District could be integrated with future projects to simplify and standardize the prioritization process.

Monitoring will be beneficial for understanding community response to stewardship

Conclusions

The Cadillac-Manistee District of the Huron-Manistee National Forest historically supported numerous fire-dependent natural communities. Today, lingering remnants of those community types persist within the unfragmented landscape of the District. The changes in the land over the past two centuries and fire suppression have caused these fire-dependent communities to shrink and become obscured. The vast extent of the District also poses challenges for developing a rapid and methodical survey approach. We employed a prescribed fire needs assessment model to help focus surveys for recoverable, fire-dependent systems (RFDS) that remain on the District. We used the model results, aerial photographic interpretation, and input from District staff to focus ground surveys to identify RFDS.

The approach of combining the prescribed fire needs assessment model and on-the-ground expert interpretation was an effective method for identifying RFDS. We documented 16 new natural communities and updated records of 2 previously documented natural communities in 10 of the 14 surveyed compartments. The Pine River Hillside Prairie, Yonkers Prairie, and Hoxeyville Oak-Pine Barrens are the highest priority conservation targets identified during the survey efforts of 2022.

This project demonstrated a novel and effective approach to identifying fire-dependent systems that could be recovered to improved conditions with stewardship. The process of restoration requires time and dedication and the sites identified through this project have excellent potential for recoverability. While there is cause to be optimistic about the potential to recover remnant prairies and barrens in the District, we also hope to have conveyed an urgency. There are numerous interacting degrading forces that are influencing the condition and composition of remnants. The response to this reality must be swift and sustained, particularly in the face of an increasingly uncertain future.

Many important high-quality natural communities were documented through this pilot project. However, the District has many areas that were not surveyed during this initial effort and we hope to continue this approach for identifying valuable natural communities across the landscape. The results of this project will allow us to adjust future iterations of the model and strengthen its predictive abilities so that the best undocumented RFDS remaining on the District can be identified and a holistic approach to stewardship prioritization be implemented.

Many high-quality natural communities were documented over the course of this project. These are some of the best examples of recoverable, fire-dependent systems we have in the state and are worthy of sustained stewardship.

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Appendix 1. Global and State Ranking Criteria.

GLOBAL RANKS

G1 = critically imperiled: at very high risk of extinction due to extreme rarity (often 5 or fewer occurrences), very steep declines, or other factors.

G2 = imperiled: at high risk of extinction due to very restricted range, very few occurrences (often 20 or fewer), steep declines, or other factors.

G3 = vulnerable: at moderate risk of extinction due to a restricted range, relatively few occurrences (often 80 or fewer), recent and widespread declines, or other factors.

G4 = apparently secure: uncommon but not rare; some cause for long-term concern due to declines or other factors.

G5 = secure: common; widespread.

GU = currently unrankable due to lack of information or due to substantially conflicting information about status or trends.

GX = eliminated: eliminated throughout its range, with no restoration potential due to extinction of dominant or characteristic species.

G? = incomplete data.

STATE RANKS

S1 = critically imperiled in the state because of extreme rarity (often 5 or fewer occurrences) or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the state.

S2 = imperiled in the state because of rarity due to very restricted range, very few occurrences (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation from the state.

S3 = vulnerable in the state due to a restricted range, relatively few occurrences (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation.

S4 = uncommon but not rare; some cause for long-term concern due to declines or other factors.

S5 = common and widespread in the state.

SX = community is presumed 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.

S? = incomplete data.

Appendix 2. Species list for Pine River Hillside Prairie.

Scientific Name
Achillea millefolium
Agrimonia gryposepala
Agrostis gigantea
Alnus incana
Amelanchier interior
Amelanchier spicata
Andropogon gerardii
Anemone cylindrica
Anemone virginiana
Antennaria howellii
Antennaria parlinii
Anticlea elegans
Apocynum androsaemifolium
Aquilegia canadensis
Arabidopsis lyrata
Artemisia campestris
Asclepias syriaca
Asclepias tuberosa
Avenella flexuosa
Bromus kalmii
Calystegia spithamaea
Campanula rotundifolia
Carex eburnea
Carex pensylvanica
Carex tonsa
Carpinus caroliniana
Ceanothus americanus
Celastrus orbiculatus
Centaurea stoebe
Cerastium fontanum
Cirsium hillii
Cirsium muticum
Clinopodium vulgare
Comandra umbellata
Comptonia peregrina
Conyza canadensis
Coreopsis lanceolata
Cornus amomum
Corylus cornuta
Crocanthemum canadense
Danthonia spicata
Daucus carota
Desmodium perplexum
Dichanthelium depauperatum
Dichanthelium dichotomum
Dichanthelium latifolium
Dichanthelium xanthophysum
Doellingeria umbellata
Elaeagnus umbellata
Elymus canadensis
Elymus riparius
Elymus trachycaulus
Equisetum arvense
Erigeron philadelphicus
Erigeron pulchellus
Eurybia macrophylla
Festuca saximontana
Fragaria virginiana
Galium boreale
Galium pilosum
Geranium maculatum
Helianthus divaricatus
Helianthus strumosus
Hepatica americana
Hieracium gronovii
Hieracium kalmii
Houstonia longifolia
Hypericum perforatum
Juniperus communis
Koeleria macrantha
Krigia virginica
Lactuca canadensis
Lathyrus palustris
Lathyrus venosus
Lespedeza hirta
Liatris scariosa
Lithospermum canescens
Maianthemum canadense
Maianthemum racemosum
Maianthemum stellatum
Melampyrum lineare
Melilotus albus
Minuartia michauxii
Monarda fistulosa
Monarda punctata
Muhlenbergia mexicana
Oenothera biennis
Oryzopsis asperifolia
Packera paupercula
Pedicularis canadensis
Physalis heterophylla
Physocarpus opulifolius
Pinus resinosa
Pinus strobus
Poa compressa
Poa pratensis
Polanisia dodecandra
Polygonella articulata
Populus balsamifera
Populus grandidentata
Populus tremuloides
Potentilla simplex
Prunella vulgaris
Prunus virginiana
Pseudognaphalium obtusifolium
Pteridium aquilinum
Quercus alba
Quercus rubra
Quercus velutina
Rhus copallina
Rhus glabra
Rhus typhina
Robinia pseudoacacia
Rosa carolina
Rudbeckia hirta
Salix exigua
Sanicula marilandica
Sassafras albidum
Schizachyrium scoparium
Securigera varia
Selaginella rupestris
Smilax hispida
Solidago canadensis
Solidago hispida
Symphoricarpos albus var. albus
Symphyotrichum laeve
Symphyotrichum urophyllum
Thuja occidentalis
Toxicodendron rydbergii
Trifolium pratense
Trifolium repens
Verbascum densiflorum
Vicia americana
Vitis riparia

Appendix 3. Species list for Pine River Oak-Pine Barrens.

