

# An Ecological Evaluation of the Frost Pocket Pine Barrens in the Grayling Forest Management Unit



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Following the first ecological evaluation by MNFI in 1997, managers of the Frost Pocket Pine Barrens began to take action. Wildlife Division biologist Elaine Carlson was an early proponent of the restoration efforts. Brian Piccolo is the current biologist for the Grayling Forest Management Unit and has continued with those restoration efforts, working with Fire Officer Mike Janisse to continue to apply prescribed fire on a regular basis. Brian Piccolo has also engaged with Huron Pines, a local conservation organization to treat invasive species and control black cherry. This collaborative, consistent, and long-term commitment to such an important site is critical and serves as an excellent model for protecting pine barrens around the state.

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**Cover Photo:** The Frost Pocket Pine Barrens, southcentral Stand 406, looking northeast. Photo by Jesse M. Lincoln, 2023. All pictures by Jesse M. Lincoln unless otherwise noted.

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

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## Introduction

Pine barrens are one of several fire-dependent natural community types in Michigan. In the past, fires set by Indigenous Peoples and lightning frequently spread over large areas of the landscape, helping to reduce colonization by trees and shrubs and maintaining the open structure and composition of fire-dependent communities. Prior to European settlement, the fire return intervals of the system were estimated to be around one to two burns per decade (Cohen et al. 2021). In the absence of frequent fires, barrens, prairies, and savannas have converted to closed-canopy forests, resulting in significant reductions in species and habitat diversity (Cohen et al. 2021).

There are over 4 million acres of state forest across the Upper Peninsula and Northern Lower Peninsula of Michigan. State Forests are jointly managed by the Forest Resources Division (FRD) and Wildlife Division (WLD) of the Michigan Department of Natural Resources (DNR) for long-term forest health, sustainable forest products, wildlife habitat, recreational opportunities, and ecosystem services. The FRD and WLD are responsible for assuring that management activities do not harm threatened and

endangered species. Through dual forest certification, the DNR maintains a network of Ecological Reference Areas composed of high-quality and representative natural communities. Michigan Natural Features Inventory (MNFI) maintains a geospatial database of populations of rare and declining plants and animals and benchmark ecosystems. The DNR partnered with MNFI to evaluate the condition and management needs of a fire-dependent pine barrens north of Mio, known as the Frost Pocket.

The Frost Pocket Pine Barrens is in Oscoda County in Northeastern Lower Peninsula within the Grayling State Forest Management Unit (Compartment 72929; Figure 1). A pine barrens natural community was first described at the Frost Pocket site in the mid-1990s and designated as an Ecological Reference Area following forest certification. Prior to this project, the site was last surveyed in 2015 and has since been impacted by prescribed fires, timber harvests, deer herbivory, and ATVs. This report summarizes the 2022 field surveys and ecological evaluation of the Frost Pocket Pine Barrens by MNFI scientists.

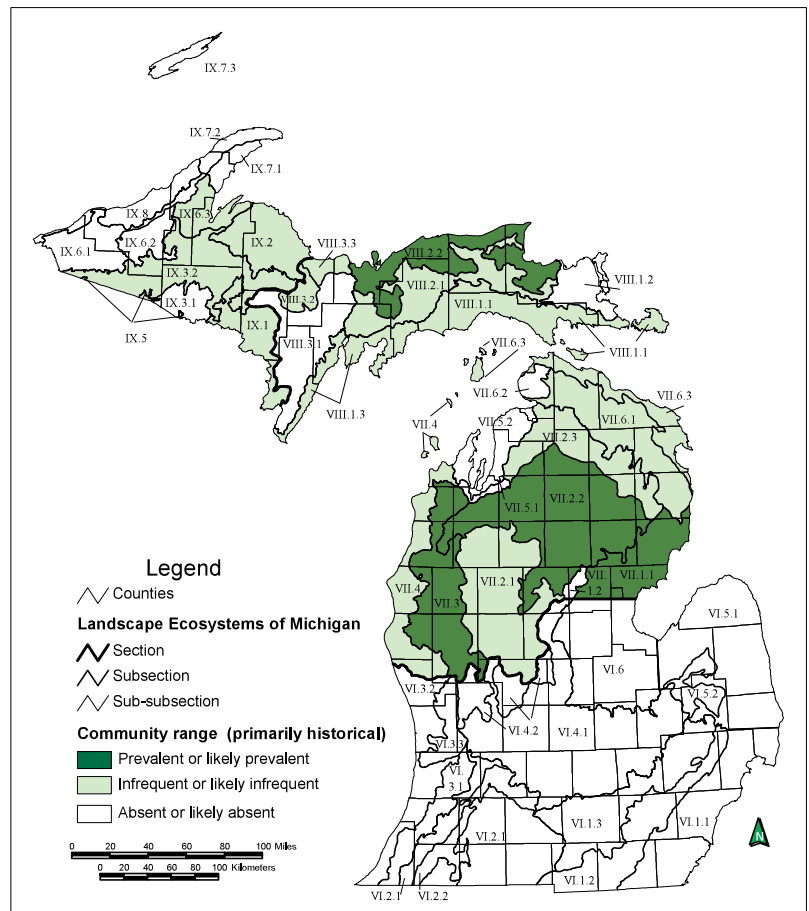


**Figure 1.** Michigan State Forests are highlighted in green. The Frost Pocket Pine Barrens (highlighted in red) in the Northern Lower Peninsula occurs within the Grayling Forest Management Unit.

## Natural Community Description and Landscape Context

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, alterations to hydrology, and fire suppression (Kost et al. 2007, Cohen et al. 2015). The natural community classification includes native management since Indigenous Peoples were part of the natural systems. Historically, Indigenous Peoples were an integral part of many community types throughout the Great Lakes region with many natural communities being maintained by native management practices such as cultural fire, wildlife management, and harvesting and planting of plant materials. The interactions between Indigenous cultures and their landscape were widespread, sophisticated, and central to maintaining historical abundances of biodiversity (Stewart 2009).

In Michigan, pine barrens occur on droughty, sandy soils, in the northern Lower Peninsula and Upper Peninsula (Figure 2). They are fire-dependent, savanna communities that are characterized by a canopy cover between 5 and 60% and often dominated by jack pine with red and white pine as important canopy constituents.



**Figure 2.** Historical distribution of pine barrens in Michigan (Albert et al. 2008).



Pine barrens are characterized by widely spaced trees and diverse herbaceous vegetation. Picture from Stand 14.

Prior to Michigan's logging era in the late 1800s and early 1900s, red pine was much more common in the community type and formed a scattered supercanopy (Comer 1996). The herbaceous layer consists predominantly of graminoids and contains plant species associated with both prairie and forest (Comer 1996, Kost et al. 2007, Cohen et al. 2015).

Pine barrens is a heterogeneous savanna community with variable structure in time and space. These systems typically occur with other fire-adapted systems in a mosaic of dry sand prairie and dry forest. Structurally, pine barrens can range from dense thickets of brush and understory scrub oak and pine among a matrix of grassland pockets, to park-like woodlands of widely spaced mature pines with virtually no tall-shrub or subcanopy layer above the ground flora. The structural variations, which occur along a continuum, are the function of the complex interplay between fire frequency, fire intensity, and site factors such as soils, landform, slope, and aspect. (Comer 1996, Kost et al. 2007, Cohen et al. 2015). Large herbivores, such as elk, may have also helped inhibit the succession of pine barrens to woodland and forest.

Surveyors from the General Land Office (GLO) took detailed notes of the Michigan landscape prior to widespread logging. Based on those notes, we know that nearly 270,000 acres of pine barrens were present in Michigan in the 1800s (Comer et al. 1995). About

210,000 acres were distributed in the Lower Peninsula of Michigan from Kent and Muskegon Counties northeast to Cheboygan and Alpena Counties. Most of this acreage was concentrated in Crawford County (55,000 acres), Iosco County (33,000 acres), and Oscoda County (28,000 acres). In Upper Michigan, pine barrens were mostly concentrated on the Raco Plains of Chippewa County and the Baraga Plains in Baraga County. Since European expansion, most of these systems have been lost to agriculture, converted to forest because of fire suppression, or developed as cities and towns (Comer et al. 1995, Comer 1996, Chapman and Brewer 2008).

There are currently 4,012 acres of documented high-quality pine barrens in the state – approximately 1.5% of the historical extent. Of the 25 documented sites, only 4 are of good to excellent viability with the remainder qualifying as fair to poor viability. There are likely additional areas of recoverable pine barrens that have not been documented. However, the rarity of the community type and the fragmented and degraded status of most of Michigan's remaining documented pine barrens has led to local extirpations and reduced abundances of many species associated with barrens. Pine barrens is an imperiled natural community type in Michigan and their conservation and restoration is paramount to protecting rare biodiversity and preventing additional taxa from becoming rare or extirpated (Comer 1996, Kost et al. 2007, Cohen et al. 2015).



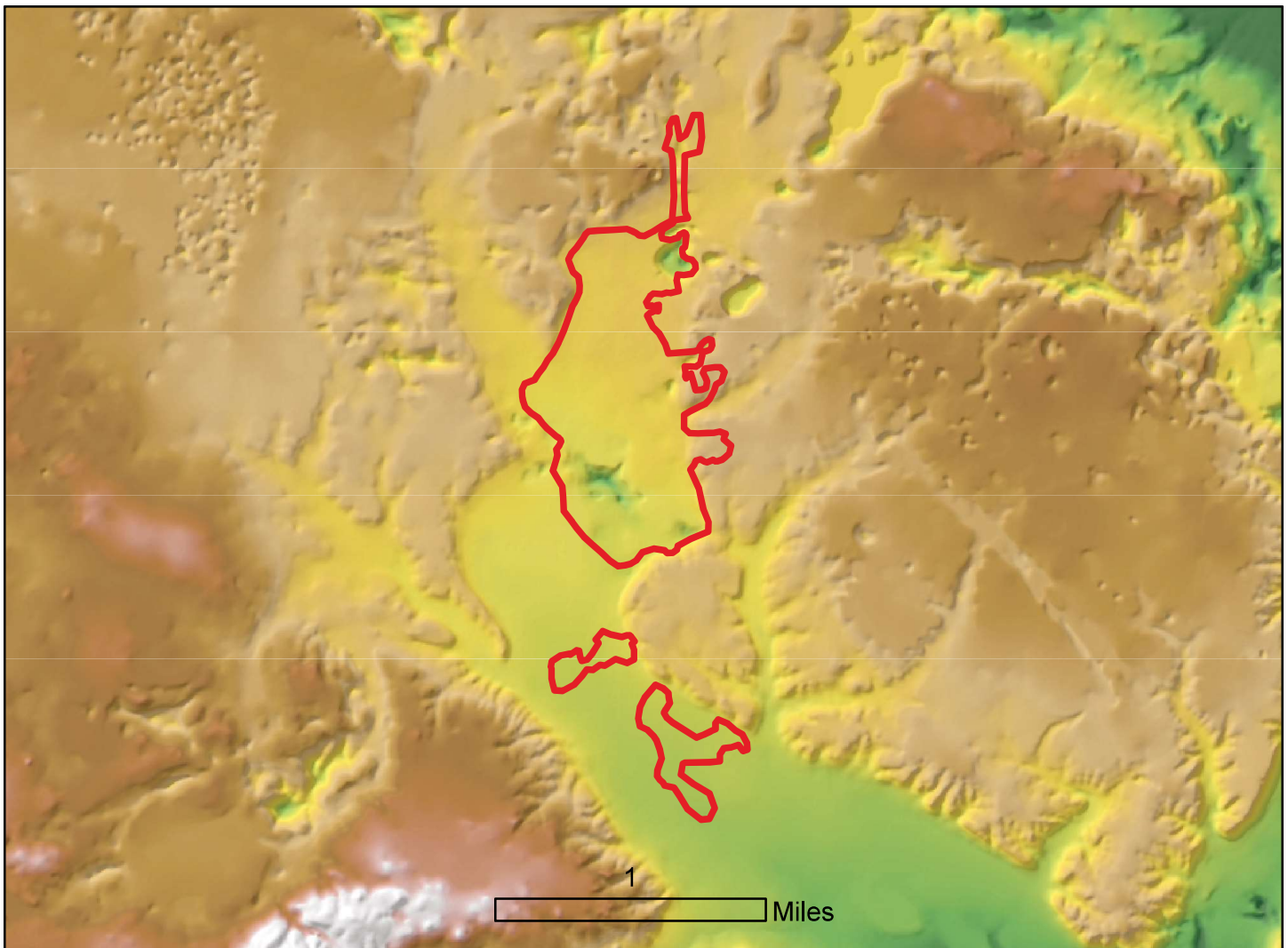
A photograph from the Grayling area in the late 1880s. This depicts historical conditions of many pine barrens in Michigan before they were cleared. The picture reflects descriptions from the General Land Office surveyor's notes from the Frost Pocket Pine Barrens where red pine was the dominant species and formed an uneven-aged supercanopy over jack pine thickets. The removal of red pine has facilitated the dominance of jack pine, northern pin oak, and black cherry that is so frequently seen in pine barrens remnants today.

The Frost Pocket Pine Barrens occupies a major drainage channel coming off the Port Huron moraine to the north (Figure 3). Deep kettle features occur in the drainage channel where ice blocks melted and were surrounded by outwash deposits. Erosion caused by meltwater in that channel left gravel and rocks at the surface of the sandy deposits of the outwash features. The drainage channel collects cold air and the kettles especially serve as frost pockets where growing season frosts slow woody encroachment and maintain the open barrens structure, even in the absence of fire.

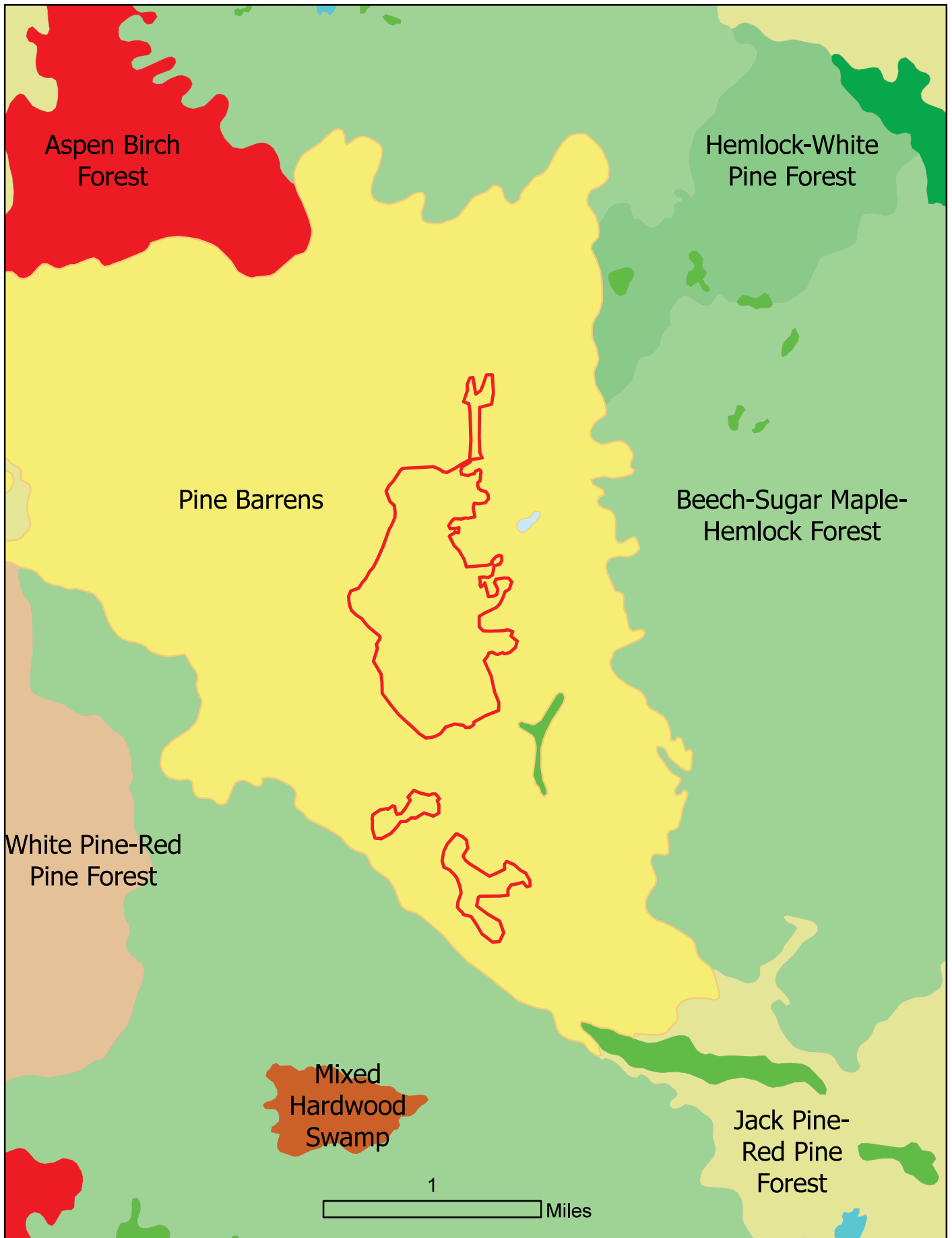
The sandy, droughty soils of the landscape support natural communities that were historically shaped by regular fires. Fire frequencies are difficult to know with certainty but likely occurred at a rate of every 5 years to every 40 years, depending on climate and human occupancy (Cohen et al. 2021). This relatively high rate of fire would have governed the structure and composition the pine barrens. The GLO surveyors in 1839 described the site as rolling land with “dry pine scrub” and “third-rate” forests with a “thin growth” of red pine, sparse white pine, “jack pine thickets”,

and infrequent aspen (Coon 1839). Locally, this mosaic of open pine barrens and mixed pine forest encompassed about 5,000 acres at the time of the first surveys (Figure 4). There was no mention of oak or black cherry in the surveyors notes from the immediate area and these were presumably absent or rare historically. A map with early survey notes is provided in Appendix 1.

All merchantable timber was removed in the late 1800s and it is likely that subsequent slash fires impacted the area. Removal of pine and a lack of fire following land clearing has led to fewer red and white pine; an increase in northern pin oak and black cherry; and greater tree densities. Imagery from 1938 shows portions of the site were cleared for agriculture and plowed or grazed (Appendix 2). By 1952, farming and grazing had ceased. Red pine was planted during the 1970s in portions of the barrens that were recovering from agriculture (western Stand 404; Comer 1997). After fire suppression throughout the 20<sup>th</sup> century, managers have recently returned fire to the landscape in the 2000s and focused on promoting ecosystem integrity of the site.



**Figure 3.** Digital Elevation Model showing the topography and landforms of the Frost Pocket Pine Barrens. The Frost Pocket Pine Barrens (red outline) occurs within a large drainage channel in a broader outwash plain. The drainage was formed by meltwater from a receding glacier that was stationed a few miles north for several hundred years (Schaeztl, personal communication, April 3,2023).



