Natural Features Inventory and Management Recommendations for Gourdneck State Game Area

Prepared By:

Jesse M. Lincoln, Yu Man Lee, Peter J. Badra, Tyler J. Bassett, Logan M. Rowe, Ashley A. Cole-Wick, Aaron P. Kortenhoven, Nicole J. Smith, and Joshua G. Cohen, Michigan Natural Features Inventory, Michigan State University Extension, P.O. Box 13036, Lansing, MI 48901-3036

Prepared For:

Michigan Department of Natural Resources; Wildlife Division

July 2023

MNFI Document Number 2023–18

Michigan Natural Features Inventory

MICHIGAN STATE UNIVERSITY | Extension

Suggested Citation:

Lincoln, J.M., Y.M. Lee, P.J. Badra, T. J. Bassett, L.M. Rowe, A.A. Cole-Wick, A.P. Kortenhoven, N.J. Smith, and J.G. Cohen. 2023. Natural Features Inventory and Management Recommendations for Gourdneck State Game Area. Michigan Natural Features Inventory, Report Number 2023-18, Lansing, MI.

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

Cover Photo: Hampton Creek Swamp within Gourdneck State Game Area and the surrounding City of Portage. Photo by Jesse M. Lincoln.

ACKNOWLEDGEMENTS

This project was supported by the Michigan Department of Natural Resources Wildlife Division. Funding for this project was through the Federal Aid in Wildlife Restoration Act program grant W-153-M (Habitat and Species Management with Technical Guidance) in cooperation with the U.S. Fish and Wildlife Service, Wildlife and Sport Fish Restoration Program. We express our gratitude to the numerous DNR staff that helped administer and guide this project including Michael Donovan, Mark Sargent, Amy Derosier, Steve Chadwick, Mark Mills, Don Poppe, Nate DeVries, Nathan Poley, and Rachel Leightner.

Russ Schipper and Todd Barkman provided important information for updating records of several rare plant populations. Jen Moore of Grand Valley State University and Bill Flanagan of John Ball Zoo provided data for several populations of rare reptiles. Bill also provided several pictures that enhanced this report.

This report relies on data collected by many former Michigan Natural Features Inventory field scientists, especially Dennis Albert, Michael Kost, Mike Penskar, Bradford Slaughter, John Paskus, and Ryan O'Connor. For their support and assistance throughout this project, we thank our MNFI colleagues, Dan Earl (thanks for the photos), Rebecca Rogers, Courtney Ross, Helen Enander, Mike Monfils, Michael Sanders, Paul Schilke, David Cuthrell, Ashley Adkins, Phyllis Higman, Rachel Hackett, Kraig Korroch, Sarah Carter, Scott Warner, Elizabeth Haber, Clay Wilton, Julie McLaughlin, Eric Branch, Danielle Smith, and Brian Klatt. Thank you to AmeriCorps Servicemembers Nathan Hilbrands and Marta Springer who assisted with field work.

DNR Wildlife Technician Nate DeVries assisted during field surveys. Photo by J.M. Lincoln.

EXECUTIVE SUMMARY

The Gourdneck State Game Area (SGA) is a block of semi-contiguous public land in southwest Michigan, consisting of 2,295 acres in Kalamazoo County. Gourdneck SGA is important ecologically because it provides critical habitat for a myriad of game and non-game species and supports 940 acres of upland forest, 466 acres of forested wetland, and 570 acres of non-forested wetlands and lakes. The wetlands are especially prominent features of Gourdneck SGA and the natural cover within the game area supports a diversity of rare herptiles (reptiles and amphibians), plants, birds, insects, mollusks, and fish.

Michigan Natural Features Inventory (MNFI) conducted Stage 1 Michigan Forest Inventory (MiFI) in 2016 and surveys for high-quality natural communities and rare animals were conducted in 2022 as part of the Integrated Inventory Project. This project is part of a long-term effort by MNFI to document areas of high conservation significance on state lands and provide information to the Michigan Department of Natural Resources, Wildlife Division regarding sustainable management of those important areas.

MNFI scientists documented 4 new natural community Element Occurrences (EOs) and 7 new rare animal EOs and provided information for updating 21 existing EOs. In total, 66 EOs and 20 species of greatest conservation need have been documented in Gourdneck SGA including 23 animal EOs, 37 plant EOs, and 6 natural community EOs.

Two high-quality prairie fens had been documented from Gourdneck SGA prior to the 2016 MiFI surveys and these fens were re-evaluated in 2022. During the 2022 field season MNFI ecologists documented 4 additional new natural communities, including a bog, a hardwood-conifer swamp, a rich tamarack swamp, and a southern hardwood swamp. Together, these high-quality represent 9.8% of the game area, harbor populations of rare plants, and provide critical habitat for the rare herptiles populations found within the game area.

Several populations of rare plants had been documented from Gourdneck SGA prior to the Integrated Inventory. Records for 9 plant species were updated during the natural community surveys. Of the 37 documented populations of rare plants at Gourdneck, only 40.5% have been relocated. The other 59.5% of rare plant populations are presumed extirpated.

MNFI scientists conducted visual encounter surveys for rare herptiles. Three rare herptile species including [redacted] and Blanchard's cricket frog (*Acris blanchardi*; State Threatened) were found during the surveys. Additional rare herptiles recently documented in the game area include [redacted]. Several of these observations were made by conservation partners at Grand Valley State University, Central Michigan University, and John Ball Zoo. Two additional rare herptile species, the pickerel frog (*Lithobates palustris*; State Special Concern), and mudpuppy (*Necturus maculosus*; State Special Concern) have been documented in the vicinity of the game area and have good potential or likely occur in the game area as well based on connectivity and available habitat.