Acer rubrum	*Pedicularis canadensis*
Agrostis gigantea	*Phleum pratense*
Amelanchier spicata	*Physalis heterophylla*
Andropogon gerardii	*Pinus resinosa*
Antennaria howellii	*Pinus strobus*
Antennaria parlinii	*Piptatherum racemosum*
Aquilegia canadensis	*Piptochaetium avenaceum*
Asclepias exaltata	*Poa compressa*
Asclepias tuberosa	*Scientific Name*
Avenella flexuosa	*Poa pratensis*
Bromus inermis	*Populus grandidentata*
Bromus kalmii	*Populus tremuloides*
Calystegia spithamaea	*Prunella vulgaris*
Campanula rotundifolia	*Prunus virginiana*
Carex pensylvanica	*Pteridium aquilinum*
Centaurea stoebe	*Quercus alba*
Cirsium hillii	*Quercus rubra*
Clinopodium vulgare	*Quercus velutina*
Comptonia peregrina	*Rhus copallina*
Coreopsis lanceolata	*Rubus flagellaris*
Corylus cornuta	*Rudbeckia hirta*
Crocanthemum canadense	*Salix humilis*
Danthonia spicata	*Schizachne purpurascens*
Dichanthelium columbianum	*Schizachyrium scoparium*
Dichanthelium latifolium	*Solidago caesia*
Dichanthelium xanthophysum	*Solidago hispida*
Doellingeria umbellata	*Solidago nemoralis*
Elymus canadensis	*Symphyotrichum laeve*
Elymus trachycaulus	*Symphyotrichum urophyllum*
Fragaria virginiana	*Thuja occidentalis*
Galium boreale	*Tragopogon pratensis*
Galium pilosum	*Vaccinium angustifolium*
Gaylussacia baccata	*Veronica officinalis*
Hamamelis virginiana	*Viburnum acerifolium*
Helianthus divaricatus	*Viburnum rafinesquianum*
Hieracium gronovii	*Vicia americana*
Hypericum perforatum	
Juniperus communis	
Koeleria macrantha	
Lathyrus venosus	
Lespedeza hirta	
Liatris cylindracea	
Liatris scariosa	
Maianthemum stellatum	
Monarda fistulosa	
Ostrya virginiana	

Appendix 3. Species list for Pine Bowl Dry Sand Prairie

Acer rubrum
Amelanchier arborea
Apocynum androsaemifolium
Asclepias tuberosa
Asclepias verticillata
Avenella flexuosa; deschampsia f.
Campanula rotundifolia
Carex pensylvanica
Clinopodium vulgare
Comptonia peregrina
Crocanthemum canadense; helianthemum c.
Danthonia spicata
Dichanthelium columbianum; panicum c.
Dichanthelium depauperatum; panicum d.
Dichanthelium latifolium; panicum l.
Dichanthelium xanthophysum; panicum x.
Fragaria virginiana
Galium pilosum
Gaultheria procumbens
Hieracium aurantiacum
Hieracium venosum
Hypericum perforatum
Koeleria macrantha
Krigia virginica
Maianthemum canadense
Maianthemum racemosum; smilacina r.
Melampyrum lineare
Melica smithii
Pinus strobus
Pinus sylvestris
Poa pratensis
Polygala polygama
Populus grandidentata
Prunus serotina
Pteridium aquilinum
Quercus alba
Quercus velutina
Rosa carolina
Rumex acetosella
Schizachyrium scoparium; andropogon s.
Solidago nemoralis
Vaccinium angustifolium
Viburnum acerifolium

Appendix 4. Species list for Yonkers Prairie.

Acer rubrum	*Euthamia graminifolia*	*Pinus resinosa*	*Trientalis borealis*
Achillea millefolium	*Eutrochium maculatum*	*Pinus strobus*	*Vaccinium angustifolium*
Agrostis gigantea	*Fimbristylis autumnalis*	***Poa compressa***	*Vaccinium myrtilloides*
Agrostis scabra	*Fragaria virginiana*	***Poa pratensis***	*Verbena hastata*
Alnus incana	*Fraxinus pennsylvanica*	*Populus balsamifera*	*Viburnum cassinoides*
Amelanchier arborea	*Galium pilosum*	*Populus tremuloides*	*Viola lanceolata*
Amelanchier laevis	*Galium tinctorium*	*Potentilla simplex*	*Viola sagittata*
Andropogon gerardii	*Gaultheria procumbens*	*Prunella vulgaris*	*Viola sororia*
Apocynum androsaemifolium	*Gaylussacia baccata*	*Prunus pumila*	
Aristida basiramea	*Hamamelis virginiana*	*Prunus serotina*	
Asclepias hirtella	*Hieracium venosum*	*Pteridium aquilinum*	
Asclepias incarnata	*Houstonia longifolia*	*Quercus alba*	
Bartonia virginica	*Hypericum kalmianum*	*Quercus rubra*	
Bidens frondosa	*Hypericum majus*	*Quercus velutina*	
Calamagrostis canadensis	*Ilex verticillata*	*Rhynchospora capitellata*	
Carex bebbii	*Iris versicolor*	*Rosa carolina*	
Carex buxbaumii	*Juncus biflorus*	*Rosa palustris*	
Carex intumescens	*Juncus brachycarpus*	*Rubus allegheniensis*	
Carex lacustris	*Juncus canadensis*	*Rubus flagellaris*	
Carex oligosperma	*Juncus effusus*	*Rubus hispidus*	
Carex pellita	*Juncus greenei*	***Rumex acetosella***	
Carex scoparia	*Juncus nodosus*	*Salix exigua*	
Carex stricta	*Juncus tenuis*	*Salix humilis*	
Carex tenera	*Juncus vaseyi*	*Salix petiolaris*	
Carex utriculata	*Lactuca canadensis*	*Sassafras albidum*	
Carex vesicaria	*Lechea intermedia*	*Schizachyrium scoparium*	
Cephalanthus occidentalis	*Liatris aspera*	*Scirpus atrovirens*	
Chamaedaphne calyculata	*Lobelia spicata*	*Scirpus cyperinus*	
Cicuta maculata	*Lycopus americanus*	*Scutellaria galericulata*	
Comptonia peregrina	*Lycopus uniflorus*	*Scutellaria lateriflora*	
Coreopsis lanceolata	*Lysimachia ciliata*	*Sisyrinchium angustifolium*	
Cornus canadensis	*Lysimachia quadrifolia*	*Smilax hispida*	
Cornus foemina	*Lysimachia thyrsiflora*	*Solidago canadensis*	
Cypripedium acaule	*Maianthemum canadense*	*Solidago gigantea*	
Danthonia spicata	*Melampyrum lineare*	*Solidago juncea*	
Deschampsia cespitosa	*Mentha canadensis; m. arvensis*	*Solidago nemoralis*	
Dichanthelium boreale	***Myosoton aquaticum***	*Solidago rugosa*	
Dichanthelium implicatum	*Nyssa sylvatica*	*Spartina pectinata*	
Dichanthelium lindheimeri	*Oenothera perennis*	*Spiraea alba*	
Diervilla lonicera	*Onoclea sensibilis*	*Spiranthes romanzoffiana*	
Doellingeria umbellata	*Osmunda regalis*	*Stachys hyssopifolia*	
Dryopteris carthusiana	*Packera paupercula*	*Symphyotrichum dumosum*	
Eleocharis elliptica	*Panicum flexile*	*Symphyotrichum lanceolatum*	
Elymus trachycaulus	*Panicum virgatum*	*Symphyotrichum robynsianum*	
Equisetum hyemale	***Phalaris arundinacea***	*Thelypteris palustris*	
Erechtites hieraciifolius	***Phleum pratense***	*Toxicodendron radicans*	
Erigeron strigosus	*Pinus banksiana*	*Triadenum fraseri*	

Appendix 5. Species list for Hoxeyville Oak-Pine Barrens.

