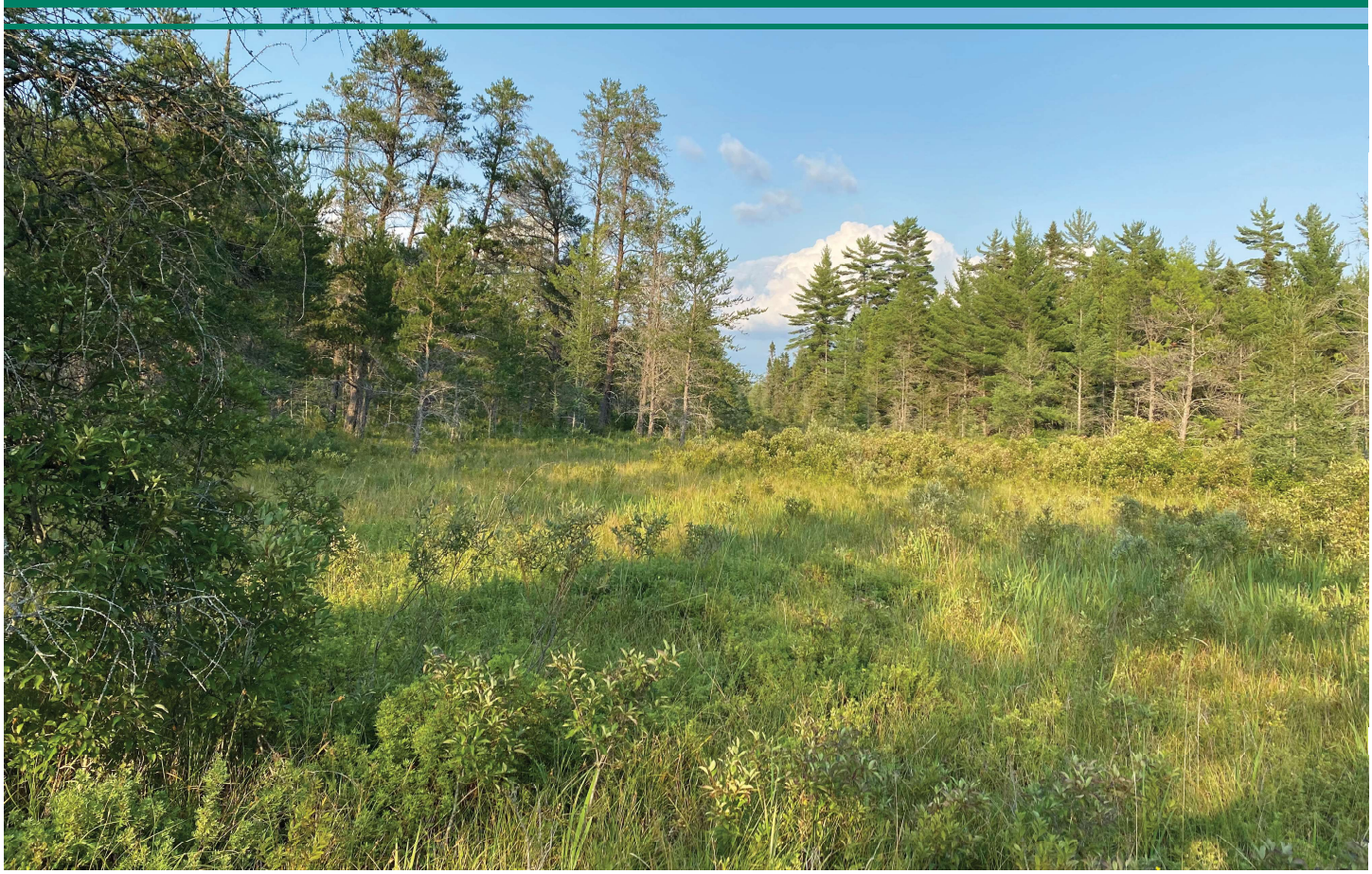
An Ecological Evaluation of the Portage Creek Complex at Camp Grayling



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Cover Photo: Portage Creek Wet-Mesic Sand Prairie (WP-9). Photo by Jesse M. Lincoln, 2021. All pictures by Jesse M. Lincoln unless otherwise noted.

Acknowledgements

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Portage Creek Wet-Mesic Sand Prairie (WP-9), July 27, 2021.

Executive Summary

Camp Grayling Joint Maneuver Training Center is a military installation in the central Northern Lower Peninsula of Michigan. The Department of Natural Resources partners with Camp Grayling and is responsible for assuring that management activities do not harm threatened and endangered species. The Department maintains a network of Ecological Reference Areas composed of high-quality and representative natural communities, including several important conservation sites on Camp Grayling.

A significant wet-mesic sand prairie was described during Michigan Natural Features Inventory surveys in the 1990s at a site within Camp Grayling known as the Portage Creek Complex. This site is north of Portage Creek, between Lake Margrethe, Howes Lake, and the Manistee River. The prairie within the Portage Creek Complex was designated as an Ecological Reference Area. The wet-mesic sand prairie was last surveyed in 2020 when extensive ditching was documented in and around the prairie. This site was re-evaluated in 2021 to thoroughly assess the impacts of the ditching and planned forestry activities in the surrounding forest on the prairie and habitat supporting populations of numerous rare species, particularly Voss's goldenrod (*Solidago vossii*) and massasauga rattlesnake (*Sistrurus catenatus*), both Federally Threatened.

The surveys that are the basis for this report occurred in July of 2021 and while the wet-mesic sand prairie was the focus of the evaluation, four additional natural communities within the Portage Creek Complex were identified and opportunistically evaluated. These included intermittent wetland, northern wet meadow, and two distinct poor fens. The surveys detailed threats and have helped inform the development of management recommendations presented here that will serve to protect the high-quality examples of natural communities on the landscape and the rare taxa therein.

While portions of the wet-mesic sand prairie are in excellent condition, there are several factors degrading the condition of portions of the prairie system and those threats appear to be interacting in complicated ways. Some prairie openings are degraded by road crossings and extensive damage from tanks or off-road vehicles. Some areas have been the focus of continual ditching efforts aimed at moving water off the gun range. Within the prairie, the ditch has cut through habitat supporting numerous rare species, including Voss's goldenrod. Because inundation during late winter and early spring is integral to the dynamic nature of the prairie's hydrology, this ditching will continue to further degrade the prairie system by reducing the water table and thereby facilitating encroachment of trees and shrubs. The lack of consistent, properly timed fire in recent decades is also contributing to the decline of the wet-mesic sand prairie and the landscape as a whole. The silvicultural activities across the landscape are having substantial, accumulating, and potentially irreversible detrimental impacts on the condition of the wet-mesic sand prairie through clear-cutting, trenching, and application of broad-scale herbicides. The combined effects of these stressors are causing a continuing decline in the ecological condition of the landscape and are jeopardizing the long-term viability of the wet-mesic sand prairie as an Ecological Reference Area.

The Portage Creek wet-mesic sand prairie is a high-quality remnant of substantial conservation value facing many serious threats. The site needs considerable ecosystem management to allow it to persist as an Ecological Reference Area. As recommended in the original report describing the Portage Creek Complex, intensive military training exercises and silvicultural actions should not take place within a 200 to 300 m buffer around the prairie. We recommend avoiding intensive training exercises, infrastructure development, and forest management methods such as clear-cutting, trenching, and applying herbicide within as large of an area as possible surrounding the prairie and populations of Voss's goldenrod.

Detailed management recommendations are provided for your consideration. These include evaluation of the site for eligibility and legal dedication as a Natural Area; restoring hydrology by repairing ditching in and near the prairie; returning landscape-scale fire to the site; and treating invasive species. Without swift, substantial, and sustained intervention this site will continue on its current trajectory of degradation, ultimately featuring a high rate of local plant extinctions and the continued decline of ecological integrity.

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Introduction

Camp Grayling Joint Maneuver Training Center is an approximately 147,000-acre military installation in the central Northern Lower Peninsula of Michigan and consists of lands owned by the Michigan Department of Military and Veterans Affairs (DMVA) and Michigan Department of Natural Resources (DNR). There are over 4 million acres of state forest in Michigan and the lands are jointly managed by the DNR's Forest Resources Division (FRD) and Wildlife Division (WLD) for sustainable forest products, long-term forest health, wildlife habitat, recreational opportunities, and ecosystem services. The FRD and WLD partner with Camp Grayling and are responsible for assuring that management activities do not harm threatened and endangered species, and through dual forest certification, the DNR maintains a network of Ecological Reference Areas composed of high-quality and representative natural communities, including several important conservation sites on Camp Grayling.

Michigan Natural Features Inventory (MNFI) is Michigan's natural heritage program and maintains a geospatial database of populations of rare and declining plants and animals and benchmark ecosystems. MNFI was contracted to conduct a Land Condition Trend Analysis at Camp Grayling in the early 1990s. The effort was a two-year, systematic floristic and natural features inventory of Camp Grayling. The project resulted in the documentation of many new populations of rare taxa and the recognition of several previously unknown high-quality natural communities, including the Portage Creek Complex (Higman et al 1994). The Portage Creek Complex sits between Lake Margrethe, Howes Lake, and the Manistee River within the Grayling State Forest Management Unit.

A significant wet-mesic sand prairie was described within the Portage Creek Complex during the MNFI surveys of the early 1990s and the prairie was designated as an Ecological Reference Area following forest certification. Prior to the 2021 ecological evaluation that is the basis for this report, the site was last surveyed in 2020 when extensive ditching was documented in the wet-mesic sand prairie (Cohen 2020). This site was re-evaluated in 2021 to thoroughly assess the impacts of the ditching and planned forestry activities in the surrounding forest on the prairie and habitat supporting populations of numerous rare species, particularly the Federally Threatened Voss's goldenrod (*Solidago vossii*) and massasauga rattlesnake (*Sistrurus catenatus*). This report summarizes the 2021 field surveys and ecological evaluation of Portage Creek Complex by MNFI.

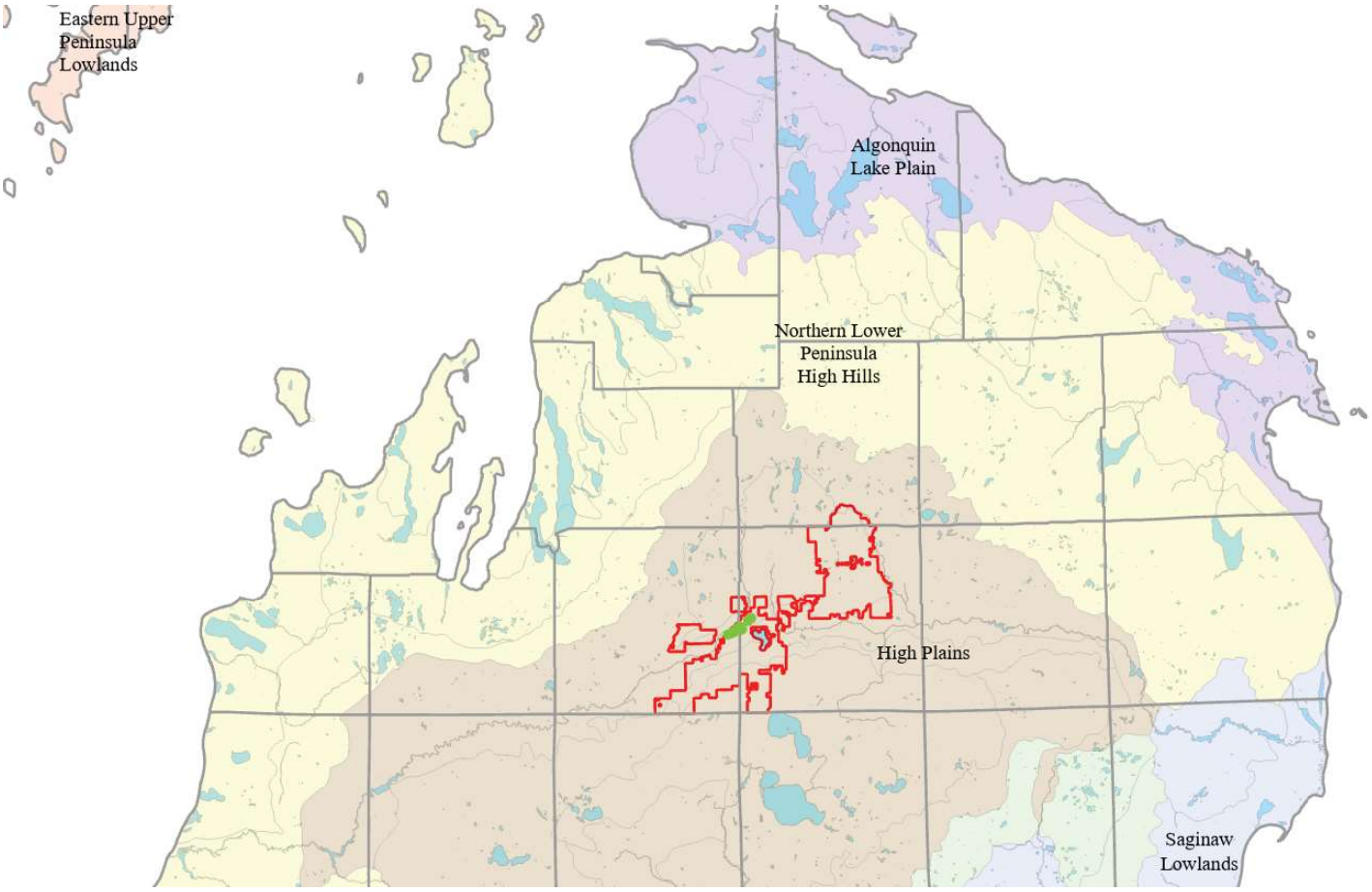


Figure 1. Ecoregions and location of Camp Grayling (red outline) in the Northern Lower Peninsula of Michigan (Albert 1995). The location of the Portage Creek Complex within Camp Grayling is outlined in green.

Landscape and Historical Context

Michigan has been sub-divided into ecoregions based on glacial features, climate, and characteristic ecosystems (Albert 1995). This study area occurs within the Grayling Sub-subsection of the Highplains Subsection (VII.2) (Figure 1), which is characterized by deep sands associated with glacial outwash and drainage. Portage Creek drains Lake Margrethe, a large kettle lake formed by an ice block buried in sandy outwash over clay lacustrine deposits. The Portage Creek Complex is north of Portage Creek within the confluence of the outwash channel associated with the Manistee River and the drainage of Lake Margrethe (Figure 2). The interplay between deep outwash sands, clay deposits, and a high water table in the spring leads to unusual hydro-xeric conditions. These conditions enable spring floods – with standing water even in some of the forested "uplands" – and late summer or early fall droughts that favor a prevalence of jack pine and short fire return intervals.

The river systems through this area provided a historic transportation nexus for indigenous tribes, connecting the eastern and western sides of the state. The Manistee River flows into Lake Michigan to the west and the Au Sable River, which is 2500 m from the eastern shore of Lake Margrethe, flows into Lake Huron to the east. These rivers served as key east/west transportation routes in the prehistoric past. Portage Creek was named because of its use as a portage between the two river systems. Though no indigenous villages have been found from the area, historic encampments have been described along the junction of Lake Margrethe and Portage Creek. This area was used as early as the mid- to late-woodland period, and most recently by the Odawa, as a thoroughfare and following European colonization remained an important region for obtaining critical resources. Indigenous peoples maintained specific areas with fire to make them more desirable for occupancy and fires were periodically and intentionally set to improve berry crops, reduce ticks and flying insects, and to maintain a more open landscape to facilitate travel and clear areas for temporary encampments (Hambacher et al 1998; Hemenway 2021; Larson et al. 2021).

Early accounts of the area were provided by General Land Office surveyors John Mullett in 1839 and Addison P. Brewer in 1852. Mullett described extensive jack pine plains and conifer swamps in early maps of eastern Kalkaska County. Brewer provided detailed descriptions of the area in Crawford County: "Sand level, 3rd rate timber principally yellow [red], white, and spruce-pine [jack pine]; with jack, white, and yellow pine in swamp with tamarack and cedar. A swamp west of the lake is timbered with spruce-pine [jack pine], tamarack, fir, spruce, cedar, alder… where the timber is not thick, a first-rate quality of wild grasses grows" (Michigan Library and Historical Center, accessed January 2022). The activities of Indigenous people doubtlessly influenced the structure and composition of the landscape, with the open red pine forests featuring grassy expanses being more prevalent as a result of the deliberate application of fire (Larson et al. 2021).

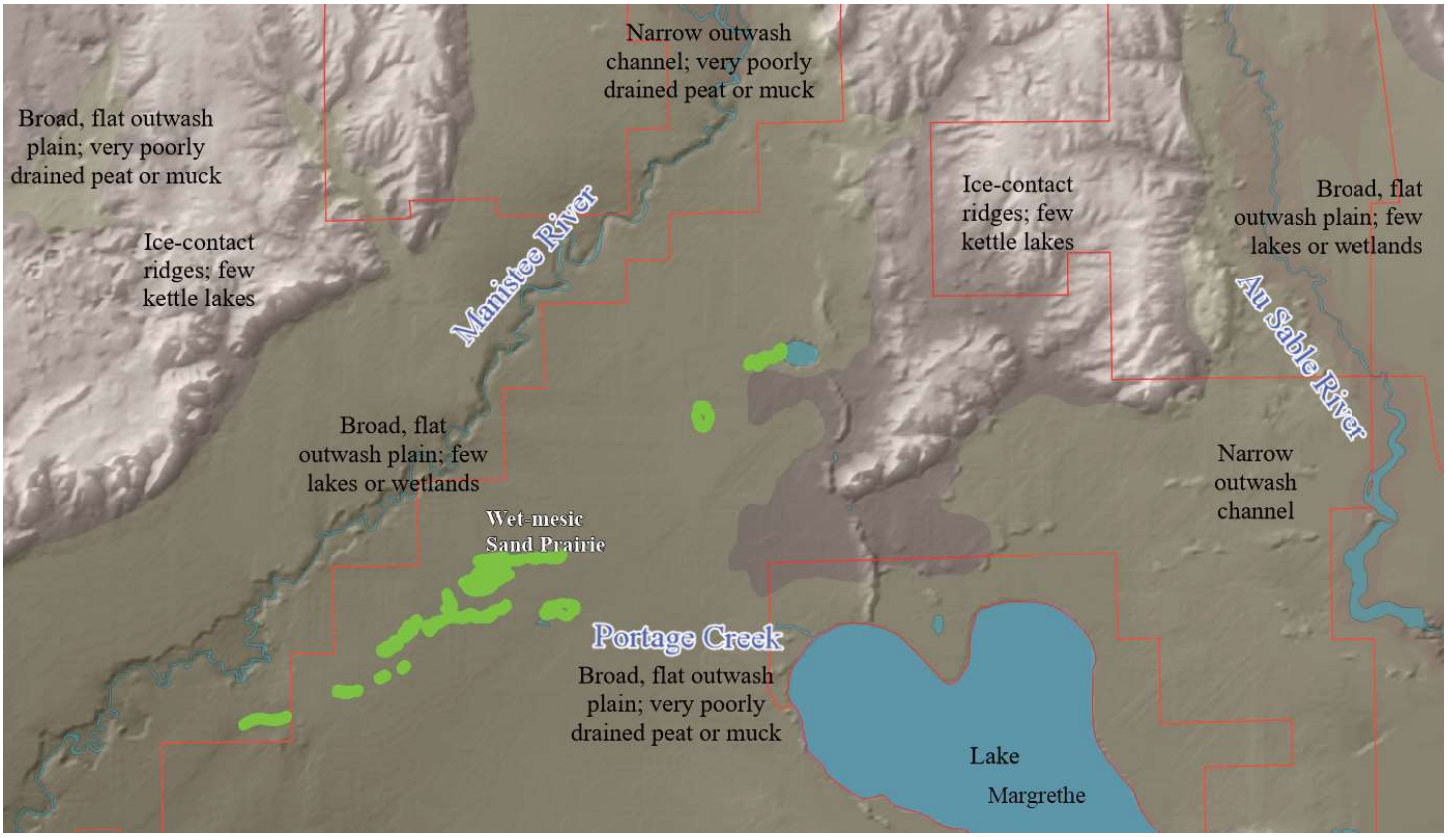


Figure 2. The Portage Creek Complex with physiographic features overlaying a digital elevation model (DEM). The Portage Creek wet-mesic sand prairie (green) occurs in depressions that were historic interdunal wetlands and small drainage channels on the broad outwash plain between Lake Margrethe and the Manistee River.

Widespread timber extraction altered the composition of the forest in the region through removal of the largest red and white pine starting in the late 1800s. The deep outwash sands that characterize large areas of Camp Grayling limited agricultural operations that converted much of the state's forested areas to farmland. Today, Camp Grayling is managed primarily for timber, biodiversity, recreation, and hunting along with extensive military operations. Camp Grayling is moderately fragmented by logging with low densities of roads and power/gas line rights-of-way and scattered residences. Road density is relatively high near the prairie and gun range.

The forests in the vicinity of the Portage Creek Complex are characterized as a mosaic of natural and planted jack pine (*Pinus banksiana*) and red pine (*Pinus resinosa*) forests. These natural upland systems are fire-adapted, though fire suppression, historic logging, and high deer densities have altered structure and composition of plant communities. Notes from original surveys indicate that red and white pine were more prevalent and this is supported by the presence of large stumps (many around 70 cm diameter) in areas that have not been trenched and converted to plantations.

Large pine stumps persist on the landscape, suggesting that historically the area featured much larger trees.

A photo taken from the Grayling area prior to the extensive logging in the 1880s shows large, widely spaced red pine and matches descriptions of the area around Lake Margrethe provided by the first surveyors.

Today the landscape surrounding the Portage Creek Complex is a mosaic of conifer forest managed for timber.

The hydro-xeric landscape provides conditions for unusual forest types. This forest in Stand 9 features jack and red pine which generally favor drier conditions. Black spruce is also prevalent in the canopy and subcanopy and is generally associated with moist acid soils, as are sheep-laurel and leatherleaf, the dominant shrubs.

The prairie vegetation persists in openings surrounded by dry forest dominated by jack pine.

Natural Community Description

A natural community is defined as an assemblage of interacting plants, animals, and other organisms that repeatedly occurs under similar environmental conditions across the landscape. They are predominantly structured by natural processes rather than modern anthropogenic disturbances such as timber harvest, hydrological alteration, and fire suppression (Kost et al. 2007, Cohen et al. 2015, Cohen et al. 2020). Historically, Indigenous peoples were an integral part of Michigan's natural communities with many natural community types being maintained by Indigenous management practices such as prescribed fire.

Numerous high-quality natural communities have been described within the Portage Creek Complex area including wet-mesic sand prairie, poor fen, northern wet meadow, and intermittent wetland (Higman et al. 1994; Kost and Cohen 2005; Cohen et al. 2009). These communities persist in a mosaic of degraded dry northern forest dominated by jack pine that is managed for timber. Unique versions of poor conifer swamp dominated by jack pine with leatherleaf and bog-laurel also occur throughout the complex. The rarest and most diverse of the community types in the complex is the wet-mesic sand prairie.

Wet-mesic sand prairies are one of the 5 wet prairie community types recognized by MNFI. All wet prairie types are considered globally vulnerable to globally imperiled. There are currently 13 examples of wet-mesic sand prairie in Michigan and the example within the Portage Creek Complex is the second largest.

It is difficult to reliably determine the total acreage of wet-mesic sand prairie in Michigan prior to European colonization, but as with most North American prairie types, the community has been significantly reduced, likely to less than 0.01% of the historic extent (Sampson and Knopf 1994; Kost and Slaughter 2008; Cohen et al. 2020). The protection of prairies is vital for the conservation of native biodiversity because these are very diverse ecosystems that support high proportions of rare taxa, and the extent of prairies has diminished substantially in the past two centuries.

The Portage Creek Complex was identified as one of the two areas of highest conservation priority in Camp Grayling in the early 1990s (Higman et al 1994). The complex is characterized by a series of small prairie openings in subtle depressions and drainages on the flat glacial outwash plain. The prairie openings are the persisting remnants of a broader landscape continuum of natural community types that included prairie, pine savanna, and open wetlands. The mosaic landscape features dynamic water tables, frequent fires, and droughty conditions that historically led to the formation of a sparsely-canopied savanna with extensive prairie and localized fen elements in the wettest zones. Periodic drying out of soils seasonally and across years allows for the decomposition of peats, preventing their accumulation. With decades of fire suppression, the prairie vegetation is now relegated only to the most hydrologically dynamic spaces on the landscape.

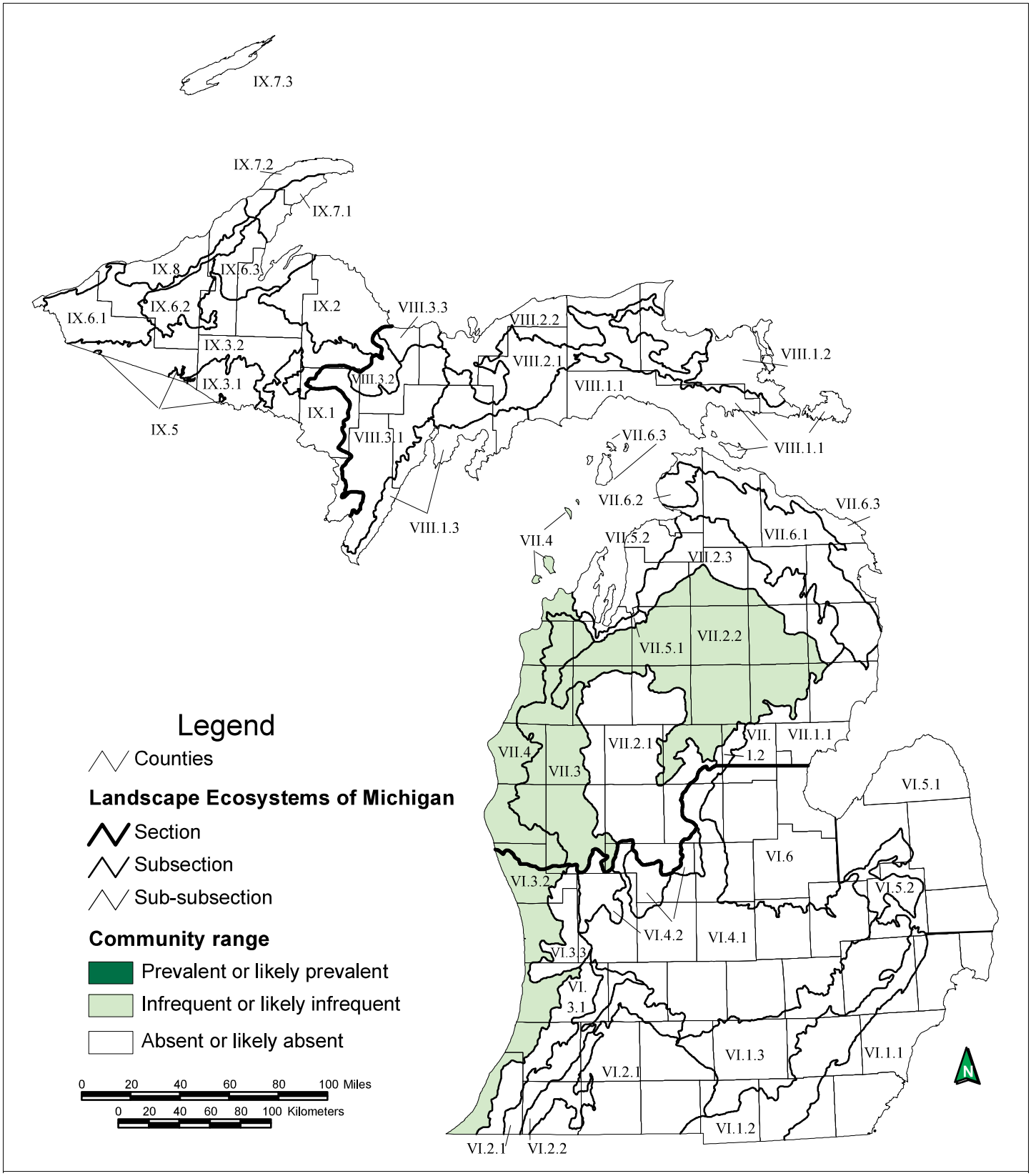


Figure 3. Statewide distribution and abundance of Wet-Mesic Sand Prairie natural communities (Albert et al. 2008).

Table 1: Michigan's documented wet-mesic sand prairies. Portage Creek Complex in Camp Grayling is in bold. EO Rank categories are as follows: A, excellent occurrence; B, good occurrence; BC, good to fair occurrence; C, fair occurrence; CD, fair to poor occurrence; D, poor occurrence.