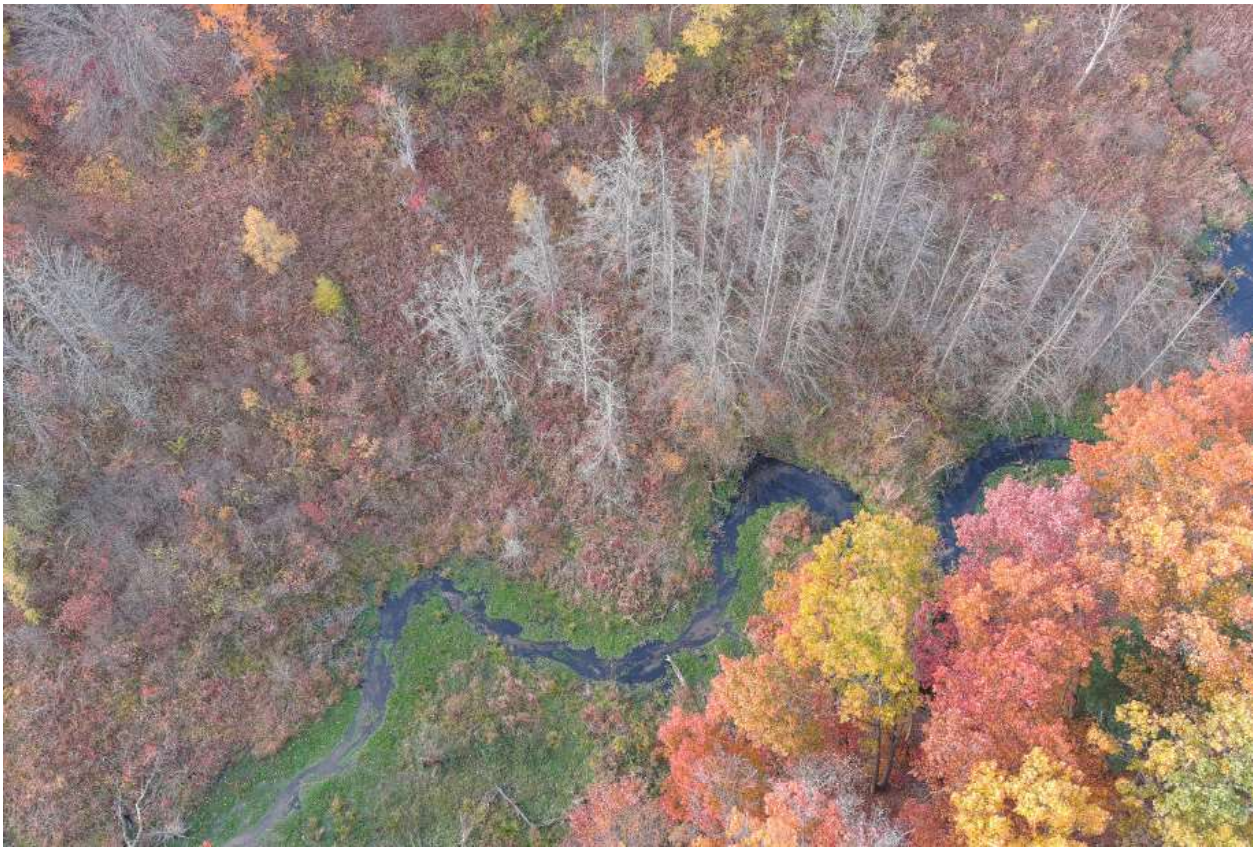
Aquatic surveys were performed at 12 sites within Gourdneck SGA. A total of 7 unionid mussel species were found including 1 State Threatened species and 2 species of State Special Concern. Rare mussel species documented included slippershell (*Alasmidonta viridis;* State Threatened), rainbow (*Cambarunio iris;* State Special Concern), and creek heelsplitter (*Lasmigona compressa;* State Special Concern). All three of these mussel species are Species of Greatest Conservation Need. Watercress snail (*Fontigens nickliniana*; State Special Concern) and spotted gar (*Lepisosteus oculatus*; State Special Concern) were also documented during aquatic surveys.

Three types of rare insect surveys were conducted at Gourdneck SGA targeting butterflies, borer moths, and tamarack tree cricket. We documented 1 new occurrence of tamarack tree cricket (*Oecanthus laricis*; State Special Concern), updated 1 existing occurrence of royal fern borer (*Papaipema speciosissima*; State Special Concern), and recorded a total of 168 observations of 38 common butterfly species.

Surveys for rare avian species included point-counts for raptors, forest songbirds, and grassland birds. An existing occurrence of a Henslow's sparrow (*Ammodramus henslowii*; State Endangered) was updated as a result of the 2022 surveys.

Considering the concentrations of rare herptiles and plants, it will be increasingly important to consider the game area in the context of regional conservation goals and the prevention of extirpation of rare species. We recommend that management efforts to maintain ecological integrity be focused in natural communities to maintain ecosystem services and provide maximum benefit for the numerous rare species documented in the area. We also recommend developing a comprehensive approach to treating severe infestations of invasive species, applying prescribed fire in fire-dependent uplands, and mitigating the impacts of beaver within the high-quality wetlands.

We provide the following management recommendations to protect native biodiversity and ecosystem integrity in order of importance: 1) establish conservation corridors around the highest quality wetlands, populations of rare taxa, and forested uplands that have the greatest potential for recovery to oak savanna; 2) protect hydrology of wetlands within those corridors; 3) develop and prioritize stewardship actions within the high-quality natural communities and connecting conservation corridors focusing on invasive species control and application of prescribed fire; and 4) monitor populations of rare taxa and the effectiveness of stewardship actions.



Hampton Creek from above. The wetland complex along Hampton Creek supports two high-quality natural communities and populations of rare plants and animals. Gourdneck State Game Area occurs within the City of Portage and serves as an important refuge for native biodiversity. Photo by J.M. Lincoln.