Acer rubrum	*Melampyrum lineare*
Agrostis gigantea	*Monarda fistulosa*
Agrostis scabra; a. hyemalis	*Muhlenbergia mexicana*
Amelanchier interior	*Oenothera biennis*
Amelanchier spicata	*Oryzopsis asperifolia*
Andropogon gerardii	*Physalis virginiana*
Anemone cylindrica	*Pinus banksiana*
Antennaria parlinii	*Pinus resinosa*
Apocynum androsaemifolium	*Pinus strobus*
Arctostaphylos uva-ursi	*Poa compressa*
Artemisia campestris	*Poa saltuensis*
Asclepias syriaca	*Polygala polygama*
Asclepias tuberosa	*Populus grandidentata*
Avenella flexuosa; deschampsia f.	*Populus tremuloides*
Bromus kalmii	*Potentilla simplex*
Campanula rotundifolia	*Prunus pumila*
Carex pensylvanica	*Prunus serotina*
Carex tonsa; c. rugosperma	*Prunus virginiana*
Centaurea stoebe; c. maculosa	*Pseudognaphalium obtusifolium; gnaphalium o.*
Cirsium hillii	*Pteridium aquilinum*
Clinopodium vulgare	*Quercus alba*
Comptonia peregrina	*Quercus velutina*
Cornus foemina	*Rosa carolina*
Corylus cornuta	*Rubus allegheniensis*
Crataegus macrosperma; c. brumalis; c. merita	*Rubus flagellaris*
Crocanthemum canadense; helianthemum c.	*Rubus setosus*
Danthonia spicata	*Rudbeckia hirta*
Dichanthelium columbianum; panicum c.	*Rumex acetosella*
Dichanthelium depauperatum; panicum d.	*Salix humilis*
Dichanthelium latifolium; panicum l.	*Schizachne purpurascens*
Dichanthelium linearifolium; panicum l.	*Schizachyrium scoparium; andropogon s.*
Digitaria ischaemum	*Solidago juncea*
Elymus repens; agropyron r.	*Solidago nemoralis*
Elymus trachycaulus; agropyron t.	*Solidago speciosa*
Erigeron strigosus	*Symphoricarpos albus var. albus*
Euthamia graminifolia	*Symphyotrichum laeve; aster l.*
Fragaria virginiana	*Tragopogon dubius*
Galium pilosum	*Turritis glabra; arabis g.*
Galium triflorum	*Vaccinium angustifolium*
Gaultheria procumbens	*Viola sagittata*
Helianthus divaricatus	
Helianthus occidentalis	
Hieracium caespitosum	
Hieracium gronovii	
Hieracium kalmii	
Houstonia longifolia	
Hypericum perforatum	
Juncus tenuis	
Koeleria macrantha	
Krigia virginica	
Lactuca canadensis	
Lepidium campestre	
Liatris scariosa	
Maianthemum racemosum; smilacina r.	
Malus coronaria	

Appendix 6. Species list for Steinberg Pine Barrens.

Acer rubrum
Agrostis scabra
Amelanchier interior
Amelanchier spicata
Andropogon gerardii
Arctostaphylos uva-ursi
Asclepias syriaca
Avenella flexuosa
Boechera stricta
Bromus kalmii
Carex pensylvanica
Carex siccata
Carex tonsa
Cirsium hillii
Clinopodium vulgare
Comandra umbellata
Comptonia peregrina
Crocanthemum canadense
Danthonia spicata
Dichanthelium columbianum
Dichanthelium depauperatum
Elymus trachycaulu
Erechtites hieraciifolius
Fragaria virginiana
Galium pilosum
Helianthus divaricatus
Hieracium aurantiacum
Hieracium caespitosum
Hieracium gronovii
Hieracium venosum
Houstonia longifolia
Hypericum perforatum
Koeleria macrantha
Liatris cylindracea
Maianthemum racemosum
Melampyrum lineare
Oryzopsis asperifolia
Packera paupercula
Pinus banksiana
Pinus resinosa
Pinus strobus
Piptochaetium avenaceum
Poa saltuensis
Prunus pumila
Prunus serotina
Prunus virginiana
Pseudognaphalium macounii
Pseudognaphalium obtusifolium
Quercus alba
Quercus velutina
Rumex acetosella
Schizachne purpurascens
Schizachyrium scoparium
Selaginella rupestris
Vaccinium angustifolium
Viola pedata

Appendix 7. Species list for Little River Oak-Pine Barrens.

Acer rubrum
Amelanchier spicata
Andropogon gerardii
Antennaria howellii
Avenella flexuosa
Campanula rotundifolia
Carex pensylvanica
Carex tonsa
Comandra umbellata
Comptonia peregrina
Crocanthemum canadense
Danthonia spicata
Dichanthelium columbianum
Dichanthelium depauperatum
Dichanthelium linearifolium
Elymus trachycaulus
Galium pilosum
Gaultheria procumbens
Hieracium caespitosum
Hieracium venosum
Houstonia longifolia
Hypericum perforatum
Koeleria macrantha
Krigia virginica
Liatris cylindracea
Melampyrum lineare
Oryzopsis asperifolia
Pinus banksiana
Pinus strobus
Piptochaetium avenaceum
Poa compressa
Poa pratensis
Poa saltuensis
Prunus pumila
Prunus serotina
Quercus alba
Quercus velutina
Rumex acetosella
Schizachne purpurascens
Schizachyrium scoparium
Symphyotrichum laeve
Tragopogon dubius
Vaccinium angustifolium
Viola pedata

Appendix 8. Species list for Little River Dry Sand Prairie.