**Figure 4.** Notes from the General Land Office surveys were transcribed to develop the circa 1800 vegetation map of the area around the Frost Pocket Pine Barrens (Comer et al. 1995). The Element Occurrence is outlined in red.



The Frost Pocket Pine Barrens is the fourth largest documented pine barrens communities in Michigan with areas of exemplary composition and structure. The purpose of this report is to update the Element Occurrence (EO) data for Frost Pocket Pine Barrens after an ecological evaluation and provide management recommendations to the DNR to address threats and promote the ecological integrity of this Ecological Reference Area.

The site also supports populations of rare plants, including pale agoseris (*Agoseris glauca*, State Threatened), rough fescue (*Festuca altaica*, State Threatened), Hill's thistle (*Cirsium hillii*, State Special Concern), and Alleghany plum (*Prunus umbellata*, State Special Concern). The rare insects that have been documented at the site are dusted skipper (*Atrytonopsis hianna*, State Special Concern) and blazing star borer (*Papaipema beeriana*, State Special Concern). This report provides descriptions of the Frost Pocket Pine Barrens' context, current condition, status of populations

of rare species, threats, and management considerations. It is intended to complement existing management plans and incorporates the findings detailed in past reports (Comer 1997, Cohen et al. 2009). The Frost Pocket Pine Barrens was surveyed and specific stewardship recommendations were developed to help managers protect and sustain this important example of a fire-dependent natural community. 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 ecological evaluation is intended to help create a more diverse and resilient landscape that prevents continuing degradation of the Frost Pocket Pine Barrens and protects the habitat of the rare species that occupy the system.



The Frost Pocket Pine Barrens occurs in a broad drainage channel with localized kettle depressions that formed where ice blocks from a disintegrating glacier became buried in sediment and then melted to leave behind large depressions. These depressions collect cold air in the growing season and the interaction between drought and cold air allow openings to persist in the absence of fire. These areas were not historically cleared for agriculture and have representative barrens vegetation.

## Methods

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. Throughout this report, a documented occurrence of a high-quality natural community or a population of a rare species at a specific location is referred to as an “Element Occurrence” (EO). MNFI methodology considers three factors to assess a natural community’s ecological integrity or quality: landscape context, size, and condition (Faber-Langendoen et al. 2008, Faber-Langendoen et al. 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 (excellent estimated viability) to D (poor estimated viability) based on how well it meets the above criteria.

Field surveys of the Frost Pocket Pine Barrens and surrounding stands were conducted on June 30 and July 7, 8, and 9 of 2022. 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). We used aerial photographic interpretation and Geographic Information Systems (GIS) to navigate and guide qualitative meander surveys to assess boundaries of the natural community, landscape context, and other abiotic factors. Vegetative composition, community structure, tree size and age, populations of rare plants, and soils were all assessed and described while evaluating overall rank of the pine barrens. We carefully documented and framed threats to the barrens to develop management recommendations to identify restoration opportunities that will serve to protect the ecological integrity of the site and populations of rare species therein.



Wildlife Biologist Brian Piccolo of the Michigan Department of Natural Resources surveying portions of the Frost Pocket Pine Barrens after a recent burn.

Floristic data from the surveys were compiled into the Universal Floristic Quality (FQA) Assessment Calculator (Reznicek et al. 2014, Freyman et al. 2016). We utilized the FQA utilizes plant species composition to derive the Floristic Quality Index (FQI) of the Frost Pocket Pine Barrens. The FQI is a quantitative metric of habitat quality that can be used as a relatively objective comparison among natural community occurrences of a type. Drawing upon expert consensus among botanists familiar with the flora of Michigan, each vascular plant species native to Michigan has been assigned an a priori coefficient of conservatism (C-value) that ranges from 0 to 10 on a scale of increasing conservatism or fidelity to pre-European colonization habitats (Reznicek et al. 2014). Plant species with a C-value of 7-10 are considered highly conservative with a strong fidelity to specific, quality habitats (Herman et al. 2001). A C-value of 4-6 indicates moderate conservatism and a C-value of 1-3 indicates low or no conservatism (e.g., ruderal species). Non-native species were given a C-value of 0 for these calculations.

We calculated FQI for each natural community occurrence as:

$$FQI = \bar{C} \times \sqrt{n}$$

where  $\bar{C}$  = mean C-value and  $n$  = species richness. Michigan sites with an FQI of 35 or greater possess sufficient conservatism and richness that they are considered floristically important from a statewide perspective (Herman et al. 2001). 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 appendix (Matthews et al. 2005; Slaughter et al. 2015). Tracking changes to the FQI or Mean C of a site following biodiversity stewardship is a useful means of evaluating the success of management. The comprehensive species list for the Frost Pocket Pine Barrens is provided in the Appendix 3.



During the field surveys, we noted signs of past disturbance, such as this rockpile in the far western portion of Stand 18. Rockpiles indicate that portions of the barrens in Stand 404 were historically tilled.

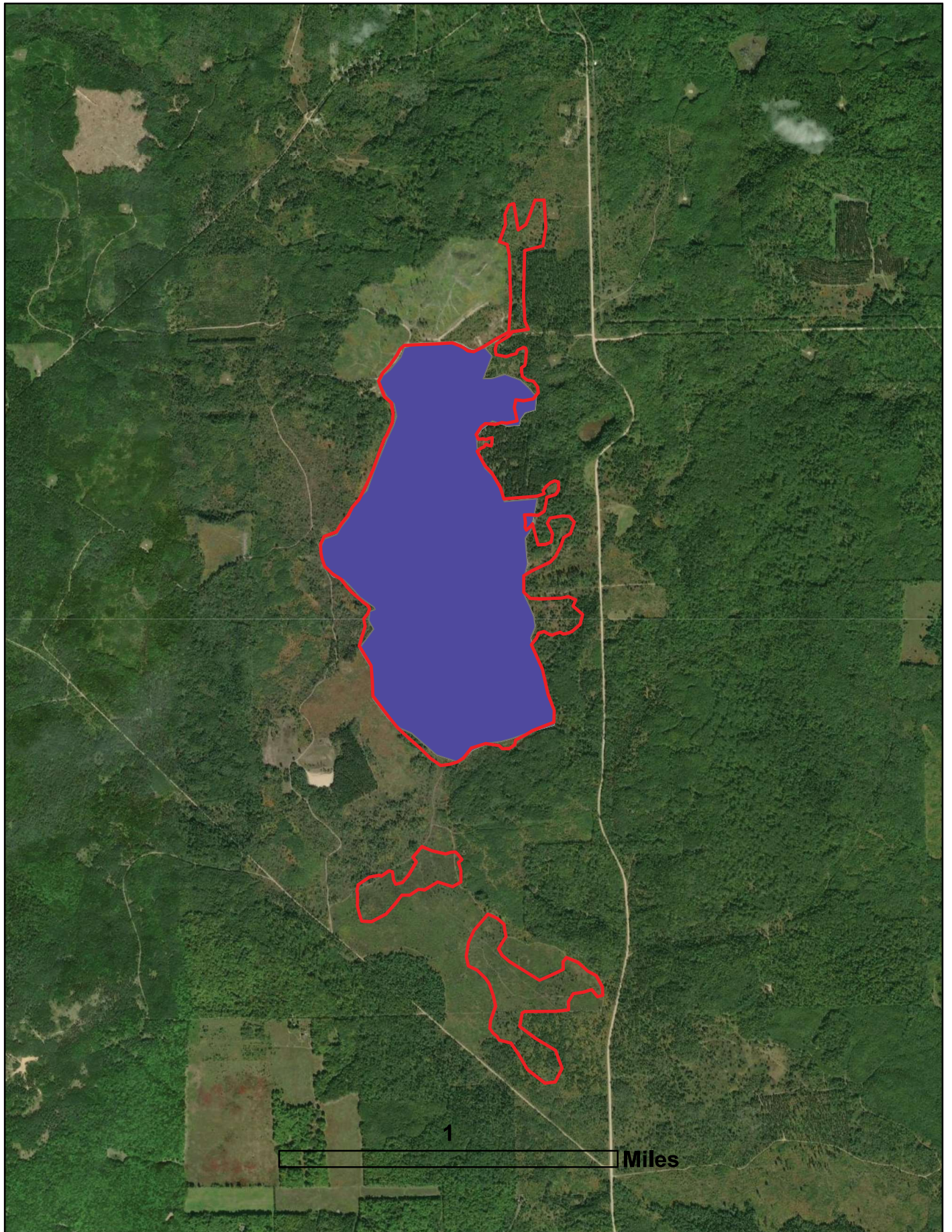
## Results

Prior to the 2022 ecological evaluation of the Frost Pocket Pine Barrens, a single 336 acre polygon was mapped as high-quality habitat and the EO had previously been assigned a rank of C, or fair. After the 2022 survey, the area of high-quality barrens was remapped and the acreage was expanded to 445 acres over three distinct polygons. The pine barrens EO was upgraded from C to BC, or good to fair estimated viability as a result of the inclusion of additional high-quality habitat with representational barrens structure and composition. The condition of the barrens remnant patches across the site ranges from B to CD, with the latter rank characterizing areas that have been clearcut in recent decades.

Areas that were added to the EO are in eastern Stand 406, Stand 35, Stand 54, and southern Stand 46. Portions of Stands 408, 410, and 411 with decent composition but structures degraded by timber harvest were also included in the new EO boundaries. The highest quality zones are in the kettle depressions that were never utilized for agriculture and have escaped recent forestry actions. Stands 14 and 406 support the highest quality structure and composition. Barrens indicator species persist throughout Stands 404 and 22, though the characteristic barrens structure has been eliminated by prescriptive timber harvest. Detailed maps with stand numbers are provided in the Appendices 5 and 6.



Some of the areas with the best remaining barrens structure of jack pine and red pine forming a sparse canopy persist in Stand 406. Southcentral Stand 406, looking north.



**Figure 5.** The previous Frost Pocket Pine Barrens EO boundaries in purple were expanded to include areas of characteristic vegetation documented during the 2022 surveys. The updated boundaries are in red.

### ***Description of the Frost Pocket Pine Barrens***

The Frost Pocket Pine Barrens occurs in a major glacial drainage channel. The site is characterized by sandy soils with areas of gravel. A soil sample from the edge of the central kettle depression had gravel and fist-sized rocks at the surface. In this location there is a dense thatch of grass and the top 3" of soil are coarse loamy sand with dark organics (pH 5.5-6.0). Below, soils are acidic (pH 5.0 to 5.5), coarse loamy sands with some small gravel up to ½" diameter. A second soil sample was taken on a hilltop at the edge of the drainage channel from below a thatch of sedge and grasses and the top 2" of soil in this location are acidic (pH 4.5), silty, fine sands with dark organics overlying acidic (pH 5.5-6.0), fine, tan sands. No gravel was found in the sample from the hilltop. Presumed badger dens were observed frequently throughout the landscape, particularly on south-facing slopes. Large areas of excavated soil and gravel occurred at the mouth of their dens.

The area mapped as pine barrens has several different zones ranging in quality, structure, and composition. The areas with characteristic pine barrens structure have between 20 and 60% canopy coverage of jack pine (*Pinus banksiana*) with sparse red pine (*Pinus resinosa*) and black cherry (*Prunus serotina*) and infrequent northern pin oak (*Quercus ellipsoidalis*) and red oak (*Q. rubra*). Several areas have been clearcut but still support characteristic barrens herbaceous vegetation. In these areas, the pine barrens has locally transitioned to dry sand prairie structure and the canopy is less than 5% and is primarily black cherry with some sparse jack pine. A number of tree sizes and ages were recorded, including a 14.9" diameter at breast height (dbh) jack pine, a 10.4" dbh jack pine with 48 rings observed, an 18.4" dbh red pine with 76 rings observed, and a large 30.8" dbh red oak.



One of the higher quality portions of the Frost Pocket Pine Barrens. Photo taken from the northern portion of Stand 14, looking south.



The boundary between Stand 406 (left) and Stand 22 (right) highlight the ongoing transition from barrens to prairie structure as a result of clearcuts and intense burns that are eliminating pine from the pine barrens.



Within Stand 404 repeated prescribed fires and overstory removal of canopy trees has resulted in the elimination of a key component of pine barrens: the scattered pine overstory. The site is shifting towards prairie structure with an increasing dominance of black cherry.

The subcanopy and understory layer is absent to sparse (1 to 15% coverage) and generally dominated by black cherry with some zones having jack pine and patches of northern pin oak. There were some individuals that appeared to be black oak (*Quercus velutina*), but this was not confirmed. Other understory species include choke cherry (*Prunus virginiana*), pin cherry (*P. pensylvanica*), quaking aspen (*Populus tremuloides*), Siberian crab (*Malus baccata*), red maple (*Acer rubrum*), and serviceberry (*Amelanchier interior*).

The low shrub layer ranges from 10 to 30% coverage and includes sweet fern (*Comptonia peregrina*), sand cherry (*Prunus pumila*), low sweet blueberry (*Vaccinium angustifolium*), prairie willow (*Salix humilis*), chokecherry, round-leaved serviceberry (*Amelanchier sanguinea* or *A. spicata*), wild rose (*Rosa blanda*), common blackberry

(*Rubus allegheniensis*), northern dewberry (*R. flagellaris*), bearberry (*Arctostaphylos uva-ursi*), hawthorn (*Crataegus brainerdii*, unconfirmed but based on nearby collections), and rarely downy arrow-wood (*Viburnum rafinesquianum*) and American wild plum (*Prunus americana*). Northern pin oak and black cherry saplings are locally dominant in the low shrub layer as well. Sweet fern is frequently dominant, especially in disturbed areas along with northern dewberry. Bearberry, downy arrow-wood, round-leaved serviceberry, and sand cherry are typically indicative of higher quality zones with a greater diversity of native species. The State Special Concern Alleghany plum (*Prunus umbellata*) is infrequent and local, concentrated on the western margin of the largest polygon. The non-native shrubs autumn-olive (*Elaeagnus umbellata*), Siberian crab, and morrow honeysuckle (*Lonicera morrowii*) are infrequent throughout the system.



Various shrubs characterize the pine barrens. Prairie willow at right in the foreground, ranges from locally dominant to infrequent. Low bush blueberry and sweetfern are locally dominant though their abundance is often obscured by dense herbaceous vegetation as above to the left. Compartment 72016, Stand 54 looking north.





Siberian crab has polymorphic leaves but the three-lobed morphology is evident on new growth following a burn.



Sand cherry is a low shrub that was most prevalent in the highest quality areas. Here it is growing with June grass, hair grass, and slender-leaved panic grass. Photo by Tyler J. Bassett.

The herbaceous layer is essentially continuous (~95% coverage) and the most prevalent and conservative indicator species are provided in Table 1. Graminoids are dominant throughout the pine barrens and with several native species including fescue (*Festuca saximontana*), Pennsylvania sedge (*Carex pensylvanica*), poverty grass (*Danthonia spicata*), little bluestem (*Schizachyrium scoparium*), hair grass (*Avenella flexuosa*), big bluestem (*Andropogon gerardii*), June grass (*Koeleria macrantha*), false melic (*Schizachne purpurascens*), panic grasses (*Dichanthelium linearifolium*, *D. columbianum*, *D. xanthophysum*), slender wheatgrass (*Elymus trachycaulus*), and prairie brome (*Bromus kalmii*). The State Threatened rough fescue (*Festuca altaica*) is locally abundant. Non-native grasses are infrequent to locally dominant and the most common species include Kentucky bluegrass (*Poa pratensis*), quackgrass (*Elymus repens*), and timothy (*Phleum pratense*). Kentucky bluegrass is especially problematic and, along with *Carex pensylvanica*, may be the most dominant herbaceous species across the site, though Kentucky bluegrass can be difficult to detect later in the season. A complete list of invasive species is provided in Table 3 (page 30).



Prairie brome was locally abundant in the highest quality portions of the pine barrens.



The herbaceous layer of the Frost Pocket Pine Barrens is characterized by a prevalence of graminoids, including little and big bluestem, hair grass, Pennsylvania sedge, and the non-native Kentucky bluegrass. Southern Stand 406, looking southwest over Stand 22.

**Table 1.** The most conservative and abundant indicator species found at the Frost Pocket Pine Barrens during the 2022 field surveys. ‘C’ corresponds to the coefficient of conservatism and a high value of 7 or above indicates a species with especially high fidelity to intact habitats.

Scientific Name	Common Name	C	Physiognomy
<i>Agoseris glauca</i>	prairie or pale agoseris	9	forb
<i>Polygala polygama</i>	racemed milkwort	9	forb
<i>Festuca altaica</i>	rough fescue	9	grass
<i>Koeleria macrantha</i>	june grass	9	grass
<i>Calystegia spithamea</i>	low bindweed	8	forb
<i>Cirsium hillii</i>	hills thistle	8	forb
<i>Drymocallis arguta</i>	tall or prairie cinquefoil	8	forb
<i>Helianthus occidentalis</i>	western sunflower	8	forb
<i>Bromus kalmii</i>	prairie brome	8	grass
<i>Elymus trachycaulus</i>	slender wheatgrass	8	grass
<i>Arctostaphylos uva-ursi</i>	bearberry	8	shrub
<i>Prunus pumila</i>	sand cherry	8	shrub
<i>Prunus umbellata</i>	alleghany plum	8	shrub
<i>Lilium philadelphicum</i>	wood lily	7	forb
<i>Anemone cylindrica</i>	thimbleweed	6	forb
<i>Boechera stricta</i>	drummond rock cress	6	forb
<i>Campanula rotundifolia</i>	harebell	6	forb
<i>Melampyrum lineare</i>	cow-wheat	6	forb
<i>Avenella flexuosa</i>	hair grass	6	grass
<i>Dichanthelium xanthophysum</i>	panic grass	6	grass
<i>Festuca saximontana</i>	fescue	6	grass
<i>Oryzopsis asperifolia</i>	rough-leaved rice-grass	6	grass
<i>Comptonia peregrina</i>	sweetfern	6	shrub
<i>Anemone quinquefolia</i>	wood anemone	5	forb
<i>Krigia biflora</i>	false dandelion	5	forb
<i>Liatris scariosa</i>	northern blazing-star	5	forb
<i>Solidago speciosa</i>	showy goldenrod	5	forb
<i>Symphyotrichum laeve</i>	smooth aster	5	forb
<i>Andropogon gerardii</i>	big bluestem	5	grass
<i>Dichanthelium columbianum</i>	panic grass	5	grass
<i>Schizachne purpurascens</i>	false melic	5	grass
<i>Schizachyrium scoparium</i>	little bluestem	5	grass
<i>Amelanchier sanguinea</i>	round-leaved serviceberry	5	shrub
<i>Viburnum rafinesquianum</i>	downy arrow-wood	5	shrub



Low bindweed (left) and prairie cinquefoil (right) are conservative species that are relatively abundant in the Frost Pocket.