EO ID	Survey Site	County	EO Rank	Size (Ac)	Last Observed
1544	Lidkey Swamp Prairie -- Huron-Manistee NF	Oceana	B	115.3	2010
20110	Heath Prairie -- Allegan State Game Area	Allegan	B	19.2	2021
23897	Grand Competitor Prairie -- Huron-Manistee NF	Lake	B	8.5	2020
11947	36th Street Prairie -- Allegan State Game Area	Allegan	B	6.2	2014
2078	**Portage Creek Complex -- Camp Grayling**	**Crawford/Kalkaska**	**BC**	**45.3**	**2021**
15729	Muskegon Prairies -- Muskegon State Game Area	Newaygo	BC	26.2	2021
4431	Tussing Prairie	Lake	BC	16.5	1989
21677	Pentwater Prairies -- Pentwater State Game Area	Oceana	BC	7.7	2015
12915	130th Avenue Prairie -- Allegan State Game Area	Allegan	BC	4.4	2021
8291	Beaver Meadow -- Allegan State Game Area	Allegan	C	8.1	1989
22259	Silver Creek Prairie -- Allegan State Game Area	Allegan	C	4.6	2018
24237	Tyndall Wetlands -- Huron-Manistee NF	Lake	CD	17.2	2020
11946	Goose Lake Prairie -- Allegan State Game Area	Allegan	D	2.9	2018

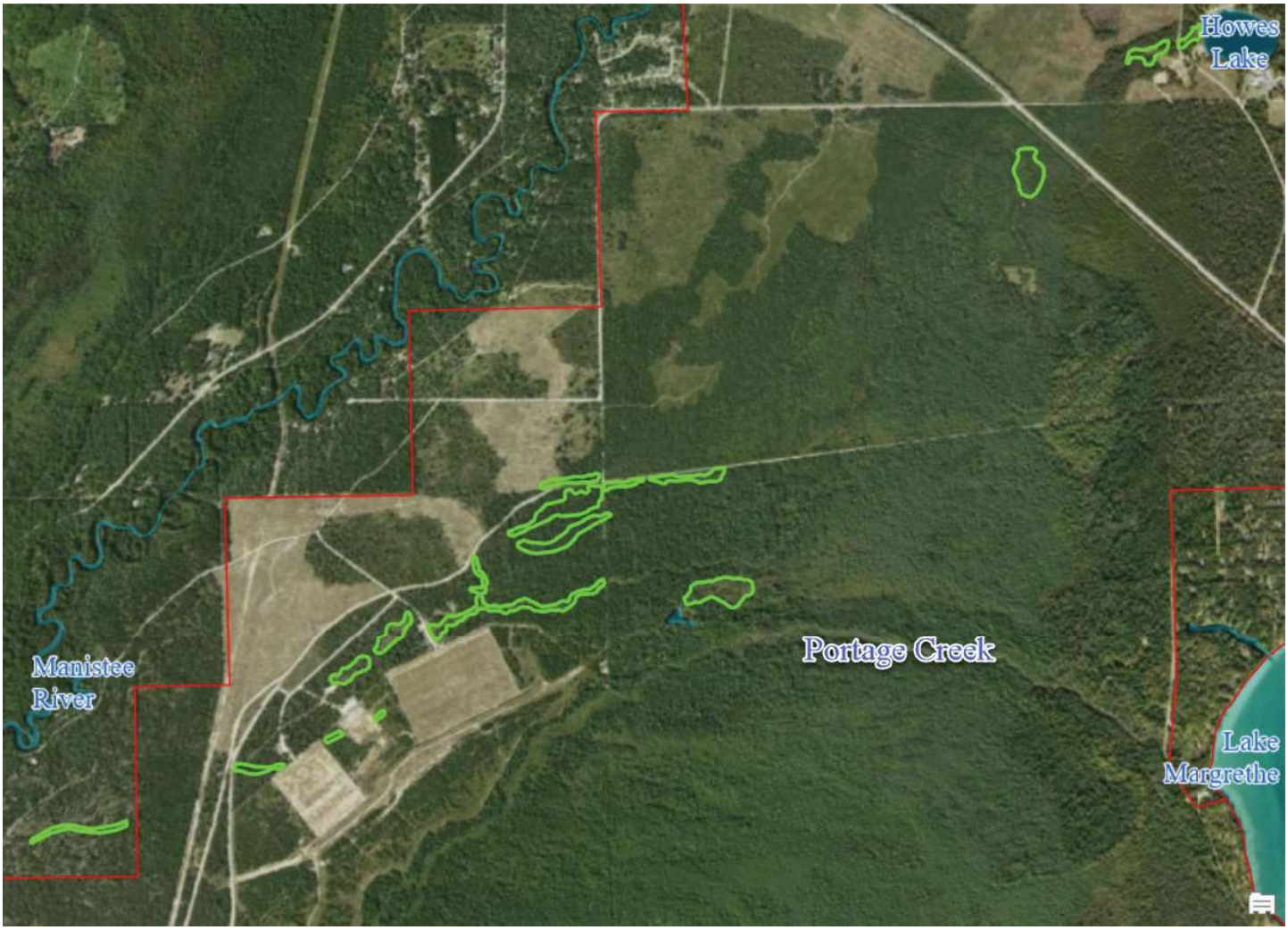


Figure 4. Portage Creek Complex wet-mesic sand prairie outlined in green with Camp Grayling compartment boundaries in red.

The prairie persists as a series of small, grass- and sedge-dominated openings in a mosaic of conifer forest. Voss's goldenrod is found in many of these openings.

Voss's Goldenrod

Houghton's goldenrod (*Solidago houghtonii*) is a Federally Threatened plant endemic to the Great Lakes region (Figure 5). This species' distribution is almost entirely restricted to calcareous ecosystems along the northern shores of Lakes Michigan and Huron associated with the Niagara escarpment, a band of dolomitic limestone extending in an arc from Niagara Falls to Dorr County, Wisconsin (Guire and Voss 1963; Penskar 1997; Laureto and Pringle 2010). The species was first described by Douglass Houghton from a collection made in 1839 and later named in his honor by botanist Asa Gray (Gray 1848; McVaugh 1970; Penskar 1997). The species was designated a Federally Threatened species in in 1988 under the U.S. Endangered Species Act (U.S. Dept. of Interior 1987, 1988; Penskar 1997).

Inland Houghton's goldenrod populations have been known to occur outside of the Niagara escarpment in Crawford and Kalkaska Counties since a 1933 collection by Somervile near Howes Lake in Camp Grayling (Collection at Wayne State University). Botanist Edward Voss visited the site in the 1960s and identified the population as *S. houghtonii,* despite being 96 km southeast of the nearest known Lake Michigan shoreline population (Penskar 1997; Laureto and Pringle 2010). Botanist James S. Pringle, a taxonomist specializing in the plant family Asteracae in which the genus *Solidago* is found, visited the site in the early 1970s and based on morphological differences, believed the population at Camp Grayling to be distinct from *S. houghtonii* (Penskar 1997; Laureto and Pringle 2010).

Laureto and Pringle (2010) tested Pringle's hypothesis that the population of *Solidago* at Camp Grayling was a distinct species from *S. houghtonii* using molecular analysis. They found evidence supporting this hypothesis and determined that this separate species formed through hybridization between *S. houghtonii* and at least one other *Solidago* species, followed by reproductive isolation (Laureto and Pringle 2010). The proglacial landscape created abundant suitable habitat within the outwash channels that course through Crawford and Kalkaska counties, where historical populations of Houghton's goldenrod likely became established. During the successional processes following glaciation, suitable habitat for Houghton's goldenrod shrank and the species became restricted to Great Lakes shoreline. The population of *S. houghtonii* isolated in the Portage Creek Complex area hybridized with *Solidago gigantea* (late goldenrod) and became a new, stable species (Laureto and Pringle 2010). This new goldenrod species occupies a unique habitat at Camp Grayling, in geographic and reproductive isolation from *S. houghtonii* which is now restricted to Great Lakes shoreline.

Following their genetic analysis, Laureto and Pringle named this new species *Solidago vossii*, Voss's goldenrod, in honor of University of Michigan Botany Professor Edward Voss. Voss's goldenrod occurs almost exclusively at the Portage Creek Complex in a wedge-shaped area north of Portage Creek between Howes Lake, the gun range, and Lake Margrethe (Figure 6; Laureto and Pringle 2010; Laureto 2010).

A few scattered populations occur within five miles of this concentrated area. The populations of what is now known as Voss's goldenrod were given Federal protection in 1998 under the Endangered Species Act under the name *Solidago houghtonii*. Because the disjunct population at Camp Grayling was included in the original listing, it remains federally protected, despite the taxonomic split, and will remain protected as *Solidago houghtonii* until the U.S. Fish and Wildlife Service takes the listing of *Solidago vossii* as a separate entity under consideration (Hicks, USFWS, personal communication, 2021). Given that the distribution of Voss's goldenrod is far more restricted than Houghton's goldenrod, the former is likely to receive federal protection at that time.

MNFI scientists Mike Penskar and Patrick Comer targeted the Portage Creek Complex for vegetation surveys during the Land Condition Trend Analysis conducted by MNFI in the early 1990s because of the importance of conserving this disjunct *Solidago* population. The team detailed the extent of the *Solidago* and were the first to describe the prairie. The extensive plant diversity, the size of the prairie community, and the concentration of rare species led to the site being designated by MNFI as one of the two highest conservation priorities for Camp Grayling and the report called for large buffers of 200 to 300 m to be established around the prairie openings where they recommended no damaging military training exercises or intensive forest management (Higman et al. 1994).

Since its initial documentation, an accumulation of degrading factors – such as fire suppression, ditching, and silvicultural practices – have negatively impacted the site, as documented by subsequent surveys (Kost and Cohen 2005; Cohen 2016; Cohen 2020). The glacial history, landscape position, natural and anthropogenic disturbance histories, and the modern silvicultural practices complicate the understanding of this high-profile site and this 2021 evaluation relied heavily on the substantial work done by preceding botanists and ecologists.

The extensive surveys that are the basis for this report occurred over 5 days in July of 2021 and resulted in a thorough examination of the wet-mesic sand prairie and other natural communities persisting on the landscape. These surveys also focused on a careful documentation and framing of the threats to develop management recommendations that will serve to protect the high-quality examples of natural communities on the landscape and the rare taxa therein.

Preserving biodiversity is best done by protecting intact natural communities and Portage Creek Complex features an unusual concentration of rare species, rare natural community types, and conservation opportunities that will allow the systems to persist for generations if decisive stewardship actions are rapidly and carefully implemented.

Voss's goldenrod (*Solidago vossii*, Federally Threatened) in a prairie opening.

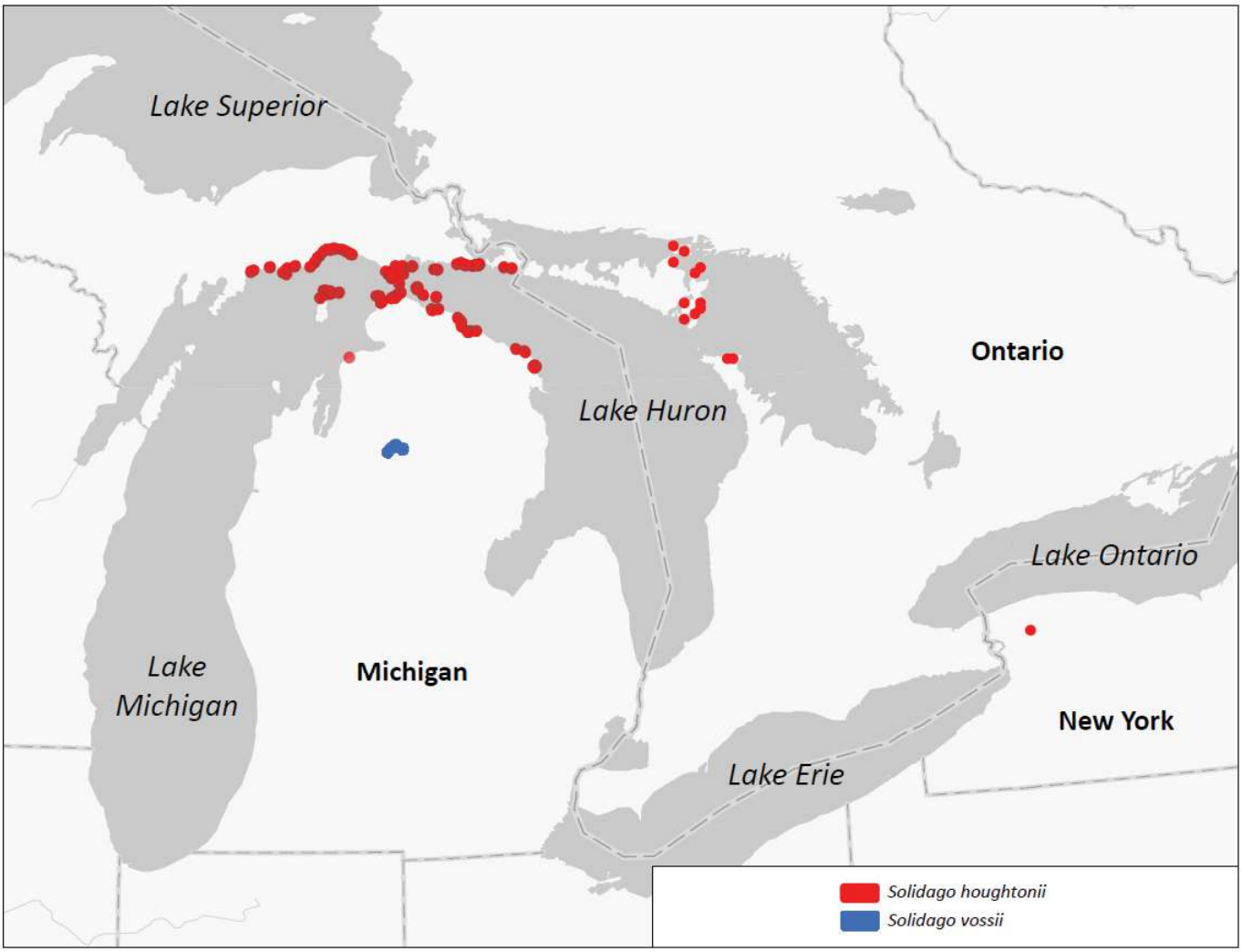


Figure 5. Distribution of Houghton's and Voss's goldenrods.

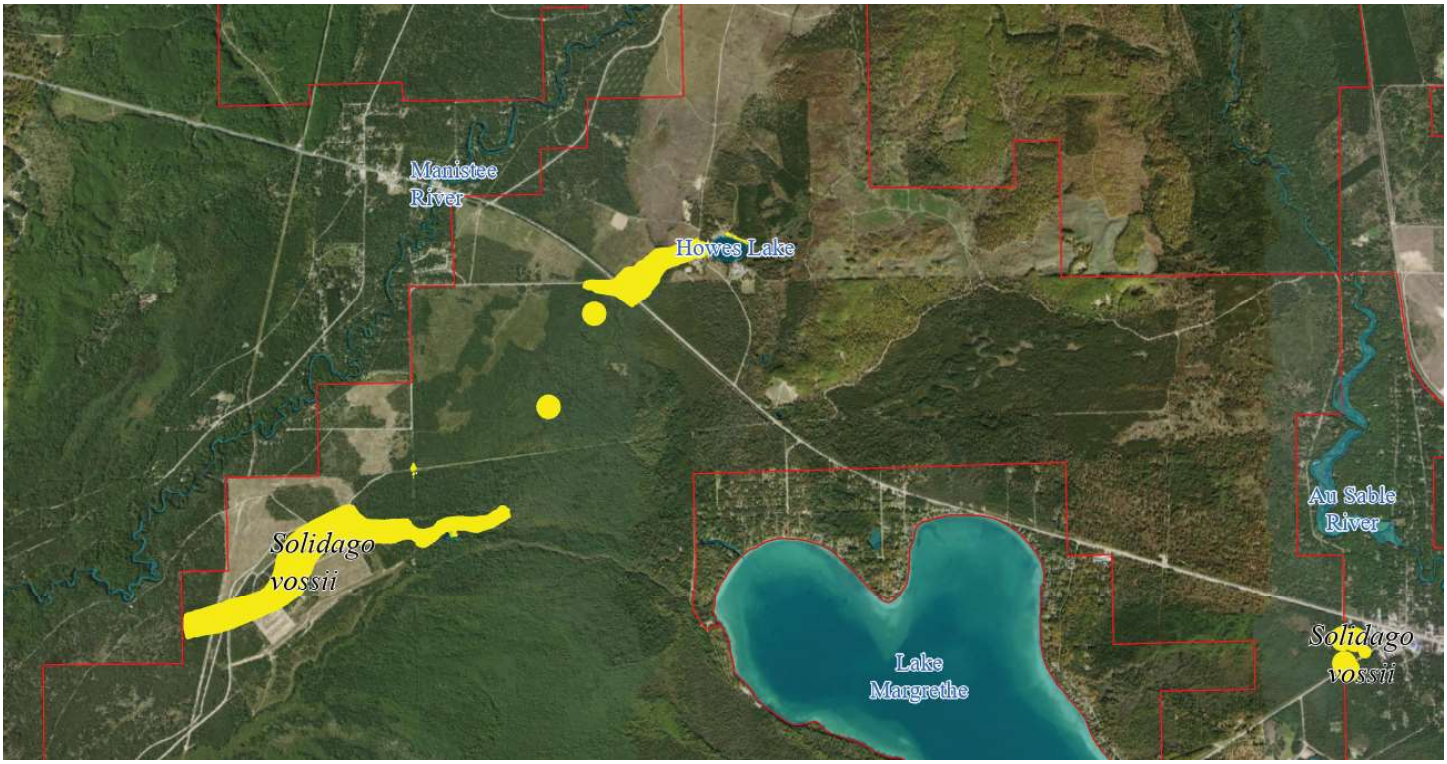


Figure 6. Distribution of Voss's goldenrod in yellow. This is the entire range of the species globally, making it one of the rarest plants in Michigan.

Methods

Throughout this report, a documented occurrence of a high-quality natural community or rare species at a specific location is referred to as an "element occurrence" (EO). The Portage Creek wet-mesic sand prairie EO was evaluated employing Natural Heritage and MNFI methodology, which considers three factors to assess a natural community's ecological integrity or quality: size, landscape context, and condition (Faber-Langendoen et al. 2008, 2015).

If a site meets defined requirements for these three criteria (MNFI 1988), it is categorized as a high-quality example of that specific natural community type, entered into MNFI's database as an EO, and given a rank of A to D based on how well it meets the above criteria. To assess natural community size and landscape context, a combination of field surveys, aerial photographic interpretation, and Geographic Information System (GIS) analysis was employed.

Ecological field surveys were conducted over five days in July of 2021 in Compartments 72180, 72181, 72182, and 61129 of the Grayling and Kalkaska FMUs on or adjacent to Camp Grayling. Qualitative meander surveys were conducted to assess the natural community classification, ecological boundaries, and ranking of this prairie. Vegetative structure and composition, soils, landscape and abiotic context, threats, management needs, and restoration opportunities were all assessed.

The primary goal of this survey effort was to provide resource managers and planners with updated information on the wet-mesic sand prairie and inform management of this unique site as an ecological reference area. This information is critical for facilitating site-level decisions about prioritizing management objectives to conserve native biodiversity, evaluating the success of restoration actions, and informing landscape-level planning efforts.

Methods employed during this survey followed the methodology developed during the initial evaluation of ecological reference areas on state forest land in 2006 and 2007 by MNFI ecologists (Cohen et al. 2008; Cohen et al. 2009).

This ecological field survey involved:

- compiling plant species lists and noting dominant and representative species
- describing site-specific structural attributes and ecological processes
- measuring tree diameter at breast height (dbh) of representative canopy trees and aging canopy dominants
- analyzing soils
- noting current and historical anthropogenic disturbances
- evaluating potential threats to ecological integrity
- ground-truthing aerial photographic interpretation using GPS
- taking digital photos
- surveying adjacent lands to assess landscape context
- analyzing various imagery including historic images, recent satellite imagery, and light detection and ranging (LiDAR)
- evaluating the natural community classification and mapped ecological boundaries
- evaluating the EO rank
- updating EO data for rare plants
- evaluating past and current management activities

Following completion of the field surveys, the collected data were analyzed and transcribed to update the existing EO record in MNFI's statewide biodiversity conservation database (MNFI 2022). Natural community boundaries were revised and information from this survey was used to update the site description, threat assessments, and management recommendations.

Floristic data were compiled into the Universal Floristic Quality Assessment Calculator (Reznicek et al. 2014, Freyman et al. 2016) to determine the Floristic Quality Index (FQI). Michigan sites with an FQI of 35 or greater possess sufficient conservatism and richness considered floristically important from a statewide perspective (Herman et al. 2001).

Former MNFI lead botanist Mike Penskar assisted in the surveys of 2021. His knowledge and familiarity with the site were critical for a thorough evaluation.

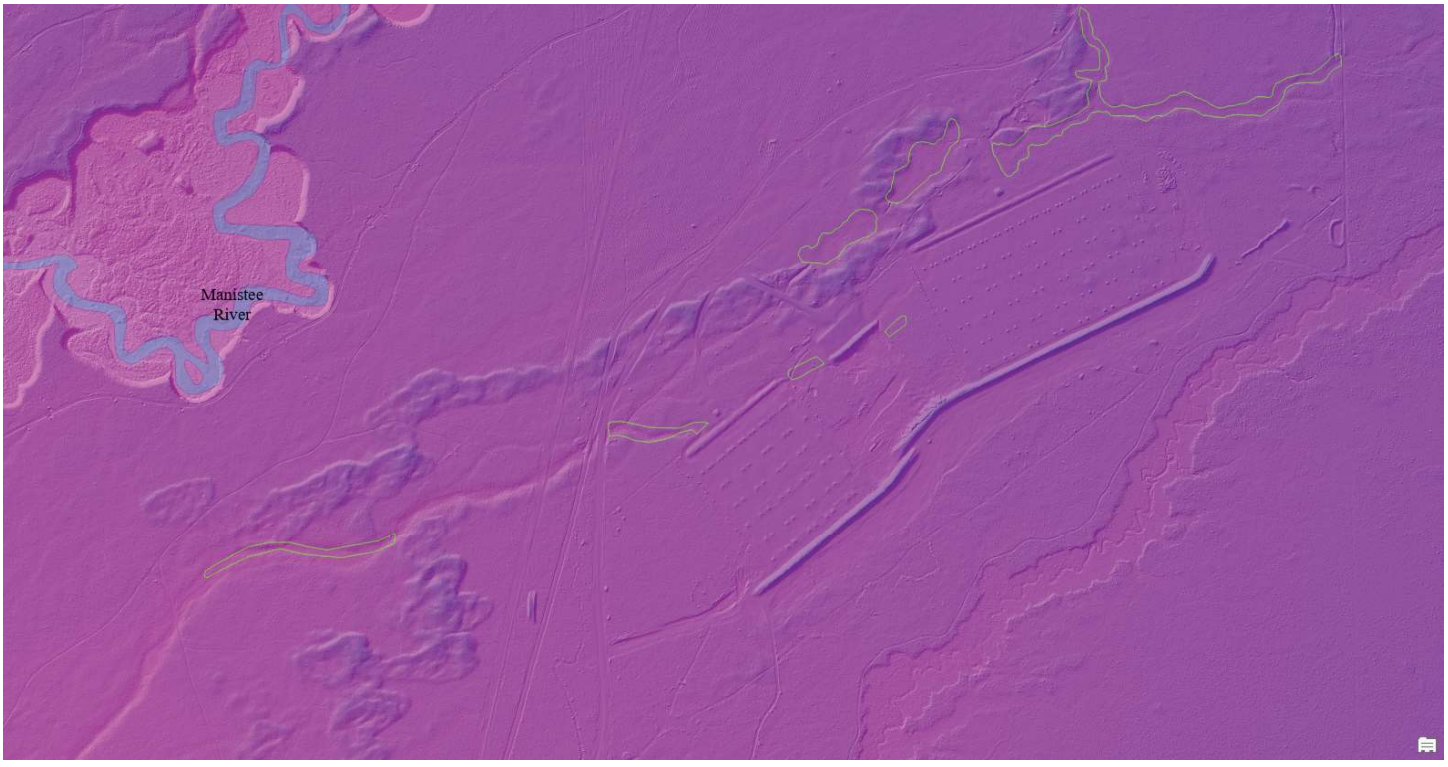


Figure 7. LiDAR was especially useful for understanding the landscape and targeting areas to survey for additional prairie habitat. Faint green polygons are areas of documented wet-mesic sand prairie.

Results

Although the wet-mesic sand prairie was the focus of the evaluation, four additional natural communities within the Portage Creek Complex were identified and opportunistically evaluated. These communities consisted of two distinct poor fens, a northern wet meadow, and an intermittent wetland (Table 2 and Figure 8). Maps and vegetation descriptions are provided for each natural community. Complete species lists from the 2021 assessment are provided in the appendix.

Description of Wet-Mesic Sand Prairie

The wet-mesic sand prairie is a series of small, especially diverse, non-forested openings with a prevalence of grasses and numerous calciphiles. The openings range in size, composition, and condition. Soils were examined in the southeasternmost polygon in 2021. The soils there are moist, slightly alkaline (pH 7.5) loamy sands mixed with organics to 8 cm deep, over medium-textured wet sands (pH 7.5). Kost and Cohen (2005) sampled thirteen soil cores and provided a general description of the soils across the wet-mesic sand prairie: 0 to 10 cm: light-colored-loamy sand (pH 6.5 -7.0) mixed with black organic matter; 10 to 50 cm: iron-colored sand or occasionally light-colored sand (pH 7.0 -7.5) with organic streaking and occasionally strong iron mottling; 50 to 130 cm: iron-colored sand or occasionally light-colored sand (pH 7.0 -7.5) with strong iron mottling, indicating a fluctuating water table. In its entirety, the system is large for the community type and extremely diverse with concentrations of rare plants, most notably the Federally Threatened Voss's goldenrod.

The site consists of 16 polygons with two new polygons added and one removed in 2021 (Figure 9). The total acreage was reduced from 28.4 ha (70 acres) to 18.3 ha (45.3 acres), with the largest polygon being reclassified as a poor fen and removed from the total acreage calculation of the prairie. Two small areas were added to the wet-mesic sand prairie EO. A polygon immediately adjacent to the west side of Howes Lake was added and is now the easternmost area of the EO (Figure 10, Page 15). Another polygon was added west of the gun range and is now the westernmost polygon (Figure 11, Page 16).

Table 2. Natural communities documented in the Portage Creek Complex.

EOID	Community Type	Community Name	First Described	Size (ac)	Size Rank	Condition Rank	Overall Rank
2078	Wet-Mesic Sand Prairie	Portage Creek Prairie	1992	45.3	A	BC	BC
24539	Northern Wet Meadow	Portage Creek Wet Meadow	2021	8	D	A	B
24538	Poor Fen	Portage Creek Poor Fen	2021	56.6	C	AB	B
24699	Poor Fen	Howes Lake Poor Fen	2021	17.4	D	A	B
24540	Intermittent Wetland	Portage Creek Intermittent Wetland	2021	3.5	D	AB	B

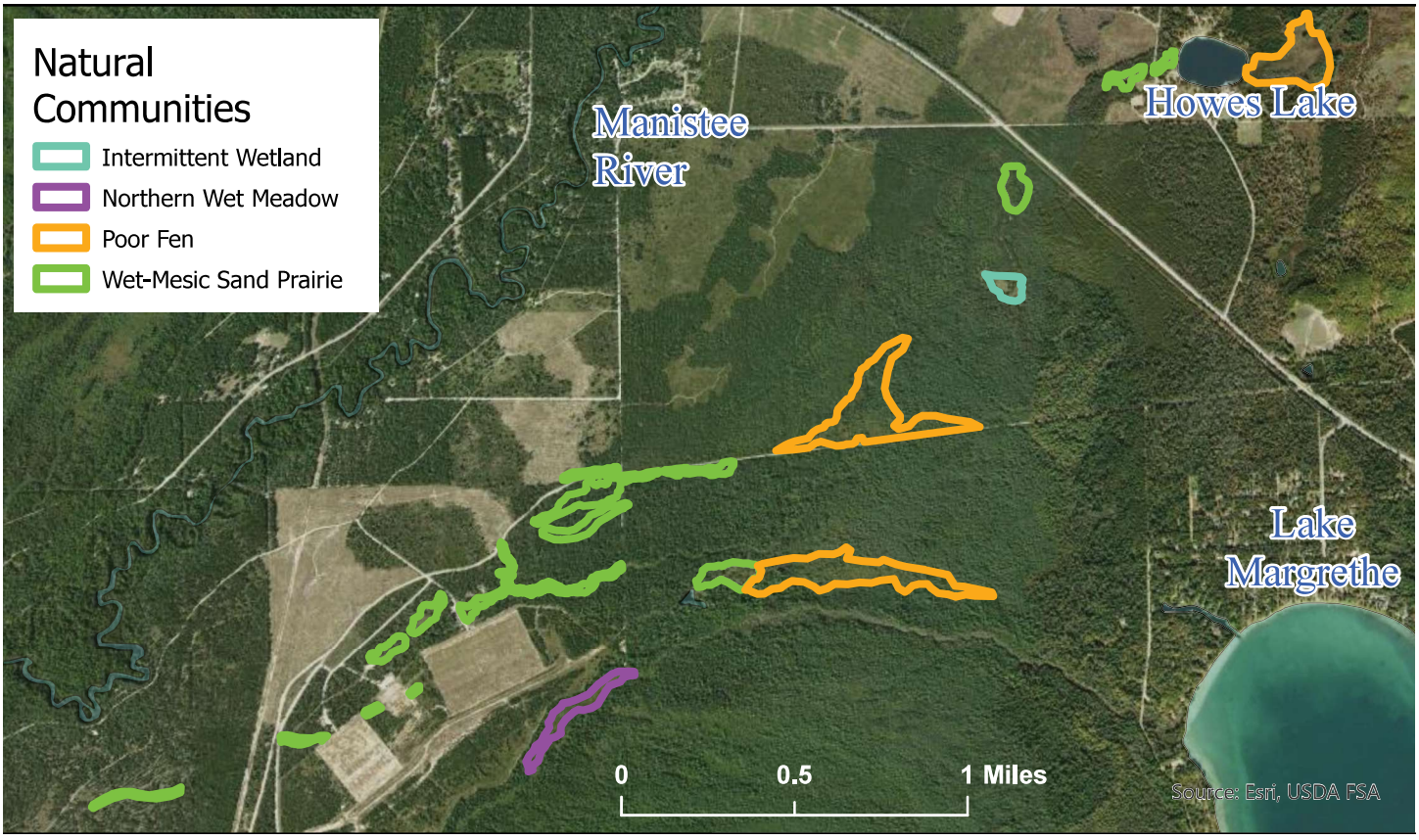


Figure 8. Location of natural communities in the Portage Creek Complex.