Antennaria parlinii
Calystegia spithamaea
Cirsium hillii
Comandra umbellata
Crocanthemum canadense
Hieracium caespitosum
Hieracium longipilum
Hieracium venosum
Houstonia longifolia
Hypericum perforatum
Lechea mucronata
Liatris cylindracea
Nuttallanthus canadensis
Polygala polygama
Viola pedata
Andropogon gerardii
Avenella flexuosa
Danthonia spicata
Dichanthelium columbianum
Dichanthelium depauperatum
Koeleria macrantha
Piptochaetium avenaceum
Poa pratensis
Poa saltuensis
Schizachyrium scoparium
Carex pensylvanica
Carex tonsa
Amelanchier spicata
Vaccinium angustifolium
Acer rubrum
Pinus resinosa
Pinus strobus
Prunus serotina
Quercus alba
Quercus velutina

Appendix 9. Species list for Koenig Dry Sand Prairie.

Amelanchier spicata
Andropogon gerardii
Antennaria parlinii
Apocynum androsaemifolium
Asclepias syriaca
Asclepias tuberosa
Avenella flexuosa
Campanula rotundifolia
Carex pensylvanica
Ceanothus americanus
Comandra umbellata
Comptonia peregrina
Crataegus populnea
Crocanthemum canadense
Danthonia spicata
Dichanthelium columbianum
Dichanthelium depauperatum
Dichanthelium implicatum
Dichanthelium latifolium
Dichanthelium linearifolium
Dichanthelium xanthophysum
Elymus trachycaulus
Fragaria virginiana
Galium pilosum
Hamamelis virginiana
Hieracium aurantiacum
Hieracium caespitosum
Hieracium gronovii
Hieracium scabrum
Hieracium venosum
Houstonia longifolia
Hypericum perforatum
Koeleria macrantha
Liatris cylindracea
Lilium philadelphicum
Malus coronaria
Melampyrum lineare
Monarda fistulosa
Oryzopsis asperifolia
Pinus banksiana
Pinus strobus
Piptatherum pungens
Piptochaetium avenaceum
Poa pratensis
Poa saltuensis
Polygala polygama
Potentilla simplex
Prunus pumila
Prunus serotina
Pteridium aquilinum
Quercus alba
Quercus velutina
Rubus allegheniensis
Rubus flagellaris
Rumex acetosella
Salix humilis
Schizachyrium scoparium
Trientalis borealis
Vaccinium angustifolium
Viola pedata

Appendix 10. Species list for Udell Wet-Mesic Sand Prairie.

Amelanchier interior	*Symphoricarpos albus*
Amelanchier spicata	*Symphyotrichum laeve*
Andropogon gerardii	*Symphyotrichum robynsianum*
Apocynum androsaemifolium	*Triodanis perfoliata*
Arabidopsis lyrata	*Vaccinium angustifolium*
Arctostaphylos uva-ursi	*Verbascum thapsus*
Asclepias amplexicaulis	*Viola pedata*
Asclepias syriaca	
Asclepias tuberosa	
Asclepias verticillata	
Avenella flexuosa	
Bromus kalmii	
Calamagrostis canadensis	
Campanula rotundifolia	
Clinopodium vulgare	
Comptonia peregrina	
Coreopsis lanceolata	
Danthonia spicata	
Dichanthelium columbianum	
Dichanthelium implicatum	
Dichanthelium linearifolium	
Dichanthelium oligosanthes	
Elymus trachycaulus	
Erigeron strigosus	
Fragaria virginiana	
Galium pilosum	
Houstonia longifolia	
Hypericum perforatum	
Iris versicolor	
Koeleria macrantha	
Liatris cylindracea	
Lycopus americanus	
Melampyrum lineare	
Monarda fistulosa	
Monarda punctata	
Oenothera perennis	
Oryzopsis asperifolia	
Packera paupercula	
Panicum virgatum	
Physalis virginiana	
Pinus banksiana	
Pinus strobus	
Piptatherum pungens	
Poa compressa	
Poa pratensis	
Polygala polygama	
Prunella vulgaris	
Prunus serotina	
Prunus umbellata	
Prunus virginiana	
Pteridium aquilinum	
Quercus alba	
Quercus velutina	
Rosa carolina	
Rubus flagellaris	
Schizachne purpurascens	
Schizachyrium scoparium	
Sisyrinchium montanum	
Solidago ptarmicoides	
Spartina pectinata	

Appendix 11. Species list for Hart Oak-Pine Barrens.

Asclepias tuberosa
Campanula rotundifolia
Comandra umbellata
Crocanthemum canadense
Galium pilosum
Hieracium venosum
Hypericum perforatum
Monarda fistulosa
Monotropa uniflora
Polygala polygama
Potentilla simplex
Rumex acetosella
Symphyotrichum laeve
Tragopogon dubius
Andropogon gerardii
Avenella flexuosa
Danthonia spicata
Dichanthelium columbianum
Dichanthelium linearifolium
Elymus trachycaulus
Piptatherum pungens
Piptochaetium avenaceum
Poa compressa
Poa pratensis
Poa saltuensis
Schizachne purpurascens
Schizachyrium scoparium
Carex pensylvanica
Amelanchier interior
Amelanchier spicata
Arctostaphylos uva-ursi
Ceanothus americanus
Comptonia peregrina
Prunus pumila
Rubus flagellaris
Vaccinium angustifolium
Pinus banksiana
Pinus resinosa
Pinus strobus
Prunus serotina
Quercus velutina

Appendix 12. Species list for Black Lake Marsh, Intermittent Wetland.

Carex cryptolepis
Carex lasiocarpa
Chamaedaphne calyculata
Dichanthelium meridionale
Drosera rotundifolia
Dulichium arundinaceum
Eleocharis elliptica
Hypericum boreale
Lycopus uniflorus
Phragmites australis var. australis
Schoenoplectus acutus
Typha angustifolia
Utricularia cornuta

Appendix 13. Species list for Black Lake Wet-Mesic Sand Prairie.