Table of Contents

List of Figures

Figure **Page**

List of Figures

List of Tables

List of Appendicies

INTRODUCTION

The Gourdneck State Game Area (SGA) is a large block of semi-contiguous public land in the southwest Lower Peninsula of Michigan, consisting of 2,295 acres in Kalamazoo County (Figure 1). The land is owned and managed by the Wildlife Division of Michigan's Department of Natural Resources (DNR) and was purchased by funds secured by the Pittman-Robertson Federal Aid in Wildlife Restoration Act administered by the DNR's Wildlife Division (WLD). Gourdneck SGA is considered the DNR's first urban state game area. It is important ecologically because it provides critical habitat for a myriad of game and non-game species and extensive natural cover in a rapidly developing urban area. The surrounding landscape has been significantly impacted by development and agriculture, highlighting the significance of the game area and its wetlands.

Michigan Natural Features Inventory (MNFI) is Michigan's natural heritage program and maintains a geospatial database of populations of rare and declining species and benchmark natural communities. MNFI and the DNR WLD have been collaborating since 2009 to provide comprehensive ecological evaluation of state lands through an "Integrated Inventory" project which is also funded through the Pittman-Robertson Act. As part of the DNR's Integrated Inventory Project, in 2016 MNFI conducted the Michigan Forest Inventory (MiFI) habitat cover type mapping process. Surveys for high-quality natural communities and rare animals were conducted in 2022. This project is part of a long-term effort by MNFI to document areas of high conservation significance on state lands and provide the DNR WLD with information to inform

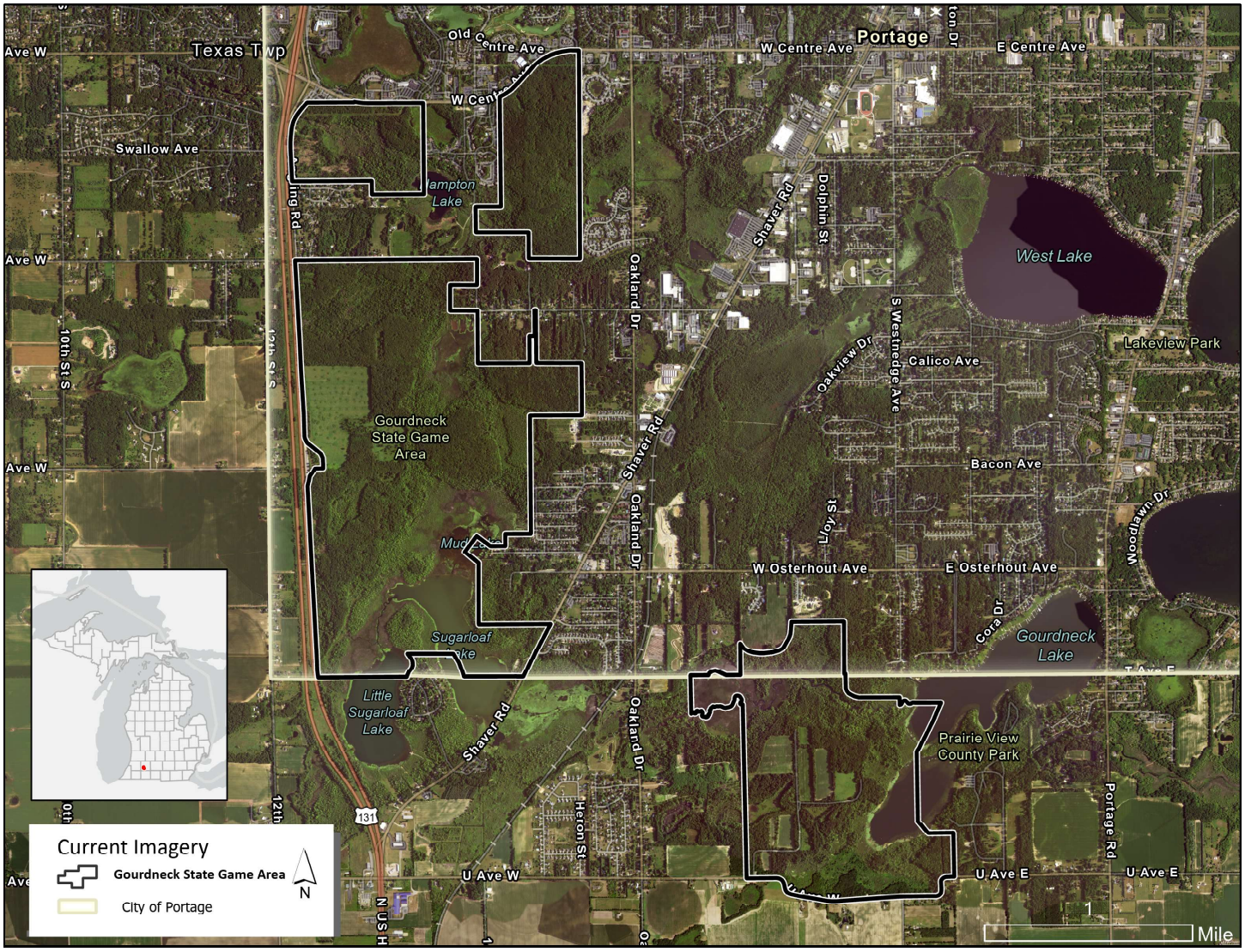


Figure 1. Imagery of Gourdneck State Game Area (ESRI 2020).