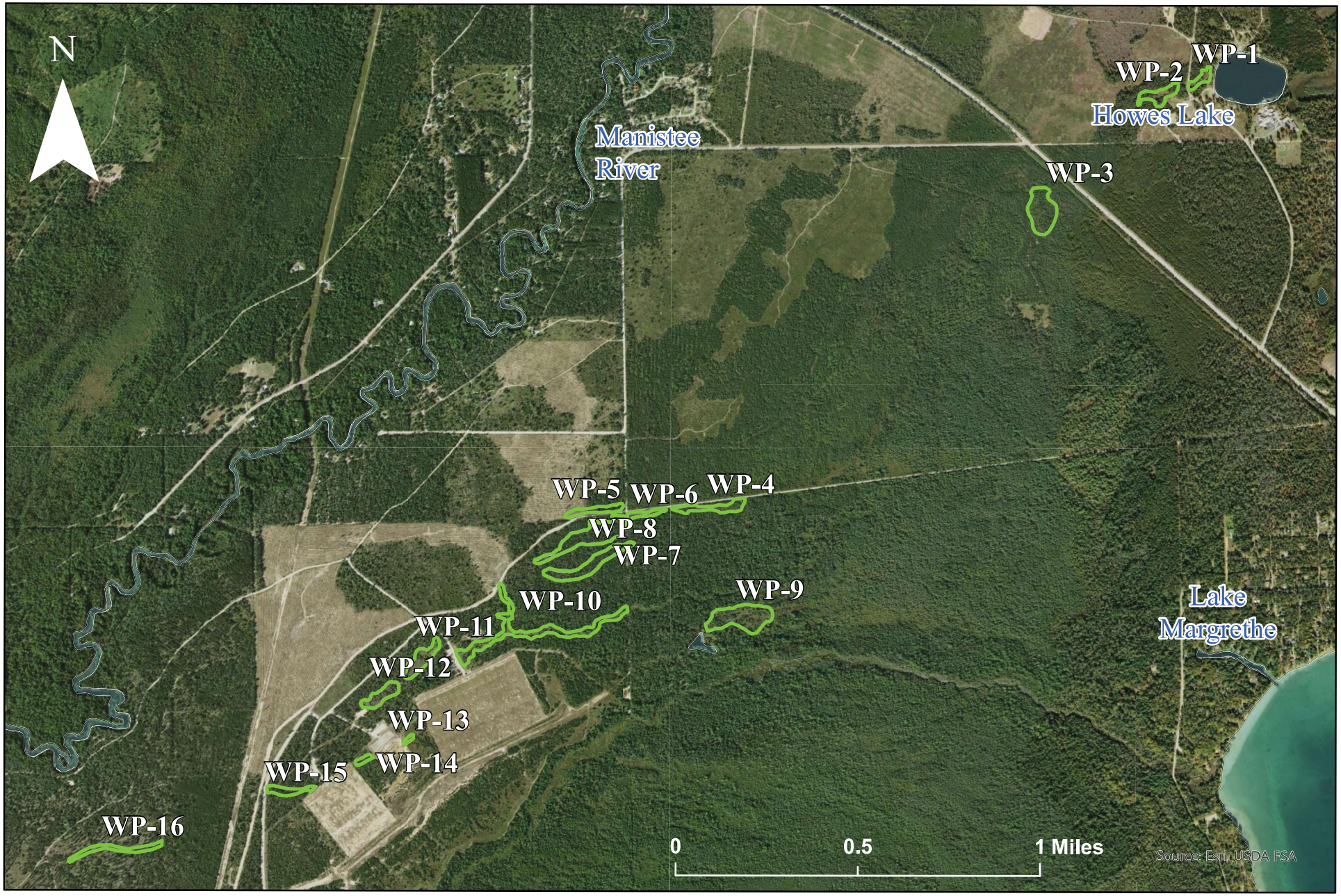


Figure 9. The extent of the wet-mesic sand prairie following the 2021 evaluation. To facilitate discussion, each polygon was assigned a unique ID with WP (wet prairie) followed by a number 1 through 16. WP-1 and WP-16 were new additions to the EO following the 2021 evaluation.

Figure 10. Polygon WP-1 was added to the wet-mesic sand prairie EO near Howes Lake. MiFI stands are included for reference.

Polygon WP-1 was added to the EO as a result of the 2021 evaluation. Though relatively low diversity compared to other polygons and impacted by the road and localized ditching near the lake, this area was dominated by native prairie vegetation and could be improved with stewardship.

Polygon WP-16 was added to the wet-mesic sand prairie EO. This is the westernmost polygon of the prairie and occurs just outside of Camp Grayling boundary, on state forest land.

Figure 11. Polygon WP-16 was added to the EO as a result of the 2021 evaluation. This prairie opening is at the drier end of the spectrum and has fewer wetland obligates. The drainage feature it occupies continues to the southwest and was followed for a considerable distance. Most of the depression to the southwest had been planted with pine but numerous prairie species persisted and the plant community could be improved with prescribed fire.

An existing polygon (WP-5) is still included in the wet-mesic sand prairie EO but has been degraded by a recent timber harvest treatment (Figure 12). The western half of WP-5 was clear-cut, trenched, planted to red pine, and herbicided. It is not clear the extent to which prairie vegetation will be recoverable and this polygon will need to be monitored for restoration potential.

A polygon along the north side of Tank Trail, between Arrowhead Rd and Hwy-72 was removed from the prairie EO and designated as a poor fen (Figure 13, pg 23) following this evaluation. This poor fen had been the largest polygon (11.9 ha/29.5 ac) of the wet-mesic sand prairie EO but is more appropriately classified as poor fen due to the accumulation of sapric peats over mineral soils, areas of standing water late into the growing season, the development of peat hummocks, an extensive shrub layer, and the prevalence of a sparse canopy of cedar (*Thuja occidentalis*), tamarack (*Larix laricina*), black spruce (*Picea mariana*), and white pine (*Pinus strobus*). Within the prairie, graminoids are dominant and there is no noticeable peat accumulation or standing water during the growing season. A more detailed description of the poor fen follows on page 23.

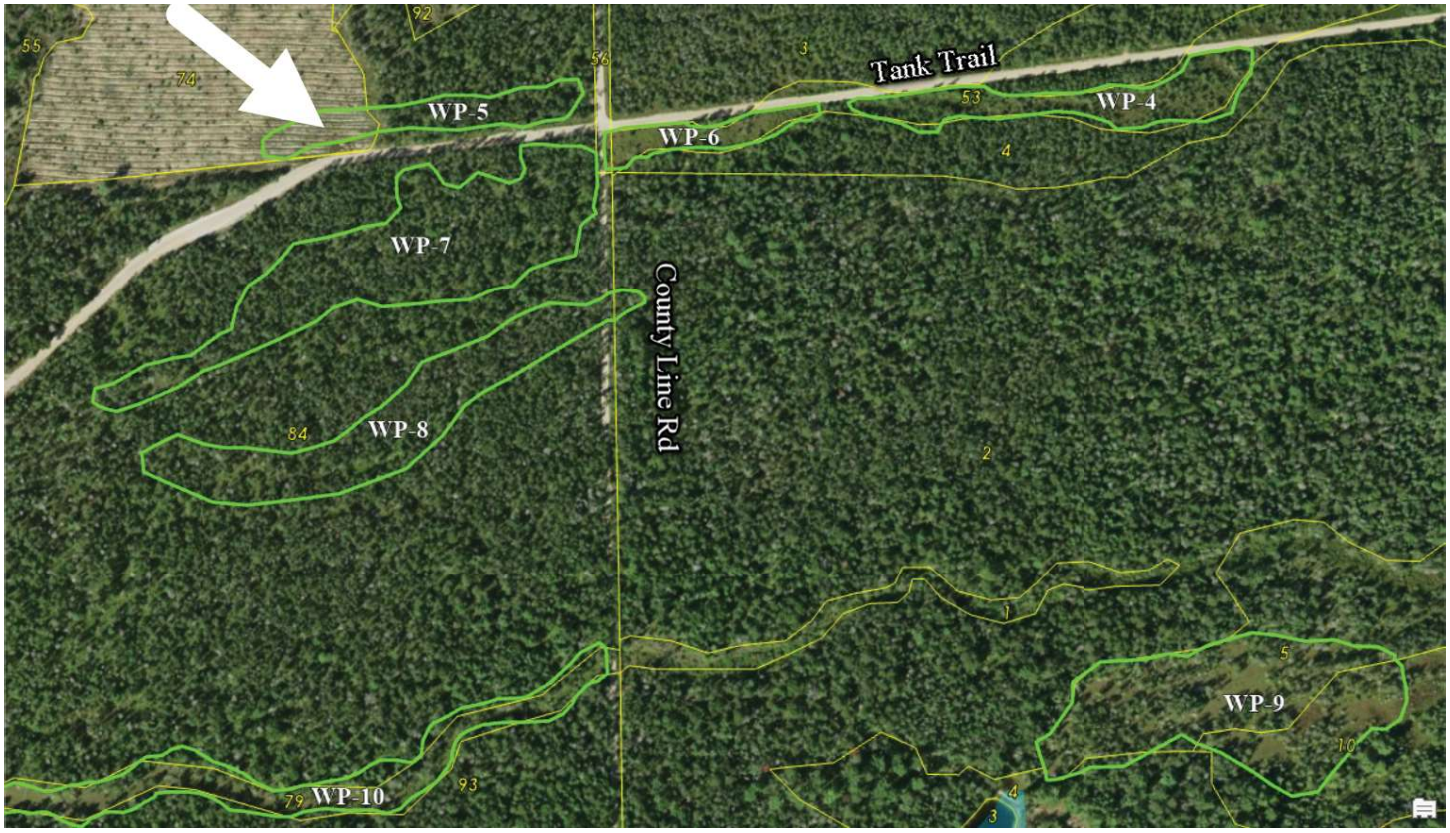


Figure 12. Polygon WP-5 in Stands 74 and 84 was impacted by a timber harvest treatment that also trenched and herbicided a portion of the prairie.

Some prairie vegetation persists between the trenches in WP-5 and the site may be recoverable with restoration.

One of the highest quality openings is in Stand 5 (WP-9), east of County Line Rd. This area also has the largest population of Voss's goldenrod that was observed in 2021. Within this single opening, an estimated 1000 to 1200 individuals were blooming or about to bloom during the late-July surveys of 2021.

The eastern portion of prairie polygon WP-5 has been impacted by the continual widening of the Tank Trail and the lingering prairie vegetation occurs in a degraded narrow strip between forest and road. Road closures will be critical for the long-term viability of the prairie.

The wet-mesic sand prairie and surrounding landscape have high conservation value. The wet-mesic sand prairie was untilled and does not appear to have been grazed. The condition of the numerous prairie openings is variable with extensive zones of high species diversity that qualify as A to AB-rank condition. Other areas are seriously degraded and rapidly converting to either shrub-dominated and low diversity or a closed-canopy forested system nearly unrecognizable as prairie. These degraded zones were not removed from the EO as a result of the 2021 analysis because they retain high restoration potential if comprehensive stewardship and threat abatement are quickly implemented.

The herbaceous layer of the prairie is diverse, variable, and graminoid-dominated. Dominant grass species shifts throughout the prairie; frequent dominants are blue-joint (*Calamagrostis canadensis*), big bluestem (*Andropogon gerardii*), switchgrass (*Panicum virgatum*), poverty grass (*Danthonia spicata*), *Carex pensylvanica,* and prairie dropseed (*Sporobolus heterolepis;* State Special Concern). Other common graminoids includes northern panic grass (*Dichanthelium borealis*), *Carex flava*, prairie brome (*Bromus kalmii*), hair grass (*Deschampsia cespitosa*), false melic (*Schizachne purpurascens*), little bluestem (*Schizachyrium scoparium*), and Clinton's bulrush (*Trichophorum clintonii,* State Special Concern).

The sedge, *Carex flava,* was locally abundant in the moister portions of the wet-mesic sand prairie.

Despite numerous degraded areas of the prairie, much of the site still supports exemplary structure and composition. This is polygon WP-10, Stand 79.

Forbs are common but generally at a much lower abundance than graminoids and include, goldenrods (*Solidago vossii*, *S. gigantea*, *S. rugosa*), white camas (*Anticlea elegans*), bastard-toadflax (*Comandra umbellata*), grass-leaved goldenrod (*Euthamia graminifolia*), balsam ragwort (*Packera pauperculus*), common water horehound (*Lycopus americanus*), wild mint (*Mentha canadensis*), pale spiked lobelia (*Lobelia spicata*), small sundrops (*Oenothera perennis*), and wild blue flag (*Iris versicolor*). There were 107 plant species observed in the wet-mesic sand prairie during the 2021 surveys, including 5 non-natives. The total FQI was 48.6. Sites are considered regionally significant to the conservation of biodiversity if their FQI is over 35 (Herman et al. 2001).

Rare plants documented from the wet-mesic sand prairie include Hill's thistle (*Cirsium hillii*; State Special Concern; observed in 2021), Vasey's rush (*Juncus vaseyi*, State Threatened), prairie dropseed (*Sporobolus heterolepis*; State Special Concern; observed in 2021), Voss's goldenrod (*Solidago vossii;* Federally Threatened; observed in 2021), Clinton's bulrush (*Trichophorum clintonii*; State Special Concern; observed in 2021), and New England violet (*Viola novae-angliae*; State Threatened).

The low shrub layer ranges from locally absent or infrequent to a coverage of 30-40% and locally dominant, especially at the base of trees and at the margins of the prairie. Shrub diversity and abundance increases in the zones with soils saturated for more of the year, especially the southeasternmost opening (WP-9). Prevalent low shrubs include leatherleaf (*Chamaedaphne calyculata*), sand cherry (*Prunus pumila*), shrubby cinquefoil (*Dasiphora fruticosa*), slender willow (*Salix petiolaris*), low sweet blueberry (*Vaccinium angustifolium*), speckled alder (*Alnus incana*), Kalm's St. John's-wort (*Hypericum kalmianum*), chokeberry (*Aronia prunifolia*), sheep-laurel (*Kalmia angustifolia*), and meadowsweet (*Spiraea alba*). The drier zones are characterized by sweetfern (*Comptonia peregrina*), low sweet blueberry, pasture rose (*Rosa carolina*), and sand cherry.

The shrub, sheep-laurel (*Kalmia angustifolia*), is uncommon in the wet-mesic prairie but locally abundant in Portage Creek Poor Fen and unusually dominant in some adjacent uplands.

Slender ladies'-tresses (*Spiranthes lacera*) is a small orchid found in dry sandy soils, often under jack pine. It is rare within the Portage Creek Wet-Mesic Sand Prairie.

The canopy is generally absent in the wet-mesic sand prairie. Jack pine and white pine occur infrequently along the margins of the prairie. Where the prairie transitions to dry northern forest canopy coverage can reach 30% creating a savanna-like structure locally. Zones of prairie vegetation with greater canopy coverage tend to have high shrub components as well. One 36.8 cm dbh jack pine in the prairie (Stand 5, WP-9) was estimated to be about 115 years old (106 observed rings). Most trees in the uplands appear to be between 70 and 90 years old; a 26.7 cm dbh jack pine was 83 years old. A 17 cm dbh jack pine in a plantation was 37 years old (WP-15). Large white pines are infrequent at the margins of the prairie; a 43.7 cm dbh individual was the largest measured. The subcanopy is sparse with jack and white pine being the most prevalent and black spruce and tamarack being infrequent or rare.

Invasive species in the prairie are generally infrequent and most abundant along roads and ditches. Canada bluegrass (*Poa compressa*) occurs frequently throughout the system. Spotted knapweed (*Centaurea stoebe*), common St. John's-wort (*Hypericum perforatum*), and sweet clover (*Melilotus albus*) generally occur near roads. The most concerning invasive species is leafy spurge (*Euphorbia virgata*) as it is clonal and has the ability to take over entire prairie remnants. Leafy spurge is presently (2021) only occupying 2 areas with quality vegetation (Compartment 61129; Stands 33 and both polygons of Stand 79). Common tansy (*Tanacetum vulgare*) was observed and removed from County Line Rd near the prairie.

Hill's thistle (*Cirsium hillii*, State Special Concern) was observed in WP-16 during the 2021 surveys.

Kalm's St. John's-wort (*Hypericum kalmianum*) was found throughout Portage Creek Complex.

White camas (*Anticlea elegans*) occurred occasionally within Portage Creek wet-mesic prairie.

Indian paintbrush (*Castilleja coccinea*) was found in one of the prairie openings and was blooming in late July 2021.

Kalm's hawkweed (*Hieracium kalmii*) was found at the margins of the prairie and surrounding uplands.

Many areas of the wet-mesic sand prairie are converting to closed-canopy jack pine forest in the absence of frequent fire. Several portions of polygons WP-7, WP-8, and WP-15 are barely recognizable as prairie with characteristic vegetation failing to flower as a result of increased canopy closure reduced light availability.

New Natural Communities

Poor Fen

Portage Creek Poor Fen features two polygons near the wet-mesic sand prairie EO (Figure 13). The northernmost polygon had been previously mapped as part of the wet-mesic sand prairie but composition and structure better fit within the parameters of poor fen. Soils are sapric peats to depths of 8 cm over wet, medium textured loamy sands mixed with organics, overlying medium-textured wet sands, and all with a pH of 7.5. The fen openings are dominated by shrubs with a sparse canopy of cedar (*Thuja occidentalis*), tamarack, white pine, and black spruce. The fen is diverse and highly variable with composition driven by duration of standing water, depth of peat, and frequency of ant mounds.

Shrubs are locally dominant with near-total coverage in places. Some zones in the northern portion of the northern polygon are dominated by leatherleaf. Other areas of the fen feature a prevalence of shrubby cinquefoil, alder-leaved buckthorn (*Rhamnus alnifolia*), slender willow, and young tamarack and these are the areas of highest diversity. Many other shrubs occur in the fen but are typically more infrequent than the aforementioned species. Additional shrub species include Kalm's St. John's-wort, low sweet blueberry, sheep-laurel, leatherleaf, meadowsweet, pussy willow (*Salix discolor*), sweet gale (*Myrica gale*), swamp rose (*Rosa palustris*), wild-raisin (*Viburnum cassinoides*), and wild black currant (*Ribes americanum*). The fen/wetland complex locally trends towards northern shrub thicket with speckled alder (*Alnus incana*) and dogwood (*Cornus amomum* and *C. sericea*) being thick and the herbaceous component simplified and less dominant with lower diversity in these areas.

Portage Creek Poor Fen is dominated by a diverse array of graminoids including sedges and grasses. More open zones of fen with less shrub cover are especially diverse.

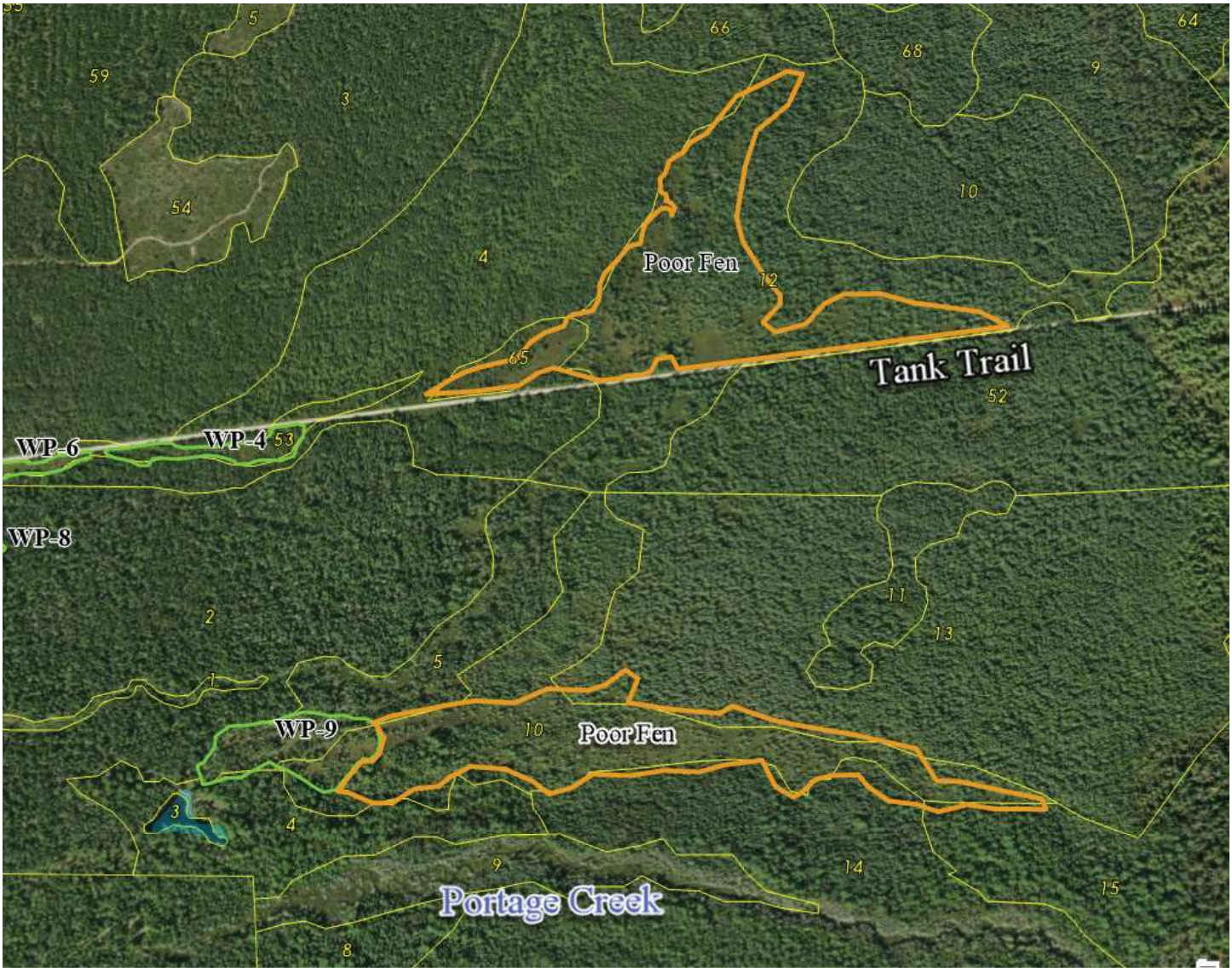


Figure 13. The two polygons of Portage Creek Poor Fen are outlined in orange. The polygon north of tank trail had been previously mapped as prairie but better fit the description of poor fen. Prairie openings are outlined in green and MiFI stands are outlined in yellow.

The portion of Portage Creek Poor Fen north of Tank Trail is drier than the southern polygon and features areas with a sparse canopy of jack pine and a shrub layer locally dominated by alder and leatherleaf. This area was previously mapped as wet-mesic sand prairie and might revert to prairie with a high frequency of prescribed fire.

The portion of Portage Creek Poor Fen south of Tank Trail is characterized by a sparse canopy of cedar and tamarack. Many of these trees had fire scars and we recommend such wetland communities be included in prescribed burns. Streams and existing roads should be used as burn breaks whenever possible as creating new burn breaks would continue to degrade the hydrology of the site and increase risk of invasive species.

The accumulation of peat - both mounding peat hummocks and sapric peats over mineral soils - was a characteristic feature that distinguished fen from prairie.

Fire scars were evident on many of the cedar within Portage Creek Poor Fen.

Characteristic sedges include *Carex stricta*, *Carex flava*, cotton-grass (*Eriophorum viridi-carinatum*), bulrush (*Scirpus atrovirens*), *Carex sterilis*, *Carex buxbaumii*, and *Carex castanea*. Prevalent grasses include hair grass (*Deschampsia cespitosa*), panic grasses (*Dichanthelium boreale and D. lindheimeri*), blue-joint, ticklegrass (*Agrostis scabra*), false melic (*Schizachne purpurascens*), fringed brome (*Bromus ciliata*), fowl manna grass (*Glyceria striata*), and marsh wild-timothy (*Muhlenbergia glomerata*). Marsh fern (*Thelypteris palustris*) is locally dominant in the open zones and sensitive fern (*Onoclea sensibilis*) and royal fern (*Osmunda regalis*) are abundant in areas with a more extensive canopy.

Forbs are ubiquitous but not as dominant as graminoids and include goldenrods (*Solidago uliginosa* and *S. rugosa*), marsh skullcap (*Scutellaria galericulata*), wild blue flag, joe-pye-weed (*Eutrochium maculatum*), boneset (*Eupatorium perfoliatum*), swamp thistle (*Cirsium muticum*), and flat-topped white aster (*Doellingeria umbellata*). Invasive species were not observed within the fen and 74 native species were observed in 2021 and the total FQI was 48.2.

Microscale gradients in soil moisture and soil chemistry correlated with micro-topographic features and contributes to the structural and floristic diversity of the fen. Factors influencing this include old stumps, ant mounds, slight variability in elevation, sedge tussocks, and the formation of peat hummocks. These factors all influence the degree of standing water and saturation throughout the growing season. The floristic composition found on the ant mounds is highly variable. Myrmecochory is the ant-mediated secondary dispersal of seeds and this process appears to be having strong influences on vegetation patterns within the fen. The seeds of these plants were likely collected by ants, the edible material of the seed consumed, and then remaining portions of the seed removed to the exterior of the ant mounds where the seeds germinated. *Dichanthelium lindheimeri*, *Viola spp*., poverty grass (*Danthonia spicata*), and bastard-toadflax (*Comandra umbellata*) were locally dominant only on the ant mounds and nearly absent elsewhere.

The canopy is sparse throughout the fen with coverage being 10 to 30%. White cedar and tamarack are the most dominant species with diameters typically 20 to 30 cm. White pine is occasional in the canopy and the largest tree species overall, with some individuals reaching 60 cm in diameter. Jack pine occurs throughout the northern polygon. There are some small inclusions of conifer swamp forming small, forested islands within the fen.

Ant mounds are prevalent throughout Portage Creek Poor Fen. Ants play an important role in dispersal of several species and the mounds create heterogeneity in structure and composition within the fen.

A massasauga rattlesnake was observed in Portage Creek Complex during the 2021 surveys.