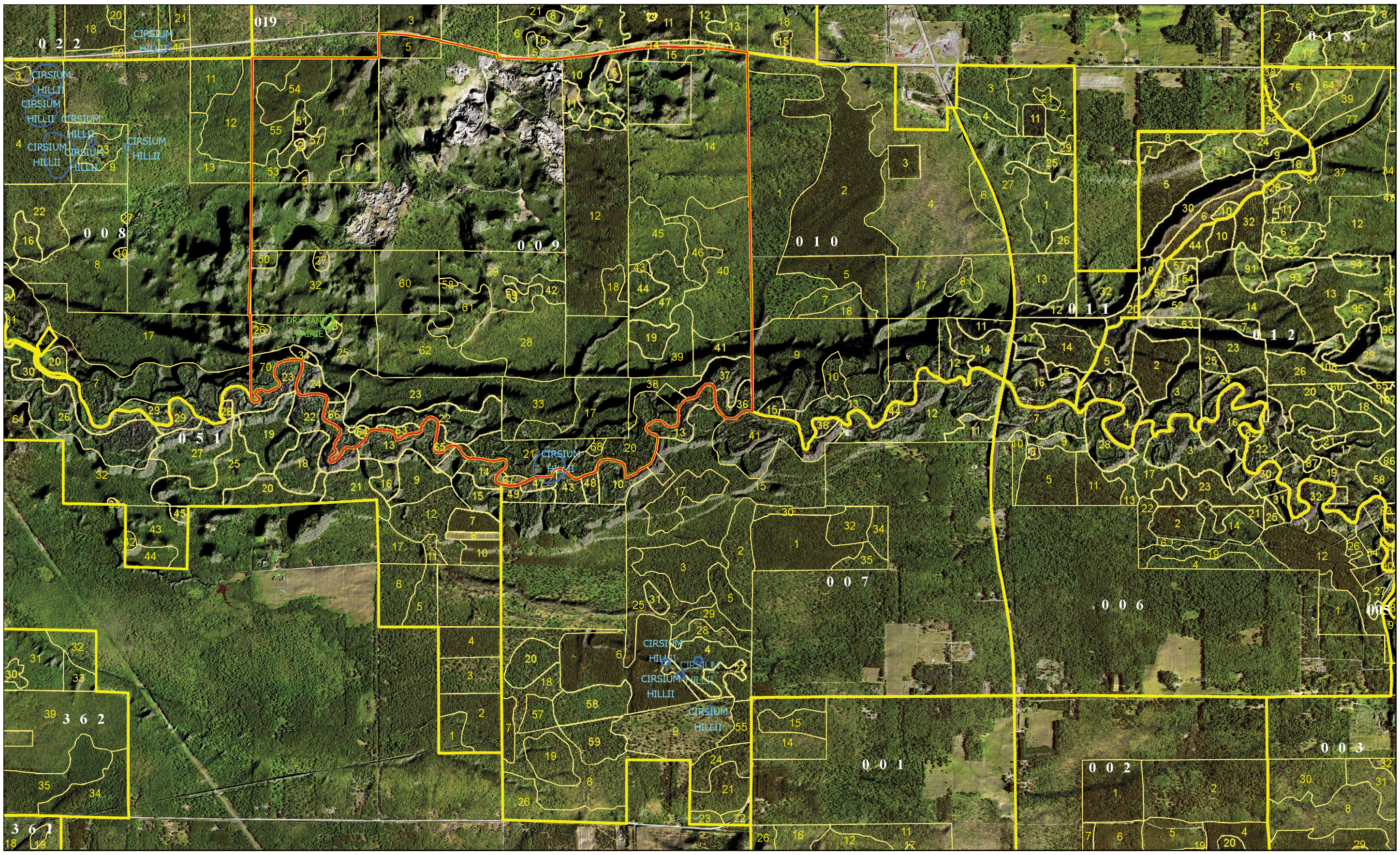
Andropogon gerardii
Anemone canadensis
Calamagrostis canadensis
Carex lasiocarpa
Carex pellita
Cirsium vulgare
Dichanthelium columbianum
Dichanthelium lindheimeri
Dichanthelium meridionale
Eleocharis elliptica
Lycopus americanus
Lycopus uniflorus
Mentha canadensis
Onoclea sensibilis
Osmunda regalis
Packera paupercula
Panicum virgatum
Phragmites australis var. australis
Poa pratensis
Rubus pubescens
Schizachyrium scoparium
Sisyrinchium montanum
Spartina pectinata
Teucrium canadense
Thelypteris palustris
Veronica officinalis

Appendix 14. Species list for Black Lake Oak-Pine Barrens.

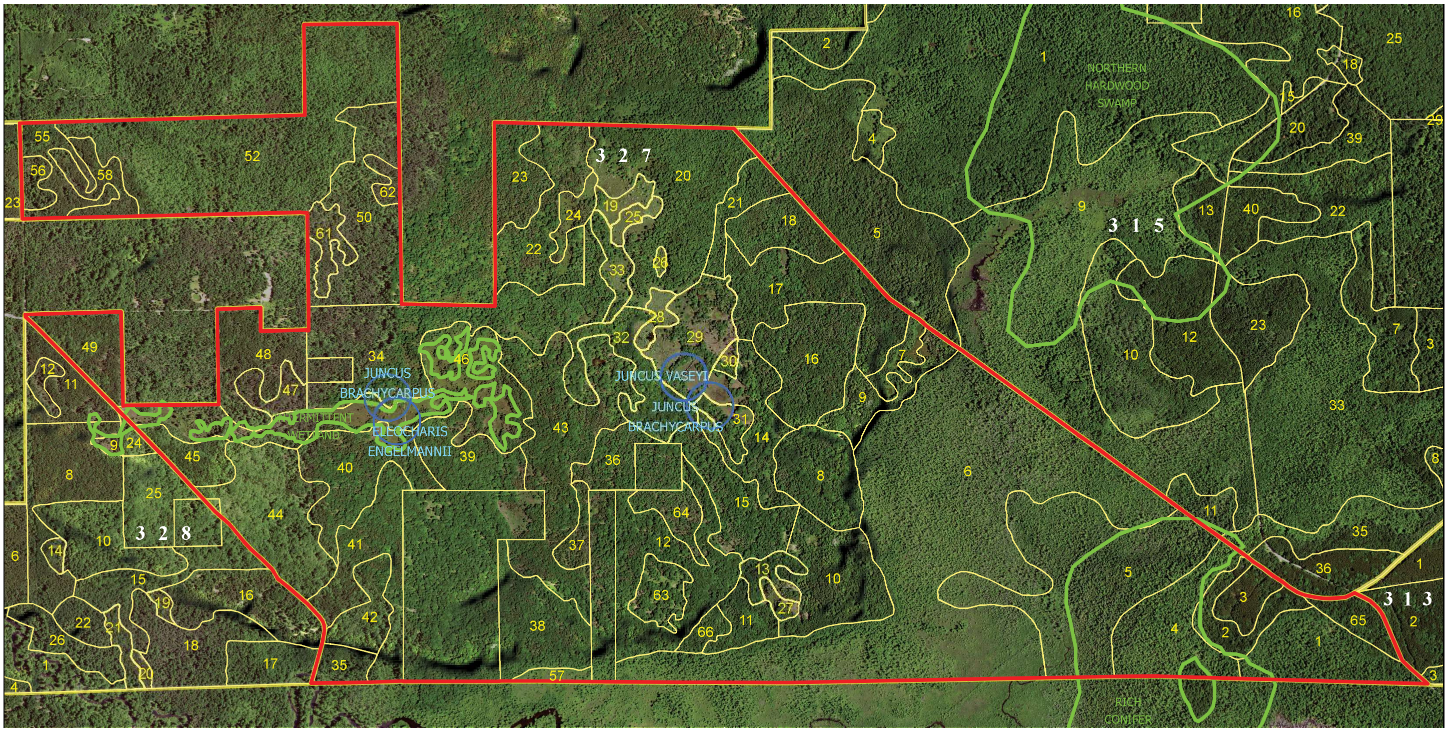
Andropogon gerardii
Antennaria parlinii
Arabidopsis lyrata
Arctostaphylos uva-ursi
Asclepias amplexicaulis
Avenella flexuosa
Carex pensylvanica
Carex tonsa
Comptonia peregrina
Danthonia spicata
Dichanthelium depauperatum
Hieracium venosum
Houstonia longifolia
Koeleria macrantha
Krigia virginica
Lithospermum canescens
Nuttallanthus canadensis
Panicum virgatum
Pinus banksiana
Piptatherum pungens
Piptochaetium avenaceum
Poa pratensis
Polygala polygama
Prunus pumila
Prunus serotina
Pteridium aquilinum
Quercus velutina
Rosa carolina
Rubus flagellaris
Rumex acetosella
Schizachyrium scoparium
Symphyotrichum laeve
Vaccinium angustifolium
Viola pedata

Appendix 15. Species list for North Country Prairie, wet-mesic sand prairie.