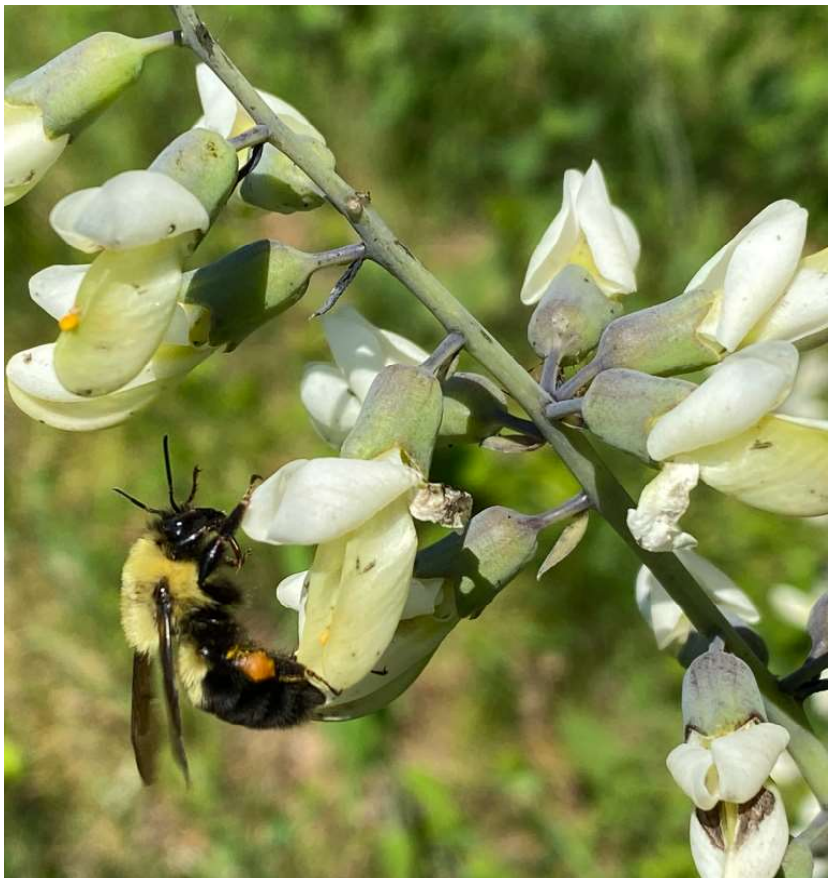
the sustainable management of those areas. This project addresses MNFI's mission to guide the conservation of Michigan's biodiversity for current and future generations by providing the highest quality scientific expertise and information and the DNR WLD's complementary mission to enhance, restore and conserve the State's wildlife resources, natural communities, and ecosystems for the benefit of Michigan's citizens, visitors, and future generations.

The primary goal of this survey effort is to provide resource managers and planners with standardized, baseline information on each natural community and rare species occurrences and identify the most critical places on state lands for biodiversity stewardship. This baseline information is vital for informing landscape-level biodiversity planning efforts; prioritizing protection, management, and restoration objectives; facilitating site-level decisions about biodiversity stewardship; and monitoring the success of management and restoration.

Gourdneck SGA supports populations of several rare species, including the tamarack tree cricket (*Oecanthus laricis*, State Special Concern). The presence of this population was confirmed during the 2022 surveys. Photo by D.D. Cuthrell.

Despite being nearly entirely within the City of Portage, Gourdneck State Game Area supports a range of high-quality natural communities, extensive wetlands, and populations of rare species. This is an oblique view of Sugarloaf Lake looking south. Photo by J.M. Lincoln.

This report provides an overview of the landscape and historical context of Gourdneck SGA, summarizes the findings of MNFI's surveys for high-quality natural communities and rare animal species, and identifies stewardship priorities within the game area. Because the landscape surrounding Gourdneck SGA has extensive agricultural and rural development, the large area of natural cover within the game area serves as an important reservoir of biodiversity for the local region. Gourdneck SGA supports several rare plant, avian, mussel, reptile, amphibian, and insect species. During the natural features inventory of this game area, MNFI scientists documented or updated element occurrences of 1 rare bird species, 9 rare herptiles, 2 rare insects, 5 rare mollusks, 1 rare fish, and 6 high-quality natural communities representing 5 natural community types. In addition, 24 rare plant species have been documented in the game area; records for 9 rare plant element occurrences were opportunistically updated during the course of this project. Management recommendations are provided for rare species, specific natural communities, and the game area in general.



A two-spotted bumble bee (*Bombus bimaculatus*) pollinating white false indigo (*Baptisia lactea*, State Threatened). Photo by J.M. Lincoln.

Vanderbilt Fen is one of several diverse wetlands within Gourdneck State Game Area. Photo by J.M. Lincoln.

MNFI Entomologist, David Cuthrell sweeps for tamarack tree crickets (*Oecanthus laricis*, State Special Concern). Photo by L.M. Rowe.

Landscape and Historical Context

Ecoregions

Michigan has been subdivided into ecoregions based on climate, glacial features, physiography, soils, and characteristic ecosystems (Albert 1995). This classification system provides a framework for understanding the distribution patterns of species, natural communities, natural disturbance regimes, and anthropogenic activities. The classification is structured with three levels, from broad landscape regions called Sections, down to smaller Subsections and Sub-Subsections. Gourdneck SGA occurs in southern lower Michigan in Section VI within the Battle Creek Outwash Plain Sub-Subsection (VI.2.1) of the Kalamazoo Interlobate Subsection (VI.2) (Albert 1995) (Figure 2). The Battle Creek Outwash Plain Sub-Subsection is a broad, flat outwash plain of glacial outwash sands, several small lakes and wetlands, and areas of ice contact sand and gravel (Figure 3). The outwash deposits of sand and gravel form well or moderately well drained soils. The Kalamazoo and the St. Joseph are the largest rivers that occur within the Sub-Subsection. This subsection historically supported extensive tallgrass prairie and oak savannas. The prairies were located on the broadest expanses of well-drained outwash plain where neither topography nor streams formed barriers to fires. Tall grass prairie occupied areas as large as 20 square miles with nearly 50 prairies known to the sub-subsection (Albert 1995).