Broadleaf flowering plants, or forbs, are typically 10 to 30% of the herbaceous layer and the diversity is especially high for the community type. Typical species include yarrow (*Achillea millefolium*), wild strawberry (*Fragaria virginiana*), northern blazing star (*Liatris scariosa*), wild-bergamot (*Monarda fistulosa*), goldenrods (*Solidago juncea*, *S. hispida*, and *S. speciosa*), harebell (*Campanula rotundifolia*), spreading dog bane (*Apocynum androsaemifolium*), wood lily (*Lilium philadelphicum*), old-field cinquefoil (*Potentilla simplex*), balsam ragwort (*Packera paupercula*), low bindweed (*Calystegia spithamea*), cow-wheat (*Melampyrum lineare*), asters (*Symphyotrichum leave* and *S. urophyllum*), racemed milkwort (*Polygala polygama*), Virginia ground-cherry (*Physalis virginiana*), and prairie cinquefoil (*Drymocallis arguta*). Northern blazing star is particularly abundant within the Frost Pocket Pine Barrens. The State Threatened pale agoseris (*Agoseris glauca*) and State Special Concern Hill's thistle (*Cirsium hillii*) are uncommon to locally abundant throughout. This site supports an exceptionally large population of pale agoseris while the overall abundance of Hill's thistle is moderate. Non-native invasive forb species are locally dominant and problematic, especially sheep sorrel (*Rumex acetosella*), common St. John's-wort (*Hypericum perforatum*), hawkweeds (*Hieracium aurantiacum* and *H. piloselloides*), spotted knapweed (*Centaurea stoebe*), and clovers (*Trifolium repens*, *T. pratense*, and *T. hybridum*).



Pale agoseris is abundant throughout the pine barrens EO. Photo by Elizabeth Haber.



Wood lily (left) and northern blazing star (right, photo by Elizabeth Haber) are conservative species that are relatively abundant in the Frost Pocket.

Rare plant species include State Threatened rough fescue (*Festuca altaica*), State Threatened pale agoseris (*Agoseris glauca*), State Special Concern Hill's thistle (*Cirsium hillii*), and State Special Concern Alleghany plum. All were observed in 2022 and the extent of the populations were updated. All but Alleghany plum, which is apparently limited to the east-central margin of the pine barrens, are widely distributed throughout this EO. State Special Concern invertebrates dusted skipper (*Atrytonopsis hianna*) and blazing star borer (*Papaipema beeriana*) have also been documented at Frost Pocket Pine Barrens. Dusted skipper feeds and oviposits on bluestems (*Andropogon* spp., *Schizachyrium* spp.) and blazing star borer feeds on blazing stars (*Liatris* spp.), both of which are abundant at the site. As a large native grassland, the Frost Pocket Pine Barrens provides excellent habitat for at-risk grassland birds, although no listed bird species have been documented here.

Kentucky bluegrass, sheep sorrel, and common St. John's-wort are especially widespread and locally dominant. Spotted knapweed is dominant along trails and has the potential to spread into quality areas, especially with the density of trails and prevalence of all-terrain vehicles (ATVs). Quackgrass forms extensive sods under current and former canopies of hardwood species, especially black cherry and trembling aspen.

A total of 110 plant species were observed in the pine barrens with 91 native species (82.7%). The total FQI is 37.8 and the total Mean C is 3.6. Sites are considered regionally significant to the conservation of biodiversity in Michigan if their FQI is over 35 (Herman et al. 2001).



The Frost Pocket Pine Barrens supports relatively large populations of rare plants including pale agoseris (top), Hill's thistle (above), and Alleghany plum (left, photo by Tyler J. Bassett).

## Discussion

The Frost Pocket Pine Barrens is a site of considerable conservation value. Regular application of prescribed fire has maintained and improved the composition of much of the site. The natural community has populations of rare species and excellent structure, despite degrading factors such as past agricultural operations, intensive forestry, a history of fire suppression following clearing, and invasive species. This ecological evaluation resulted in an expansion in the size of the element occurrence (EO), from 336 to 445 acres, and a minor shift of the EO rank from C to BC, or fair to good/fair estimated viability. We also documented new observations of rough fescue, pale agoseris, and Hill's thistle and expanded the existing EOs for those species.

Despite the site benefiting from recent stewardship, there are serious threats to its condition. This Ecological Reference Area needs continuing stewardship to maintain and increase ecological integrity and for that stewardship to be applied to a broader area.

### **Element Occurrence Rank**

The overall rank of a natural community EO is a combination of the landscape rank, size rank, and condition rank. Within this discussion section, we describe the components of the overall rank of the Frost Pocket Pine Barrens to provide a comprehensive description of the barrens and surrounding landscape and inform specific stewardship recommendations provided in the following Management Considerations section.

### **Landscape Rank**

The landscape rank for the area surrounding the Frost Pocket Pine Barrens is C, or fair. The pine barrens occurs within a landscape that is being managed for timber and early-successional forest and there are several oil pads nearby. The region features sparse private residences and is primarily characterized as natural cover consisting of early successional forests. Repeated clearcutting has led to a prevalence of third- or fourth- growth forests dominated



Several areas of the Frost Pocket Pine Barrens feature the characteristic barrens structure of widely spaced pine trees with open zones of shrubs and diverse native herbaceous vegetation. This photo is from southcentral Stand 406 looking northeast.

by aspen and lacking diversity and structure of historical land cover. The surrounding forests are generally young and degraded with low plant diversity and a high density of logging roads and trails, often maintained for ATVs. High deer densities are preventing regeneration of many components of the heavily managed forests. Many plant species disappear following forestry treatments and once-diverse assemblages of vegetation are being replaced with a limited subset of species such as aspen and maple with understories dominated by raspberry (*rubus* spp.), bracken fern (*Pteridium aquilinum*), and Pennsylvania sedge (*Carex pensylvanica*). After clearing, some forests are being furrowed, sprayed with herbicide, and planted to pine, further diminishing the landscape's native biodiversity.

The landscape rank of C is justified because of the extent of natural cover on the surrounding landscape, despite degrading factors. The primary degrading factors are the high levels of deer; the narrow application of fire on a landscape featuring extensive fire-dependent communities; the degree of herbicide application and furrowing; the prevalence of young and degraded forests; the paucity of older forests with any potential to approach old growth conditions; the high degree of fragmentation from oil

infrastructure and logging trails; and the increase of ATV use. These are all contributing a region-wide decline in diversity. Without landscape-scale stewardship intervention, the third- or fourth-growth forests that characterize the landscape are unrecoverable to conditions resembling natural communities. The landscape rank will likely continue to be reduced due to these degrading factors.

Additionally, large herbivores likely played a significant role in the structure and composition of the barrens. Indigenous Peoples set fires to the region, in part, to entice browsing by herbivores such as elk. Elk altered the structure and vegetation composition of barrens in Northern Lower Michigan. The complex dynamic between Indigenous fire and herds of large herbivores was historically a fundamental factor shaping Michigan pine barrens. Large herbivore grazing behavior may have also interrupted the sedge and grass thatch to facilitate forb diversity. Deer tend to favor forbs while elk browse more on sedges, grasses, and woody vegetation and also break up dense thatch due to their large size. The absence of large herbivores in the context of high deer densities may be contributing to the decline of the overall landscape condition.



Young aspen stands feature low plant diversity and are dominated by bracken, raspberry, and Pennsylvania sedge. These third- and fourth-growth forests have minimal potential to be recovered to barrens or dry northern forest without long periods of time, fire, and stewardship intervention.

### **Size Rank**

At 445 acres, the Frost Pocket Pine Barrens is the fourth largest pine barrens in the state and the size rank is A, or very large (Table 2). Two of the three larger barrens have not been visited in the past 17 years and their present condition is unknown. Much of the Frost Pocket Pine Barrens EO is in good condition and those areas in fair to poor condition are still recoverable to a higher rank with continuing stewardship intervention. The Frost Pocket Pine Barrens has been locally degraded from its historical condition and its current composition reflects intensive land use. Historically, the local extent of barrens habitat covered approximately 5,000 acres and would have manifested as a shifting mosaic of pine barrens, dry sand prairie openings, and dry northern forest. Only polygons with a dominance of barrens indicator species were included in the EO. There is excellent potential to increase the size of this high-quality pine barrens EO by expanding the barrens project area and applying the ongoing restoration efforts, especially prescribed fire, to more of the surrounding landscape.

### **Condition Rank**

The Frost Pocket Pine Barrens' condition rank was adjusted from C to BC due to the additional quality habitat found during the 2022 surveys. The vegetative composition of the site has also improved since previous surveys of 2009 and 2015 as a result of the consistent application of prescribed burns. The herbaceous diversity is locally exceptional with fairly robust populations of rare and conservative

species. There is no knowledge or history of the herbaceous composition being supplemented with plantings. Some of the area mapped as EO supports characteristic structure of a sparse canopy of mature trees and a composition featuring abundant conservative native vegetation and therefore qualifies as B rank. However, across much of the site the structure has been degraded from clear-cutting and intense fires that have killed several canopy pines. Some zones were cleared for historic grazing and logging practices have altered even the best portions of the Frost Pocket Pine Barrens. These areas of lower quality are a rank of C or locally CD (fair to poor estimated viability. Many of the highest quality areas appear not to have been tilled or grazed and areas that were put into agricultural operations were only minimally impacted in the late 19<sup>th</sup> and early 20<sup>th</sup> centuries.

Despite widespread degrading factors, the site has numerous areas of high native plant diversity, characteristic barrens structure, and large populations of rare plants. Agricultural operations ceased in the 1950s and the surrounding landscape was likely in much better condition and provided the seed sources for the characteristic vegetation to reestablish. The areas that have not been tilled, grazed, or furrowed tend to have the lowest component of invasive species. Species richness and evenness is higher than many examples of the community type and this is a site of significant conservation value.



Furrows are present in the western portion of Stand 404 where pines were planted in the 1970s. This disturbance has led to a somewhat elevated component of invasive species but the area still supports a high diversity of native vegetation.



**Table 2.** All pine barrens Element Occurrences in Michigan. The Frost Pocket Pine Barrens is listed in bold. Overall ranks are provided for each EO. EO rank abbreviations are as follows: AB, excellent to good estimated viability; B, good estimated viability; BC, good to fair estimated viability; C fair estimated viability; CD, fair to poor estimated viability; and, D, poor estimated viability.

Site Name	EO ID	Unit Name	Overall Rank	Acreage	First Observed	Last Observed
Raco Field North	12951	Hiawatha National Forest Sault Ste. Marie	AB	226	1997	1997
Soldier Lake/Raco-South	12419	Hiawatha National Forest Sault Ste. Marie	B	920	1996	1996
South Creek Barrens	26198	Michigan State Forest Roscommon Unit	B	139	2022	2022
Shupac Lake	5909	Michigan State Forest Grayling Unit	B	101	1993	2018
Frog Lake Barrens	16049	Michigan State Forest Grayling Unit	BC	574	2006	2020
<b>Frost Pocket Pine Barrens</b>	<b>17323</b>	<b>Michigan State Forest Grayling Unit</b>	<b>BC</b>	<b>445</b>	<b>1997</b>	<b>2022</b>
Walton Marsh	6486	Michigan State Forest Cadillac Unit	BC	124	1996	2006
Little Bear Lake Barrens	10013	Michigan State Forest Gaylord Unit	BC	47	1993	2015
Wallhalla Pine Barrens	24189	Huron-Manistee National Forest Baldwin-White Cloud District	BC	44	2020	2020
Hidden Lake Pine Barrens	23466	Michigan State Forest Atlanta Unit	BC	34	2019	2019
Little Bear Creek	16146	Private Property	BC	33	2006	2006
Tomahawk Barrens	18852	Michigan State Forest Atlanta Unit	BC	10	2011	2011
Black River Ranch	16149	Private Property	C	683	2006	2006
Walton (East)	5074	Michigan State Forest Cadillac Unit	C	99	1996	2006
Shupac Lake Barrens	15942	Michigan State Forest Grayling Unit	C	85	2004	2018
Steinberg Pine Barrens	26332	Huron-Manistee National Forest Cadillac-Manistee District	C	76	2022	2022
McManus Corner	1527	Michigan State Forest Traverse City Unit	C	60	1996	2015
Mud Lake Barrens	18774	Michigan State Forest Grayling Unit	C	35	2011	2011
Tussing Prairie	8277	Private Property	C	16	1989	1989
Mason Tract	19502	Michigan State Forest Grayling Unit	CD	43	2013	2021
Hoague Pine Barrens	26333	Huron-Manistee National Forest Cadillac-Manistee District	CD	26	2022	2022
Baraga Plains	4388	Baraga	D	172	1996	2015
Rice Pond Barrens	8223	Michigan State Forest Gladwin Unit	D	10	1996	2014
Big Bass Lake Barrens	9565	Michigan State Forest Gaylord Unit	D	10	1995	2014
Pere Cheney Railroad	3065	Michigan State Forest Grayling Unit	D	9	1993	2015

### Rare Species

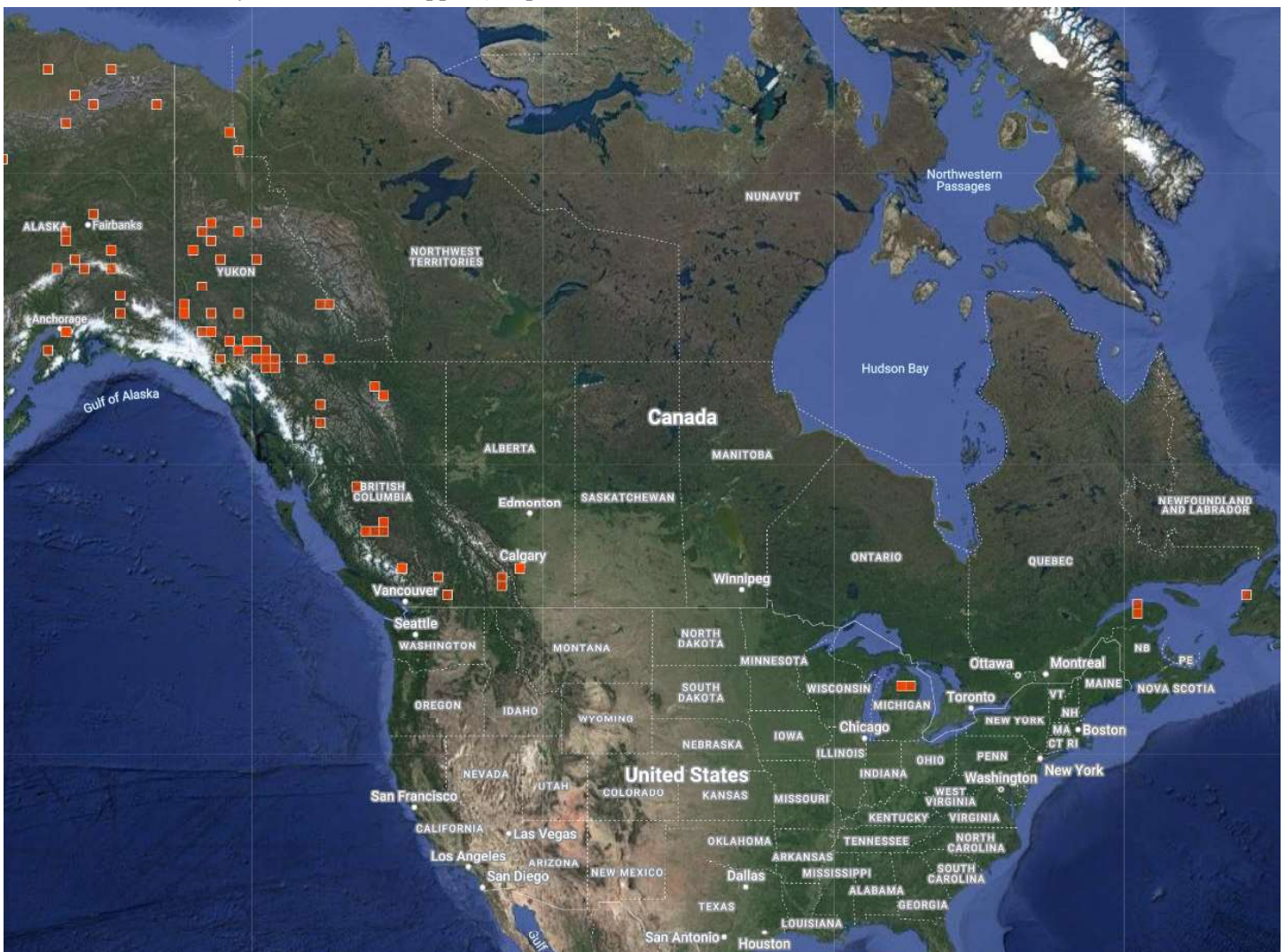
Rare plant species that have been documented at the Frost Pocket Pine Barrens include State Threatened rough fescue (*Festuca altaica*), State Threatened pale agoseris (*Agoseris glauca*), State Special Concern Hill's thistle (*Cirsium hillii*), and State Special Concern Alleghany plum. All were observed in 2022 and the extent of the populations were updated. All but Alleghany plum, which is apparently limited to the east-central margin, are widely distributed throughout this EO.