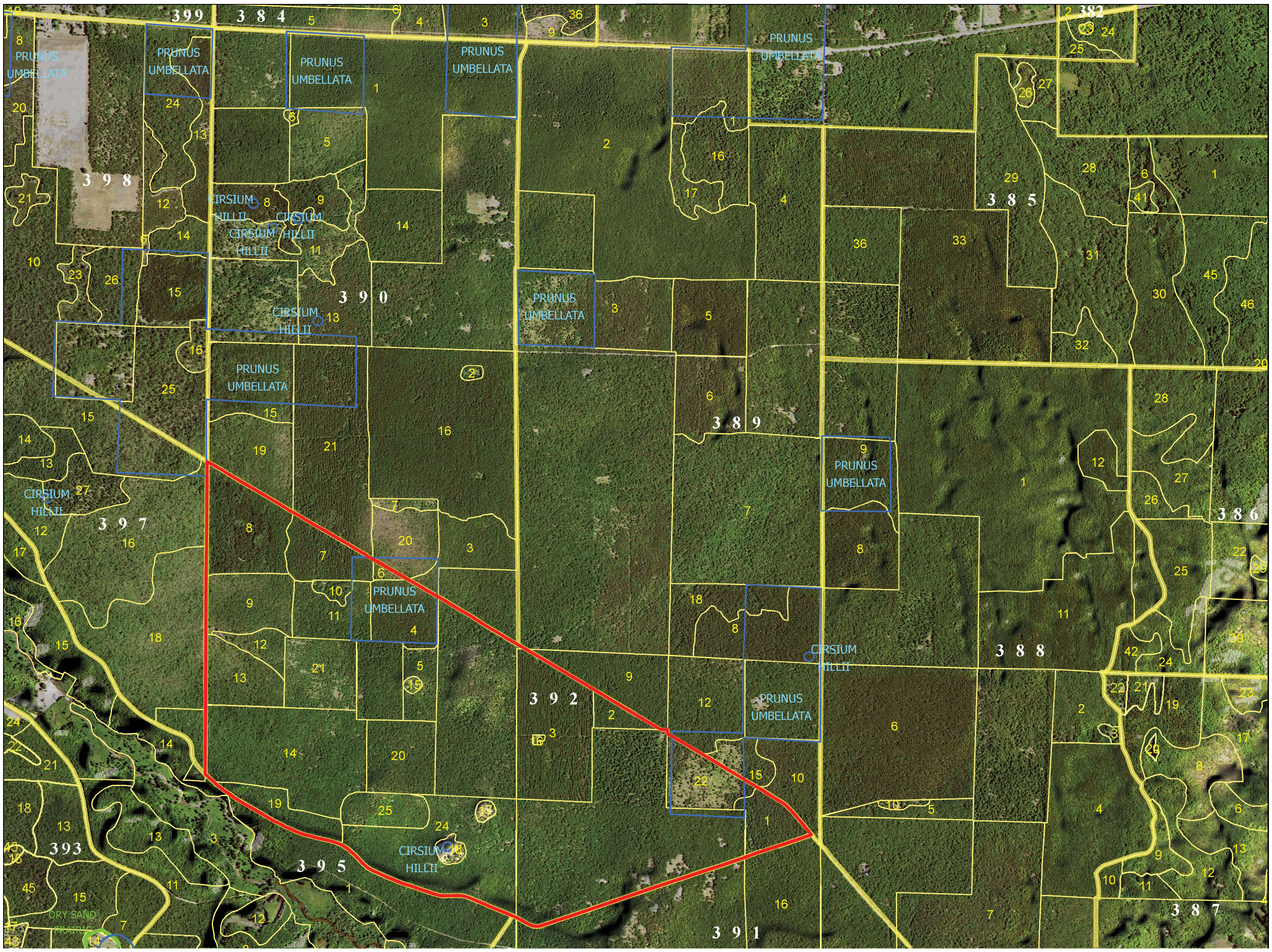
Agrostis scabra
Andropogon gerardii
Avenella flexuosa
Calamagrostis canadensis
Carex pellita
Carex stricta
Cirsium discolor
Danthonia spicata
Dichanthelium meridionale
Eleocharis melanocarpa
Hypericum kalmianum
Iris versicolor
Lobelia spicata
Pinus banksiana
Quercus alba
Rhynchospora capitellata
Rubus hispidus
Salix petiolaris
Scirpus atrovirens
Spartina pectinata
Spiraea alba
Stachys hyssopifolia
Symphyotrichum dumosum
Thelypteris palustris
Vaccinium angustifolium
Viola lanceolata
Viola sagittata