Howes Lake Poor Fen occurs east of Howes Lake between the lake and a nearby moraine (Figures 14 and 15). The fen features a continuous layer of fibric peat (pH 8.0) with very large hummocks over hemic and sapric peats to depths greater than 1 m. Its landscape position allowed for a much greater accumulation of peats than Portage Creek Poor Fen. This is likely due to a constant flow of groundwater from the moraine and possibly to its proximity to the lake which may have kept peats saturated and prevented historic fires from consuming peat. The deep peats and apparent lack of fire impacts have caused this poor fen to have a much different vegetative structure than the Portage Creek Poor Fen. Howes Lake Poor Fen is characterized by an extensive low shrub layer and low herbaceous diversity. The peatland is dominated by leatherleaf, sweet gale, shrubby cinquefoil, bog birch (*Betula pumila*), highbush blueberry (*Vaccinium corymbosum*), bog rosemary (*Andromeda glaucophylla*), Labrador-tea (*Rhododendron groenlandicum*), bog-laurel (*Kalmia polifolia*), and large cranberry (*Vaccinium macrocarpon*). There are zones with a sparse canopy of tamarack and black spruce. A 14.2 cm dbh tamarack was aged to 86 years old. The herbaceous layer is sparse and features *Carex lasiocarpa*, Canadian rush (*Juncus canadensis*), buckbean (*Menyanthes trifoliata*), blue-joint, beak-rush (*Rhynchospora alba*), and pitcher-plant (*Sarracenia purpurea*). There were no invasive species documented and 22 native species observed in 2021. The total FQI was 32.8.

Howes Lake Poor Fen features hummocks of sphagnum moss up to 1 m tall in places.

Figure 14. Howes Lake Poor Fen occurs east of the lake.

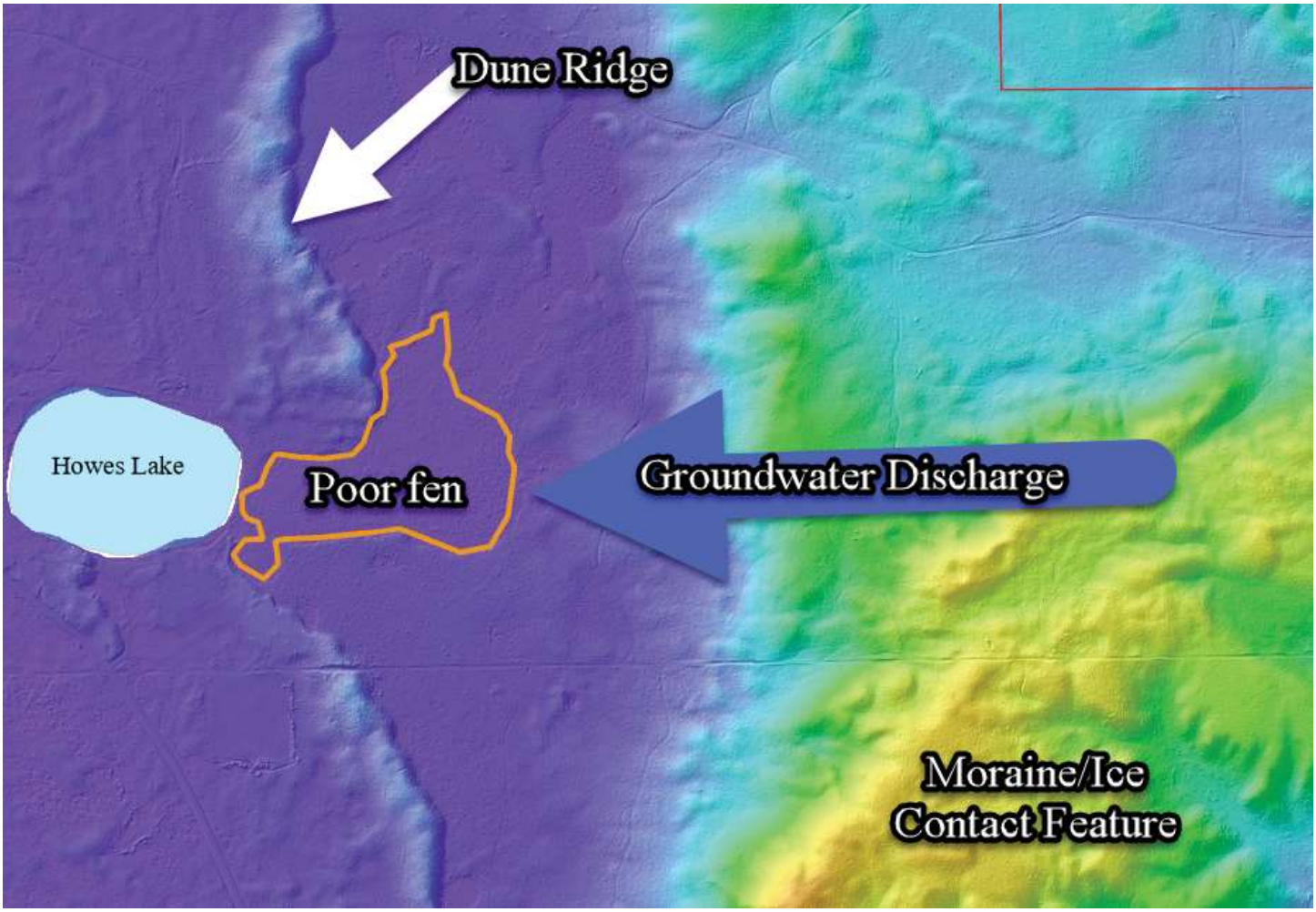


Figure 15. LiDAR imagery showing the landscape position of Howes Lake Poor Fen between the lake and nearby moraine/ice contact features. A constant flow of groundwater facilitates the accumulation of deep peats with a basic pH.

Howes Lake Poor Fen is characterized by extensive areas dominated by leatherleaf and wiregrass sedge and localized areas of sparse canopy of black spruce and tamarack.

Northern Wet Meadow

A small northern wet meadow was documented along the Portage Creek drainage channel from Lake Margrethe to the Manistee River (Figure 16). The meadow is surrounded by a large, relatively intact conifer swamp. Nearby uplands to the north are degraded by a gun range and there is only a narrow strip of natural upland cover between the gun range and the meadow. The meadow is characterized by vegetative zonation corresponding with fluctuating water levels. The extensive sedge meadow zone occurs along the stream where seasonal flooding and frequent inundation during rain events limits shrubby encroachment. Additional northern wet meadow likely occurs downstream but was not the focus of this evaluation.

There is a sparse canopy of stunted tamarack, spruce, cedar, and white pine. Alder is the dominant shrub and is locally dense, especially away from the creek where the system transitions into conifer swamp. Other shrubs include sweet gale, sandbar willow (*Salix exigua*), and meadowsweet. *Carex stricta* is overwhelmingly dominant in the herbaceous layer. Other graminoids are occasional to common, including blue-joint, softstem bulrush (*Schoenoplectus tabernaemontani*), fowl manna grass, *Carex diandra*, bulrush (*Scirpus atrovirens*), and fringed brome. Broad-leaved cat-tail (*Typha latifolia*) is common throughout the meadow. Forbs are ubiquitous but at low densities and include joe-pye-weed, boneset, wild blue flag, cardinal flower (*Lobelia cardinalis*), purple meadow-rue (*Thalictrum dasycarpum*), blue vervain (*Verbena hastata*), goldenrods (*S. rugosa* and *S. canadensis*), swamp thistle, water hemlock (*Cicuta bulbifera*), marsh bellflower (*Campanula aparinoides*), and marsh St. John's-wort (*Triadenum fraseri*). Marsh fern is common to locally dominant. Reed canary grass (*Phalaris arundinacea*) was the only invasive species observed in the meadow and was found at the margins under alder in the northeastern portion. There were 37 native species and one invasive species observed in 2021. The total FQI was 24.3.

Cardinal flower (*Lobelia cardinalis*) was blooming along Portage Creek during the time of the survey.

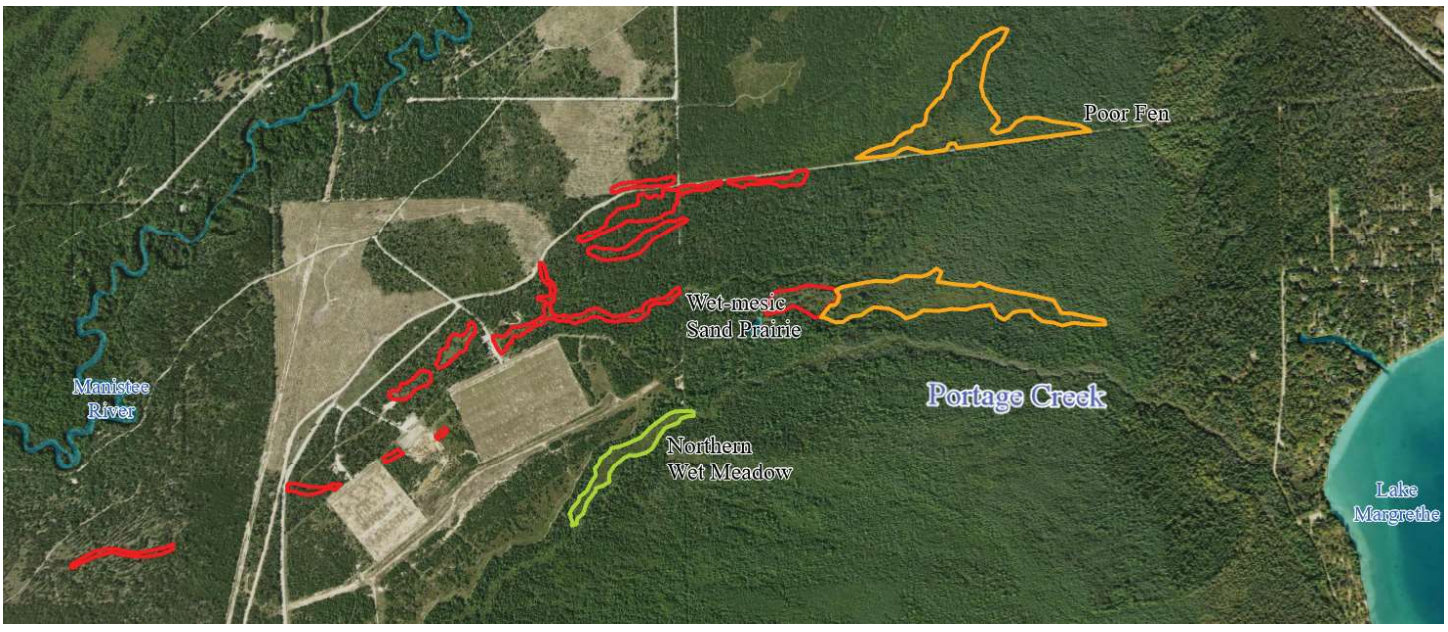


Figure 16. Portage Creek Northern Wet Meadow occurs along Portage Creek, southeast of the gun range.

Portage Creek Northern Wet Meadow occurs in a narrow band along the creek within a large conifer swamp.

The meadow is dominated by *Carex stricta* and alder.

Intermittent Wetland

A small intermittent wetland occurs in a small depression at the base of an old dune ridge. This is a sedge-dominated opening with low diversity that features deep water in the late winter and early spring and is dry by late summer. The dune ridge occurs to the west of the intermittent wetland and the flow of water over the landscape is generally from northeast to southwest, causing substantial pooling in the spring when there is snow-melt and the water table is highest. The system appears to be inundated by deeper water than the nearby prairie openings, potentially causing the differences in composition of the two communities. The system transitions quickly to jack pine-dominated dry northern forest where seasonal inundation fails to prevent encroachment by trees. Soils are medium textured, loamy sands with dark organics to 20 cm (pH 7.0) overlying medium-textured sands (pH 7.0).

This small opening is especially dominated by *Carex stricta*. Other characteristic graminoids include blue-joint, *Carex lasiocarpa*, panic grass (*Dichanthelium lindheimeri*), wool-grass (*Scirpus cyperinus*), muhly grass (*Muhlenbergia uniflora*), *Carex vesicaria*, rattlesnake grass (*Glyceria canadensis*), and *Carex buxbaumii*. Shrubs are locally dominant at the margins with the uplands. The most dominant shrub is leatherleaf; others include Kalm's St. John's-wort, meadowsweet, sand cherry, and sheep-laurel, which are infrequent. Wild blue flag and lance-leaved violet (*Viola lanceolata*) were the only forbs observed and were infrequent. There were no invasive species and 16 native species documented in 2021 and the FQI was 27.6.

Muhly grass (*Muhlenbergia uniflora*) was locally abundant in the intermittent wetland.

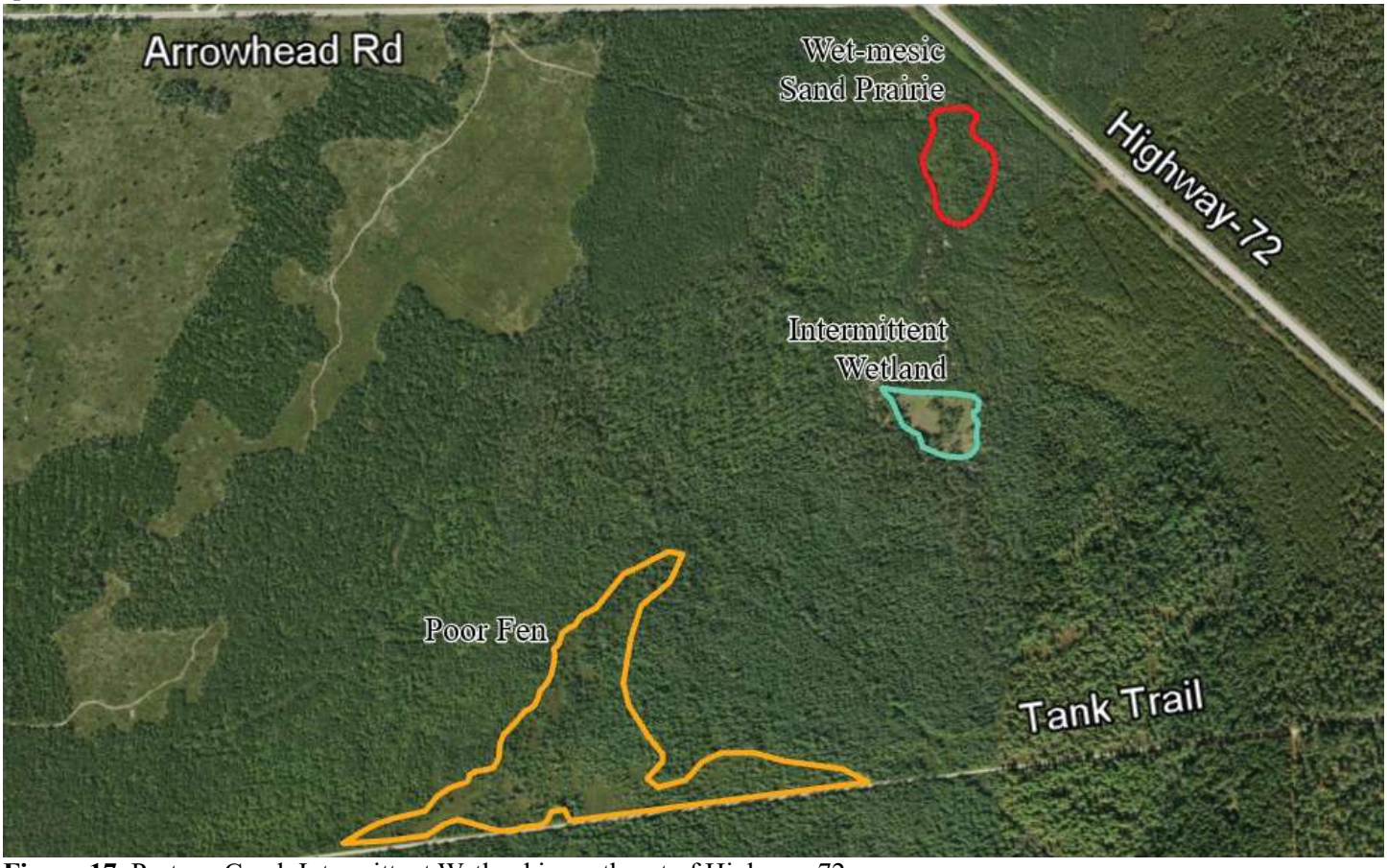


Figure 17. Portage Creek Intermittent Wetland is southeast of Highway-72.

The intermittent wetland is characterized by a sedge-dominated open zone and margins dominated by shrubs, primarily leatherleaf.

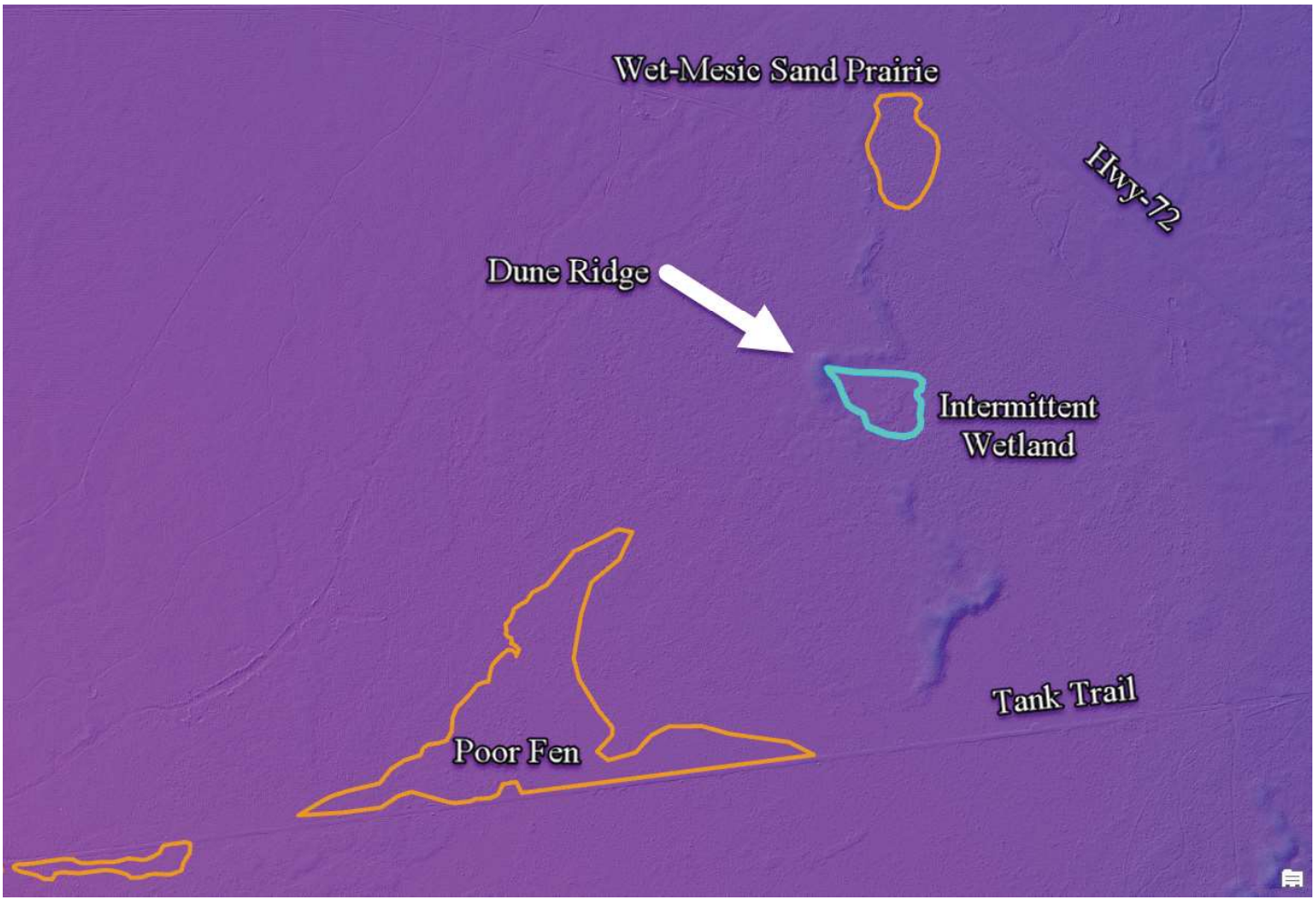


Figure 18. LiDAR imagery showing the landscape position of the intermittent wetland at the base of a small dune on the flat outwash plain.

Discussion

Overall Rank and Description of Threats

This ecological evaluation was conducted to assess the condition of the wet-mesic sand prairie after ditching within the prairie was observed during MNFI surveys in 2020 (Cohen 2020). Careful assessment of the surrounding landscape was also part of the 2021 evaluation as silvicultural actions adjacent to the wet-mesic sand prairie have the potential to reduce the conservation potential of the site.

There are currently 13 examples of wet-mesic sand prairie in Michigan and Portage Creek Wet-Mesic Sand Prairie is the second largest. This prairie and surrounding landscape were identified as one of the areas of highest conservation priority in Camp Grayling and given an overall rank of A at its first evaluation in the early 1990s (Higman et al 1994). MNFI ecologist Joshua Cohen evaluated the prairie in 2016 and removed numerous openings and lowered the EO Rank from B to BC and after the 2021 survey, keeping the Overall Rank of BC is justified.

While portions of the wet-mesic sand prairie are in excellent condition, there are several factors degrading the condition of the prairie system and those threats appear to be interacting in complicated ways. Some prairie openings are degraded by road crossings and extensive damage from tanks or off-road vehicles (ORVs). Some areas have been the focus of continual ditching efforts aimed at moving water off the gun range which was built in the middle of a wet prairie/dry forest mosaic between two rivers. Ditching occurs within and outside of the prairie at key places. Within the prairie, the ditch has cut through critical habitat for Voss's goldenrod and is emptying into a retention pond near the entrance to the gun range. Because inundation during late winter and early spring is integral to the dynamic nature of the prairie's hydrology, changes in hydrology are problematic.

This ditching will continue to further degrade the prairie system by reducing the water table and thereby facilitating encroachment of trees and shrubs. Changes in hydrology will cause the site to be less hospitable to wetland obligates and increase susceptibility to invasive species. The extensive ditching, particularly related to maintenance of the gun range and Tank Trail, is having detrimental impacts on the entire landscape and is accelerating the loss of wet-mesic sand prairie throughout the Portage Creek Complex.

The Tank Trail intersects the prairie at Stand 79 and provides access to ORVs. The ditch dug in the prairie at this location seems to have been made to move water off of the Tank Trail during high-water events.

The ditch in Stand 79 channels water, damaged populations of rare plants, and increases the prairie's susceptibility to invasive species. This appears to have been made to divert water from the gun range and away from the Tank Trail.

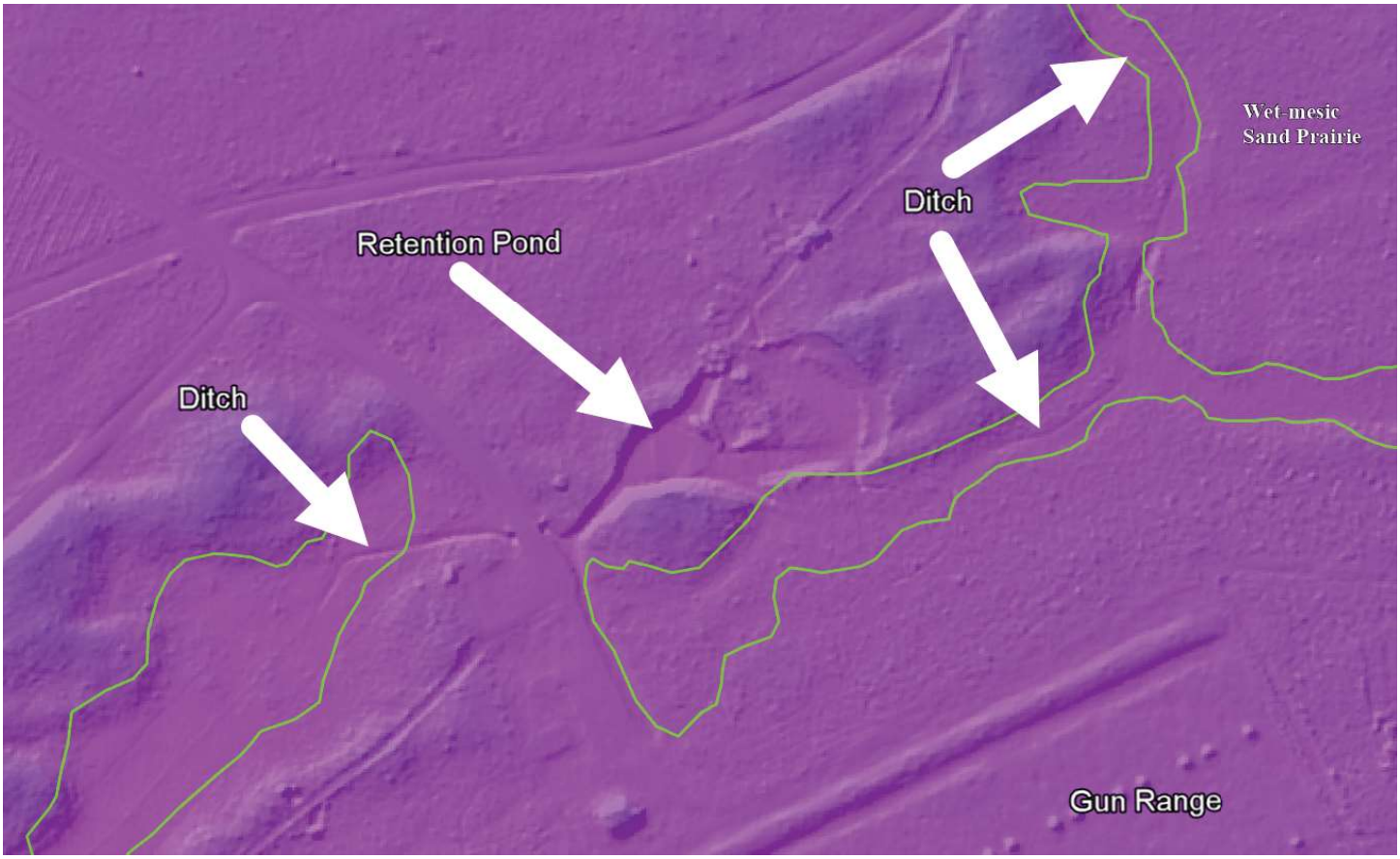


Figure 19. LiDAR imagery showing damaging hydrological alterations within and around the prairie (outlined in green). These efforts appear to be directed at draining the gun range and moving water away from the Tank Trail.

The silvicultural activities across the landscape are also having substantial, accumulating, and potentially irreversible detrimental impacts on the condition of the wet-mesic sand prairie. Clear-cutting increases the temperature of the ground layer by removing the canopy and scalding species sensitive to the hotter, droughtier, high-light conditions following the cuts. Extensive clear-cuts reduce the heterogeneity of light availability, alter competitive interactions, and lower species richness, especially in the context of high deer densities (Simard et al. 2021). Clear-cuts and trenching are increasing the prevalence of bare soil and invasive species. Following cuts, the land is being trenched before being replanted. Cutting and trenching increase the speed at which water moves across the surface of the landscape, compounding the hydrological alterations caused by ditching. Additionally, the broad-scale application of herbicides in pine plantations serves to reduce diverse pockets of native vegetation across the landscape. These silvicultural actions work in concert to further homogenize the landscape and degrade or eliminate pockets of residual prairie vegetation and habitat for massasauga rattlesnakes outside of the areas mapped as high-quality natural communities.

One small portion of the area included in the prairie EO was recently clear-cut, herbicided, and planted to pine (Figure 12, Page 17). It was probably relatively degraded and unrecognizable as a prairie when the stand was cut. However, it was degraded because of the cumulative impacts of ditching, road damage, and protracted fire suppression, causing it to be unrecognizable as prairie less than 30 years after it was first identified and mapped as prairie. Extensive clear-cutting followed by trenching and herbiciding is resulting in serious degradation of the landscape, particularly in the absence of prescribed fire.

The recoverability of the landscape to a degree that will allow natural communities and rare species to persist is being diminished by commonplace silvicultural practices.

The lack of consistent, properly timed fire in recent decades is also contributing to the decline of the wet-mesic sand prairie and the landscape as a whole. There is mention of localized application of prescribed fire (Cohen 2016), but the entire Portage Creek Complex likely experienced a high frequency of fire prior to European colonization and there was no evidence of recent prescribed fire during the 2021 survey. Prior to European colonization, forests of similar composition to the Portage Creek Complex (jack pine, northern pin oak, red pine, and white pine) burned on average every 4 to 36 years with lightning accounting for less than 2% of ignition and Indigenous peoples causing the remainder of fires (Sands and Abrams, 2011). Stand replacing burns of the adjacent dry northern forest may have occurred every 60 to 100 years and were associated with periods of drought (Dickmann and Cleland 2005).

Based on the fire return intervals frequency in similar prairie habitat types, we estimate that historic fires occurred at a frequency of 1 to 10 burns every 20 years. The fire frequency was dependent on landscape position, drought cycles, and activity of Indigenous peoples. Because of the saturated nature of large portions of the landscape in the spring, fires likely occurred in the fall which would have allowed fires to extend into even the wettest areas, especially during periods of drought. This is supported by the presence of fire scars on many trees, including the oldest surviving red pines at the margins of the prairie and several cedars growing in the poor fen. These cedars are over 100 years old with substantial fire scars, primarily on the west-facing portions of the trunks.