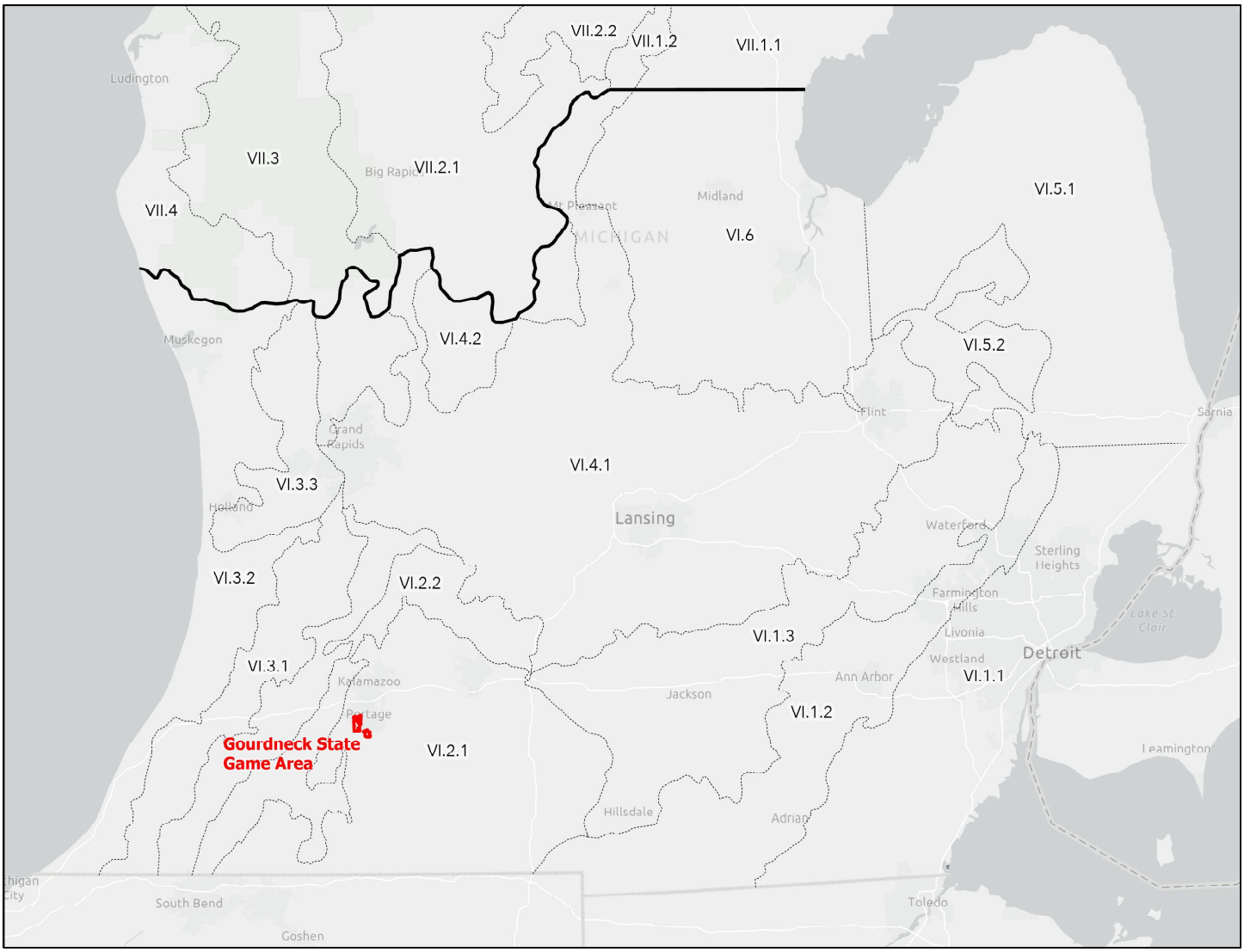


Figure 2. Gourdneck SGA occurs within the Battle Creek Outwash Plain Sub-Subsection (VI.2.1) of the ecoregions of southern Michigan (Albert 1995).

The extensive prairies that once characterized the region have been converted to agriculture and now persist as scraps along ditches, as is the case at the southern border of the game area. Photo by J. M. Lincoln.