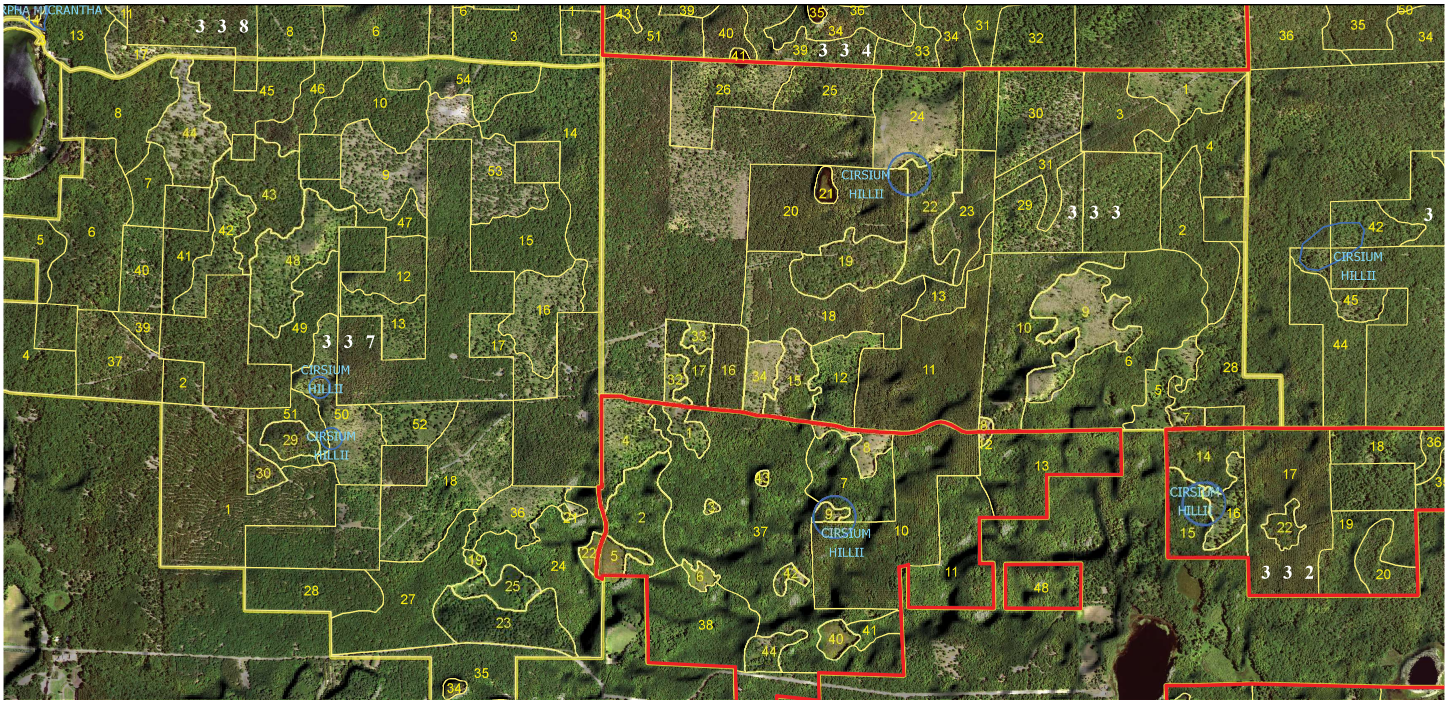
Appendix 16. Stand map for Compartment 7 and 9: Pine River Corridor and Hoxeyville Areas.



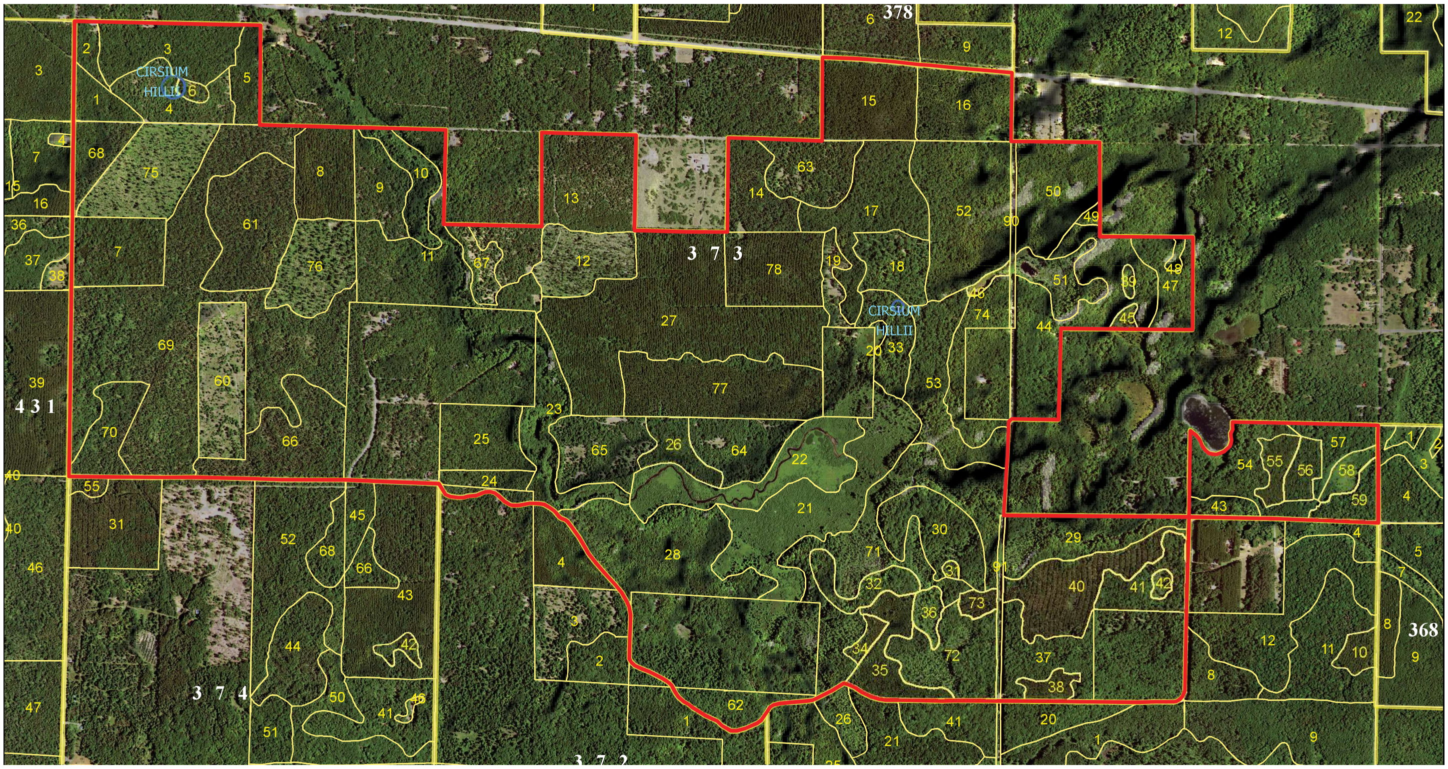
Appendix 17. Stand map for Compartment 327: Yonkers Prairie Area.