Prevailing silvicultural practices of clear-cutting, trenching, and herbiciding are leading to continual degradation of the landscape surrounding the Portage Creek Complex.

This wet-mesic sand prairie is a series of small prairie openings in subtle depressions and drainages on the flat glacial outwash plain. The broader area is a shifting mosaic between prairie, poor fen, pine barrens, dry northern forest, and poor conifer swamp. The various dominance patterns of vegetation are associated with landscape position, hydrology, disturbance history, and soil depth, composition, and texture. The zones with prolonged standing water and saturated soil longer into the growing season tend to be shrubbier and trend towards poor fen and eventually conifer swamp, especially with periods of fire suppression. Several prairie openings appear to be converting to poor fen where the accumulation of peat moss is not interrupted by fire. Periodic drying down seasonally and across years results in the decomposition of peats. In the absence of peat consumption by fire, prairie vegetation is relegated to the most hydrologically dynamic spaces on the landscape where decomposition of organic soils and seasonally-high water tables allows for the persistence of prairie habitat. Voss's goldenrod appeared to be restricted to areas where there is no accumulation of peats over of mineral soils and the species' habitat will likely expand with the application of regular, low intensity prescribed burns.

These prairie openings are the persisting remnants of a broader mosaiced landscape featuring a continuum of natural community types that included ecotones between prairie, pine savanna, and open wetlands. The mosaic landscape is characterized by dynamic water tables, frequent fires, and droughty conditions that led to the formation of a sparsely-canopied savanna structures with extensive prairie and localized poor fen in the wettest zones. Historic land clearing, timber harvesting, extensive ditching, and protracted fire suppression have eliminated these more transitional, sparsely-canopied savanna states which would feature a diverse herbaceous layer with many prairie species. These savanna states were likely more prevalent across the landscape historically.

Because the wet-mesic sand prairie is a small component of a dynamic landscape, the management that happens outside of the discrete boundaries of the prairie has impacts on the condition of the prairie and the potential for it to persist. The combined effects of these intensive, accumulating, and degrading stressors are causing a continuing decline in the ecological condition of the landscape and are jeopardizing the long-term viability of the wet-mesic sand prairie. Fire suppression acting in concert with targeted ditching of the prairie and silvicultural actions to increase tree density through trenching, planting, and herbiciding have locally eliminated the prairie component in the surrounding uplands. Ditching efforts around the gun range and along roads appear to be increasingly extensive and are eliminating many of the wetter floristic components of the landscape. In the absence of seasonal inundation and frequent fires, and with the loss of prairie species in residual upland openings, the wet-mesic sand prairie will continue to shrink. Homogenization of the landscape through ditching, clear-cutting, trenching, and fire suppression is especially damaging to the unique prairie remnant and populations of rare taxa that persist therein.

Transitional, savanna states featuring prairie vegetation and a sparse canopy were likely much more prevalent historically but have been eliminated by historic land clearing, fire suppression, and timber harvest.

Management Opportunities

The Portage Creek Complex was identified as one of the areas of highest conservation priority in Camp Grayling and given an overall rank of A at its first evaluation in 1994. Since the initial evaluation, the wet-mesic sand prairie has been continually reduced in rank and size. The Portage Creek Wet-Mesic Sand Prairie is a high-quality remnant of significant conservation value facing many serious threats and needs considerable ecosystem management to persist as an Ecological Reference Area. We recommend establishing a conservation buffer and avoiding intensive forest management methods such as clear-cutting, trenching, and applying herbicide within the buffer area (Figure 20). This is similar to previous recommendations to avoid intensive silvicultural management and training exercises within a 200 to 300 m buffer around the prairie (Higman et al. 1994; Figure 21). Additional detailed management recommendations are provided for your consideration.

Dedicated Natural Area

The maintenance of military-associated infrastructure and the current prevailing forestry practices are accelerating the degradation of prairie and zones of native vegetation outside of mapped prairie. Ditching of the prairie to drain the gun range and Tank Trail in combination with management of the landscape immediately adjacent to the prairie for forestry goals are not compatible with protection and stewardship of the prairie and the rare species residing therein. Michigan has a Natural Areas Program and the designation as a Natural Area confers various protections, including limited silvicultural activities, elimination of roads, and a commitment to stewardship of the natural communities within the designated area. For that reason, the initial management recommendation is to establish the Portage Creek Complex as a dedicated Natural Area (see Figure 22 for suggested boundaries).

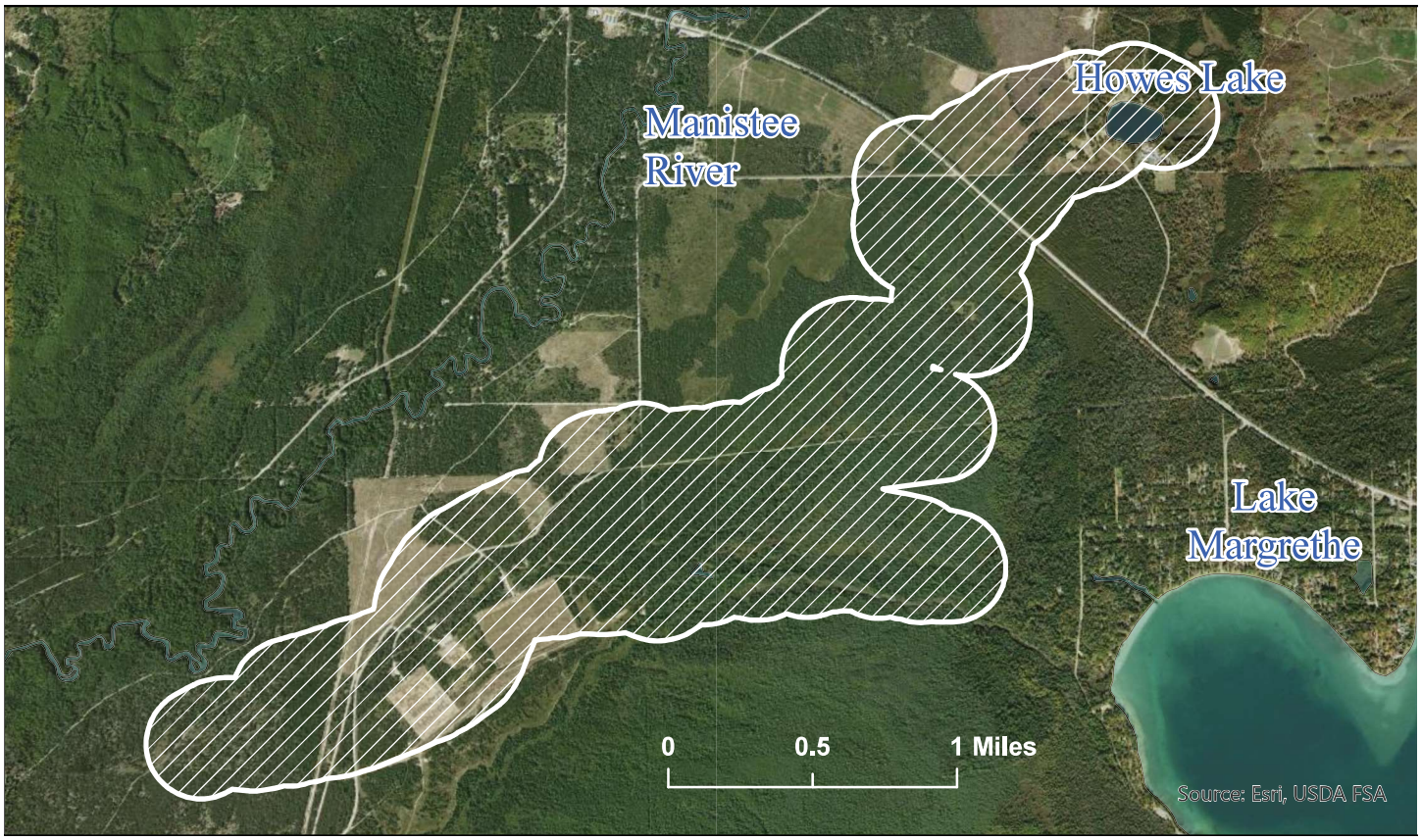
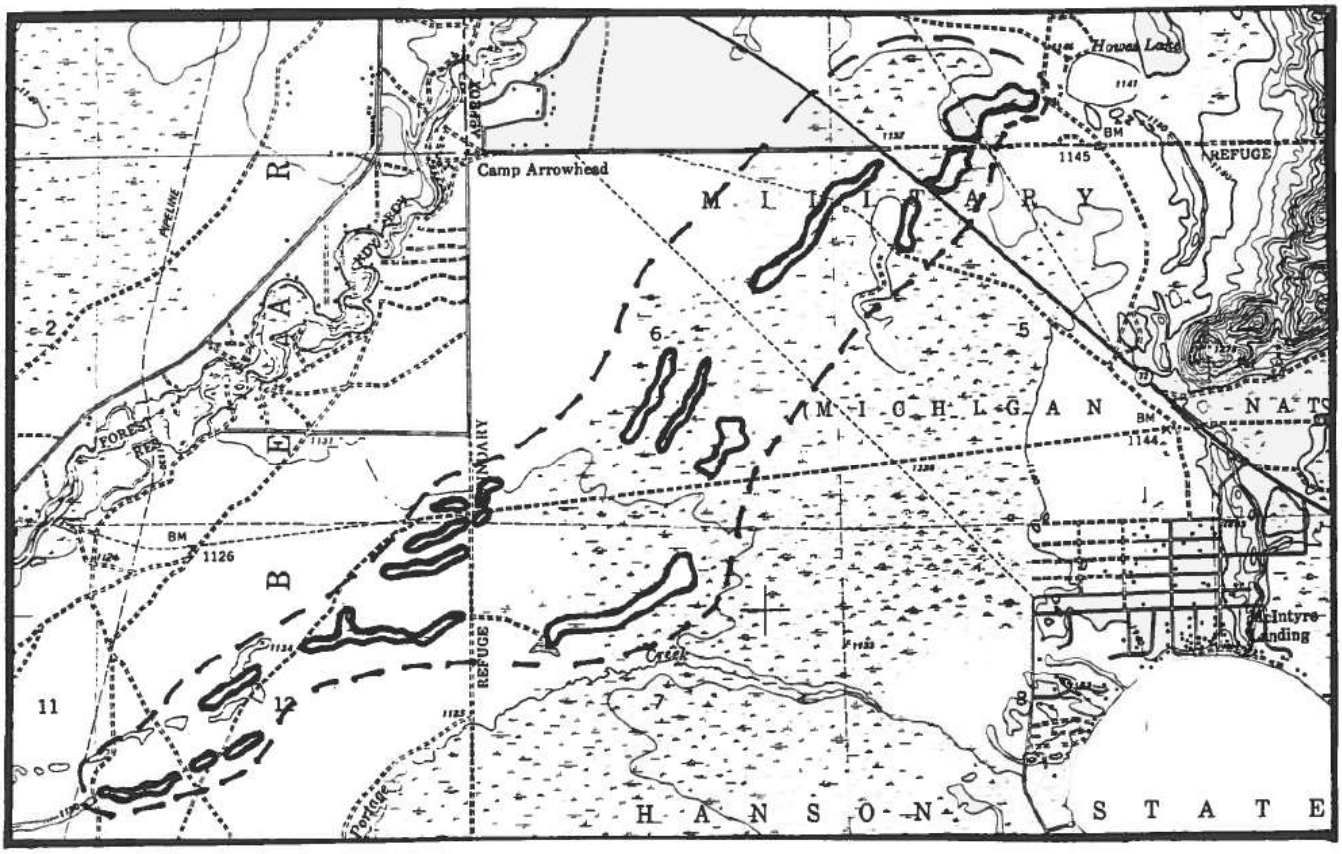


Figure 20. Proposed conservation buffers within the Portage Creek Complex. Buffers of 300 m from natural communities and populations of Voss's goldenrod were delineated to facilitate discussion. Ideally, the entirety of the Portage Creek Complex would be designated as a state Natural Area and managed for ecological integrity. If that designation is not immediately available, we recommend conservation buffers of 300 m around high-quality natural communities between Howes Lake and the gun range. Previous reports have recommended that within proposed buffers, intensive forest management and military training exercises would be avoided. We recommend that within the proposed buffer area, ditches be removed, roads be closed, and forest management focuses on preparing the uplands for prescribed burns and trenching and herbiciding would be prohibited.



Portage Creek-Howes Lake Opportunity Area, South Camp Grayling.
T26N R04W, T27N R04W, T26N R05W (scale 1:32,702)
(dotted line indicates tentative buffer zone)

Given the sensitive hydrological regime primarily responsible for the development of the mesic sand prairie, protection of this landscape should include the establishment of upland buffer areas to prevent further alterations to system hydrology. Intensive forest management and training activities should be excluded from this complex. A buffer zone of 200-300 m around an area encompassing the prairie fragments would likely be sufficient. Although existing roads probably pose little additional threat to the prairie fragments, thought should be given to the possibility of closing Arrowhead Road east of the intersection at M-72. Its use is limited because of frequent wash-outs and it has large Houghton's goldenrod colonies on either margin.

Figure 21. A map from Higman et al. (1994) showing the areas identified as prairie (black line) with a tentative buffer zone (dashed line). The excerpt from the report recommends a buffer around the prairie that would exclude intensive forest management and training activities.

While the conservation value of the site warrants investigating its eligibility for designation as a state Natural Area, the site may not meet criteria because of military leases, permanent roads and easements, and status of mineral rights. In addition, public comment regarding any proposal to limit or reduce access to Howes Lake campground may met with pushback. Given the current challenges for such a designation in Michigan, there may be other protections available to the Portage Creek Complex.

If legal protection of the areas outside of the discrete borders of the natural communities is not feasible, we still suggest considering the above recommendations that would have immediate benefits to the integrity of the system. We recommend that at a minimum, buffers should be established around the natural communities and forest management activities be restricted to site preparation for prescribed burns (Figure 20).

Within the dedicated Natural Area, we suggest eliminating as many roads as possible, repairing the extensive ditching near the gun range and tank trail, and closing Howes Lake Campground. The campground is where Voss's goldenrod was first discovered and the campground has expanded over recent years, destroying critical habitat for this Federally Threatened species. We recommend that the Tank Trail is redirected away from the most environmentally sensitive areas. We also suggest eliminating locally intensive silvicultural practices like clear-cutting, trenching, and application of broadscale herbicide within the boundaries of the Natural Area.

We provide an approximate alternate route for the Tank Trail using an existing network of trails and avoiding sensitive habitats with rare species or ecological restoration potential (Figure 22). The Tank Trail could be redirected north of Howes Lake and then to the southwest where it could continue to the tank bridge over Portage Creek.

Figure 22. Proposed Portage Creek Natural Area. The proposed alternate route for the Tank Trail would serve as the northern boundary for the proposed Natural Area. The southern and eastern boundaries would be composed of existing roads, Portage Creek, and the gun range. The concentration of high-quality natural communities, presence of rare taxa - including two Federally Threatened species - and the numerous threats to the ecological integrity of the landscape make it ideal for designation as a Natural Area. Management objectives would be focused on the promotion of native biodiversity through restoration of hydrology, the application of prescribed fire, treatment of invasive species, and the cessation of intensive silvicultural practices. Michigan is a crucial stronghold for the eastern massasauga rattlesnake and this is one of nine population clusters in the state.

There are nearby records of dusted skipper (*Atrytonopsis hianna*, State Special Concern) and the new route of the Tank Trail would be directed include as much of that habitat as possible within the proposed Natural Area because dusted skipper would benefit from prescribed fire and the protection afforded under designation as a Natural Area. The specific route of the new Tank Trail would need to be more carefully determined by planners using the most recent data for occupancy of Kirtland's warbler which occurs throughout the region.

If the current Tank Trail is decommissioned in favor of the proposed route, it is not immediately obvious how to restore its footprint. The current Tank Trail is very wide and perched above the adjacent wetland with extensive ditches and alters hydrology to an unknown extent. It may be prudent to remove some of the material to lower the trail so that it no longer interrupts hydrology. However, there is a very large amount of material that has been brought to the area to build up the trail and it seems unfeasible to remove all of it. It is also not clear where to prioritize removal and such endeavors will likely require a hydrologist and are beyond the expertise of the authors.

The existing Tank Trail is very wide and if decommissioned, could be narrowed to reduce its footprint within the wetland. It may also be useful to function as a burn break for future burns so it may be advantageous to maintain it to a certain degree, while removing sections to facilitate surface flow of water. The trail would also likely receive extensive ORV use unless measures are put in place to stop them. Numerous invasive species exist along the trail and these would ideally be treated upon its decommission and reduction in size.

The Tank Trail intersects the prairie in numerous locations. Polygon WP-6 is ditched and exposed to ORVs. Such disturbance leaves it vulnerable to invasive species.

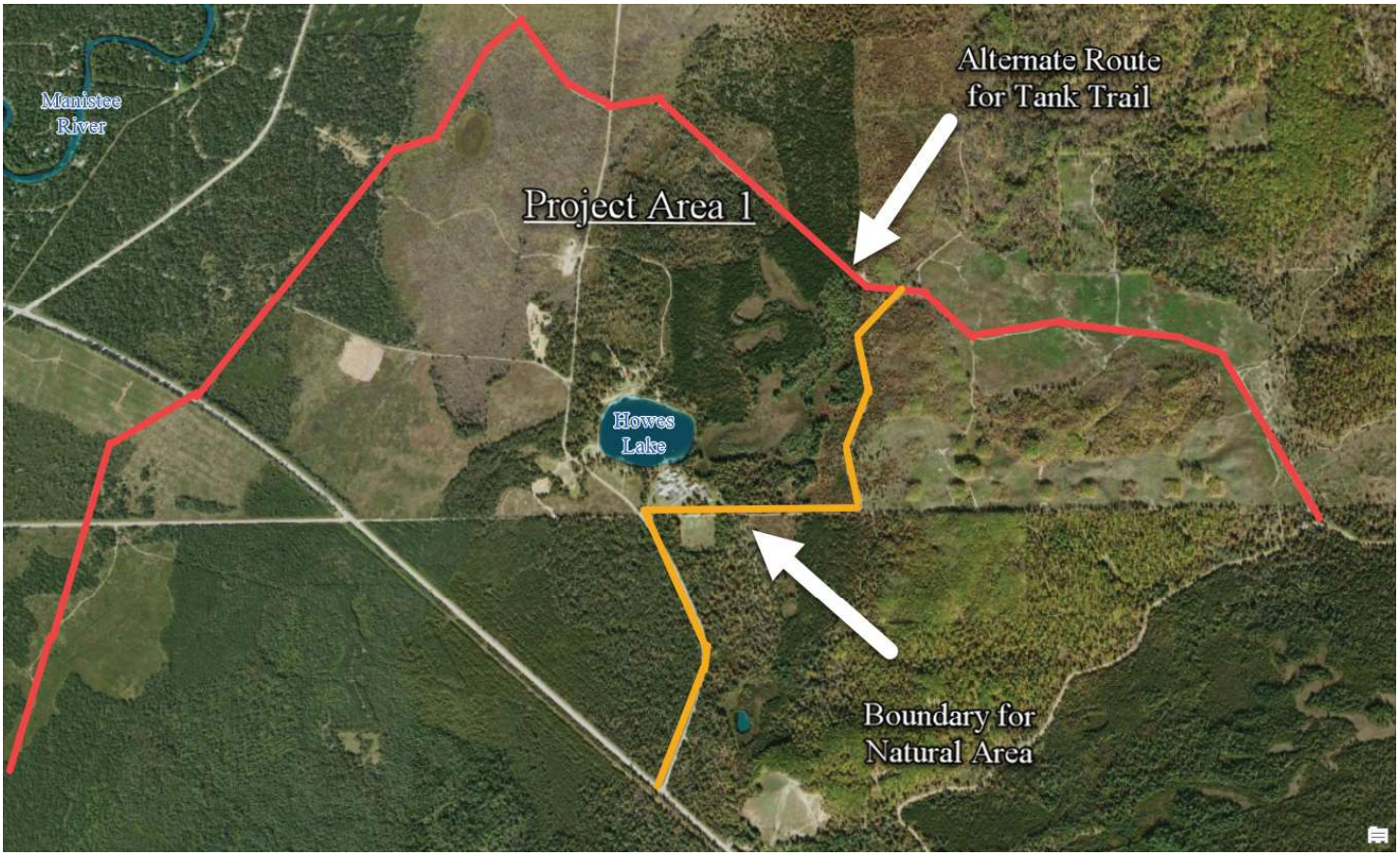


Figure 23. Project Area 1 is located in the area around Howes Lake. Here, the landscape is bisected by numerous roads, fire suppression is promoting tree growth in areas with characteristic prairie vegetation, and the campground at Howes Lake is degrading critical habitat for Voss's goldenrod. The proposed alternate Tank Trail route can function as the northern and western boundary for the proposed Natural Area. Existing roads can function as the eastern boundary of the Natural Area. Highway-72 can function as the southwestern boundary of Project Area 1.

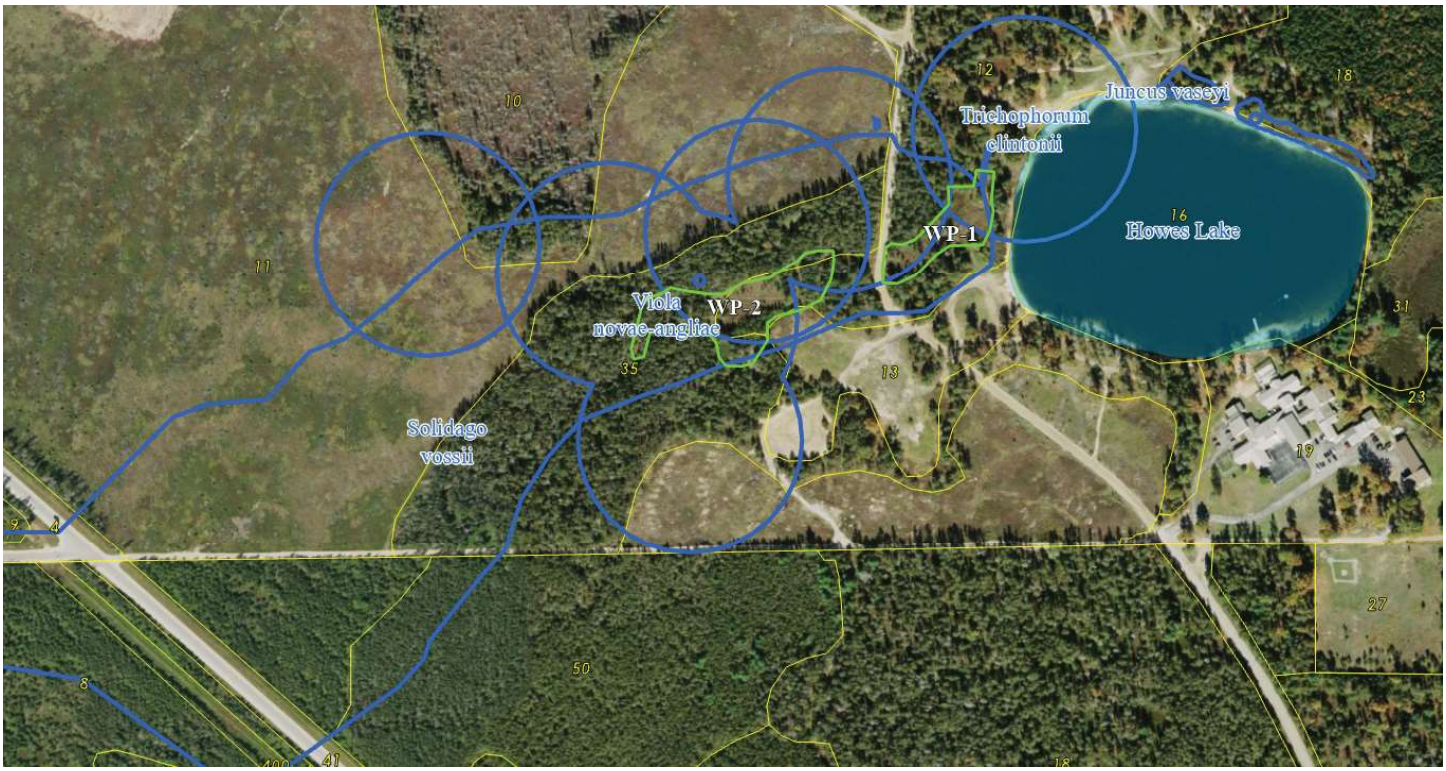


Figure 24. Numerous rare plants have been documented from the Howes Lake Area. Restoration should be prioritized around removing roads, carefully reducing canopy coverage around the prairie openings - especially Stand 35 and returning fire to as large of an area as possible.

The forest surrounding the prairie opening in Stand 35 (WP-2), west of Howes Lake, is especially diverse. The prairie vegetation is in decline and the size of the opening is being reduced by increasing abundance of jack pine. Minimal restoration efforts are necessary to expand the prairie habitat that supports so many rare species. Carefully thinning of this stand in preparation for prescribed fires should be a top priority. We suggest leaving all red pines and the largest jack pines and thinning to a canopy coverage of around 50% to minimize risk of crown fires. Ideally equipment would only be allowed on site when there is sufficient snowpack to prevent disturbance to the soil.

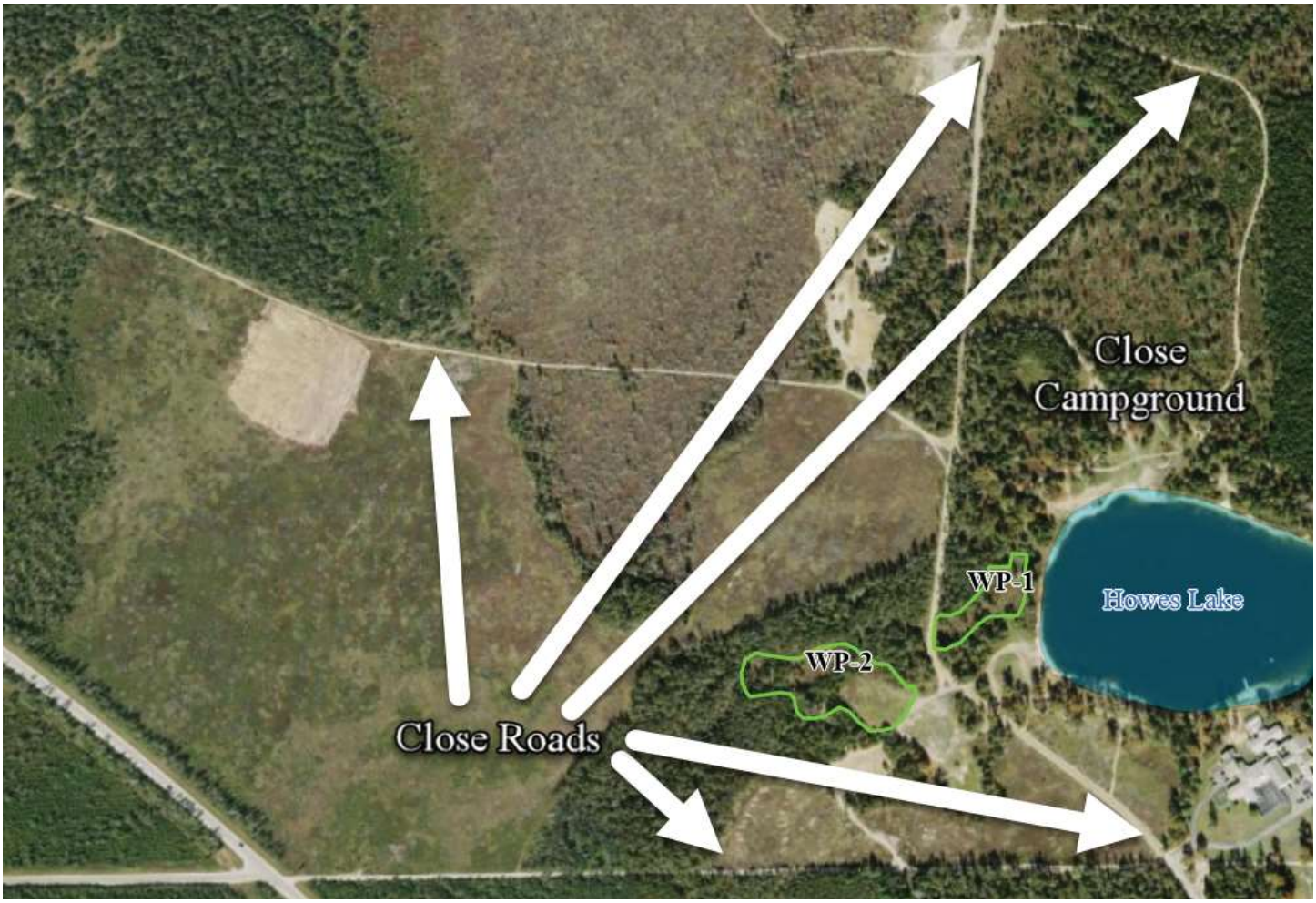


Figure 25. Roads recommended for closure in Project Area 1. The Howes Lake Campground was especially problematic for the goldenrod as people were camping, dumping trash, and defecating in habitat currently and formerly occupied by goldenrod.