Rare insects have also been documented from the site, including dusted skipper (*Atrytonopsis hianna*, State Special Concern) and blazing star borer (*Papaipema beeriana*, State Special Concern), last observed in 2018 and 2021 respectively. Dusted skipper feeds and oviposits on bluestems (*Andropogon* spp., *Schizachyrium* spp.) and blazing star borer feeds on blazing stars (*Liatris* spp.), both of which are abundant at the site. Secretive locust (*Appalachia arcana*, State Special Concern) has also been documented in a wetland just to the east of the site. Based on the extensive high-quality habitat, we recommend additional insect surveys for Cobweb skipper (*Hesperia*

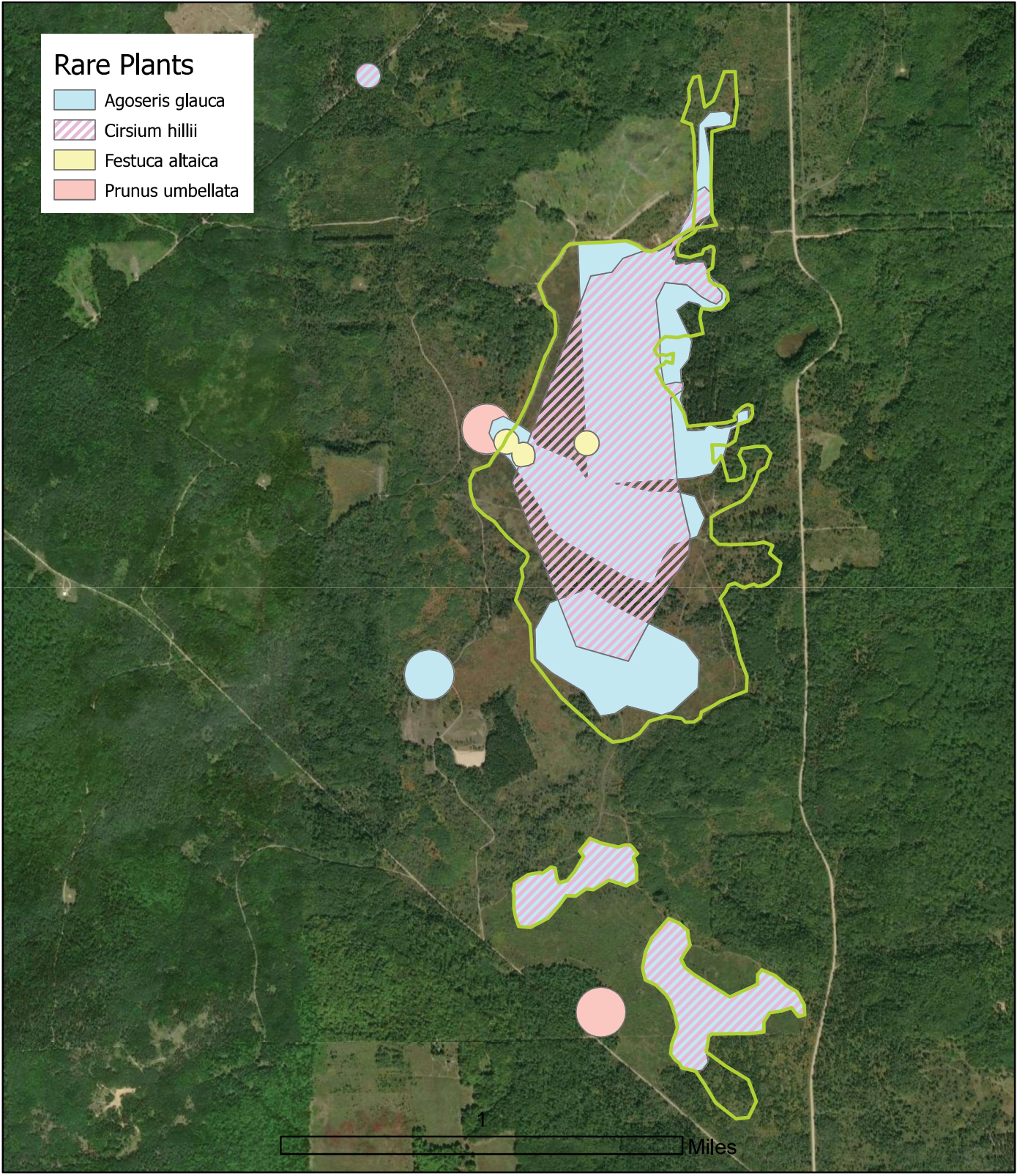
*metea*, State Special Concern) and boreal brachionyncha (*Brachionyncha borealis*, State Special Concern).

The Frost Pocket Pine Barrens provides excellent potential habitat for at-risk birds, including the Kirtland's warbler (*Setophaga kirtlandii*, State Endangered), upland sandpiper (*Bartramia longicauda*, State Threatened), black-backed woodpecker (*Picoides arcticus*, State Special Concern), prairie warbler (*Setophaga discolor*, State Special Concern), and common nighthawk (*Chordeiles minor*, State Special Concern).

The Frost Pocket Pine Barrens and proposed Barrens Project Area already supports several rare taxa. These populations would be bolstered and made more resilient by expanding the footprint of area managed for ecosystem integrity. This site could support the species mentioned above by improving barrens structure and expanding the high-quality habitat. Doing so would address several of the objectives outlined in the State's Wildlife Action Plan (Derosier 2015).



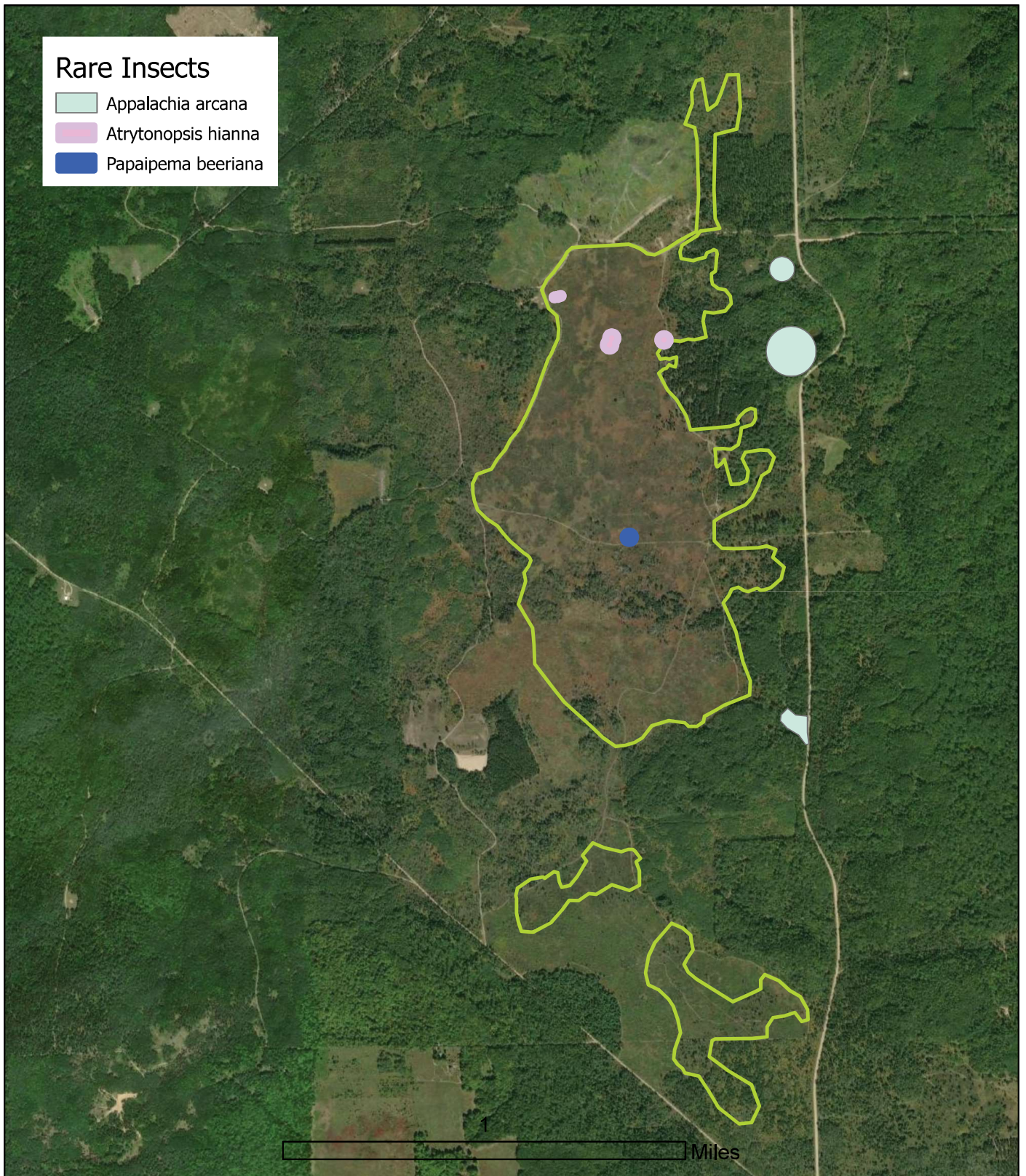
**Figure 6.** The North American distribution of the State Threatened rough fescue. The species has a northern distribution and occurs in the contiguous United States only in six counties in the Northern Lower Peninsula of Michigan where it is infrequent but locally abundant.



**Figure 7.** The location of rare plants in the Frost Pocket Pine Barrens (outline in green).



The dusted skipper (lower left) was first documented from the Frost Pocket Pine Barrens in 2009. Surveys conducted for blazing star borer in 2021 (top) resulted in the first collection of the species from the site (bottom right). Photos by Logan Rowe.



**Figure 8.** The location of rare insects in the Frost Pocket Pine Barrens EO (outline in green).

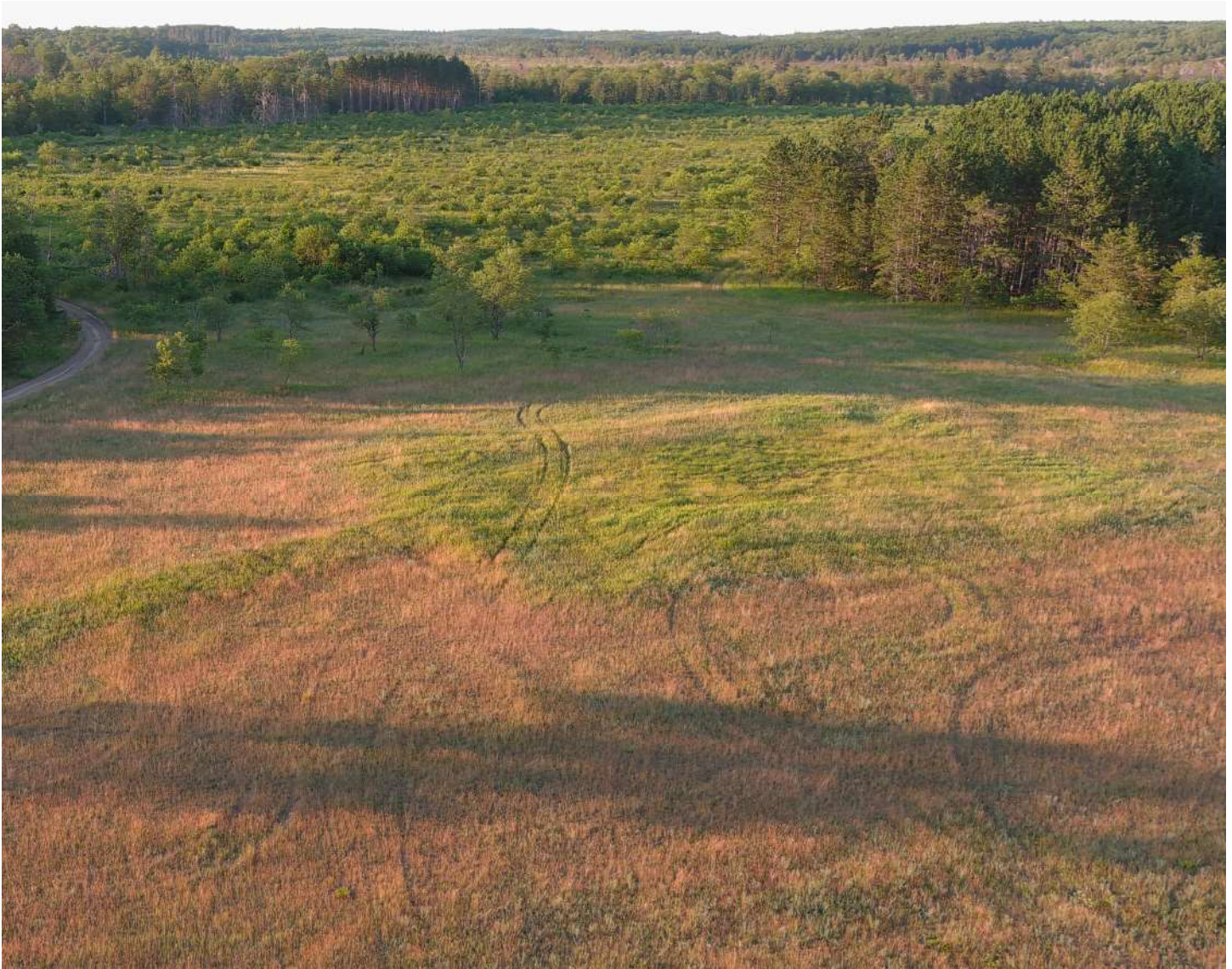
### **Threats**

The main threats to this site are silvicultural treatments that are eliminating the canopy pine; intense prescribed fires within the mapped barrens area that are promoting the dominance of black cherry; increasing abundance of invasive species; increasing damage from ATVs; the high abundance of deer which browse on forbs; and potentially the loss of larger herbivores such as elk that preferentially graze on grasses and sedges.

Silvicultural treatments are degrading canopy structure of the pine barrens. Some areas of the mapped barrens were clearcut in the past 15 years and these areas have no canopy pine and are dominated by black cherry and oak saplings. Within these areas characteristic barrens vegetation is being outcompeted by the dominance of woody regrowth.

The protracted fire suppression that characterized the 20th century is being reversed through consistent application of fire across multiple management units. Prescribed

fire has been applied recently, following MNFI's initial ecological evaluation of the site (Comer 1997). Many sites have been burned multiple times, some as many as six times in the intervening years. The application of fire is likely substantially contributing to the concentration of rare species and elevated forb diversity across the site. However, the barrens structure is being locally eliminated by intense fires. Canopy pines have been killed by intense fires and the frequent fires have reduced the recruitment of jack pine in the seedling and sapling layer. This is facilitating the dominance of black cherry to the exclusion of more desirable characteristic pine species. While dry sand prairie is a natural part of the barrens-prairie continuum, the current extent of treeless landscape over much of the site is not representative of historical conditions. These areas could be rehabilitated to barrens structure by eliminating black cherry, hand planting pine trees, temporarily extending the fire return interval, and reducing the intensity of prescribed fires.



All-terrain vehicles are going through high-quality areas as well as degraded areas filled with knapweed. This jeopardizes populations of rare plants and insects and facilitates further spread of invasive species. Picture taken from Stand 19, looking north.

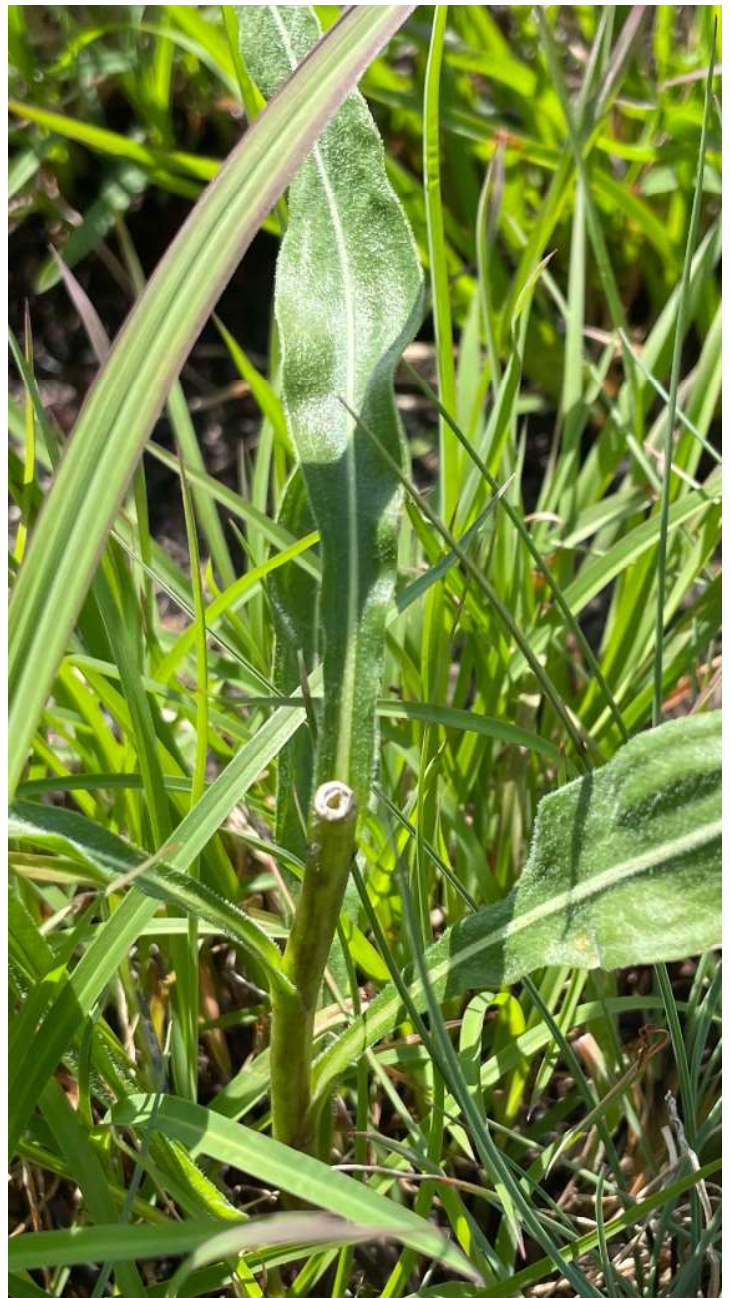


Intense fires are killing pines (top photo, by Tyler J. Bassett) and top-killing black cherry, which are able to resprout from the base (bottom photo). This is rapidly shifting the structure and composition of the barrens to dry sand prairie. We encourage controlling black cherry with judicious application of herbicide and employing lower intensity fires to allow pine to remain in the system.

Invasive species appear to be increasing in dominance throughout the site. Though native vegetation is typically dominant, invasive species are ubiquitous at low levels, locally dominant, and potentially problematic for long-term recoverability of the site. All non-native species observed during the 2022 survey are provided in Table 3. Kentucky bluegrass, sheep sorrel, common St. John's-wort, non-native hawkweeds, and quackgrass are especially widespread and locally dominant. Spotted knapweed is dominant along trails and has the potential to spread into higher-quality areas, especially with the density of trails and prevalence of ATVs that go off-trail.

Deer herbivory was obvious on flowering plants during the 2022 surveys, especially on northern blazing star, smooth aster, and wood lily in the recently burned areas. Deer favor native forbs and are increasing the competitive

advantage of invasive species and graminoids. In some areas there persists a dense thatch of sedge with very low herbaceous diversity relative to the highest quality barrens. This sedge thatch is the result of a confluence of several factors, including decades of intense deer herbivory, past agricultural land use, elimination of elk, and protracted fire suppression for most of the 20<sup>th</sup> century. The dominance of Pennsylvania sedge and other graminoids is likely influencing the successional trajectory of the system by limiting the recruitment of trees and other herbaceous species. The repeated application of prescribed fire has likely had a significant impact on the dominance of Pennsylvania sedge and increased diversity of native vegetation and we strongly encourage expanding the areas where fire is applied beyond the boundaries of the EO. This will also help diffuse deer herbivory as they often favor the regrowth of recently burned areas.



Deer browse was observed on northern blazing star on the (left) and smooth aster (right, photo by Tyler J. Bassett).