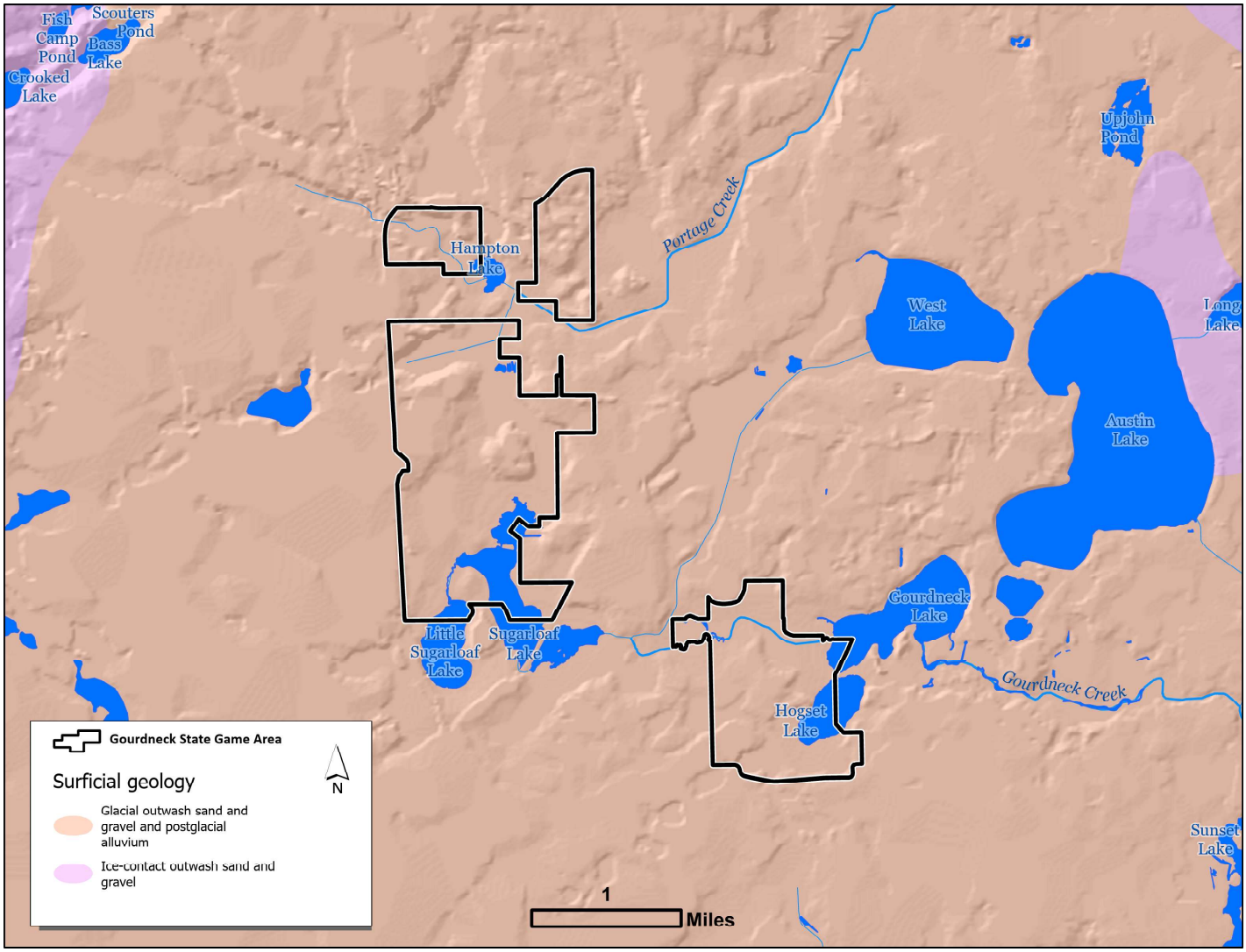


Figure 3. Surficial geology of the Gourdneck State Game Area.

Circa-1800 Vegetation

Interpretations of the General Land Office (GLO) surveyor notes by MNFI ecologists indicated that the Gourdneck SGA and surrounding area contained several distinct vegetation assemblages in the 1800s (Comer et al. 1995) (Figure 4). The GLO surveys occurred in this area in January of 1826 and surveyors recorded information on tree species composition, tree size, and general condition of the lands within and surrounding Gourdneck SGA. The surveys were conducted and transcribed by Robert Clark, Jr. The upland portions of the game area was predominantly Mixed Oak Savanna in 1826, with an estimated 48% of the game area supporting savanna or barrens ecosystems. The predominant cover types included Mixed Oak Savanna (41%), Shrub Swamp or Emergent Marsh (34%), Mixed Conifer Swamp (12%), Black Oak Barren (7%), and Lake (6%).

Areas classified by MNFI scientists as historically Mixed Oak Savanna and Black Oak Barrens were often noted by the land surveyors. Robert Clark, Jr described the area west of Hogset Lake as “barrens – good soil, white, yellow, bur”, referring to the oak species of white oak, chinquapin oak, and bur oak.

Other noteworthy descriptions include the following: from southwest of Hogset Lake - “from prairie, rolling barrens – good soil, bur, yellow oak”; west of the game area, near the truck stop - “1st rate, black, white, yellow, bur oak, hickory”; west of Highway-131 - “rolling first rate prairie”; and west of Hampton Lake - “2nd rate, thinly timbered with white, red, bur oak, hickory” (Appendix 1). These descriptions suggest a landscape of extensive savanna and barrens that transitioned from prairie and were actively managed by the local, long-standing Indigenous Peoples. The surveyors recorded and “Indian village” with several “mounds” about 1 mile southwest of Sugarloaf Lake. MNFI has described several natural community types that likely occurred across what is now the game area, including oak openings, bur oak plains, and oak barrens. Throughout this report, we will refer to the areas described as “mixed oak savanna” and “black oak barrens” by the broader, more encompassing term, “oak savanna”.

Oak savannas are characterized by an open canopy of 10 to 60% coverage, frequent fire, and ground flora characterized by woodland and prairie species.

An example of an oak savanna from Allegan County. This open-grown oak with an abundance of prairie grasses is an example of the uplands that were prevalent in and around Gourdneck SGA prior to European colonization. Photo by J. M. Lincoln.