Roads are especially damaging to the prairie because they alter the flow of water through ditching and also act as vectors for invasive species, such as spotted knapweed (pictured above).

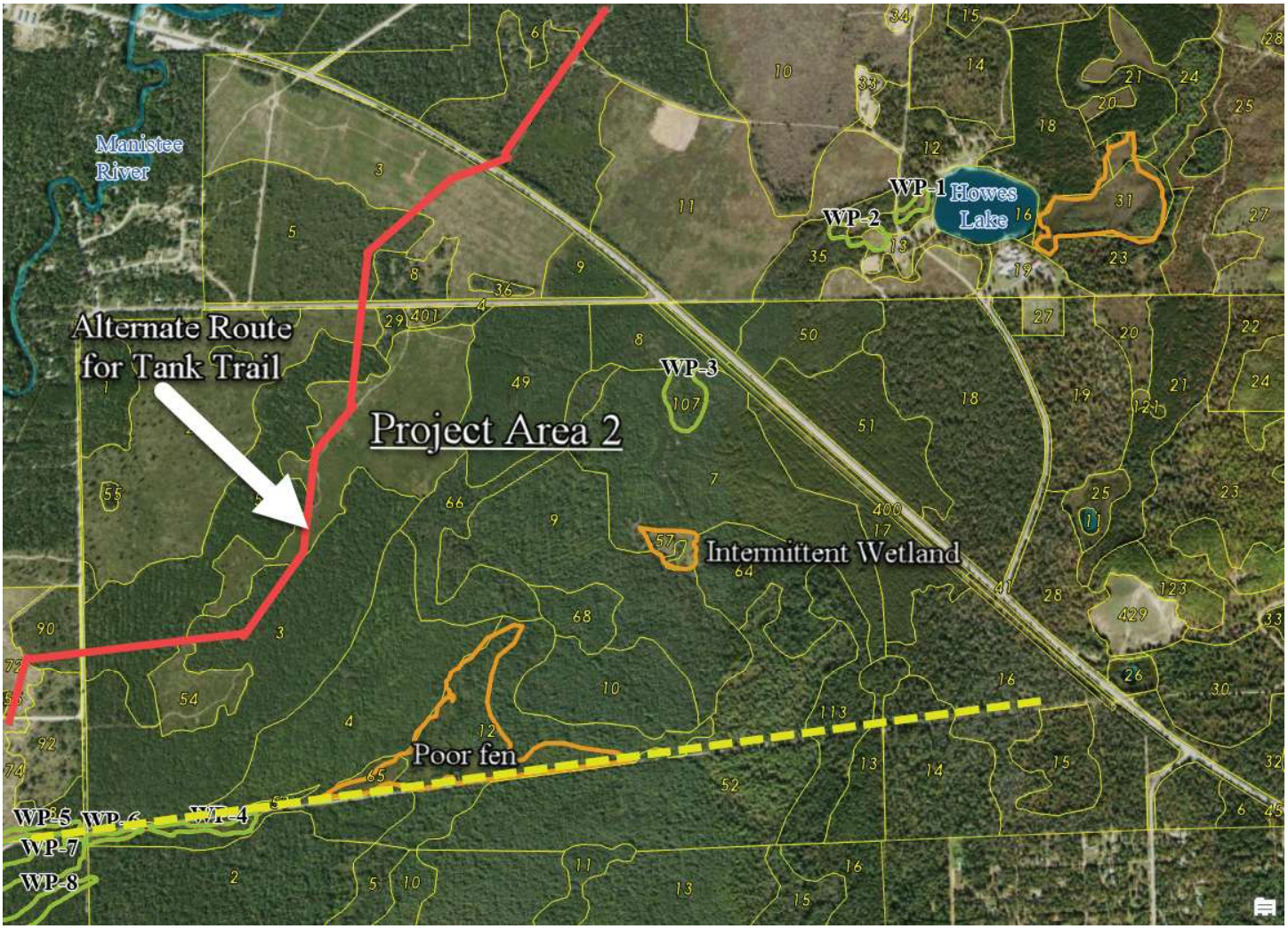


Figure 26. Project Area 2 occurs between Highway-72, the current Tank Trail (yellow dashed line) and the proposed alternate route for the Tank Trail (red).

Portions of Stand 8 in the northern portion of Project Area 2 support an abundance of characteristic prairie vegetation, despite being densely planted with jack pine. This area could be treated with a Fecon forestry mulcher (or similar equipment) when the ground is frozen to thin the trees and prevent crown fires when fire is finally applied.

Stand 9 in Project Area 2 has ideal canopy structure and likely does not need thinning prior to prescribed fire. A high-frequency of low-intensity fires would benefit composition of the forests in the compartment and minimize crowning.

Many forested zones within Project Area 2 have low diversity due to a combination of fire suppression and silvicultural practices of clear-cutting followed by trenching and herbicide. High-frequency application of low-intensity fire is a recommended starting point for restoration. Ideally burns would initially be applied at a rate of 2 to 3 burns per decade and then reevaluated.

Restoration of Hydrology

The maintenance of the gun range and Tank Trail is leading to detrimental ditching that is not conducive to the persistence of the wet-mesic sand prairie on the landscape. The ditching within the prairie, ditching along roads and trails, and the creation of the retention pond north of the gun range appears to be draining the gun range and nearby prairie when the community would otherwise be inundated during the late winter and spring.

Ideally the gun range would be included in the Natural Area, removed, and the footprint restored without supplementing with additional plant species. Even if removing the gun range is not feasible, we recommend consulting an expert to repair the hydrology of the site and focusing on careful removal of the retention pond and the recent ditch in the eastern portion of Stand 79 that runs parallel to the County Line Rd (Figure 28).

Repairing hydrology, particularly the retention pond and the recent ditch in Stand 79 are high restoration priorities but likely mean that the range will be unusable for parts of the spring and early summer. Restoration of the hydrology will need to be undertaken with the utmost care and should involve restoration ecologists familiar with systems as sensitive as prairies. Hydrological restoration should prioritize the prevention of any further impacts to the prairie, including the addition of species through plantings.

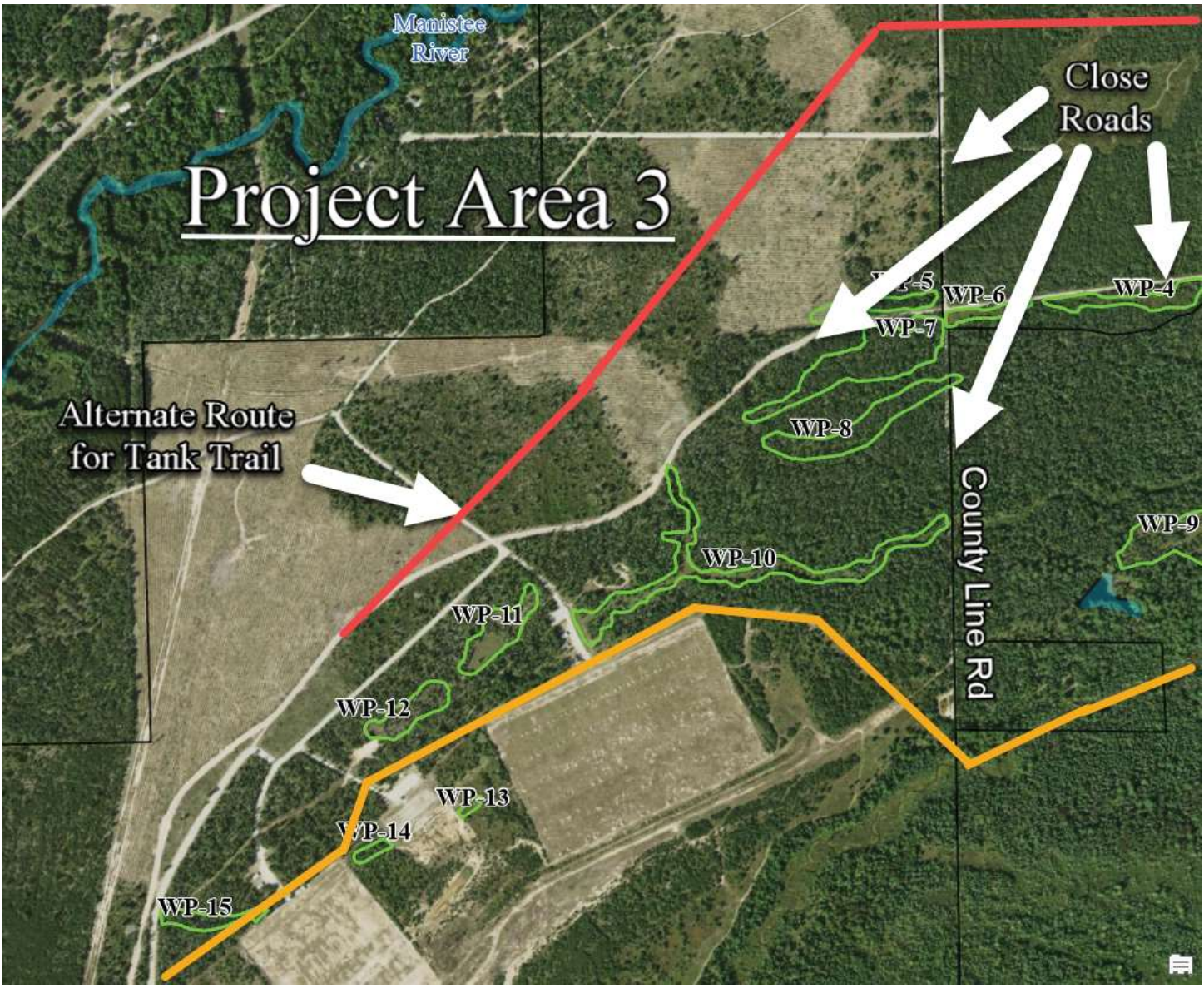


Figure 27. Project Area 3 occurs between County Line Rd, the proposed alternate route for the Tank Trail (red), and the southern boundary along the gun range (orange). This area has a concentration of prairie openings and extensive ditches that will need to be addressed.

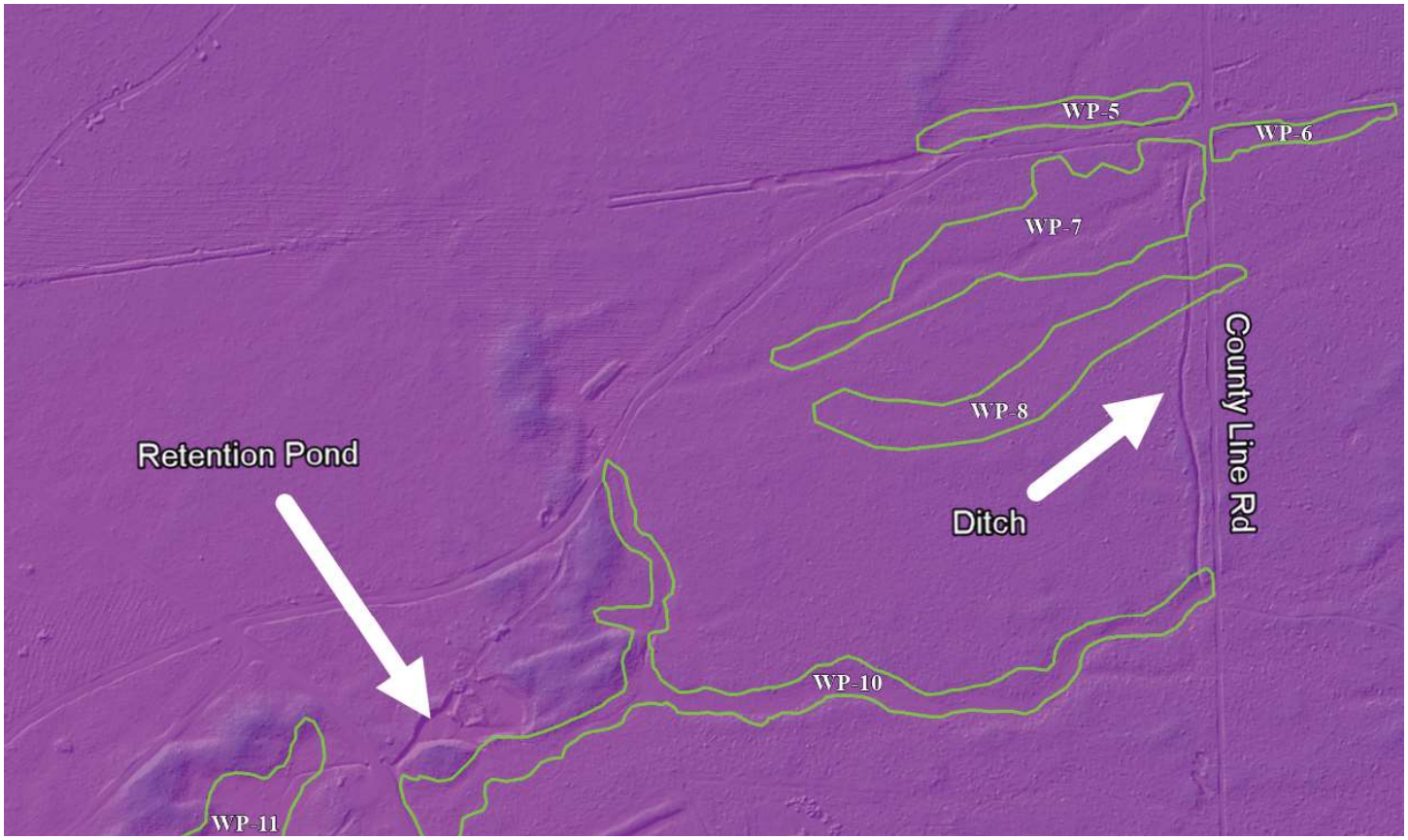


Figure 28. LiDAR imagery showing damage to the prairie through deliberate alterations to hydrology, particularly a recent ditch (white arrow) along County Line Rd and the disruption caused by the retention pond.

The most recent ditch created as part of an effort to drain the gun range. This occurs in eastern Stand 79, parallel to County Line Rd.

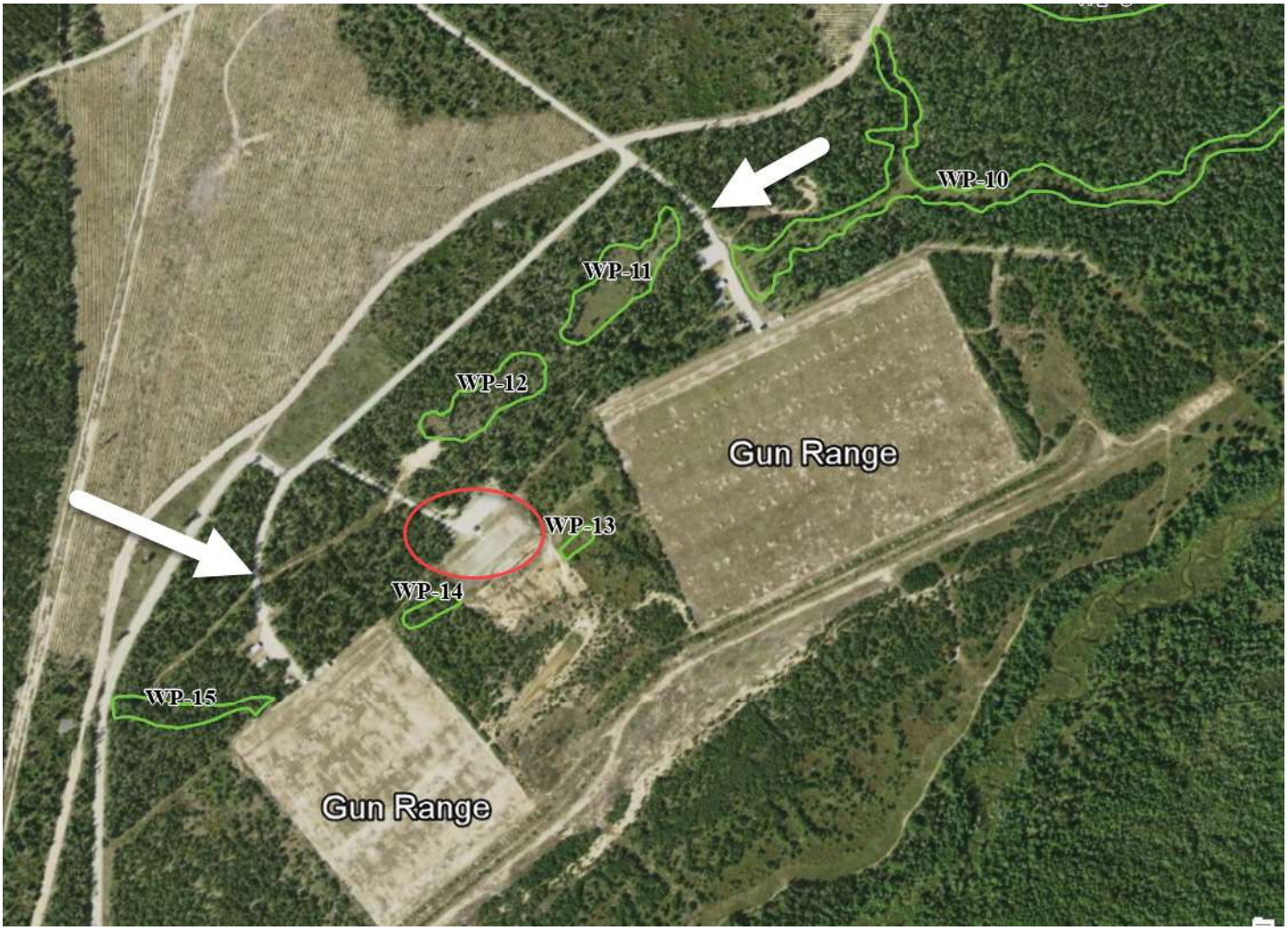


Figure 29. Construction of the gun range resulted in the destruction of prairie habitat. Some infrastructure around the gun range could be modified to mitigate impacts to the prairie. We suggest minimizing roads, especially those that most significantly impact hydrology (white arrows) and creating a central parking area (red circle). Gun range users can park in the central area and walk to the nearby ranges. Removing the roads, ditches, and eastern parking lot would improve connectivity and hydrology of the prairie could be partially repaired. Walking trails from the parking area could function as permanent burn breaks. Mitigating impacts and reversing damages to hydrology of the prairie should be a top priority.

Currently the gun range extends into the prairie. A subtle ditch drains the parking area and the gun range and feeds it into the retention pond.

Reintroduce Landscape-Scale Fire

Historic fire frequencies that shaped and maintained this system were likely highly variable, depending on drought cycles and human occupancy. Because water levels are generally high in the spring and early summer, fires likely primarily occurred in the fall. Fires were generally high frequency and low intensity with stand-replacing fires occurring at longer intervals, possibly corresponding to prolonged periods of intense drought. The entire landscape is fire suppressed with minimal fires prescribed and wildfires tending to be infrequent, catastrophic, stand-replacing fires, as was the case with the 2011 Howes Lake Fire. We recommend implementation of low-intensity maintenance burns occurring at a high frequency as would have been characteristic of the landscape prior to European colonization. This approach will be beneficial to the natural communities and reduce the severity of wildfires when they occur.

As part of the effort to reintroduce fire to the landscape, we suggest the development of permanent project boundaries using existing features such as roads, trails, and Portage Creek that can act as burn breaks to facilitate burning across ecotones and avoid creating new burn breaks near wet-mesic sand prairie and poor fen. High frequency of burning can reduce the shrub layer and provide suitable establishment and growing conditions for Voss's goldenrod and other rare species. Actions to suppress smoke following the fire should be minimal and preventing equipment from crossing sensitive soils should be prioritized to protect the prairie.

Fire suppression has likely caused a somewhat higher stand density than was historically common. The accrual of coarse woody debris and abundant ladder fuels associated with protracted fire suppression pose a serious risk of prescribed fires leading to crowning, especially in the context of the high flammability of jack pine. Therefore, the first burns should be low intensity, applied late in the season (October or November), and occur on a high-humidity day. The burns should minimize crown mortality and reduce heavy, down fuels.

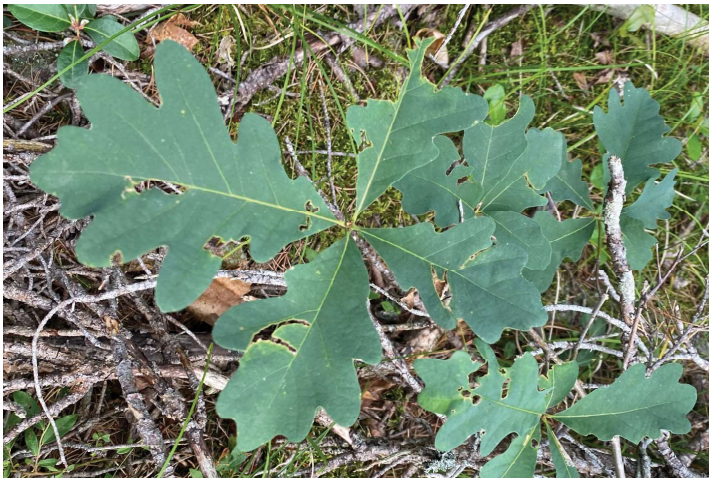
We recommend application of burns in a method that minimizes harm to populations of rattlesnakes. Dividing the Portage Creek Complex into project areas is a way to avoid minimizing impacts to the entire area in a single season. Leave refugia, use slow/incomplete burns, and avoid rattlesnake emergence periods to reduce potential impacts to the snakes.

Howes Lake Fire in 2011 was caused by lightning and was an intense, stand-replacing fire. Ideally, prescribed fires in the Natural Area would be low-intensity and high-frequency; have minimal impact on canopy composition; and serve to prevent catastrophic fires like the Howes Lake fire by consuming downed wood and ladder fuels.

Effects of fire will need to be carefully monitored and plans should be adjusted based on the response of vegetation and rare species. Because fire affects the plant species that are growing at the time of application, varying the timing of the fires will need to be carefully considered. The exact seasonality, frequency, and conditions under which burns take place should be continually evaluated by local experts familiar with the site and the rare species that occupy it.

To prevent crown fires, ladder fuels will likely need to be reduced and some mechanical harvest may be necessary in the most densely forested areas before implementing the first prescribed burn. Stands 84 and 33 in Compartment 61129, Stand 2 in Compartment 72182, and Stands 9 and 10 in Compartment 72181 were scheduled to be cut but the timber harvests were paused pending the results of this report. We believe that Stands 9 and 10 are at sufficiently low densities that they will not pose a substantial risk of crown fires when prescribed fire is applied, especially if initial fires are low intensity. Stands 84, 33, and 2 will likely require some canopy reduction to limit risk of crown fires. Mechanical restoration activities should be conducted in winter with snowpack to reduce impacts on hydric soils. Prior to implementation of prescribed fire, in these stands we recommend reducing the canopy to around 50% coverage to prevent crowning and to encourage heterogenous light availability to support ground layer plant diversity.

During the process of tree removal, we suggest that all white oak and red pine be retained in all strata to promote canopy species that are more resilient to high-frequency fire. We also suggest that white pine and northern pin oak over 15” diameter be retained. After initial burns, follow-up burns can vary in frequency to allow for white and red pine to reestablish.



Though relatively infrequent, white oaks occur throughout the Portage Creek Complex, including canopy trees in western Stand 15 (Compartment 72182). This species is more tolerant of high-frequency fire than pin oak and should be retained in all forest strata to encourage a landscape more resilient to frequent fire.

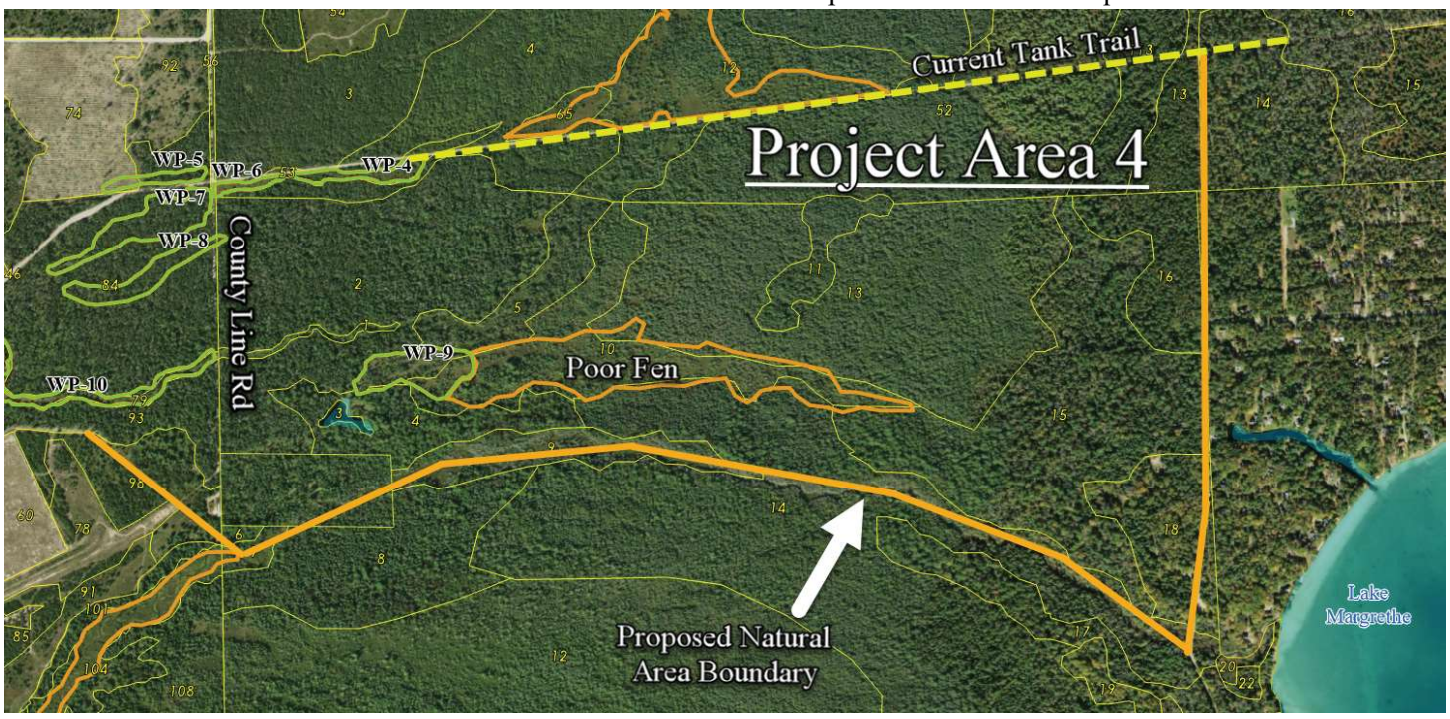
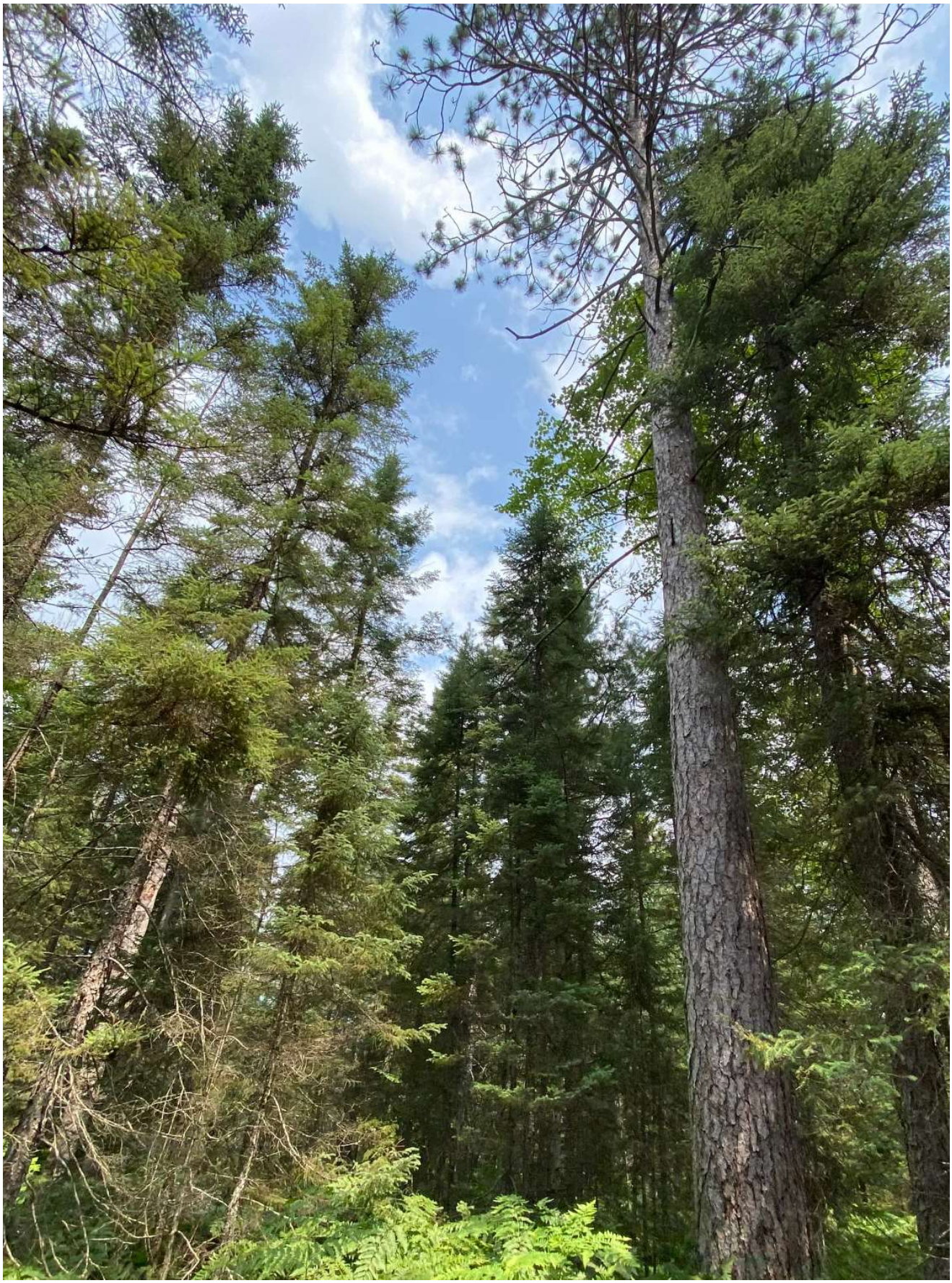


Figure 30. Project Area 4 within the proposed Portage Creek Natural Area. We propose using Portage Creek as the southern boundary, County Line Rd as the western boundary, the current Tank Trail as the northern boundary, and a small road as the eastern boundary for this Project Area. Many of the trees in the poor fen have fire scars and ideally fire would be returned to this area, using the proposed boundaries as burn breaks to eliminate the need to develop new burn breaks. Fire would be focused in the prairie zones. The forest in Stand 2 has been targeted for harvest. We recommend a harvest that will prepare the stand for prescribed fire but keep portions of the canopy intact. We suggest leaving all red pines and white oaks in all strata. We suggest keeping the largest white pine and pin oak and thinning the canopy to around 50% coverage and avoiding equipment on saturated soils. Fire return interval should be approximately 2 to 3 burns per decade and prescribed fire would ideally be applied in the fall during high humidity conditions, at least for the initial burns. Effectiveness of burn timing, frequency, and intensity can be reevaluated after the initial burns are implemented.