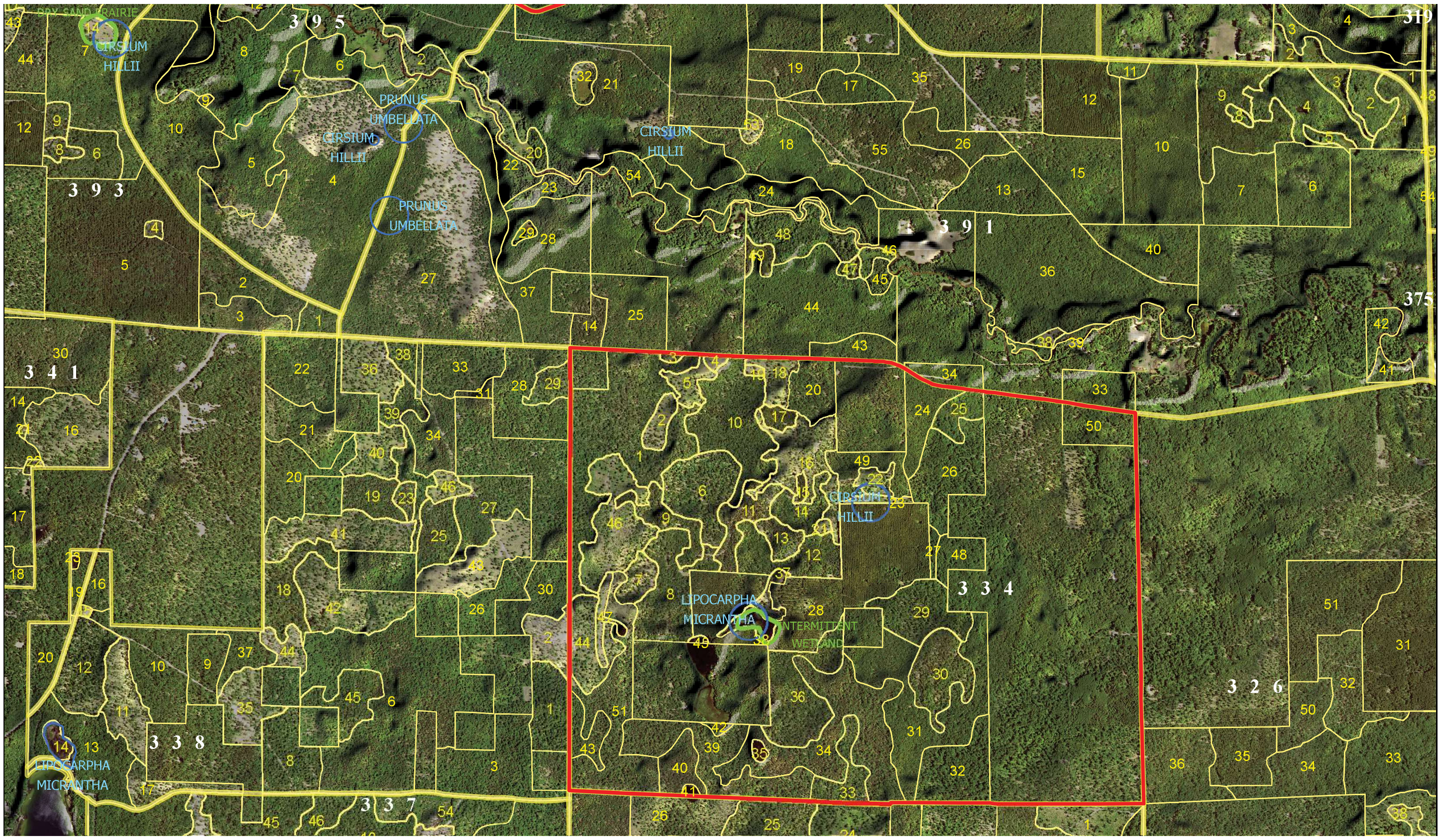
Appendix 18. Stand map for Compartments 389, 390, and 392: Steinberg-Little River Area.



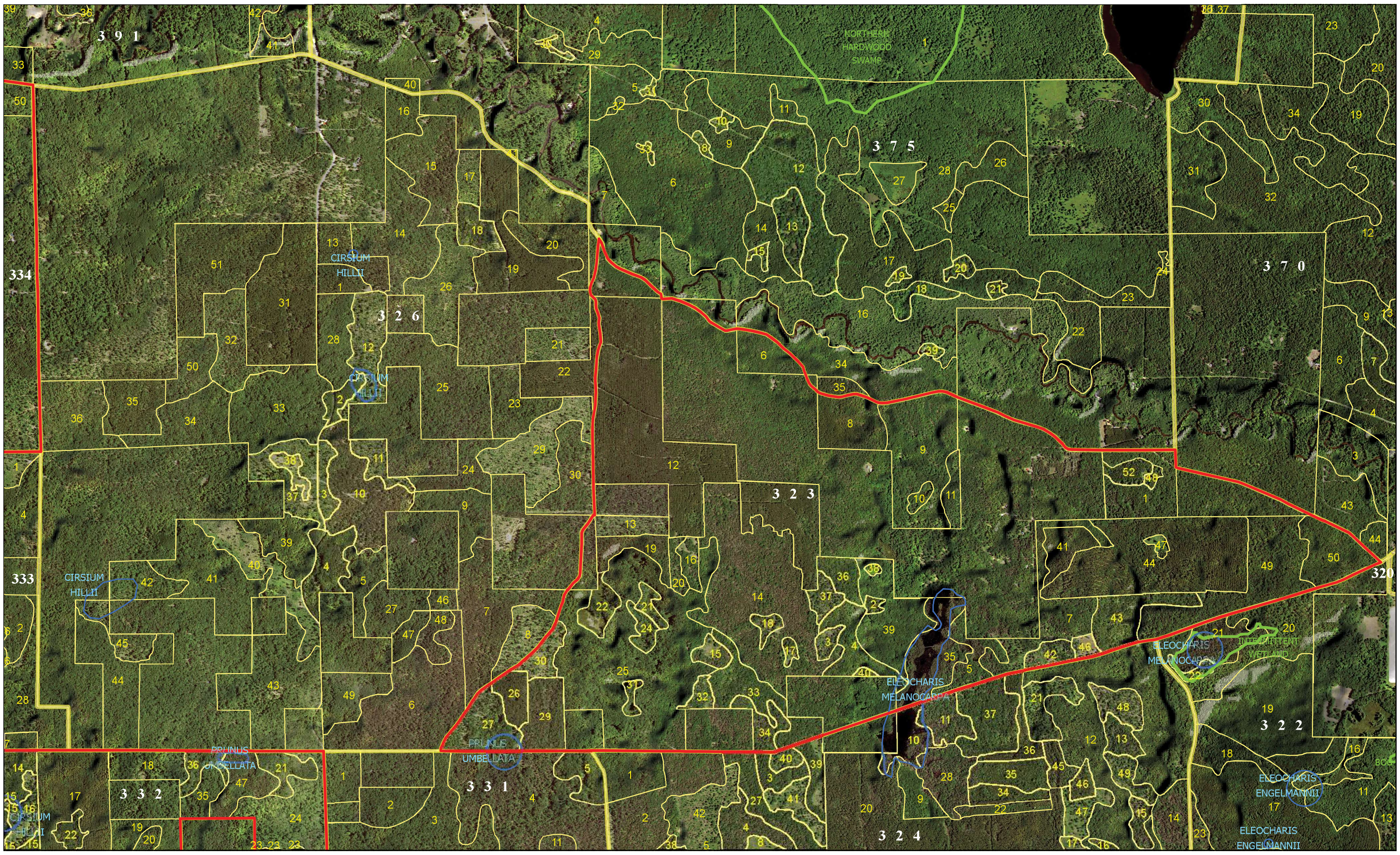
Appendix 19. Stand map for Compartments 332 and 333: Koenig Area.



Appendix 20. Stand map for Compartments 373: Pine Creek-Udell Area.



Appendix 21. Stand map for Compartments 334 and 338: Black Lake Area.



Appendix 22. Stand map for Compartments 323: North Country Prairie Area.