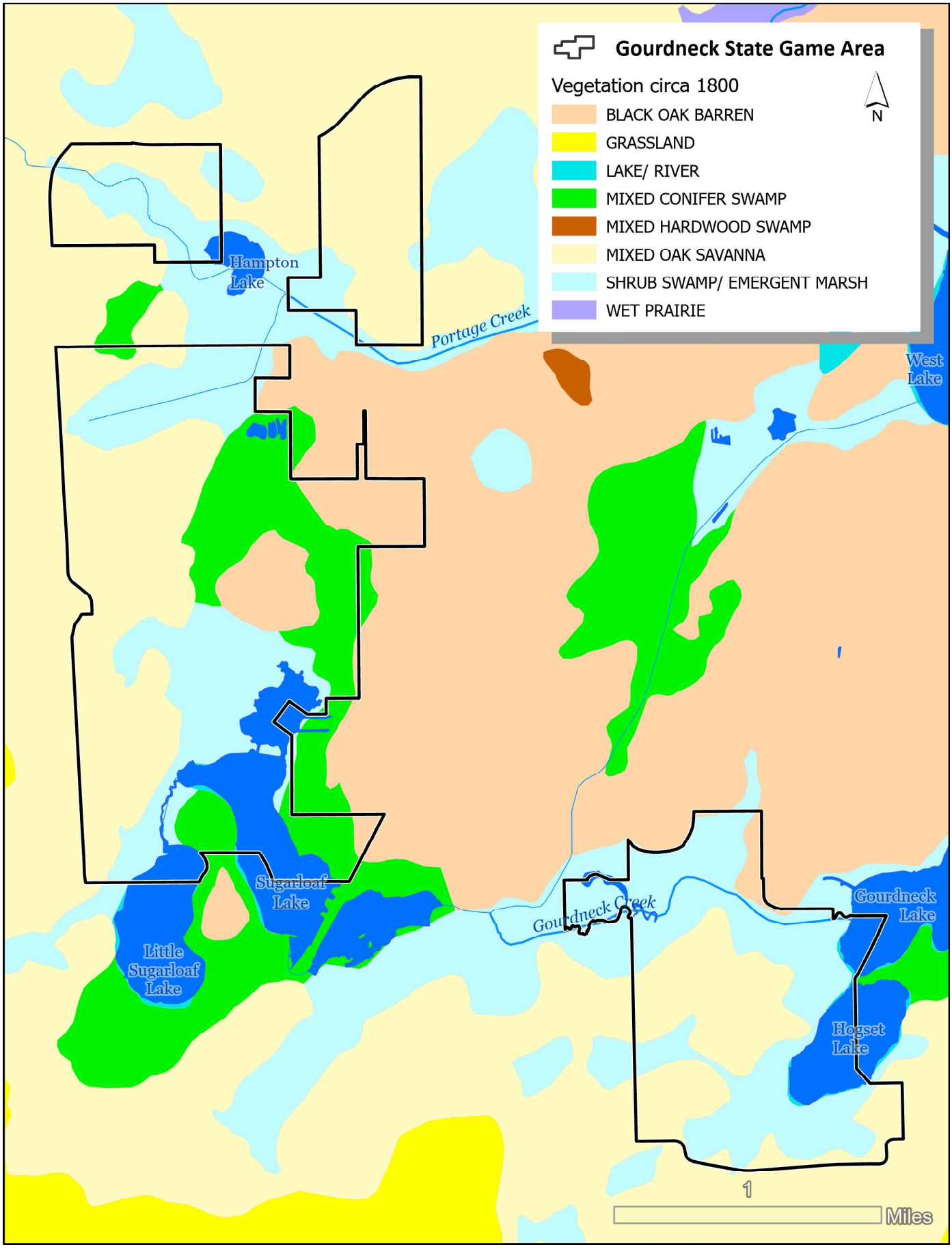


Figure 4. Vegetation of Gourdneck State Game Area circa 1800 (Comer et al. 1995).

Within this part of southwestern Michigan, prairie, oak savanna, and oak-hickory forest occurred in a shifting prairie-savanna mosaic that varied in time and space depending on the frequency and intensity of fire disturbance events. Repeated low-intensity fires, working in concert with drought and windthrow, maintained open conditions in these oak savanna ecosystems. Within savanna systems it is likely that annual or nearly annual application of fire by Indigenous Peoples was a primary factor influencing the vegetative structure and floristic composition. These fires occurred during the fall, late summer, or early spring since flammability peaks in the spring before grass and forb growth resumes and then again in the late summer and autumn after the above-ground biomass dies back (Grimm 1984). Savannas, oak openings, and oak barrens historically covered more than 1 million acres in southern Michigan but more than 99.9% have been lost to development and agriculture and those that remain generally persist in a degraded state (Comer 1995, O'Conner 2006).

We evaluated the notes of the land surveyors within the game area and the immediate vicinity of the game area to provide a summary of the composition and structure of the land in 1826. Within the barrens and savanna, white oak (*Quercus alba;* 79%) and black oak (*Q. velutina*; 11%) were the most prevalent canopy dominants with stunted chinquapin or dwarf chinquapin oak (*Q. muehlenbergii or Q. prinoides;* 10%) occurring locally in the oak savanna. Recorded diameters of trees ranged widely from 12.5 to 50 cm (5 to 20 in) with an average of 33 cm (13 in; N = 18).

Extensive areas of non-forested shrub swamp and open emergent marsh occurred in areas of poorly drained outwash and along the margins of lakes. These open wetlands transitioned to Mixed Conifer Swamp at the margins of wetlands and adjacent uplands. Where the surveyors noted canopy composition of these swamp forests, tamarack (*Larix laricina*) was the overwhelming dominant (93%) and only one white pine (*Pinus strobus*) was recorded in 1826. Recorded diameters of canopy trees ranged from 7 to 46 cm (3 to 18 in) with an average of 20.0 cm (7.9 in; N = 14). Average tree diameters for the tamarack were 18.0 cm (7.1 in; N = 13) and the sole white pine was 46 cm (18 in).

Changes in Land Cover

The landcover within and around Gourdneck SGA (Figures 4, 5, and 7) has changed significantly since the early 1800s due to logging, agriculture, removal of Indigenous Peoples, fire suppression, hydrologic alteration, tree disease, non-native insect outbreak, and invasive species infestations. Currently, upland forest is the most predominant land cover type in Gourdneck SGA (37.1% of the game area; 795.8 ac). While the GLO notes do not provide us the certainty of knowing exactly what the landscape looked like in the past, all available descriptions depict a landscape characterized by oak savanna. Logging, conversion of upland forest to agricultural lands, and cessation of cultural fires has shifted the composition of the game area with 9.8% of the game area now corresponding to non-forested uplands. These non-forested uplands are now degraded but were managed as farm fields in the past.

The non-forested wetlands and lowland forest that have not been cleared have also been dramatically altered over the past 200 years by invasive disease, invasive species infestations, and fire suppression. Though the GLO notes did not document elm and ash as significant components of the lowland forests, they are present now and were likely important components of the forested wetland communities. Dutch elm disease has virtually eliminated elm as a dominant overstory tree. In 2002, the non-native invasive emerald ash borer (*Agrilus planipennis*), was identified in southeastern Michigan. This Asiatic beetle has already killed millions of ash trees and altered the species composition and structure of upland and lowland forests (USDA Forest Service 2002, Roberts 2003). Both ash and elm are now generally relegated to the understory of forests. Within fire-dependent oak savannas that were not tilled, decades of fire suppression have resulted in mesophication or the increase in mesophytic woody species including red maple, black cherry, and invasive shrubs in the understory.