Stand 15 in Compartment 72182 has some large red and white pine and a few canopy white oak were observed here but nowhere else. One 53.8 cm dbh red pine was aged to 110 years old. This stand borders the poor fen and is one of the forests in the area that most closely reflects the description of historic notes. We recommend avoiding timber harvest in this stand but including it in prescribed burns within Project Area 4 (Figure 30), using Portage Creek as a burn break.

Portage Creek is wide enough that it should be able to function as a natural burn break without the need to create additional burn lines within Project Area 4 (Figure 30).

The prairie opening above is in Stand 79 and the forest on the right is Stand 84, which is targeted for harvest. Current silvicultural practices favor clear-cuts followed by trenching and herbicide application. This approach is degrading prairie remnants. However, the application of prescribed fire would likely cause catastrophic fire in the forest. Therefore, we suggest a silvicultural approach that only slightly reduces canopy coverage and reduce ladder fuels to minimize risk of crown fires. Red pine and white oak are rare on the landscape but ideally all red pines and white oaks would be retained in all forest strata. The largest canopy white pines and pin oaks would also ideally be retained. Jack pine would be the primary species harvested with a target canopy coverage of around 50%. This would be done during snowpack to reduce impacts to saturated soils. The application of prescribed fire in concert with reduction of canopy coverage would increase the coverage and resiliency of characteristic prairie vegetation in the uplands. This approach favors a diversity of native vegetation and also promotes habitat for the massasauga rattlesnake.

Leafy spurge is a major problem in Stand 79 near the gun range. Treatment should be a top priority.

Control of Invasive Species

Invasive species are locally problematic for the wet-mesic sand prairie. Bluegrass (*Poa compressa*) occurs throughout the prairie but treatment may not be possible as herbicide application to such a small and ubiquitous plant would pose a substantial risk to nearby native vegetation. We do recommend the treatment of leafy spurge (Compartment 61129; Stands 33 [WP-11] and especially 79 [WP-10]; Figure 31). Treatment will require careful application of herbicide by individuals familiar with prairies and native vegetation to avoid collateral damage of native species, including rare species.

Additional invasive species can be opportunistically treated along roads, gun range parking lots, and along the Tank Trail near zones of mapped prairie and fen. We discourage supplementing species composition by planting additional species because doing so jeopardizes the site's status as a valuable reference area.

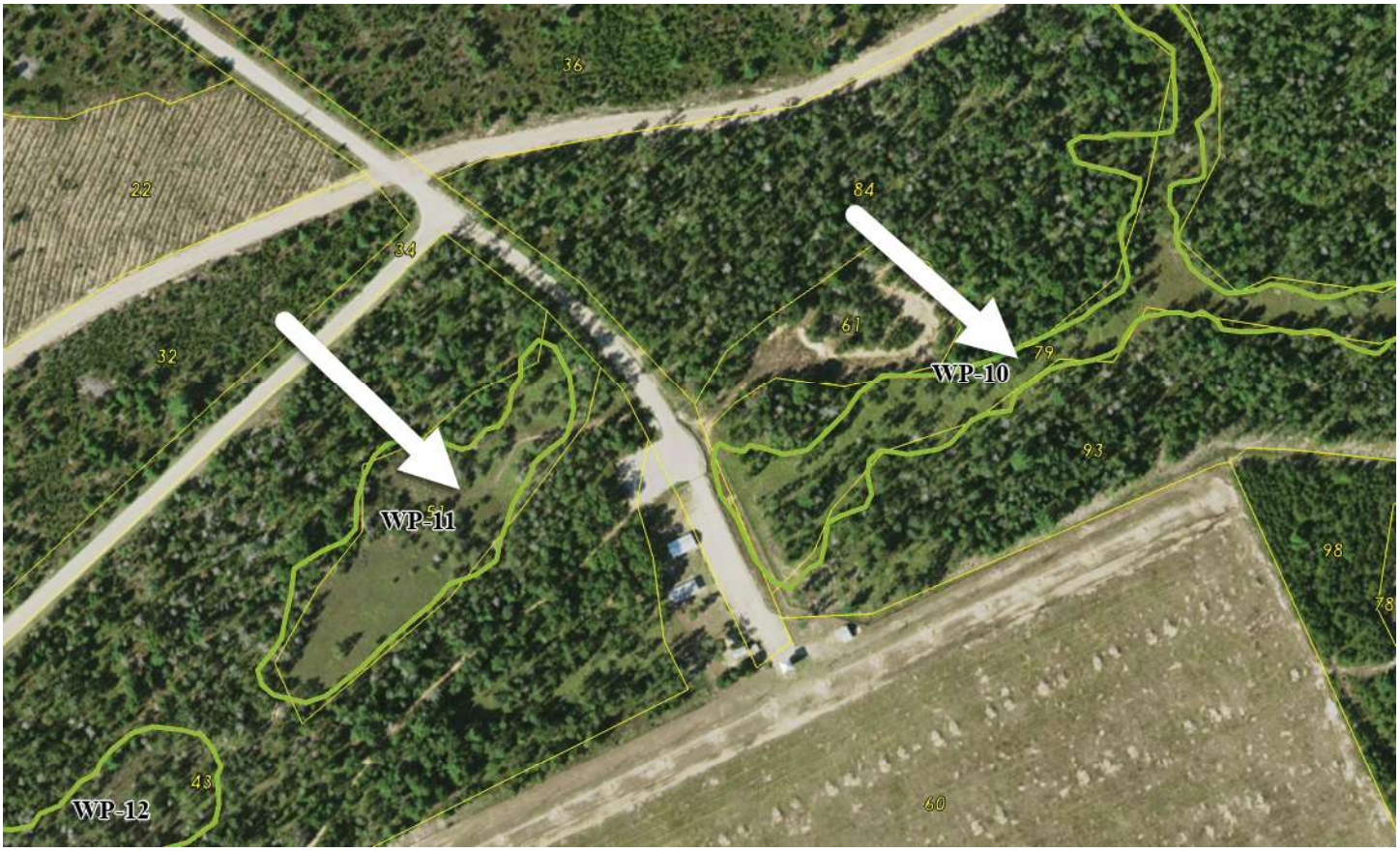


Figure 31. White arrows indicating approximate locations of leafy spurge infestations in the prairie openings adjacent to the gun range.

Conclusions

The Portage Creek Complex has long been recognized as a special place. The site was initially evaluated by MNFI conservation scientists because of the presence of the rare goldenrod around Howes Lake. Thorough surveys conducted by Mike Penskar, Pat Comer, and Phyllis Higman resulted in the recognition of a unique prairie ecosystem (Higman et al 1994). Later surveys by Bradford Slaughter, Michael Kost, and Joshua Cohen expanded the understanding of the wet-mesic sand prairie and continually reiterated the ecological significance of the site and the pressing need for biodiversity stewardship. Reports generated by previous surveys were critical for this summary following the 2021 evaluation of the Portage Creek Complex.

The Portage Creek Complex contains the only documented wet-mesic sand prairie on state forest land that qualifies as an Ecological Reference Area. This natural community is rare both globally and in Michigan, with only 13 occurrences in the state. The site features concentrations of rare taxa; including the Federally Threatened massasauga rattlesnake and the Federally Threatened Voss's goldenrod, which exists nowhere else in the world. The Portage Creek Complex is one of the most important conservation sites in Camp Grayling. However, it is still facing serious threats from ditching, fire suppression, silvicultural practices, and roads. Because of the conservation value of the site, we recommend in the strongest terms that this site should be set aside as a Natural Area. Additionally, because the site was maintained for millennia by Indigenous peoples, the state and military base should participate in a thoughtful engagement with regional tribes to understand indigenous cultural burning practices that allowed the natural communities and numerous rare species to flourish.

Without swift, substantial, and sustained intervention, this site will continue on its current trajectory of degradation, ultimately featuring a high rate of local plant extinctions and the continued decline of ecological integrity. Implementation of the recommended stewardship activities will protect the unique native biodiversity within this site and ensure that it remains a valuable Ecological Reference Area.

Ditching has occurred within the prairie and damaged populations of the Federally Threatened Voss's goldenrod. The ditching within the prairie and adjacent landscape to accommodate the gun range and Tank Trail poses a substantial threat to the long-term viability of the prairie and populations of rare species within. This is one of the most important conservation sites in the Northern Lower Peninsula and home to the only population of the endemic goldenrod. It is facing serious decline but it is not too late to correct the course. Swift, substantial, and sustained stewardship action is required to maintain this site as an Ecological Reference Area. Photo by Joshua G. Cohen; Compartment 61129, Stand 79 (WP-10).

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Appendix

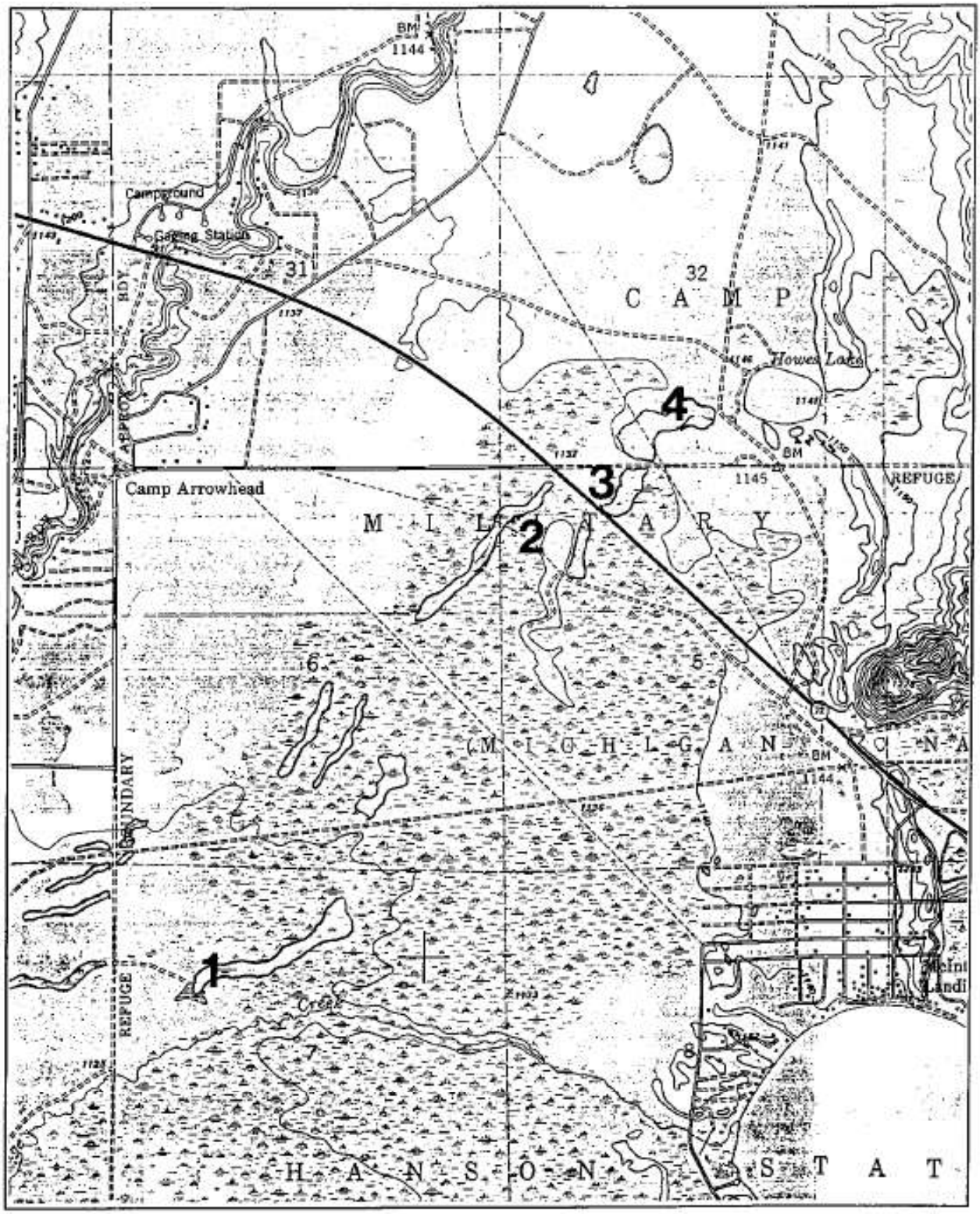

Figure 1. Houghton's goldenrod monitoring sites established within Camp Grayling Military Reservation. Site 1: Portage Creek, site 2: M-72 South, site 3: M-72, site 4: Howe's Lake.

A figure from Penskar and Comer (1995) showing concentrations of Voss's goldenrod (Houghton's) at that time. Much of the habitat around zones 2 and 3 appears to be no longer occupied due to silvicultural practices.

Table 3a. 2021 Species list for Portage Creek Wet-Mesic Sand Prairie.

Common Name	Scientific Name	Acronym	Native?	C	W	Abundance
red maple	*Acer rubrum*	ACERUB	native	1	0	U
ticklegrass	*Agrostis scabra*	AGRSCA	native	4	0	O
speckled alder	*Alnus incana*	ALNINC	native	5	-3	LA
big bluestem	*Andropogon gerardii*	ANDGER	native	5	0	C/LD
white camas	*Anticlea elegans*	ANTELE	native	10	-3	O
bearberry	*Arctostaphylos uva-ursi*	ARCUVA	native	8	5	O
chokeberry	*Aronia prunifolia*	AROPRU	native	5	-3	U
swamp milkweed	*Asclepias incarnata*	ASCINC	native	6	-5	U
common milkweed	*Asclepias syriaca*	ASCSYR	native	1	5	LA
hair grass	*Avenella flexuosa*	AVEFLE	native	6	5	LA/U
prairie brome	*Bromus kalmii*	BROKAL	native	8	0	O/C
blue-joint	*Calamagrostis canadensis*	CALCAN	native	3	-5	LD/O
harebell	*Campanula rotundifolia*	CAMROT	native	6	3	U
sedge	*Carex buxbaumii*	CXBUXB	native	10	-5	U
sedge	*Carex castanea*	CXCAST	native	6	-3	O
sedge	*Carex flava*	CXFLAV	native	4	-5	C
sedge	*Carex granularis*	CXGRAN	native	2	-3	LA
sedge	*Carex pellita*	CXPELL	native	2	-5	U
sedge	*Carex pensylvanica*	CXPENS	native	4	5	LA
indian paintbrush	*Castilleja coccinea*	CASCOC	native	8	0	R
new jersey tea	*Ceanothus americanus*	CEAAME	native	8	5	R
spotted knapweed	***Centaurea stoebe***	**CENSTO**	**non-native**	**0**	**5**	**LA**
leatherleaf	*Chamaedaphne calyculata*	CHACAL	native	8	-5	LD/O
hills thistle (state special concern)	*Cirsium hillii*	CIRHIL	native	8	5	R
wild-basil	*Clinopodium vulgare*	CLIVUL	native	3	5	U
bastard-toadflax	*Comandra umbellata*	COMUMB	native	5	3	O
sweetfern	*Comptonia peregrina*	COMPER	native	6	5	C/LD
horseweed	*Conyza canadensis*	CONCAN	native	0	3	LA
sand coreopsis	*Coreopsis lanceolata*	CORLAN	native	8	3	U
poverty grass; oatgrass	*Danthonia spicata*	DANSPI	native	4	5	LA/C
shrubby cinquefoil	*Dasiphora fruticosa*	DASFRU	native	8	-3	O/LC
hair grass	*Deschampsia cespitosa*	DESCES	native	9	-3	C
northern panic grass	*Dichanthelium boreale*	DICBOR	native	7	0	C
panic grass	*Dichanthelium implicatum*	DICIMP	native	3	0	C
panic grass	*Dichanthelium lindheimeri*	DICLID	native	8	-5	LA
mat panic grass	*Dichanthelium meridionale*	DICMER	native	7	5	LA
slender wheatgrass	*Elymus trachycaulus*	ELYTRA	native	8	3	C
smooth scouring rush	*Equisetum laevigatum*	EQULAE	native	2	-3	U
lace grass	*Eragrostis capillaris*	ERACAP	native	4	5	R
daisy fleabane	*Erigeron strigosus*	ERISTR	native	4	3	R
leafy spurge	***Euphorbia virgata***	**EUPVIR**	**non-native**	**0**	**5**	**LD/O**
grass-leaved goldenrod	*Euthamia graminifolia*	EUTGRA	native	3	0	O
wild strawberry	*Fragaria virginiana*	FRAVIR	native	2	3	U
kalms hawkweed	*Hieracium kalmii*	HIEKAL	native	3	5	R
rattlesnake-weed	*Hieracium venosum*	HIEVEN	native	6	5	R
long-leaved bluets	*Houstonia longifolia*	HOULON	native	6	5	U
kalms st. johns-wort	*Hypericum kalmianum*	HYPKAL	native	10	-3	LA
common st. johns-wort	***Hypericum perforatum***	**HYPPER**	**non-native**	**0**	**5**	**LA**
wild blue flag	*Iris versicolor*	IRIVER	native	5	-5	U
greenes rush	*Juncus greenei*	JUNGRE	native	7	0	R
sheep-laurel	*Kalmia angustifolia*	KALANG	native	7	0	LA/U
dwarf dandelion	*Krigia virginica*	KRIVIR	native	4	5	R
tamarack	*Larix laricina*	LARLAR	native	5	-3	R
northern blazing-star	*Liatris scariosa*	LIASCA	native	5	5	R

Table 3b. 2021 Species list for Portage Creek Wet-Mesic Sand Prairie, continued.

Common Name	Scientific Name	Acronym	Native?	C	W	Abundance
cardinal-flower	*Lobelia cardinalis*	LOBCAR	native	7	-5	O
pale spiked lobelia	*Lobelia spicata*	LOBSPI	native	4	0	O
common water horehound	*Lycopus americanus*	LYCAME	native	2	-5	O
canada mayflower	*Maianthemum canadense*	MAICAN	native	4	3	LA/U
cow-wheat	*Melampyrum lineare*	MELLIN	native	6	3	O
white sweet-clover	***Melilotus albus***	**MELALB**	**non-native**	**0**	**3**	**R**
wild mint	*Mentha canadensis*	MENCAS	native	3	-3	LA/U
rock sandwort	*Minuartia michauxii*	MINMIC	native	10	5	R
wild-bergamot	*Monarda fistulosa*	MONFIS	native	2	3	O
marsh wild-timothy	*Muhlenbergia glomerata*	MUHGLO	native	10	-5	R
leafy satin grass	*Muhlenbergia mexicana*	MUHMEX	native	3	-3	R
small sundrops	*Oenothera perennis*	OENPER	native	5	0	C
sensitive fern	*Onoclea sensibilis*	ONOSEN	native	2	-3	U
golden ragwort	*Packera aurea*	PACAUR	native	5	-3	O
switch grass	*Panicum virgatum*	PANVIR	native	4	0	LD/O
black spruce	*Picea mariana*	PICMAR	native	6	-3	LO
jack pine	*Pinus banksiana*	PINBAN	native	5	3	C
white pine	*Pinus strobus*	PINSTR	native	3	3	U
canada bluegrass	***Poa compressa***	**POACOM**	**non-native**	**0**	**3**	**LA**
old-field cinquefoil	*Potentilla simplex*	POTSIM	native	2	3	O
self-heal	*Prunella vulgaris*	PRUVUL	native	0	0	O
sand cherry	*Prunus pumila*	PRUPUM	native	8	5	C
choke cherry	*Prunus virginiana*	PRUVIR	native	2	3	R
bracken fern	*Pteridium aquilinum*	PTEAQU	native	0	3	LD/O
alder-leaved buckthorn	*Rhamnus alnifolia*	RHAALN	native	8	-5	U
pasture rose	*Rosa carolina*	ROSCAR	native	4	3	U
dwarf raspberry	*Rubus pubescens*	RUBPUB	native	4	-3	O
sandbar willow	*Salix exigua*	SALEXI	native	1	-3	O
prairie willow	*Salix humilis*	SALHUM	native	4	3	O
false melic	*Schizachne purpurascens*	SCHPUP	native	5	3	LA/O
little bluestem	*Schizachyrium scoparium*	SCHSCO	native	5	3	O
mountain blue-eyed-grass	*Sisyrinchium montanum*	SISMON	native	4	0	U
late goldenrod	*Solidago gigantea*	SOLCAN	native	3	-3	O
rough-leaved goldenrod	*Solidago rugosa*	SOLRUG	native	3	0	C
gillmans goldenrod	*Solidago simplex*	SOLSIM	native	10	3	U
bog goldenrod	*Solidago uliginosa*	SOLULI	native	4	-5	R
Voss' goldenrod (Federally Threatened)	*Solidago vossii; s. houghtonii*	SOLVOS	native	10	-3	LA
meadowsweet	*Spiraea alba*	SPIALB	native	4	-3	O
slender ladies-tresses	*Spiranthes lacera*	SPILAC	native	8	0	R
prairie dropseed (State Special Concern)	*Sporobolus heterolepis*	SPOHET	native	10	3	LD/U
northern heart-leaved aster	*Symphyotrichum ciliolatum*	SYMCIO	native	4	5	U
calico aster	*Symphyotrichum lateriflorum*	SYMLAT	native	2	0	U
purple meadow-rue	*Thalictrum dasycarpum*	THADAS	native	3	-3	U
marsh fern	*Thelypteris palustris*	THEPAL	native	2	-3	U
Clinton's bulrush (State Special Concern)	*Trichophorum clintonii*	TRICLI	native	10	3	LU/R
low sweet blueberry	*Vaccinium angustifolium*	VACANG	native	4	3	C

Table 4. 2021 Conservation metrics for Portage Creek Wet-Mesic Sand Prairie.

Portage Creek wet-mesic sand prairie - Camp Grayling July 27 - 31, 2021

Conservatism-Based Metrics:

Total Mean C:	4.7
Native Mean C:	5
Total FQI:	47.9
Native FQI:	49.7
Adjusted FQI:	48.8
% C value 0:	7.7
% C value 1-3:	24
% C value 4-6:	40
% C value 7-10:	28
Native Tree Mean C:	4.8
Native Shrub Mean C:	5.8
Native Herbaceous Mean C:	5

Species Richness:

Total Species:	100	
Native Species:	95	95%
Non-native Species:	5	5%

Species Wetness:

Mean Wetness:	0.6
Native Mean Wetness:	0.4

Physiognomy Metrics:

Tree:	4	4%
Shrub:	18	18%
Vine:	0	0%
Forb:	45	45%
Grass:	21	21%
Sedge:	7	7%
Rush:	1	1%
Fern:	4	4%
Bryophyte:	0	0%

Duration Metrics:

Annual:	4	4%
Perennial:	93	93%
Biennial:	3	3%
Native Annual:	4	4%
Native Perennial:	90	90%
Native Biennial:	1	1%

Table 5a. 2005 Species list for Portage Creek Wet-Mesic Sand Prairie.