**Table 3.** Invasive species documented at the Frost Pocket Pine Barrens during the 2022 field surveys.

Scientific Name	Common Name	Physiognomy
<i>Bromus inermis</i>	smooth brome	grass
<i>Centaurea stoebe</i>	spotted knapweed	forb
<i>Elaeagnus umbellata</i>	autumn-olive	shrub
* <i>Elymus repens</i>	quack grass	grass
* <i>Hieracium aurantiacum</i>	orange hawkweed	forb
<i>Hieracium piloselloides</i>	king devil	forb
* <i>Hypericum perforatum</i>	common St. Johns-wort	forb
<i>Lonicera morrowii</i>	morrow honeysuckle	shrub
* <i>Malus baccata</i>	siberian crab	tree
<i>Phleum pratense</i>	timothy	grass
<i>Poa compressa</i>	Canada bluegrass	grass
* <i>Poa pratensis</i>	Kentucky bluegrass	grass
<i>Potentilla inclinata</i>	ashy cinquefoil	forb
<i>Potentilla recta</i>	rough fruited cinquefoil	forb
* <i>Rumex acetosella</i>	sheep sorrel	forb
<i>Tragopogon dubius</i>	goats beard	forb
<i>Trifolium hybridum</i>	alsike clover	forb
<i>Trifolium pratense</i>	red clover	forb
<i>Trifolium repens</i>	white clover	forb

\* denotes the most problematic invasive species



Some areas of the EO support a low diversity of native vegetation. This is likely due to interactions between historical land clearing, fire suppression in the 20th century, and a high abundance of deer. Eastern Stand 406.

## **Management Considerations**

We suggest adopting a management goal of restoring a broader area surrounding the Frost Pocket Pine Barrens to a condition of improved ecological integrity for the protection of rare native biodiversity and a more resilient landscape.

We believe this is best accomplished by: 1) expanding the Barrens Project Area with the management goal of improved ecological integrity for a larger area surrounding the Frost Pocket Pine Barrens (Figure 9); 2) closing several trails and logging roads throughout the Barrens Project Area to reduce access to ATVs; 3) modifying silvicultural practices within the Barrens Project Area to maintain a sparse canopy of pines within the pine barrens and manage surrounding forests with fire and selective timber harvests that allow for uneven age structure with greater representation of older, larger trees; 4) changing the fire regime by applying prescribed burns across the entire proposed Barrens Project Area at a rate of one to two burns per decade but applying fire in a way that allows for low severity and low intensity to minimize crown fires and reduce the mortality of canopy trees, particularly within the EO; 5) controlling invasive species and select native woody species, and; 6) conducting restoration of the plant community by hand planting pines in areas that were clearcut and currently reflect prairie structure.

Ultimately, we believe this approach will create a more diverse, stable, and resilient pine barrens that provides habitat for rare taxa and game species but is also a system that is compatible with judicious forestry practices that allow for timber harvest by employing single or group selection techniques that remove only a small proportion of the canopy at a time.

### ***Expanding the Barrens Project Area***

The Frost Pocket Pine Barrens was historically part of a large shifting mosaic of barrens, dry sand prairie, and dry northern forest. The landscape was cleared of merchantable timber and some areas were cleared for agriculture, including areas within the drainage that the Frost Pocket Pine Barrens now occupies. When these agricultural operations were abandoned in the 1950s, the surrounding landscape maintained barrens structure and a higher diversity of barrens species which functioned as a seed source for the recovering barrens in the drainage channel. Since then, the broader landscape surrounding the Frost Pocket Pine Barrens EO has been degraded through intensive forestry actions, fire suppression, and deer herbivory.

Decreasing barrens vegetation in the surrounding landscape jeopardizes increasingly isolated populations of rare species and leads to decreased species diversity and abundance

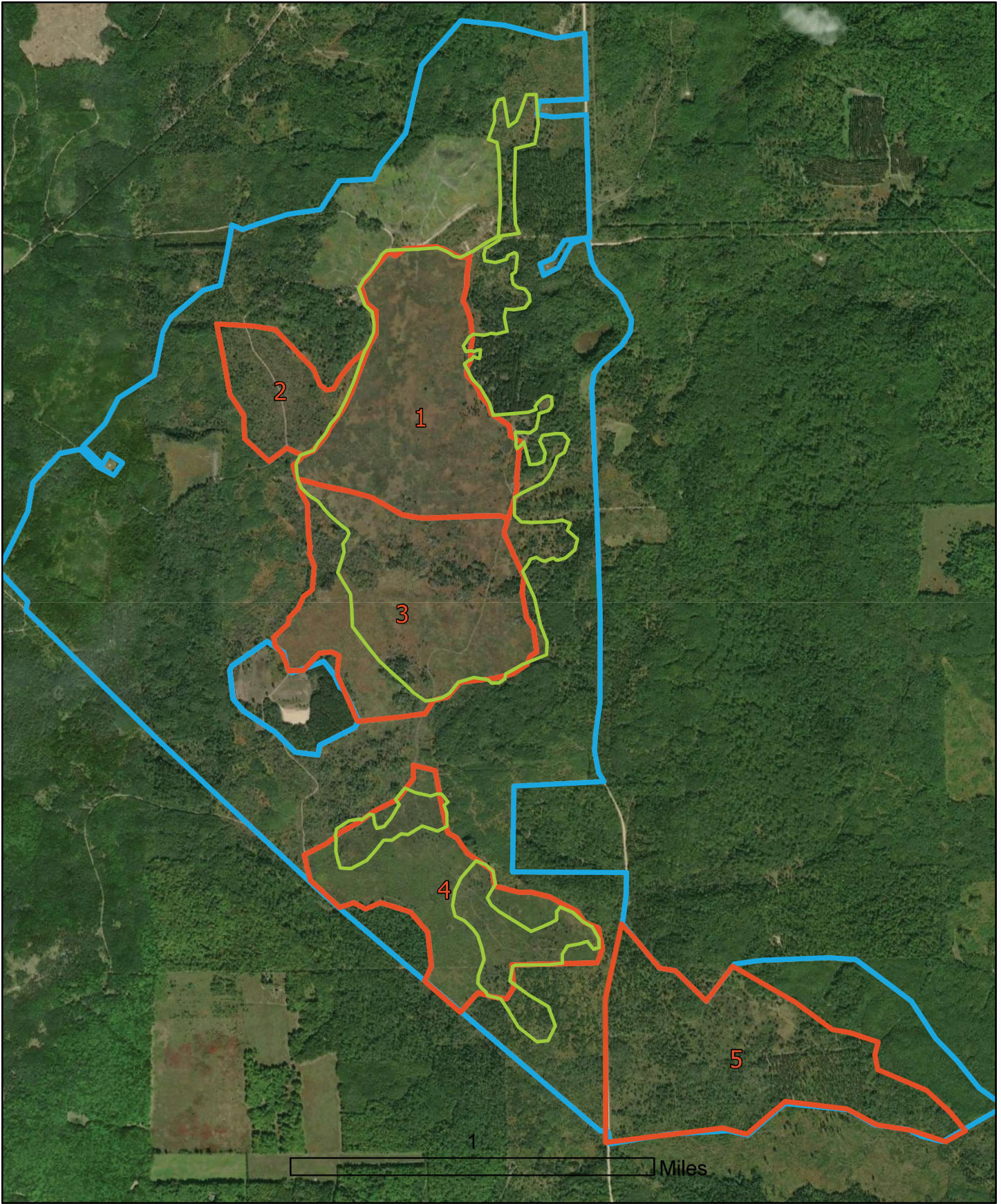
within the pine barrens over time. A larger, more connected landscape being managed for ecosystem integrity is more resilient and will sustain the native biodiversity of the Ecological Reference Area, help the site better avoid localized extinctions, and support more rare species.

Therefore, our top recommendation for promoting the long-term ecological integrity of the Frost Pocket Pine Barrens is to include a greater portion of the landscape in this Barrens Project Area. Many portions of the adjacent forested stands still support barrens vegetation and these areas should be evaluated for improvement under an appropriate management regime, including Stands 81, 18, 35, 19, 43, 40, and 46. These surrounding stands could be included in prescribed fires and barrens management, slowly converting them to a more sparsely canopied forest. Many of the surrounding forests are being clearcut and there is very little mature forest being maintained around the mapped pine barrens. Prescribed fire should be used as a primary mechanism to maintain open canopy conditions. Clearcutting does not approximate the impacts of fire as a disturbance and should be avoided within the Ecological Reference Area and entire proposed Barrens Project Area. We urge managers to halt clearcutting within the EO and the broader Barrens Project Area and to replicate the conditions of the historic landscape that allowed the pine barrens and rare species therein to develop and persist.

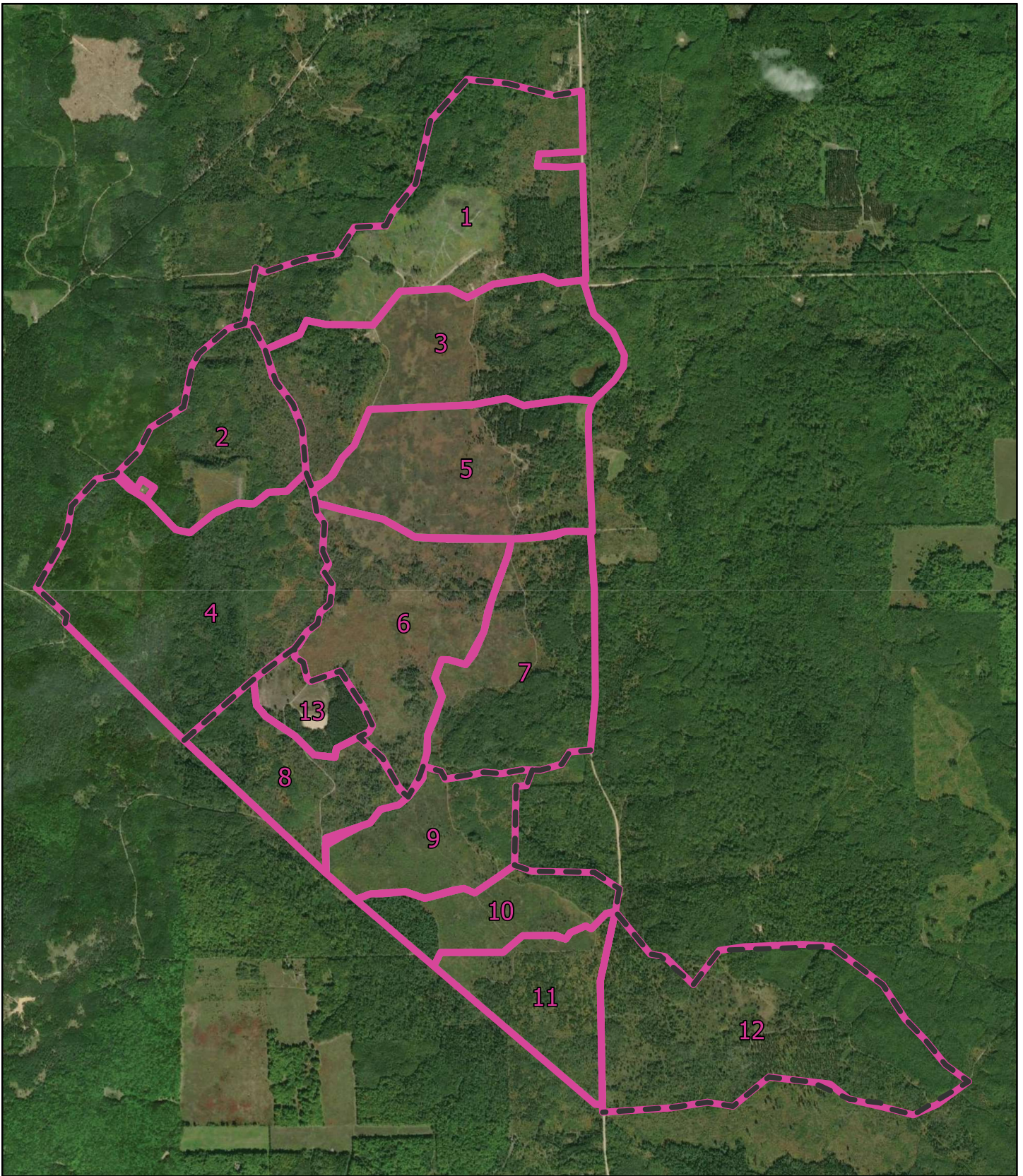
To facilitate the expansion of the Barrens Project Area, we have provided a potential boundary for the site (Figure 9). Within the larger project boundary, we have developed several smaller units, each would function as a burn unit with permanent burn breaks as boundaries (Figure 10, page 33). We have provided a table describing each unit with descriptions and corresponding goals aimed at improving the overall landscape context for the Frost Pocket Pine Barrens (Table 4, page 34).

### ***Closing Trails***

Invasive species are especially prevalent along trails. We observed that ATVs frequently leave the numerous trails which risks spreading invasive species, degrading quality habitat through soil disturbance, and jeopardizing rare species populations. We urge managers to close most of the trails within the EO and broader Barrens Project Area and maintain a small set of narrow burn lines within the Barrens Project Area that are accessible only to state employees. We provide suggested locations for roads in Figure 10. The remainder of the roads within the entire project area should be closed unless being used for permanent burn breaks. Permanent burn breaks being used as burn unit boundaries should be inaccessible to ATVs to minimize risk to the overall site.



**Figure 9.** The proposed expanded Barrens Project Area is outlined in blue. The existing project boundaries are provided in red. We propose expanding the existing project boundaries to include adjacent forested stands that may still contain marginal barrens habitat and areas where the exiting pine barrens EO (green) could be expanded.



**Figure 10.** The potential new management units within the proposed Barrens Project Area. New proposed roads are indicated with a dark dashed line. Within this broad area area, the primary objectives include allowing forests to be managed as mixed age stands by stopping clearcuts within the entire project area; burning all units with a priority for burning in the highest quality barrens most frequently; closing as many trails as possible; treating invasive species from the highest quality areas; restoring characteristic barrens structure in areas that have been transitioned towards prairie structure; and stopping the addition of oil pads. All proposed borders are to function as fire breaks and unless mapped as a road, the fire breaks should be off limits to ATVs to best protect the barrens and rare species therein.

**Table 4.** Initial management recommendations for specific management units of the proposed Barrens Project Area. Priority 1 areas have natural community, plant, and/or insect EOs; Priority 2 areas have very little high-quality habitat or are adjacent to high-quality area and need more rehabilitation to achieve elevated condition. Priority 3 areas have minimal restoration potential in the immediate future but should be included with the overall project to improve landscape context of the pine barrens. Maps with stand locations are provided in Appendices.

Project Area	Priority Level	Acres	Management Actions
1	2	252	<ul style="list-style-type: none"> <li>•Protect mapped barrens habitat and rare species in Stands 46 and 54</li> <li>•Reduce canopy of plantation in Stand 50 to about 50%</li> <li>•Protect openings during thinning and conduct in winter to avoid damaging soil</li> <li>•Expand and protect openings in Stands 40 and 43 with fire and gradual thinning</li> <li>•Treat spotted knapweed in Stand 49</li> </ul>
2	2	124	<ul style="list-style-type: none"> <li>•Protect barrens habitat in depressions in Stand 81 and similar features</li> <li>•Focus prescribed burn in Stands 23 and 81</li> <li>•Focus black cherry and Siberian crab removal in Stands 23 and 81</li> </ul>
3	1	218	<ul style="list-style-type: none"> <li>•Reduce canopy of plantation in Stand 17 to about 50%</li> <li>•Protect openings during thinning and conduct in winter to avoid damaging soil</li> <li>•Do not exclude wetland in Stand 16 from prescribed fire, but do not target with fire</li> <li>•Close trails on east and west end of Stand 404 to extend burns into Stands 24 and 14</li> <li>•Treat Siberian crab, black cherry, and spotted knapweed</li> <li>•Hand plant red pine and jack pine in Stand 404 to establish a variable canopy between 20 and 50%</li> </ul>
4	3	271	<ul style="list-style-type: none"> <li>•Focus initial prescribed fire and reestablishing barrens structure in Stand 18, 22, and 78</li> <li>•After burns, gradually reduce canopy through selective harvest to reestablish better composition and structure, favoring the retention of natural pine and large oaks</li> </ul>
5	1	180	<ul style="list-style-type: none"> <li>•Close north/south trail at eastern 404 to extend burns into adjacent forested Stands 18 and 19</li> <li>•Investigate best management practices for controlling quackgrass, common St. John's-wort, sheep sorrel, Siberian crab, and the spotted knapweed along roads</li> <li>•Reduce black cherry in all strata</li> <li>•Hand plant red pine and jack pine in Stand 404 to establish a variable canopy between 20 and 50%</li> <li>•Reduce canopy of plantation in Stand 17 to about 50%</li> <li>•Prevent equipment in the openings in Stand 17 during thinning</li> </ul>
6	1	183	<ul style="list-style-type: none"> <li>•Limit mortality of canopy pines in Stand 406 by implementing low intensity burns initially</li> <li>•Remove black cherry saplings throughout Stand 22</li> <li>•Kill canopy black cherry in Stands 416 and 406; potentially with the 'hack and squirt' method</li> <li>•Hand plant red pine and jack pine in Stand 22 following treatment of black cherry</li> <li>•Focus invasive species treatment in Stand 416, especially knapweed, smooth brome, and quackgrass</li> </ul>
7	1	170	<ul style="list-style-type: none"> <li>•Eliminate north/south trail along eastern Stands 22 and 406 to extend burns into adjacent forested Stands 12 and 27</li> <li>•Investigate potential to expand and restore openings in Stand 12</li> <li>•Reduce black cherry in all strata in eastern 406</li> </ul>
8	3	98	<ul style="list-style-type: none"> <li>•Focus prescribed fire and reestablishing barrens structure in Stand 18</li> </ul>
9	1	103	<ul style="list-style-type: none"> <li>•Close north/south trail along eastern edge of Stands 408 and 410 to extend burns into adjacent forested Stand 19</li> <li>•Reduce black cherry in all strata</li> <li>•Hand plant red pine and jack pine in Stand 408 to establish a variable canopy between 20 and 70%</li> <li>•Expand and protect openings in Stand 19</li> </ul>
10	1	81	<ul style="list-style-type: none"> <li>•Close trail along eastern edge of Stand 32 and 410 to include Stands 32 and 20 in burns</li> </ul>
11	1	83	<ul style="list-style-type: none"> <li>•Focus prescribed fire and reestablishing barrens structure in Stand 35</li> <li>•Reduce black cherry in all strata, ideally before the initial burn</li> <li>•Conduct low intensity initial burn to reduce coarse woody debris and ladder fuels and minimize canopy mortality</li> </ul>
12	2	264	<ul style="list-style-type: none"> <li>•Incorporate surrounding forested hills to the northeast in prescribed burn, especially Stands 1 and 2</li> <li>•Reestablish barrens structure</li> <li>•Reduce black cherry in all strata</li> </ul>
13	3		<ul style="list-style-type: none"> <li>•Rehabilitate openings where cattle burial is with native planting</li> <li>•Prevent ATVs from accessing to limit spread of invasive species</li> </ul>

### ***Modifying Silvicultural Practices***

Pine barrens are a natural community with trees. The system developed and maintained diversity with a greater extent of trees than is present across much of the site and we recommended managing towards that semi-forested structure. Historical tree coverage within the Frost Pocket Pine Barrens was probably between 20 to 60% (Coon 1839). Red pine was at least as abundant as jack pine, white pine was infrequent, and black cherry was absent from the notes. The system was maintained by frequent low intensity fires and the resulting structure featured widespread, old, open-grown red pine and scattered jack pine (see top picture on page 36). Between the widely spaced red pine were thickets of younger jack pine that shifted around in response to infrequent but more intense canopy fires that were more localized around jack pine thickets.