ACRONYM	C	SCIENTIFIC NAME	W	WETNESS	PHYSIOGNOMY	COMMON NAME
AGRREP	0	*AGROPYRON REPENS*	3	FACU	Ad P-Grass	QUACK GRASS
AGRTRA	8	*Agropyron trachycaulum*	0	FAC	Nt P-Grass	SLENDER WHEAT GRASS
AGRHYE	4	*Agrostis hyemalis*	1	FAC-	Nt P-Grass	TICKLEGRASS
ALNRUG	5	*Alnus rugosa*	-5	OBL	Nt Shrub	TAG ALDER
ANDGER	5	*Andropogon gerardii*	1	FAC-	Nt P-Grass	BIG BLUESTEM
ANDSCO	5	*Andropogon scoparius*	3	FACU	Nt P-Grass	LITTLE BLUESTEM GRASS
AROPRU	5	*Aronia prunifolia*	-3	FACW	Nt Shrub	BLACK CHOKEBERRY
ASCINC	6	*Asclepias incarnata*	-5	OBL	Nt P-Forb	SWAMP MILKWEED
ASTBOR	9	*Aster borealis*	-5	OBL	Nt P-Forb	NORTHERN BOG ASTER
ASTLAT	2	*Aster lateriflorus*	-2	FACW-	Nt P-Forb	SIDE FLOWERING ASTER
ASTLON	9	*Aster longifolius*	-2	FACW-	Nt P-Forb	LONG LEAVED ASTER
ASTSAG	2	*Aster sagittifolius*	5	UPL	Nt P-Forb	ARROW LEAVED ASTER
ASTUMB	5	*Aster umbellatus*	-3	FACW	Nt P-Forb	TALL FLAT TOP WHITE ASTER
BROCIL	6	*Bromus ciliatus*	-3	FACW	Nt P-Grass	FRINGED BROME
BROPUB	5	*Bromus pubescens*	3	FACU	Nt P-Grass	CANADA BROME
CALCAN	3	*Calamagrostis canadensis*	-5	OBL	Nt P-Grass	BLUE JOINT GRASS
CAMPER	0	*CAMPANULA PERSICIFOLIA*	5	UPL	Ad P-Forb	WILLOW HAREBELL
CAMROT	6	*Campanula rotundifolia*	1	FAC-	Nt P-Forb	HAREBELL
CXBEBB	4	*Carex bebbii*	-5	OBL	Nt P-Sedge	SEDGE
CXBUXB	10	*Carex buxbaumii*	-5	OBL	Nt P-Sedge	SEDGE
CXCRYP	10	*Carex cryptolepis*	-5	OBL	Nt P-Sedge	SEDGE
CXFLAV	4	*Carex flava*	-5	OBL	Nt P-Sedge	SEDGE
CXLEPA	5	*Carex leptalea*	-5	OBL	Nt P-Sedge	SEDGE
CXPELL	2	*Carex pellita*	-5	OBL	Nt P-Sedge	SEDGE
CXPENS	4	*Carex pensylvanica*	5	UPL	Nt P-Sedge	SEDGE
CXSTRI	4	*Carex stricta*	-5	OBL	Nt P-Sedge	SEDGE
CASCOC	8	*Castilleja coccinea*	0	FAC	Nt A-Forb	INDIAN PAINTBRUSH
CENMAU	0	*CENTAUREA MACULOSA*	5	UPL	Ad B-Forb	SPOTTED BLUET
CHACAL	8	*Chamaedaphne calyculata*	-5	OBL	Nt Shrub	LEATHERLEAF
CIRHIL	8	*Cirsium hillii*	5	UPL	Nt P-Forb	HILL'S THISTLE
CIRMUT	6	*Cirsium muticum*	-5	OBL	Nt B-Forb	SWAMP THISTLE
COMUMB	5	*Comandra umbellata*	3	FACU	Nt P-Forb	BASTARD TOADFLAX
COMPER	6	*Comptonia peregrina*	5	UPL	Nt Shrub	SWEET FERN
CORLAN	8	*Coreopsis lanceolata*	3	FACU	Nt P-Forb	SAND COREOPSIS
CORSTO	2	*Cornus stolonifera*	-3	FACW	Nt Shrub	RED OSIER DOGWOOD
DANSPI	4	*Danthonia spicata*	5	UPL	Nt P-Grass	POVERTY GRASS; OATGRASS
DESCES	9	*Deschampsia cespitosa*	-4	FACW+	Nt P-Grass	HAIR GRASS
DRYCRI	6	*Dryopteris cristata*	-5	OBL	Nt Fern	CRESTED SHIELD FERN
ELEELL	6	*Eleocharis elliptica*	-3	FACW	Nt P-Sedge	GOLDEN SEEDED SPIKE RUSH
EPILEP	6	*Epilobium leptophyllum*	-5	OBL	Nt P-Forb	FEN WILLOW HERB
EQULAE	2	*Equisetum laevigatum*	-3	FACW	Nt Fern Ally	SMOOTH SCOURING RUSH
EUPMAM	4	*Eupatorium maculatum*	-5	OBL	Nt P-Forb	JOE PYE WEED
EUPESU	0	*EUPHORBIA ESULA*	5	UPL	Ad P-Forb	LEAFY SPURGE
EUTGRA	3	*Euthamia graminifolia*	-2	FACW-	Nt P-Forb	GRASS LEAVED GOLDENROD
FESRUB	0	*FESTUCA RUBRA*	1	FAC-	Ad P-Grass	RED FESCUE
FRAVIR	2	*Fragaria virginiana*	1	FAC-	Nt P-Forb	WILD STRAWBERRY
GAUPRO	5	*Gaultheria procumbens*	3	FACU	Nt Shrub	WINTERGREEN
GENRUB	7	*Gentiana rubricaulis*	-5	OBL	Nt P-Forb	GREAT LAKES GENTIAN
GEURIV	7	*Geum rivale*	-5	OBL	Nt P-Forb	PURPLE AVENS
GLYCAN	8	*Glyceria canadensis*	-5	OBL	Nt P-Grass	RATTLESNAKE GRASS
GLYSTR	4	*Glyceria striata*	-5	OBL	Nt P-Grass	FOWL MANNA GRASS
HELCAN	8	*Helianthemum canadense*	5	UPL	Nt P-Forb	COMMON ROCKROSE
HIEAUR	0	*HIERACIUM AURANTIACUM*	5	UPL	Ad P-Forb	ORANGE HAWKWEED
HIESCA	3	*Hieracium scabrum*	5	UPL	Nt P-Forb	ROUGH HAWKWEED

Table 5b. 2005 Species list for Portage Creek Wet-Mesic Sand Prairie, continued.

ACRONYM	C	SCIENTIFIC NAME	W	WETNESS	PHYSIOGNOMY	COMMON NAME
HIEVEN	6	*Hieracium venosum*	5	UPL	Nt P-Forb	RATTLESNAKE WEED
HOULON	6	*Houstonia longifolia*	5	UPL	Nt P-Forb	LONG LEAVED BLUETS
HYPCAN	6	*Hypericum canadense*	-3	FACW	Nt A-Forb	CANADIAN ST. JOHN'S WORT
HYPKAL	10	*Hypericum kalmianum*	-2	FACW-	Nt Shrub	KALM'S ST. JOHN'S WORT
HYPPER	0	*HYPERICUM PERFORATUM*	5	UPL	Ad P-Forb	COMMON ST. JOHN'S WORT
IRIVER	5	*Iris versicolor*	-5	OBL	Nt P-Forb	WILD BLUE FLAG
JUNBAL	4	*Juncus balticus*	-5	OBL	Nt P-Forb	RUSH
JUNEFF	3	*Juncus effusus*	-5	OBL	Nt P-Forb	SOFT STEMMED RUSH
JUNGRE	10	*Juncus greenei*	0	FAC	Nt P-Forb	GREENE'S RUSH
JUNVAS	10	*Juncus vaseyi*	-3	FACW	Nt P-Forb	VASEY'S RUSH
KALANG	7	*Kalmia angustifolia*	0	FAC	Nt Shrub	SHEEP LAUREL
KALPOL	10	*Kalmia polifolia*	-5	OBL	Nt Shrub	SWAMP LAUREL
LARLAR	5	*Larix laricina*	-3	FACW	Nt Tree	TAMARACK
LEDGRO	8	*Ledum groenlandicum*	-5	OBL	Nt Shrub	LABRADOR TEA
LIAASP	4	*Liatris aspera*	5	UPL	Nt P-Forb	ROUGH BLAZING STAR
LOBCAR	7	*Lobelia cardinalis*	-5	OBL	Nt P-Forb	CARDINAL FLOWER
LOBSPI	4	*Lobelia spicata*	0	FAC	Nt P-Forb	PALE SPIKED LOBELIA
LYCAME	2	*Lycopus americanus*	-5	OBL	Nt P-Forb	COMMON WATER HOREHOUND
LYCUNI	2	*Lycopus uniflorus*	-5	OBL	Nt P-Forb	NORTHERN BUGLE WEED
LYSCIL	4	*Lysimachia ciliata*	-3	FACW	Nt P-Forb	FRINGED LOOSESTRIFE
LYSTHY	6	*Lysimachia thyrsiflora*	-5	OBL	Nt P-Forb	TUFTED LOOSESTRIFE
MAICAC	4	*Maianthemum canadense*	0	FAC	Nt P-Forb	CANADA MAYFLOWER
MELLIN	6	*Melampyrum lineare*	1	FAC-	Nt A-Forb	COW WHEAT
MENARV	3	*Mentha arvensis*	-3	FACW	Nt P-Forb	WILD MINT
MONFIS	2	*Monarda fistulosa*	3	FACU	Nt P-Forb	WILD BERGAMOT
MUHGLO	10	*Muhlenbergia glomerata*	-4	FACW+	Nt P-Grass	MARSH WILD TIMOTHY
MUHUNI	8	*Muhlenbergia uniflora*	-5	OBL	Nt P-Grass	MUHLY GRASS
OENPER	5	*Oenothera perennis*	0	FAC	Nt P-Forb	SMALL SUNDROPS
PANBOR	7	*Panicum boreale*	2	FACU+	Nt P-Grass	NORTHERN PANIC GRASS
PANIMP	3	*Panicum implicatum*	0	FAC	Nt P-Grass	PANIC GRASS
PANVIR	4	*Panicum virgatum*	-1	FAC+	Nt P-Grass	SWITCH GRASS
PICMAR	6	*Picea mariana*	-3	FACW	Nt Tree	BLACK SPRUCE
PINBAN	5	*Pinus banksiana*	3	FACU	Nt Tree	JACK PINE
PINRES	6	*Pinus resinosa*	3	FACU	Nt Tree	RED PINE
PINSTR	3	*Pinus strobus*	3	FACU	Nt Tree	WHITE PINE
PLALAC	6	*Platanthera lacera*	-3	FACW	Nt P-Forb	GREEN FRINGED ORCHID
POAPRA	0	*POA PRATENSIS*	1	FAC-	Ad P-Grass	KENTUCKY BLUEGRASS
POLPAU	7	*Polygala paucifolia*	3	FACU	Nt P-Forb	GAY WINGS
POTFRU	10	*Potentilla fruticosa*	-3	FACW	Nt Shrub	SHRUBBY CINQUEFOIL
POTSIM	2	*Potentilla simplex*	4	FACU-	Nt P-Forb	OLD FIELD CINQUEFOIL
PRUVUL	0	*PRUNELLA VULGARIS*	0	FAC	Nt P-Forb	LAWN PRUNELLA
PRUPUM	8	*Prunus pumila*	5	UPL	Nt Shrub	SAND CHERRY
PRUSER	2	*Prunus serotina*	3	FACU	Nt Tree	WILD BLACK CHERRY
PTEAQU	0	*Pteridium aquilinum*	3	FACU	Nt Fern	BRACKEN FERN
RHAALN	8	*Rhamnus alnifolia*	-5	OBL	Nt Shrub	ALDER LEAVED BUCKTHORN
ROSCAR	4	*Rosa carolina*	4	FACU-	Nt Shrub	PASTURE ROSE
ROSPAL	5	*Rosa palustris*	-5	OBL	Nt Shrub	SWAMP ROSE
RUBFLA	1	*Rubus flagellaris*	4	FACU-	Nt Shrub	NORTHERN DEWBERRY
RUBHIS	4	*Rubus hispidus*	-3	FACW	Nt Shrub	SWAMP DEWBERRY
RUBPUB	4	*Rubus pubescens*	-4	FACW+	Nt P-Forb	DWARF RASPBERRY
SALDIS	1	*Salix discolor*	-3	FACW	Nt Shrub	PUSSY WILLOW
SALHUM	4	*Salix humilis*	3	FACU	Nt Shrub	PRAIRIE WILLOW
SALPET	1	*Salix petiolaris*	-4	FACW+	Nt Shrub	SLENDER WILLOW
SCHPUP	5	*Schizachne purpurascens*	2	FACU+	Nt P-Grass	FALSE MELIC

Table 5c. 2005 Species list for Portage Creek Wet-Mesic Sand Prairie, continued.

ACRONYM	C	SCIENTIFIC NAME	W	WETNESS	PHYSIOGNOMY	COMMON NAME
SCICYP	5	*Scirpus cyperinus*	-5	OBL	Nt P-Sedge	WOOL GRASS
SENPAU	3	*Senecio pauperculus*	-1	FAC+	Nt P-Forb	BALSAM RAGWORT
SOLGIG	3	*Solidago gigantea*	-3	FACW	Nt P-Forb	LATE GOLDENROD
SOLHOU	10	*Solidago houghtonii*	-5	OBL	Nt P-Forb	HOUGHTON'S GOLDENROD
SOLRUG	3	*Solidago rugosa*	-1	FAC+	Nt P-Forb	ROUGH GOLDENROD
SOLULI	4	*Solidago uliginosa*	-5	OBL	Nt P-Forb	BOG GOLDENROD
SPIALB	4	*Spiraea alba*	-4	FACW+	Nt Shrub	MEADOWSWEET
SPILAC	8	*Spiranthes lacera*	-1	FAC+	Nt P-Forb	SLENDER LADIES' TRESSES
SPOHET	10	*Sporobolus heterolepis*	4	FACU-	Nt P-Grass	PRAIRIE DROPSEED
THADAS	3	*Thalictrum dasycarpum*	-2	FACW-	Nt P-Forb	PURPLE MEADOW RUE
THEPAL	2	*Thelypteris palustris*	-4	FACW+	Nt Fern	MARSH FERN
THUOCC	4	*Thuja occidentalis*	-3	FACW	Nt Tree	ARBOR VITAE
TRADUB	0	*TRAGOPOGON DUBIUS*	5	UPL	Ad B-Forb	GOAT'S BEARD
TRICLI	10	*Trichophorum clintonii*	4	FACU-	Nt P-Sedge	CLINTON'S BULRUSH
VACANG	4	*Vaccinium angustifolium*	3	FACU	Nt Shrub	BLUEBERRY
VIOLAN	8	*Viola lanceolata*	-5	OBL	Nt P-Forb	LANCE LEAVED VIOLET
VIONOV	10	*Viola novae-angliae*	-5	OBL	Nt P-Forb	NEW ENGLAND BLUE VIOLET
ZIGGLA	10	*Zigadenus glaucus*	-3	FACW	Nt P-Forb	WHITE CAMAS

Table 6. 2021 Conservation metrics for Portage Creek Poor Fen.

Conservatism-Based Metrics:

Total Mean C:	5.6
Native Mean C:	5.6
Total FQI:	48.2
Native FQI:	48.2
Adjusted FQI:	56
% C value 0:	1.4
% C value 1-3:	13.5
% C value 4-6:	54.1
% C value 7-10:	31.1
Native Tree Mean C:	4.6
Native Shrub Mean C:	5.4
Native Herbaceous Mean C:	5.8

Species Richness:

Total Species:	74	
Native Species:	74	100%
Non-native Species:	0	0%

Species Wetness:

Mean Wetness:	-2.5
Native Mean Wetness:	-2.5

Physiognomy Metrics:

Tree:	5	6.80%
Shrub:	24	32.40%
Vine:	1	1.40%
Forb:	19	25.70%
Grass:	12	16.20%
Sedge:	11	14.90%
Rush:	0	0%
Fern:	2	2.70%
Bryophyte:	0	0%

Duration Metrics:

Annual:	0	0%
Perennial:	73	98.60%
Biennial:	1	1.40%
Native Annu	0	0%
Native Peren	73	98.60%
Native Bienn	1	1.40%

Table 7a. 2021 Species list for Portage Creek Poor Fen.

Common Name	Scientific Name	Acronym	Native?	C	W
ticklegrass	*Agrostis scabra*	AGRSCA	native	4	0
speckled alder	*Alnus incana*	ALNINC	native	5	-3
chokeberry	*Aronia prunifolia*	AROPRU	native	5	-3
swamp milkweed	*Asclepias incarnata*	ASCINC	native	6	-5
bog birch	*Betula pumila*	BETPUM	native	8	-5
long-awned wood grass	*Brachyelytrum erectum*	BRAERE	native	7	5
fringed brome	*Bromus ciliatus*	BROCIL	native	6	-3
blue-joint	*Calamagrostis canadensis*	CALCAN	native	3	-5
marsh bellflower	*Campanula aparinoides*	CAMAPA	native	7	-5
sedge	*Carex buxbaumii*	CXBUXB	native	10	-5
sedge	*Carex castanea*	CXCAST	native	6	-3
sedge	*Carex flava*	CXFLAV	native	4	-5
sedge	*Carex lasiocarpa*	CXLASI	native	8	-5
sedge	*Carex leptalea*	CXLEPA	native	5	-5
sedge	*Carex prairea*	CXPRAI	native	10	-3
sedge	*Carex sterilis*	CXSTER	native	10	-5
sedge	*Carex stricta*	CXSTRI	native	4	-5
leatherleaf	*Chamaedaphne calyculata*	CHACAL	native	8	-5
water hemlock	*Cicuta bulbifera*	CICBUL	native	5	-5
swamp thistle	*Cirsium muticum*	CIRMUT	native	6	-5
silky dogwood	*Cornus amomum*	CORAMO	native	2	-3
red-osier	*Cornus sericea*	CORSER	native	2	-3
poverty grass; oatgrass	*Danthonia spicata*	DANSPI	native	4	5
shrubby cinquefoil	*Dasiphora fruticosa*	DASFRU	native	8	-3
hair grass	*Deschampsia cespitosa*	DESCES	native	9	-3
northern panic grass	*Dichanthelium boreale*	DICBOR	native	7	0
panic grass	*Dichanthelium lindheimeri*	DICLID	native	8	-5
flat-topped white aster	*Doellingeria umbellata*	DOEUMB	native	5	-3
spike-rush	*Eleocharis palustris*	ELEPAL	native	5	-5
slender wheatgrass	*Elymus trachycaulus*	ELYTRA	native	8	3
fen willow-herb	*Epilobium leptophyllum*	EPILEP	native	6	-5
green-keeled cotton-grass	*Eriophorum viridi-carinatum*	ERIVID	native	8	-5
boneset	*Eupatorium perfoliatum*	EUPPER	native	4	-3
joe-pye-weed	*Eutrochium maculatum*	EUTMAC	native	4	-5
northern bedstraw	*Galium boreale*	GALBOR	native	3	0
wintergreen	*Gaultheria procumbens*	GAUPRO	native	5	3
fowl manna grass	*Glyceria striata*	GLYSTR	native	4	-5
kalms st. johns-wort	*Hypericum kalmianum*	HYPKAL	native	10	-3
michigan holly	*Ilex verticillata*	ILEVER	native	5	-3
wild blue flag	*Iris versicolor*	IRIVER	native	5	-5
sheep-laurel	*Kalmia angustifolia*	KALANG	native	7	0
tamarack	*Larix laricina*	LARLAR	native	5	-3
cardinal-flower	*Lobelia cardinalis*	LOBCAR	native	7	-5
red honeysuckle	*Lonicera dioica*	LONDIO	native	5	3
whorled loosestrife	*Lysimachia quadriflora*	LYSQUR	native	10	-5
tufted loosestrife	*Lysimachia thyrsiflora*	LYSTHY	native	6	-5
marsh wild-timothy	*Muhlenbergia glomerata*	MUHGLO	native	10	-5
sweet gale	*Myrica gale*	MYRGAL	native	6	-5
small sundrops	*Oenothera perennis*	OENPER	native	5	0
royal fern	*Osmunda regalis*	OSMREG	native	5	-5
black spruce	*Picea mariana*	PICMAR	native	6	-3
jack pine	*Pinus banksiana*	PINBAN	native	5	3
white pine	*Pinus strobus*	PINSTR	native	3	3
self-heal	*Prunella vulgaris*	PRUVUL	native	0	0

Table 7b. 2021 Species list for Portage Creek Poor Fen, continued.

Common Name	Scientific Name	Acronym	Native?	C	W
sand cherry	*Prunus pumila*	PRUPUM	native	8	5
alder-leaved buckthorn	*Rhamnus alnifolia*	RHAALN	native	8	-5
labrador-tea	*Rhododendron groenlandicum*	RHOGRO	native	8	-5
wild black currant	*Ribes americanum*	RIBAME	native	6	-3
swamp rose	*Rosa palustris*	ROSPAL	native	5	-5
dwarf raspberry	*Rubus pubescens*	RUBPUB	native	4	-3
pussy willow	*Salix discolor*	SALDIS	native	1	-3
prairie willow	*Salix humilis*	SALHUM	native	4	3
slender willow	*Salix petiolaris*	SALPET	native	1	-3
false melic	*Schizachne purpurascens*	SCHPUP	native	5	3
bulrush	*Scirpus atrovirens*	SCIATV	native	3	-5
marsh skullcap	*Scutellaria galericulata*	SCUGAL	native	5	-5
rough-leaved goldenrod	*Solidago rugosa*	SOLRUG	native	3	0
bog goldenrod	*Solidago uliginosa*	SOLULI	native	4	-5
vosss goldenrod	*Solidago vossii*	SOLVOS	native	10	-3
meadowsweet	*Spiraea alba*	SPIALB	native	4	-3
marsh fern	*Thelypteris palustris*	THEPAL	native	2	-3
arbor vitae	*Thuja occidentalis*	THUOCC	native	4	-3
low sweet blueberry	*Vaccinium angustifolium*	VACANG	native	4	3
wild-raisin	*Viburnum cassinoides*	VIBCAS	native	6	3

Table 8. 2021 Conservation metrics for Howes Lake Poor Fen.

Conservatism-Based Metrics:

Total Mean C:	7
Native Mean C:	7
Total FQI:	32.8
Native FQI:	32.8
Adjusted FQI:	70
% C value 0:	0
% C value 1-3:	9.1
% C value 4-6:	36.4
% C value 7-10:	54.5
Native Tree Mean C:	4.7
Native Shrub Mean C:	7.5
Native Herbaceous Mean C:	7.1

Physiognomy Metrics:

Tree:	3	13.60%
Shrub:	11	50%
Vine:	0	0%
Forb:	3	13.60%
Grass:	1	4.50%
Sedge:	3	13.60%
Rush:	1	4.50%
Fern:	0	0%
Bryophyte:	0	0%

Species Richness:

Total Species:	22	
Native Species:	22	100%
Non-native Species:	0	0%

Duration Metrics:

Annual:	0	0%
Perennial:	22	100%
Biennial:	0	0%
Native Annu	0	0%
Native Pere	22	100%
Native Bien	0	0%

Species Wetness:

Mean Wetness:	-3.7
Native Mean Wetness:	-3.7

Table 9. 2021 Species list for Howes Lake Poor Fen.

Common Name	Scientific Name	Acronym	Native?	C	W
bog-rosemary	*Andromeda glaucophylla*	ANDGLA	native	10	-5
bog birch	*Betula pumila*	BETPUM	native	8	-5
blue-joint	*Calamagrostis canadensis*	CALCAN	native	3	-5
sedge	*Carex disperma*	CXDISP	native	10	-5
sedge	*Carex lasiocarpa*	CXLASI	native	8	-5
leatherleaf	*Chamaedaphne calyculata*	CHACAL	native	8	-5
shrubby cinquefoil	*Dasiphora fruticosa*	DASFRU	native	8	-3
canadian rush	*Juncus canadensis*	JUNCAN	native	6	-5
sheep-laurel	*Kalmia angustifolia*	KALANG	native	7	0
bog-laurel	*Kalmia polifolia*	KALPOL	native	10	-5
tamarack	*Larix laricina*	LARLAR	native	5	-3
buckbean	*Menyanthes trifoliata*	MENTRI	native	8	-5
sweet gale	*Myrica gale*	MYRGAL	native	6	-5
water smartweed	*Persicaria amphibia*	PERAMP	native	6	-5
black spruce	*Picea mariana*	PICMAR	native	6	-3
white pine	*Pinus strobus*	PINSTR	native	3	3
labrador-tea	*Rhododendron groenlandicum*	RHOGRO	native	8	-5
beak-rush	*Rhynchospora alba*	RHYALB	native	6	-5
pitcher-plant	*Sarracenia purpurea*	SARPUR	native	10	-5
low sweet blueberry	*Vaccinium angustifolium*	VACANG	native	4	3
highbush blueberry	*Vaccinium corymbosum*	VACCOR	native	6	-3
large cranberry	*Vaccinium macrocarpon*	VACMAC	native	8	-5

Table 10. 2021 Conservation metrics for Portage Creek Northern Wet Meadow.

Conservatism-Based Metrics:

Total Mean C:	4
Native Mean C:	4
Total FQI:	24.3
Native FQI:	24.3
Adjusted FQI:	40
% C value 0:	2.7
% C value 1-3:	35.1
% C value 4-6:	54.1
% C value 7-10:	8.1
Native Tree Mean C:	4.5
Native Shrub Mean C:	3.6
Native Herbaceous Mean C:	4

Species Richness:

Total Species:	37	
Native Species:	37	100%
Non-native Species:	0	0%

Species Wetness:

Mean Wetness:	-3.6
Native Mean Wetness:	-3.6

Physiognomy Metrics:

Tree:	4	10.80%
Shrub:	5	13.50%
Vine:	0	0%
Forb:	17	45.90%
Grass:	4	10.80%
Sedge:	5	13.50%
Rush:	0	0%
Fern:	2	5.40%
Bryophyte:	0	0%

Duration Metrics:

Annual:	0	0%
Perennial:	36	97.30%
Biennial:	1	2.70%
Native Annual:	0	0%
Native Perennial:	36	97.30%
Native Biennial:	1	2.70%

Table 11. 2021 Species list for Portage Creek Northern Wet Meadow.

Common Name	Scientific Name	Acronym	Native?	C	W
speckled alder	*Alnus incana*	ALNINC	native	5	-3
fringed brome	*Bromus ciliatus*	BROCIL	native	6	-3
blue-joint	*Calamagrostis canadensis*	CALCAN	native	3	-5
marsh bellflower	*Campanula aparinoides*	CAMAPA	native	7	-5
sedge	*Carex diandra*	CXDIAN	native	8	-5
sedge	*Carex stricta*	CXSTRI	native	4	-5
water hemlock	*Cicuta bulbifera*	CICBUL	native	5	-5
swamp thistle	*Cirsium muticum*	CIRMUT	native	6	-5
spike-rush	*Eleocharis palustris*	ELEPAL	native	5	-5
boneset	*Eupatorium perfoliatum*	EUPPER	native	4	-3
joe-pye-weed	*Eutrochium maculatum*	EUTMAC	native	4	-5
marsh bedstraw	*Galium palustre*	GALPAL	native	3	-5
fowl manna grass	*Glyceria striata*	GLYSTR	native	4	-5
wild blue flag	*Iris versicolor*	IRIVER	native	5	-5
tamarack	*Larix laricina*	LARLAR	native	5	-3
cardinal-flower	*Lobelia cardinalis*	LOBCAR	native	7	-5
common water horehound	*Lycopus americanus*	LYCAME	native	2	-5
sweet gale	*Myrica gale*	MYRGAL	native	6	-5
sensitive fern	*Onoclea sensibilis*	ONOSEN	native	2	-3
reed canary grass	***Phalaris arundinacea***	**PHAARU**	**native**	**0**	**-3**
black spruce	*Picea mariana*	PICMAR	native	6	-3
white pine	*Pinus strobus*	PINSTR	native	3	3
wild red raspberry	*Rubus strigosus*	RUBSTR	native	2	0
common arrowhead	*Sagittaria latifolia*	SAGLAT	native	4	-5
sandbar willow	*Salix exigua*	SALEXI	native	1	-3
softstem bulrush	*Schoenoplectus tabernaemontani*	SCHTAB	native	4	-5
bulrush	*Scirpus atrovirens*	SCIATV	native	3	-5
canada goldenrod	*Solidago canadensis*	SOLCAN	native	1	3
rough-leaved goldenrod	*Solidago rugosa*	SOLRUG	native	3	0
common bur-reed	*Sparganium eurycarpum*	SPAEUR	native	5	-5
meadowsweet	*Spiraea alba*	SPIALB	native	4	-3
purple meadow-rue	*Thalictrum dasycarpum*	THADAS	native	3	-3
marsh fern	*Thelypteris palustris*	THEPAL	native	2	-3
arbor vitae	*Thuja occidentalis*	THUOCC	native	4	-3
marsh st. johns-wort	*Triadenum fraseri*	TRIFRA	native	6	-5
broad-leaved cat-tail	*Typha latifolia*	TYPLAT	native	1	-5
blue vervain	*Verbena hastata*	VERHAS	native	4	-3

Table 12. 2021 Conservation metrics for Portage Creek Intermittent Wetland.

Conservatism-Based Metrics:

Total Mean C:	6.9
Native Mean C:	6.9
Total FQI:	27.6
Native FQI:	27.6
Adjusted FQI:	69
% C value 0:	0
% C value 1-3:	6.3
% C value 4-6:	25
% C value 7-10:	68.8
Native Tree Mean C:	n/a
Native Shrub Mean C:	7.4
Native Herbaceous Mean C:	6.7

Physiognomy Metrics:

Tree:	0	0%
Shrub:	5	31.30%
Vine:	0	0%
Forb:	2	12.50%
Grass:	4	25%
Sedge:	5	31.30%
Rush:	0	0%
Fern:	0	0%
Bryophyte:	0	0%

Species Richness:

Total Species:	16	
Native Species:	16	100%
Non-native Species:	0	0%

Duration Metrics:

Annual:	0	0%
Perennial:	16	100%
Biennial:	0	0%
Native Annual	0	0%
Native Perenn	16	100%
Native Biennia	0	0%

Species Wetness:

Mean Wetness:	-3.8
Native Mean Wetness:	-3.8

Table 13. 2021 Species list for Portage Creek Intermittent Wetland.

Common Name	Scientific Name	Acronym	Native?	C	W
blue-joint	*Calamagrostis canadensis*	CALCAN	native	3	-5
sedge	*Carex buxbaumii*	CXBUXB	native	10	-5
sedge	*Carex lasiocarpa*	CXLASI	native	8	-5
sedge	*Carex stricta*	CXSTRI	native	4	-5
sedge	*Carex vesicaria*	CXVESI	native	7	-5
leatherleaf	*Chamaedaphne calyculata*	CHACAL	native	8	-5
panic grass	*Dichanthelium lindheimeri*	DICLID	native	8	-5
rattlesnake grass	*Glyceria canadensis*	GLYCAN	native	8	-5
kalms st. johns-wort	*Hypericum kalmianum*	HYPKAL	native	10	-3
wild blue flag	*Iris versicolor*	IRIVER	native	5	-5
sheep-laurel	*Kalmia angustifolia*	KALANG	native	7	0
muhly grass	*Muhlenbergia uniflora*	MUHUNI	native	8	-5
sand cherry	*Prunus pumila*	PRUPUM	native	8	5
wool-grass	*Scirpus cyperinus*	SCICYP	native	5	-5
meadowsweet	*Spiraea alba*	SPIALB	native	4	-3
lance-leaved violet	*Viola lanceolata*	VIOLAN	native	8	-5