Clearcuts have eliminated areas with characteristic sparse canopy of pines, creating extensive areas with no canopy structure (Figure 11). Management actions that have caused the system to shift towards prairie structure without trees are simplifying the complex, heterogenous nature of the pine barrens system. This simplification is not ideal because many species are less competitive in the high-light environments of the open prairie structure. We recommend promoting a complex, uneven age class structure with widely spaced, super canopy red pine and scattered thickets of jack pine. Additionally, black cherry has increased in density across this landscape and will require intervention with herbicide. The structure and composition of the pine barrens are in need of rehabilitation throughout much of the mapped EO.

Notes from Stand 22 within the EO suggest managers have been pushing the system towards an open prairie structure: “Objective for unit 3 is to convert area to open grassy

area dominated by herbaceous and short shrubs.” We offer alternative language for the goal of the habitat structure: The objectives for the barrens management units include a sparse canopy of jack pine with a supercanopy of red pine, varying age classes, and canopy coverage from 20 to 60%.

In general, we do not recommend managers supplement the species composition by planting additional species. Doing so jeopardizes the site’s status as a valuable floristic reference area, and herbaceous diversity is already locally very high. However, much of the site has been impacted by historical agricultural operations, timber harvests, and intense fires and the system lacks the characteristic pine barrens structure in several areas. We suggest planting native pines by hand to improve conditions in those areas. We discourage trenching and broadcast herbicide because these management techniques negatively impact native biodiversity. Planting trees will need to be done following treatment of black cherry and Siberian crab.

The desired condition is a variable canopy with overall coverage around 50% but with areas supporting between 20 and 60% canopy coverage. Overall, red pine and jack pine will be the most dominant trees, have a similar prevalence, and together comprise about 70% of the total canopy composition. White pine will be a lower abundance with infrequent aspen and oak and very little cherry. Some of the red pine should be allowed to reach ages of 200 to 300 years and the wide spacing should prevent catastrophic crown fires. This approach is intended to maximize overlap of biodiversity management and sustainable forestry operations and should feature a canopy with widely distributed age classes, sparse tree densities, and complex composition corresponding to landscape position.



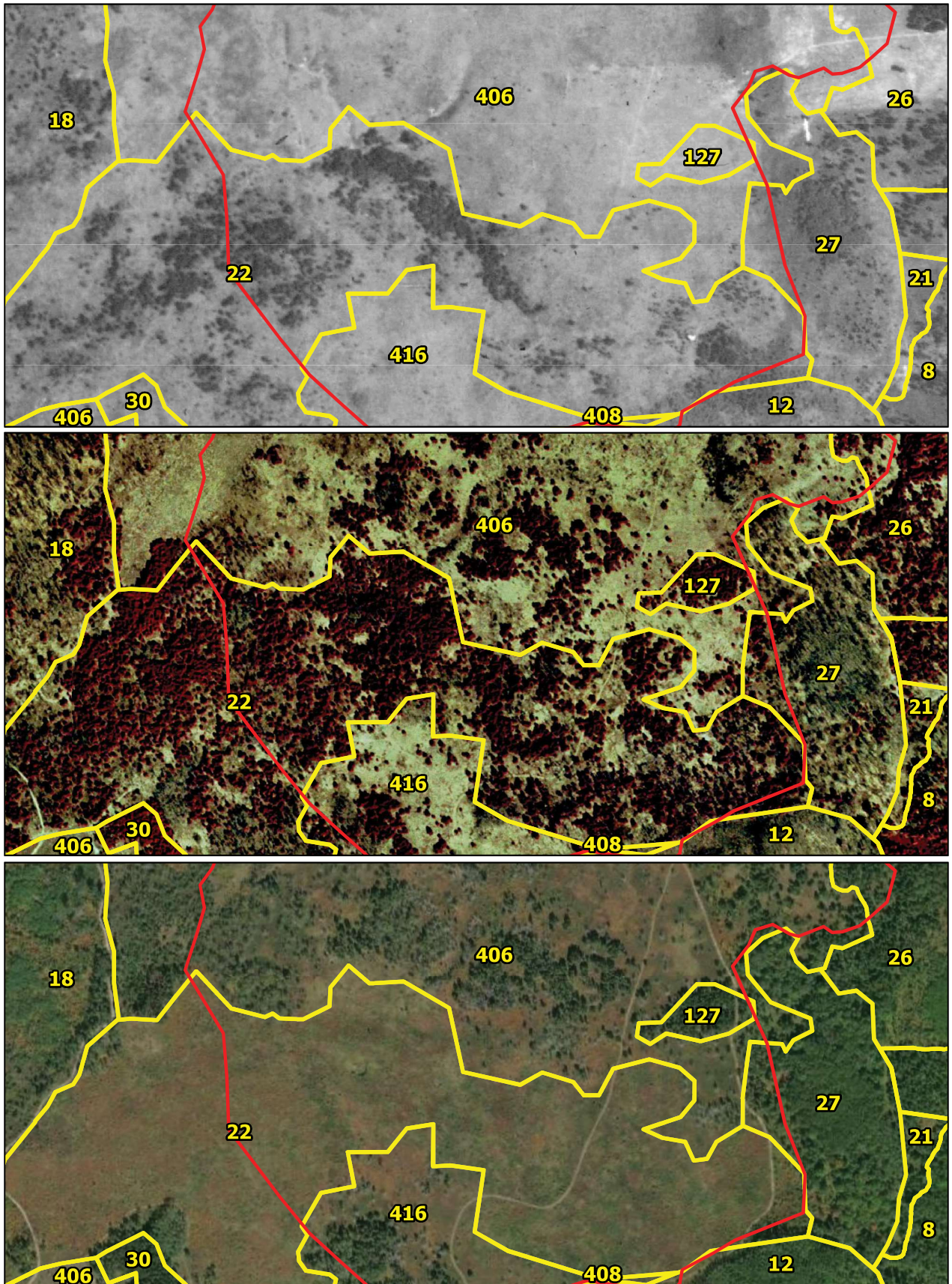
Repeated intense fires have reduced the component of canopy pine in Stand 404 and the structure of the area more closely reflects a dry sand prairie. We suggest hand planting pine in this area to develop a variable structure of 20 to 60% canopy coverage of red and jack pine.



This historical photograph approximates the conditions of the Frost Pocket Pine Barrens described by General Land Office surveyor William Coon in 1839. Red pine was the dominant species and formed an uneven-aged supercanopy over jack pine thickets. We suggest this as an ideal future state of the Frost Pocket Pine Barrens and this approach will maximize the overlap between management for biodiversity, sustainable forestry operations, and climate resilience.



Western Stand 406 is in the foreground and is an area that has shifted towards extensive canopy of deciduous species. Looking north to Stand 404 in the background, the system has too few trees. The ideal pine barrens structure is between these two systems and can be achieved by handplanting trees in Stand 404 to recreate the barrens structure and by applying prescribed fire and selective tree removal and leaving existing pine to continue maturing in Stand 406.



**Figure 11.** Comparison of imagery from the Frost Pocket Pine Barrens across multiple years. Top: imagery from 1938 showing forest in Stand 22. Middle: imagery from 1998 showing that this forest was still present. Bottom: imagery from 2020 shows the forest had been clearcut. Ideally, this area would have been selectively harvest or managed towards a more open condition with fire alone. This would have been an especially valuable area to protect as the 1938 tree cover indicates minimal disturbance compared to other areas.



### ***Changing the Fire Regime***

Prescribed burns have been instrumental in the maintenance of this system's herbaceous composition. We urge managers to continue this approach of frequent fires with some minor adjustments to seasonality, intensity, frequency, and extent of burning. We also recommend that these burns are a lower intensity and severity and that they are applied across a larger area.

Ideally fires will be applied at a relatively high frequency of one to two burns per decade and will be of relatively low intensity so as not to kill canopy trees or create crown fires. We suggest that, when possible, these burns could be conducted in late fall or early winter to mimic historical timing of burns (September through early November). This approach of employing low intensity fires is especially important when introducing fire to areas that have not been recently burned. A goal of the initial fires in areas that have not been recently burned is to consume ladder fuel and fuel on the ground without killing more than 10% of the canopy trees or causing a crown fire. Such burns may not appear to be having a dramatic impact but over time they fundamentally alter and improve the structure and composition of the pine barrens.

The Frost Pocket Pine Barrens historically developed in the context of a broad shifting mosaic and we recommend including a broader area of the Barrens Project Area in prescribed burns. While surrounding forested stands typically support marginal habitat, they could be improved

with fire and selective timber harvest to improve and expand existing openings that still support barrens vegetation.

Because some parts of the barrens have transitioned to open prairie structure, restoring barrens structure will require replanting of pines in areas such as Stands 404, 22, 408, 411, and 410. We suggest conducting a burn, treating black cherry and Siberian crab, and then planting with native pines to achieve ideal pine barrens structure. Managers will likely need to wait five to ten years to conduct the next follow up burn, depending on the timing of the burn and the condition of the fuels. After planting trees, fire should be strategically applied to minimize damage to seedlings. This might mean watering trees and back-burning around individual trees or groups of trees.

The presence of rare insects requires careful application of prescribed burns. When developing a schedule for burns, consider not burning more than 25% of the entire project area in a given year. Minimizing burning in adjacent burn units during any 2-year period will allow the opportunity for insect reestablishment. We support varying the seasonality of burns but recommend applying burns in late fall or early winter to create patchy burns which provide refugia for the rare species in the system. We believe that the approach of frequent, low intensity burns over a larger area will create a system that is resilient to climate change and stable enough to support populations of rare species.



Prescribed burns will ideally be applied to more areas to improve openings and express areas of recoverable barrens in the landscape. The existing openings in eastern Stand 406 were included in the Ecological Reference Area following the 2022 ecological evaluation and could be improved with fire and treatment of black cherry. Eastern Stand 406, looking north.

### ***Treating Invasive Species***

Invasive species are likely increasing in dominance over time and reducing native vegetation. We recommend developing a comprehensive plan for the focused and continuous monitoring and treatment of invasive species. Invasive species and deciduous woody vegetation, particularly black cherry and Siberian crab, do not appear to be decreasing in abundance due to prescribed burns and intervention with herbicide is needed. Kentucky bluegrass, sheep sorrel, common St. John's-wort, non-native hawkweeds, and quackgrass are especially widespread and locally dominant. Spotted knapweed is dominant along trails and has the potential to spread into high-quality areas, especially with the density of trails and prevalence of ATVs that go off-trail.

Many of the rare and conservative species at the site have non-native look-alikes. Pale agoseris looks like the non-native goat's beard. Siberian crab has polymorphic leaves and it can be difficult to distinguish from Alleghany plum. Hill's thistle resembles any of a number of non-native thistles. Northern blazing star can look like spotted knapweed, especially if browsed. Slender wheatgrass is in the same genus as quackgrass and the two can be very difficult to tell apart without familiarity of grasses. The native prairie brome looks similar to the invasive smooth brome. The treatment of the most problematic species within the barrens vegetation seems very difficult without introducing substantial risk to conservative and rare

species and should only be undertaken by highly qualified individuals trained to recognize important vegetation (both invasive and rare plant species) and minimize risk of collateral damage to rare plant populations.

### ***Future Work***

While the entirety of the existing EO was surveyed in 2022, there are additional areas that we recommend be surveyed for marginal habitat that could be recovered with stewardship intervention. Stands 35, 19, 416, 23, 43, 38, 40 and Stand 81 should all be more closely evaluated for pockets of barrens vegetation. Similarly, we strongly recommend a survey dedicated to the mapping of invasive species across the entire barrens project area. This effort should be conducted once early in the year and again later in the summer to identify as many populations of invasive species as possible.

This condition rank and overall rank of the Frost Pocket Pine Barrens could continue to be improved by implementing the management recommendations and addressing the threats outlined in this report. We encourage the Wildlife Division fund long-term monitoring across the site to determine the effectiveness of restoration actions. Because of the importance of this site to regional biodiversity and because of the complicated and wide-ranging recommendations in this report, we recommend another ecological evaluation to take place in 10 years.



The State Threatened pale agoseris (left) has a very narrow distribution in Michigan but can look similar to goat's beard (right), which is a non-native species that is fairly common throughout the Frost Pocket Pine Barrens.



Sheep sorrel (top) and quackgrass (bottom) are problematic throughout the site and locally dominant. It is not clear what the best management approach is for many of the most abundant invasive species as there is extreme risk for collateral damage to native vegetation, particularly populations of rare plants. Any treatment of invasive species should be conducted by highly trained individuals with knowledge of the location of rare plant populations, comprehensive understanding of best management practices for the target invasive, and a familiarity of native species that might resemble the invasive targets.

## Concluding Remarks

This ecological evaluation substantially increased the existing Frost Pocket Pine Barrens EO with additional quality, recoverable barrens habitat and expanded known populations of rare species. In this report, we have outlined an approach to broaden and protect this very important example of a pine barrens. Adjustments to management are needed but excellent work has been done to apply prescribed burns and protect the site from degradation.

The Frost Pocket Pine Barrens has incredible restoration potential and local managers are already aware of its value and are working to protect it. Following MNFI's

initial evaluation (Comer 1997), DNR managers began to implement prescribed fire. The site was first burned in 1999 and several sites have received a total of six burns since then. The DNR's Wildlife Division was an early proponent of the restoration efforts which have focused on the application of prescribed fire on a regular basis. In addition, the DNR has engaged with Huron Pines, local conservation organization, to treat invasive species and improve the habitat. This collaborative, consistent, and long-term commitment to such an important site is critical and serves as an excellent model for protecting pine barrens across Michigan.



The Frost Pocket Pine Barrens supports several areas with exemplary structure and composition. The frequent application of fire over the past two decades has improved the condition of the site. With minor adjustments to fire and an expansion of the area managed as pine barrens, the integrity of the site and surrounding landscape will continue to improve.

Pine barrens are a rare and imperiled natural community and this important example has many serious threats to its ecological integrity and standing as an Ecological Reference Area. We recommend the following measures to continue to protect this place and address the threats: 1) expanding the Barrens Project Area with the management goal of improved ecological integrity for a larger area surrounding the Frost Pocket Pine Barrens; 2) closing several trails and logging roads throughout the Barrens Project Area to reduce access to ATVs; 3) modifying silvicultural practices within the Barrens Project Area to maintain a sparse canopy of pines within the pine barrens and manage surrounding forests with fire and selective timber harvests that allow for uneven age structure with greater representation of older, larger trees; 4) changing the fire regime by applying prescribed burns across the entire proposed Barrens Project Area at a rate of one to two burns per decade but applying fire in a way that allows for low severity and low intensity to minimize crown fires and reduce the mortality of canopy trees, particularly within the EO; 5) controlling invasive species and select native woody species, and; 6) conducting restoration of the plant community by hand planting pines in areas that were clearcut and currently reflect prairie structure.

Fire-dependent natural communities across Michigan had been managed by Indigenous Peoples for thousands of years. Historically the barrens at this site occurred as a mosaic of forest and prairie over 5,000 acres. Now, the 445 acres that comprise the Frost Pocket Pine Barrens qualify it as one of the largest pine barrens in the state. Over 98% of pine barrens have been lost around the state and this site offers a unique opportunity to increase the acreage of an imperiled natural community type. This place has benefited from recent management, but by including the above recommendations, we believe the site can be improved and made more resilient.

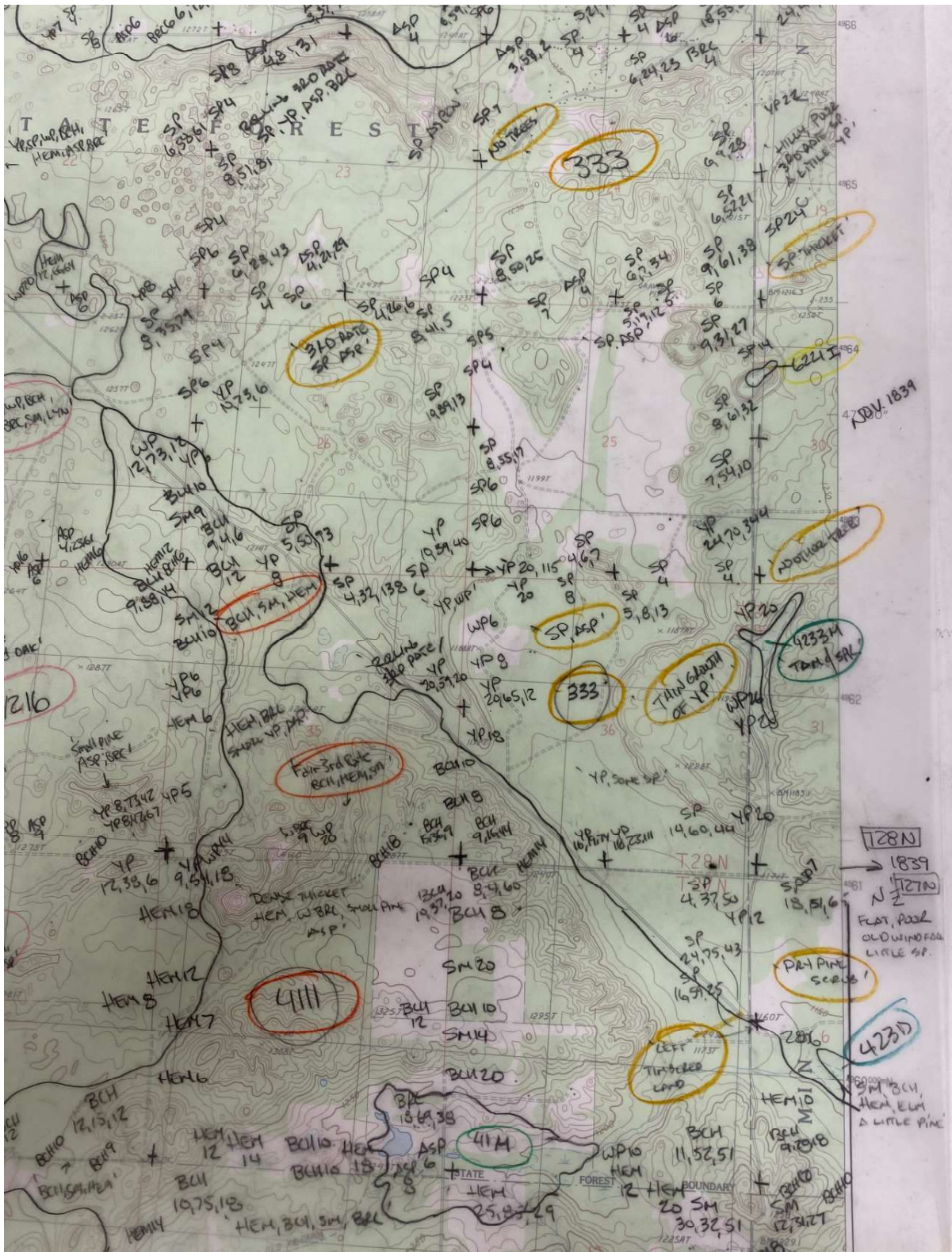
Furthermore, the approach outlined in this report addresses stated goals in the State of Michigan's Wildlife Action Plan by improving habitat for game species; improving habitat for myriad rare species; maintaining the integrity of an imperiled natural community; and creating a landscape more resilient to climate change. We celebrate previous efforts to manage this critical ecological asset and hope that this ecological evaluation will support and guide the future endeavors to protect and preserve this valuable piece of our natural heritage.



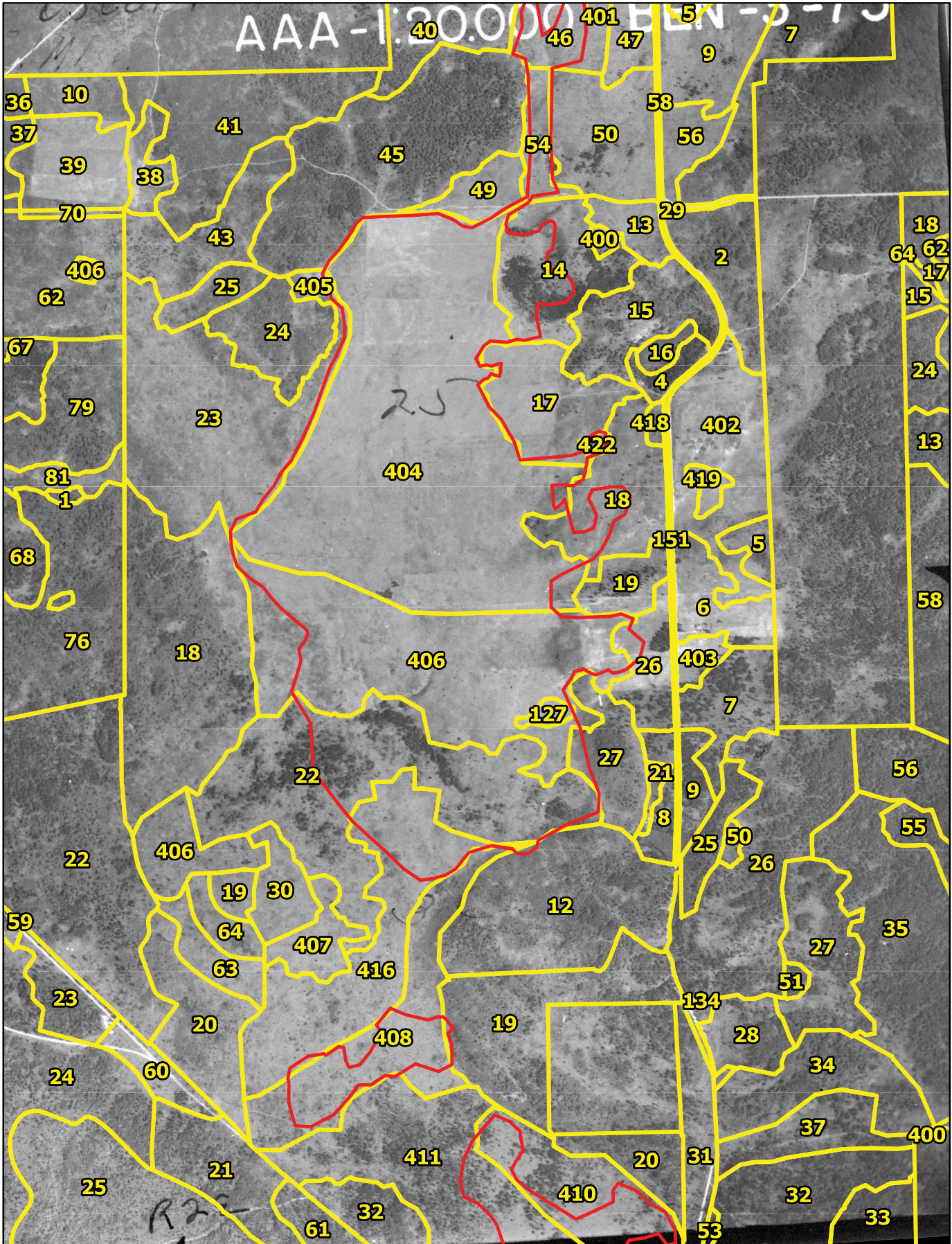
The Frost Pocket Pine Barrens supports several areas with characteristic structure and composition. The frequent application of fire over the past two decades has improved the site. With minor adjustments to fire and expansion of the area managed as pine barrens, the site and landscape will continue to improve.

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**Appendix 1.** Notes from the General Land Office Surveyor William Coon, 1839 transcribed on to mylar topographic maps. These notes and maps serve as the basis for the circa 1800 maps of presettlement vegetation. ‘YP’ stands for yellow pine, the common name used for red pine (*Pinus resinosa*) at the time of the original surveys. ‘SP’ stands for spruce-pine, the common name used for jack pine (*Pinus banksiana*) at the time of the original surveys.



**Appendix 2.** Frost Pocket Pine Barrens EO boundaries in red and MiFI stands with 1938 imagery. Stands 404 and 406 show evidence of being cleared for agriculture.



Appendix 3. Species list for Frost Pocket Pine Barrens.

Scientific Name	Common Name	Acronym	Native?	C	Physiognomy
<i>Acer rubrum</i>	red maple	ACERUB	native	1	tree
<i>Achillea millefolium</i>	yarrow	ACHMIL	native	1	forb
<i>Agoseris glauca</i>	prairie or pale agoseris	AGOGLA	native	9	forb
<i>Amelanchier interior</i>	serviceberry	AMEINT	native	4	shrub
<i>Amelanchier sanguinea</i>	round-leaved serviceberry	AMESAN	native	5	shrub
<i>Andropogon gerardii</i>	big bluestem	ANDGER	native	5	grass
<i>Anemone cylindrica</i>	thimbleweed	ANECYL	native	6	forb
<i>Anemone quinquefolia</i>	wood anemone	ANEQUI	native	5	forb
<i>Anemone virginiana</i>	thimbleweed	ANEVIR	native	3	forb
<i>Antennaria howellii</i>	small pussytoes	ANTHOW	native	2	forb
<i>Apocynum androsaemifolium</i>	spreading dogbane	APOAND	native	3	forb
<i>Aralia nudicaulis</i>	wild sarsaparilla	ARANUD	native	5	forb
<i>Arctostaphylos uva-ursi</i>	bearberry	ARCUVA	native	8	shrub
<i>Asclepias syriaca</i>	common milkweed	ASCSYR	native	1	forb
<i>Avenella flexuosa</i>	hair grass	AVEFLE	native	6	grass
<i>Boechera stricta</i>	drummond rock cress	BOESTR	native	6	forb
<b><i>Bromus inermis</i></b>	<b>smooth brome</b>	<b>BROINE</b>	<b>non-native</b>	<b>0</b>	<b>grass</b>
<i>Bromus kalmii</i>	prairie brome	BROKAL	native	8	grass
<i>Calystegia spithamea</i>	low bindweed	CALSPI	native	8	forb
<i>Campanula rotundifolia</i>	harebell	CAMROT	native	6	forb
<i>Carex pensylvanica</i>	sedge	CXPENS	native	4	sedge
<i>Carex tonsa</i>	sedge	CXTONS	native	5	sedge
<b><i>Centaurea stoebe</i></b>	<b>spotted knapweed</b>	<b>CENSTO</b>	<b>non-native</b>	<b>0</b>	<b>forb</b>
<i>Cirsium hillii</i>	hills thistle	CIRHIL	native	8	forb
<i>Clinopodium vulgare</i>	wild-basil	CLIVUL	native	3	forb
<i>Comptonia peregrina</i>	sweetfern	COMPER	native	6	shrub
<i>Crataegus brainerdii</i>	hawthorn	CRABRA	native	4	tree
<i>Danthonia spicata</i>	poverty grass; oatgrass	DANSPI	native	4	grass
<i>Dichanthelium columbianum</i>	panic grass	DICCOL	native	5	grass
<i>Dichanthelium linearifolium</i>	slender-leaved panic grass	DICLIE	native	4	grass
<i>Dichanthelium xanthophyllum</i>	panic grass	DICXAN	native	6	grass
<i>Drymocalis arguta</i>	tall or prairie cinquefoil	DRYARG	native	8	forb
<b><i>Elaeagnus umbellata</i></b>	<b>autumn-olive</b>	<b>ELAUMB</b>	<b>non-native</b>	<b>0</b>	<b>shrub</b>
<b><i>Elymus repens</i></b>	<b>quack grass</b>	<b>ELYREP</b>	<b>non-native</b>	<b>0</b>	<b>grass</b>
<i>Elymus trachycaulus</i>	slender wheatgrass	ELYTRA	native	8	grass
<i>Erigeron strigosus</i>	daisy fleabane	ERISTR	native	4	forb
<i>Eurybia macrophylla</i>	big-leaved aster	EURMAC	native	4	forb
<i>Festuca altaica</i>	rough fescue	FESALT	native	9	grass
<i>Festuca saximontana</i>	fescue	FESSAX	native	6	grass
<i>Fragaria virginiana</i>	wild strawberry	FRAVIR	native	2	forb
<i>Helianthus occidentalis</i>	western sunflower	HELOCC	native	8	forb
<b><i>Hieracium aurantiacum</i></b>	<b>orange hawkweed</b>	<b>HIEAUR</b>	<b>non-native</b>	<b>0</b>	<b>forb</b>
<i>Hieracium kalmii</i>	kalms hawkweed	HIEKAL	native	3	forb
<b><i>Hieracium piloselloides</i></b>	<b>king devil</b>	<b>HIEPIS</b>	<b>non-native</b>	<b>0</b>	<b>forb</b>
<i>Hieracium scabrum</i>	rough hawkweed	HIESCA	native	3	forb
<b><i>Hypericum perforatum</i></b>	<b>common st. johns-wort</b>	<b>HYPPER</b>	<b>non-native</b>	<b>0</b>	<b>forb</b>
<i>Juncus tenuis</i>	path rush	JUNTEN	native	1	rush
<i>Koeleria macrantha</i>	june grass	KOEMAC	native	9	grass
<i>Krigia biflora</i>	false dandelion	KRIBIF	native	5	forb
<i>Krigia virginica</i>	dwarf dandelion	KRIVIR	native	4	forb
<i>Lactuca canadensis</i>	tall lettuce	LACCAN	native	2	forb

Appendix 3, Continued. Species list for Frost Pocket Pine Barrens.

Scientific Name	Common Name	Acronym	Native?	C	Physiognomy
<i>Lactuca canadensis</i>	tall lettuce	LACCAN	native	2	forb
<i>Liatris scariosa</i>	northern blazing-star	LIASCA	native	5	forb
<i>Lilium philadelphicum</i>	wood lily	LILPHI	native	7	forb
<i>Lonicera dioica</i>	red honeysuckle	LONDIO	native	5	vine
<b><i>Lonicera morrowii</i></b>	<b>morrow honeysuckle</b>	<b>LONMOR</b>	<b>non-native</b>	<b>0</b>	<b>shrub</b>
<i>Maianthemum canadense</i>	canada mayflower	MAICAN	native	4	forb
<b><i>Malus baccata</i></b>	<b>siberian crab</b>	<b>MALBAC</b>	<b>non-native</b>	<b>0</b>	<b>tree</b>
<i>Malus coronaria</i>	american crab	MALCOR	native	4	tree
<i>Melampyrum lineare</i>	cow-wheat	MELLIN	native	6	forb
<i>Monarda fistulosa</i>	wild-bergamot	MONFIS	native	2	forb
<i>Oenothera biennis</i>	common evening-primrose	OENBIE	native	2	forb
<i>Oryzopsis asperifolia</i>	rough-leaved rice-grass	ORYASP	native	6	grass
<i>Packera paupercula</i>	balsam ragwort	PACPAU	native	3	forb
<b><i>Phleum pratense</i></b>	<b>timothy</b>	<b>PHLRA</b>	<b>non-native</b>	<b>0</b>	<b>grass</b>
<i>Physalis virginiana</i>	virginia ground-cherry	PHYVIG	native	4	forb
<i>Pinus banksiana</i>	jack pine	PINBAN	native	5	tree
<i>Pinus resinosa</i>	red pine	PINRES	native	6	tree
<i>Pinus strobus</i>	white pine	PINSTR	native	3	tree
<b><i>Poa compressa</i></b>	<b>canada bluegrass</b>	<b>POACOM</b>	<b>non-native</b>	<b>0</b>	<b>grass</b>
<b><i>Poa pratensis</i></b>	<b>kentucky bluegrass</b>	<b>POAPRA</b>	<b>non-native</b>	<b>0</b>	<b>grass</b>
<i>Polygala polygama</i>	racemed milkwort	POLPOL	native	9	forb
<i>Populus grandidentata</i>	big-tooth aspen	POPGRA	native	4	tree
<i>Populus tremuloides</i>	quaking aspen	POPTRE	native	1	tree
<b><i>Potentilla inclinata</i></b>	<b>ashy cinquefoil</b>	<b>POTINC</b>	<b>non-native</b>	<b>0</b>	<b>forb</b>
<i>Potentilla norvegica</i>	rough cinquefoil	POTNOR	native	0	forb
<b><i>Potentilla recta</i></b>	<b>rough-fruited cinquefoil</b>	<b>POTREC</b>	<b>non-native</b>	<b>0</b>	<b>forb</b>
<i>Potentilla simplex</i>	old-field cinquefoil	POTSIM	native	2	forb
<i>Prunus americana</i>	american wild plum	PRUAME	native	4	tree
<i>Prunus pensylvanica</i>	pin cherry	PRUPEN	native	3	tree
<i>Prunus pumila</i>	sand cherry	PRUPUM	native	8	shrub
<i>Prunus serotina</i>	wild black cherry	PRUSER	native	2	tree
<i>Prunus umbellata</i>	alleghany plum	PRUUMB	native	8	shrub
<i>Prunus virginiana</i>	choke cherry	PRUVIR	native	2	shrub
<i>Pteridium aquilinum</i>	bracken fern	PTEAQU	native	0	fern
<i>Quercus ellipsoidalis</i>	hills oak	QUEELL	native	4	tree
<i>Quercus rubra</i>	red oak	QUERUB	native	5	tree
<i>Quercus velutina</i>	black oak	QUEVEL	native	6	tree
<i>Rosa blanda</i>	wild rose	ROSLA	native	3	shrub
<i>Rubus allegheniensis</i>	common blackberry	RUBALL	native	1	shrub
<i>Rubus flagellaris</i>	northern dewberry	RUBFLA	native	1	shrub
<i>Rubus setosus</i>	bristly blackberry	RUBSET	native	3	shrub
<i>Rubus strigosus</i>	wild red raspberry	RUBSTR	native	2	shrub
<b><i>Rumex acetosella</i></b>	<b>sheep sorrel</b>	<b>RUMACL</b>	<b>non-native</b>	<b>0</b>	<b>forb</b>
<i>Salix humilis</i>	prairie willow	SALHUM	native	4	shrub
<i>Sceptridium multifidum</i>	leather grape-fern	SCMUL	native	5	fern
<i>Schizachne purpurascens</i>	false melic	SCHPUP	native	5	grass
<i>Schizachyrium scoparium</i>	little bluestem	SCHSCO	native	5	grass
<i>Solidago hispida</i>	hairy goldenrod	SOLHIS	native	3	forb
<i>Solidago juncea</i>	early goldenrod	SOLJUN	native	3	forb
<i>Solidago speciosa</i>	showy goldenrod	SOLSPE	native	5	forb
<i>Symphotrichum laeve</i>	smooth aster	SYMLAE	native	5	forb

**Appendix 3, Continued.** Species list for Frost Pocket Pine Barrens.

Scientific Name	Common Name	Acronym	Native?	C	Physiognomy
<i>Symphotrichum urophyllum</i>	arrow-leaved aster	SYMURO	native	2	forb
<i>Tragopogon dubius</i>	goats beard	TRADUB	non-native	0	forb
<i>Trifolium hybridum</i>	alsike clover	TRIHYP	non-native	0	forb
<i>Trifolium pratense</i>	red clover	TRIPRA	non-native	0	forb
<i>Trifolium repens</i>	white clover	TRIREP	non-native	0	forb
<i>Turritis glabra</i>	tower mustard	TURGLA	native	3	forb
<i>Vaccinium angustifolium</i>	low sweet blueberry	VACANG	native	4	shrub
<i>Viburnum rafinesquianum</i>	downy arrow-wood	VIBRAF	native	5	shrub
<i>Viola adunca</i>	sand violet	VIOADU	native	4	forb

**Appendix 4.** Conservation metrics for Frost Pocket Pine Barrens.

Frost Pocket Pine Barrens

Practitioners: Jesse M. Lincoln and Tyler J. Bassett

07/08/2022

Conservatism-Based Metrics:

Total Mean C:	3.6
Native Mean C:	4.4
Total FQI:	37.8
Native FQI:	42
Adjusted FQI:	40
% C value 0:	19.1
% C value 1-3:	27.3
% C value 4-6:	40.9
% C value 7-10:	12.7
Native Tree Mean C:	3.7
Native Shrub Mean C:	4.3
Native Herbaceous Mean C:	4.6

Species Richness:

Total Species:	110	
Native Species:	91	82.7%
Non-native Species:	19	17.3%

Species Wetness:

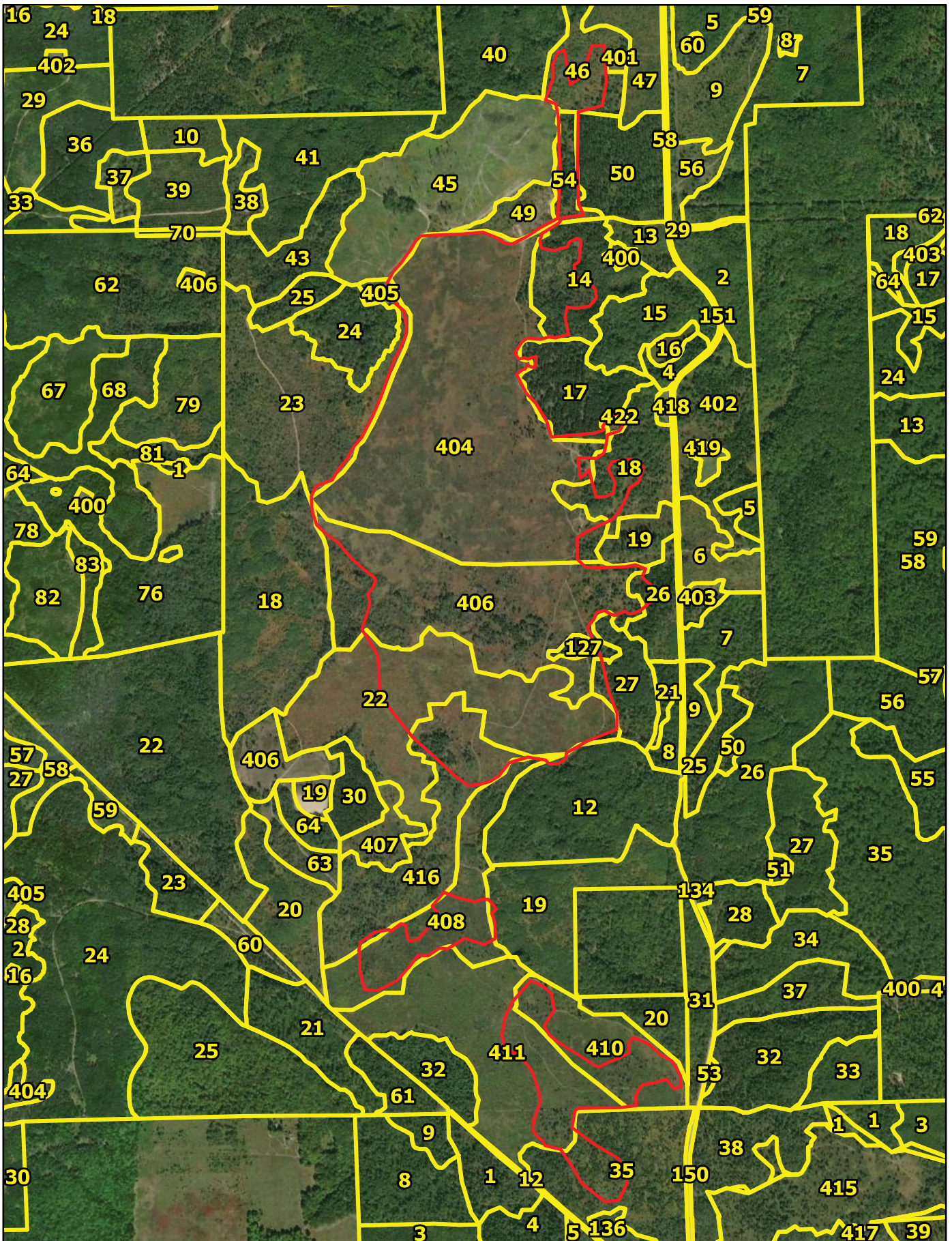
Mean Wetness:	3.6
Native Mean Wetness:	3.5

Physiognomy Metrics:

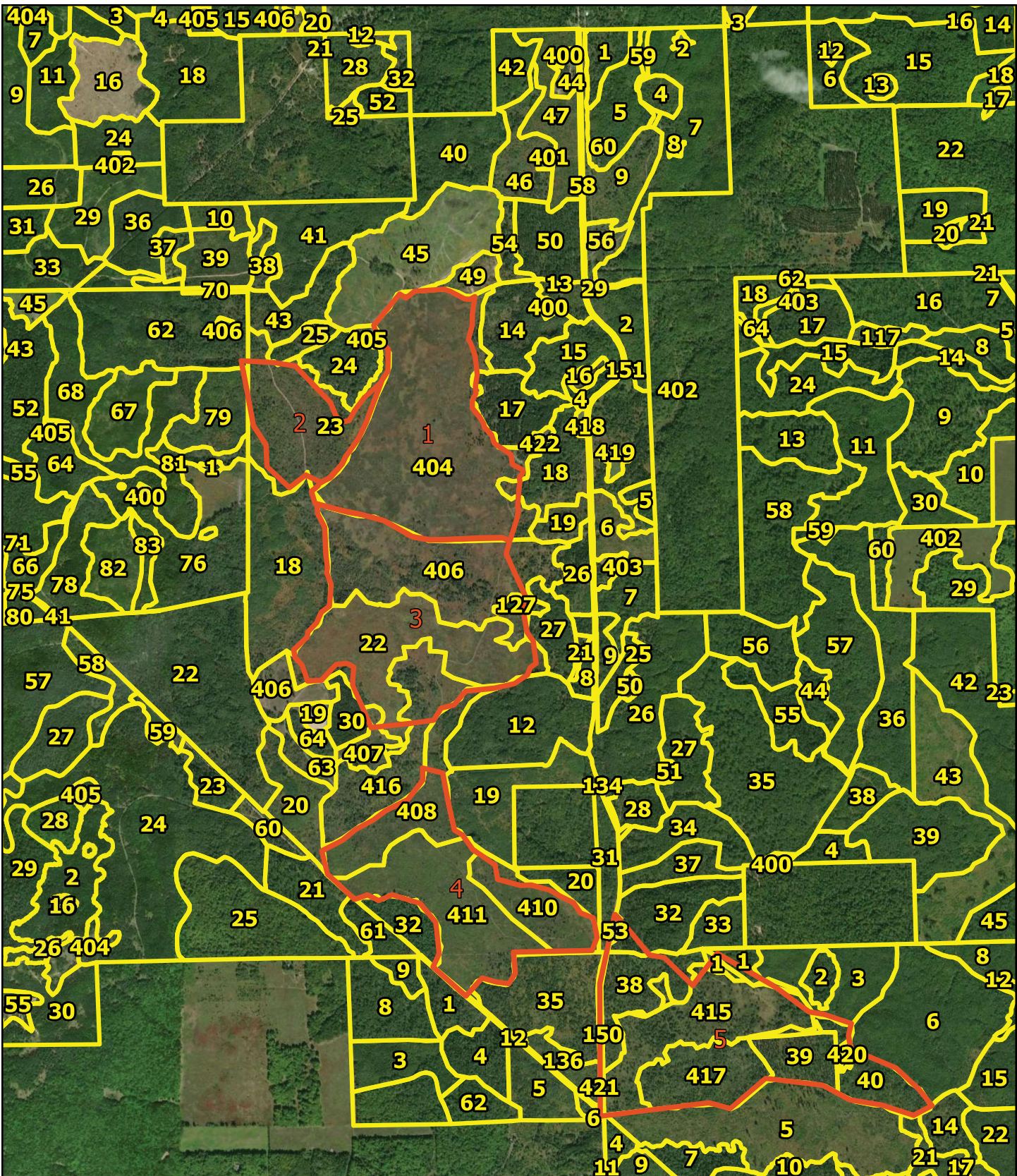
Tree:	15	13.6%
Shrub:	17	15.5%
Vine:	1	0.9%
Forb:	53	48.2%
Grass:	19	17.3%
Sedge:	2	1.8%
Rush:	1	0.9%
Fern:	2	1.8%
Bryophyte:	0	0.0%

Duration Metrics:

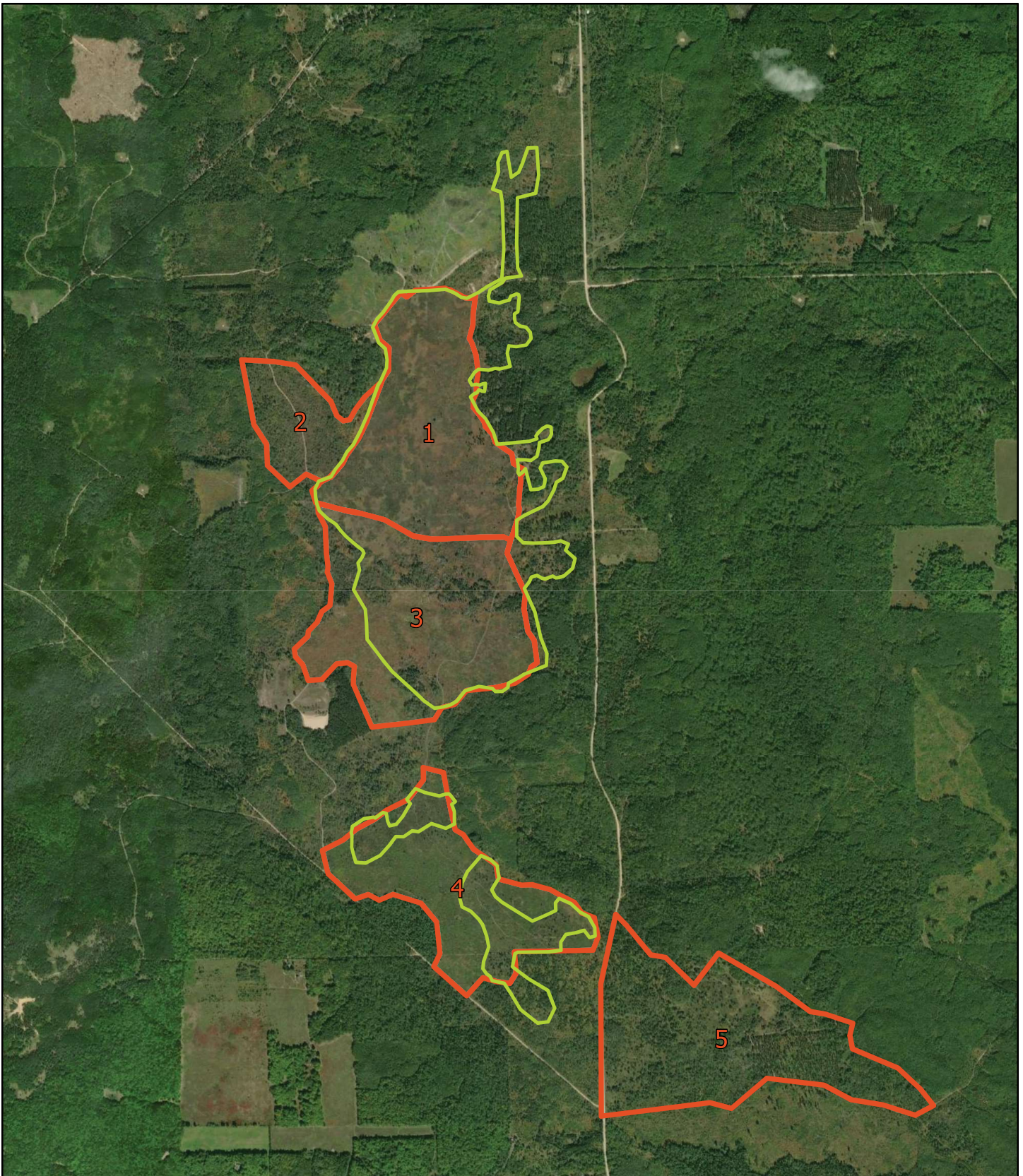
Annual:	3	2.7%
Perennial:	100	90.9%
Biennial:	7	6.4%
Native Annual:	3	2.7%
Native Perennial:	83	75.5%
Native Biennial:	5	4.5%



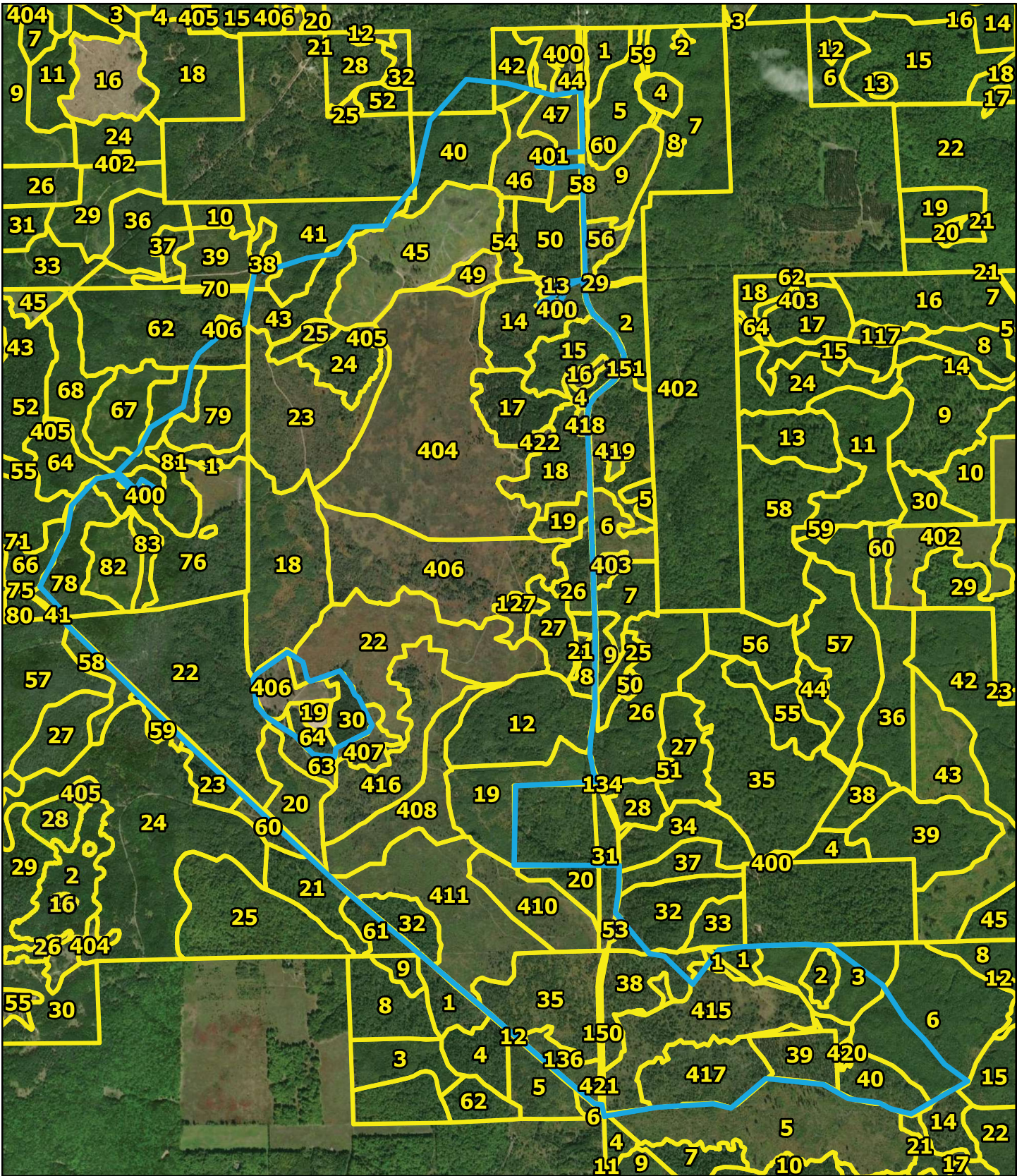
Appendix 5. Frost Pocket Pine Barrens EO boundaries in red and MiFI stands with 2020 imagery.



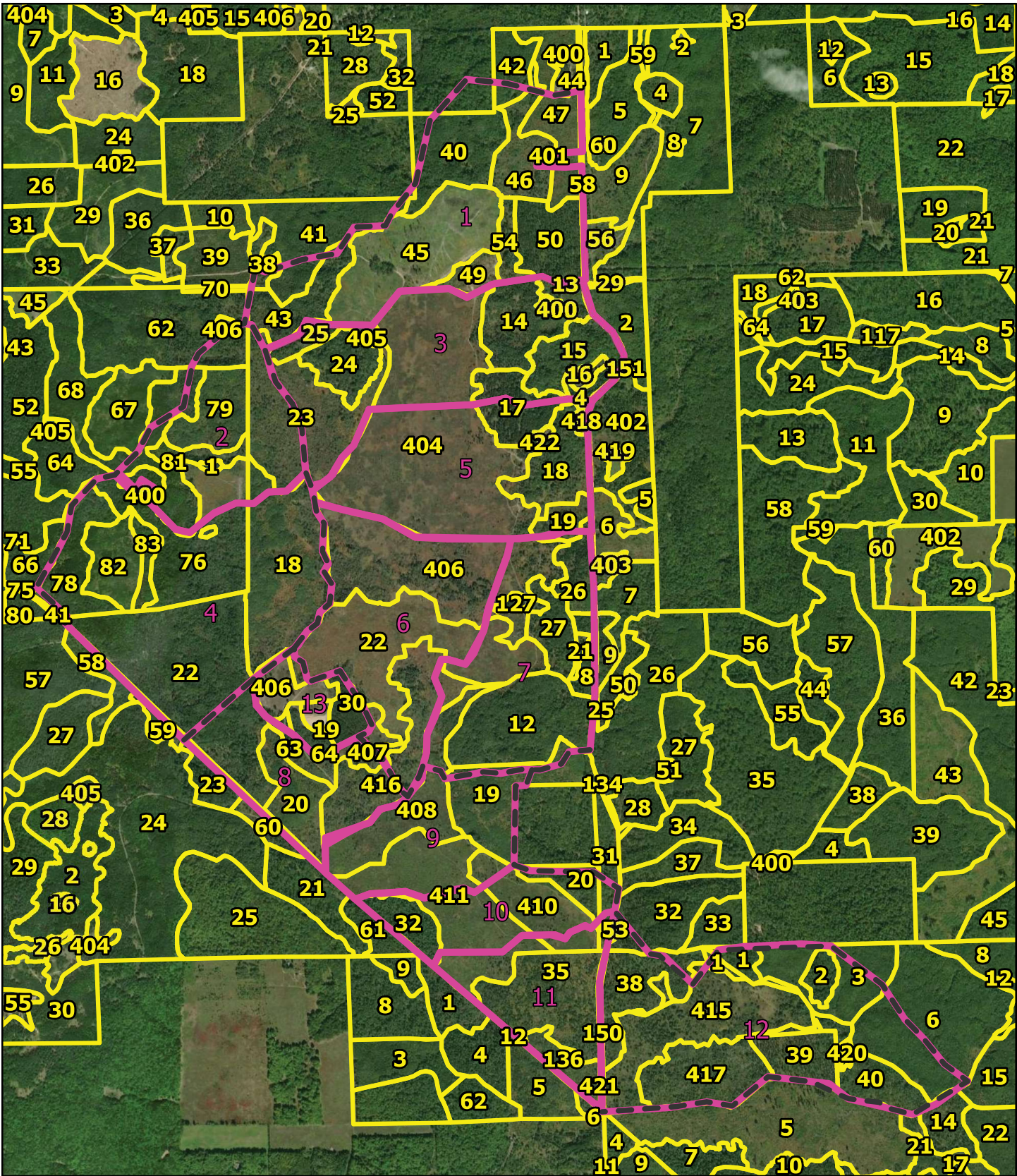
Appendix 6. Existing DNR Project boundaries (red) and MiFI stands with 2020 imagery.



**Appendix 7.** Frost Pocket Pine Barrens EO boundaries in green and existing DNR project boundaries in red.



Appendix 8. Proposed Barrens Project Area boundaries in blue, with MiFI stands.



**Appendix 9.** Various units of the proposed Barrens Project Area in pink and proposed roads in gray dash, with MiFI stands in yellow.