Aerial photographs from 1938 (Figure 5) show how logging and the expansion of agriculture have contributed to habitat fragmentation and ecological degradation across the landscape. The majority of the uplands in the game area were at one time cleared for agriculture and subsequently reverted to forest after the state took ownership in 1941. These forested stands that were cleared tend to have the greatest concentrations of invasive species. The imagery from 1938 is particularly useful for the identification of important forest and savanna remnants. Areas that were forested or savanna in the imagery that have not since been logged have the lowest proportion of invasive species, oldest trees, and have the greatest potential for restoring savanna communities because the seedbank and soil biota are potentially still intact.

Despite the dramatic shifts in composition from anthropogenic disturbance, abundant natural cover remains within Gourdneck SGA with 96% of the game area constituting natural cover and 9.8% (225 ac) documented as high-quality natural communities.

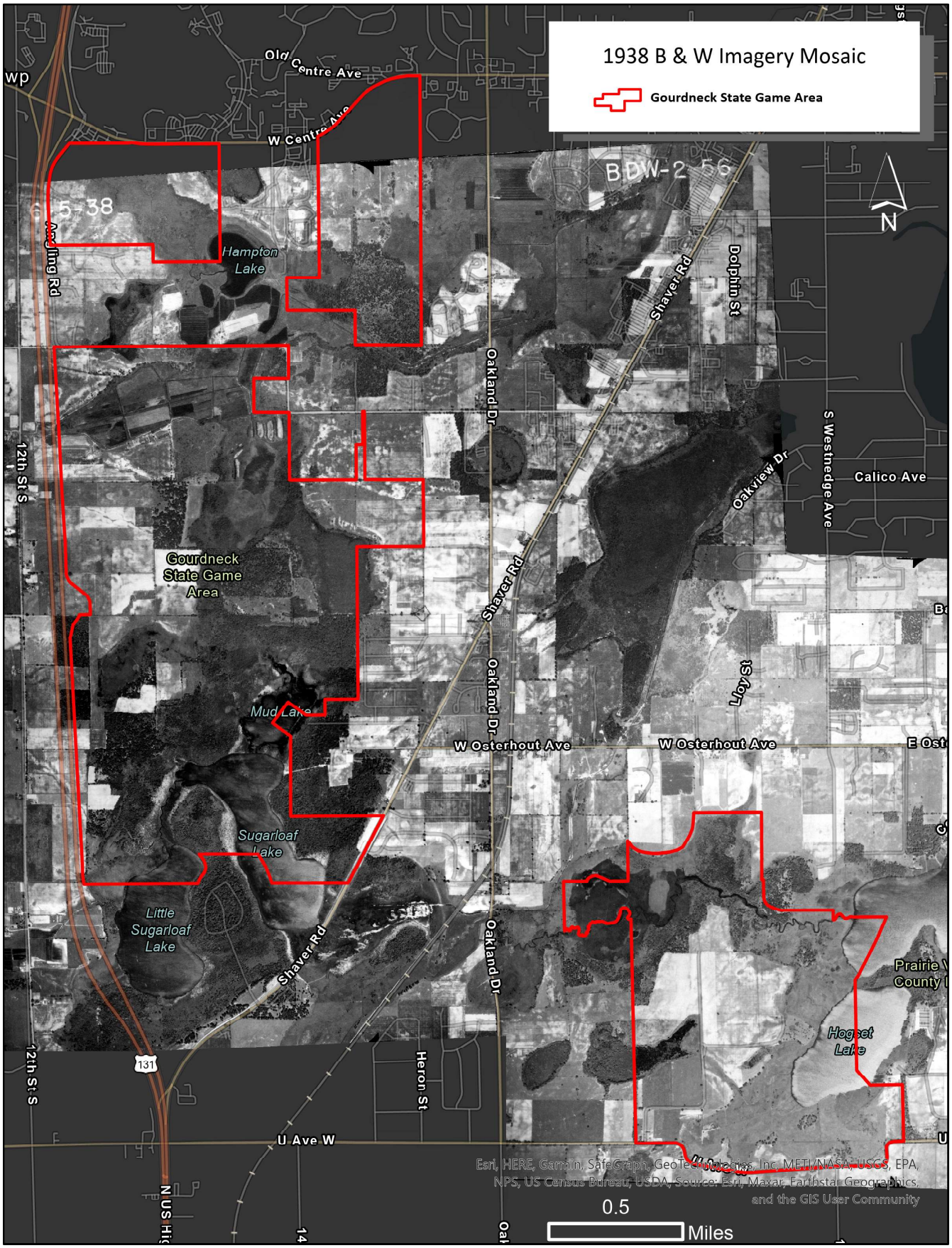


Figure 5. Mosaic of 1938 aerial photographs of Gourdneck State Game Area. This resource can inform managers about important conservation targets because areas that were forested in the picture (typically the darker hues) tend to be dominated by native vegetation, have the oldest trees, and also exhibit the lowest levels of invasive species. Therefore, these areas generally have the highest conservation value for native biodiversity.

In addition, Gourdneck SGA remains predominantly unfragmented, especially in comparison with the surrounding land. As a whole, the Kalamazoo Interlobate Subsection (VI.2) is 53% agriculture, 8% developed, and just 27% forested. In comparison, the game area is currently 64% forested. To gauge landscape integrity, MNFI has developed a land use integrity index that is based on the proportion of land use in a buffer surrounding an area of interest. Stands surrounded by intensive land use (e.g., row crops and residences) receive lower scores and stands surrounded by natural cover (e.g., hardwood-conifer swamp and prairie fen) receive higher scores. Gourdneck SGA is characterized by high land use index scores across the game area and especially in comparison with the concentration of urban and suburban areas surrounding the game area (See Figure 6).

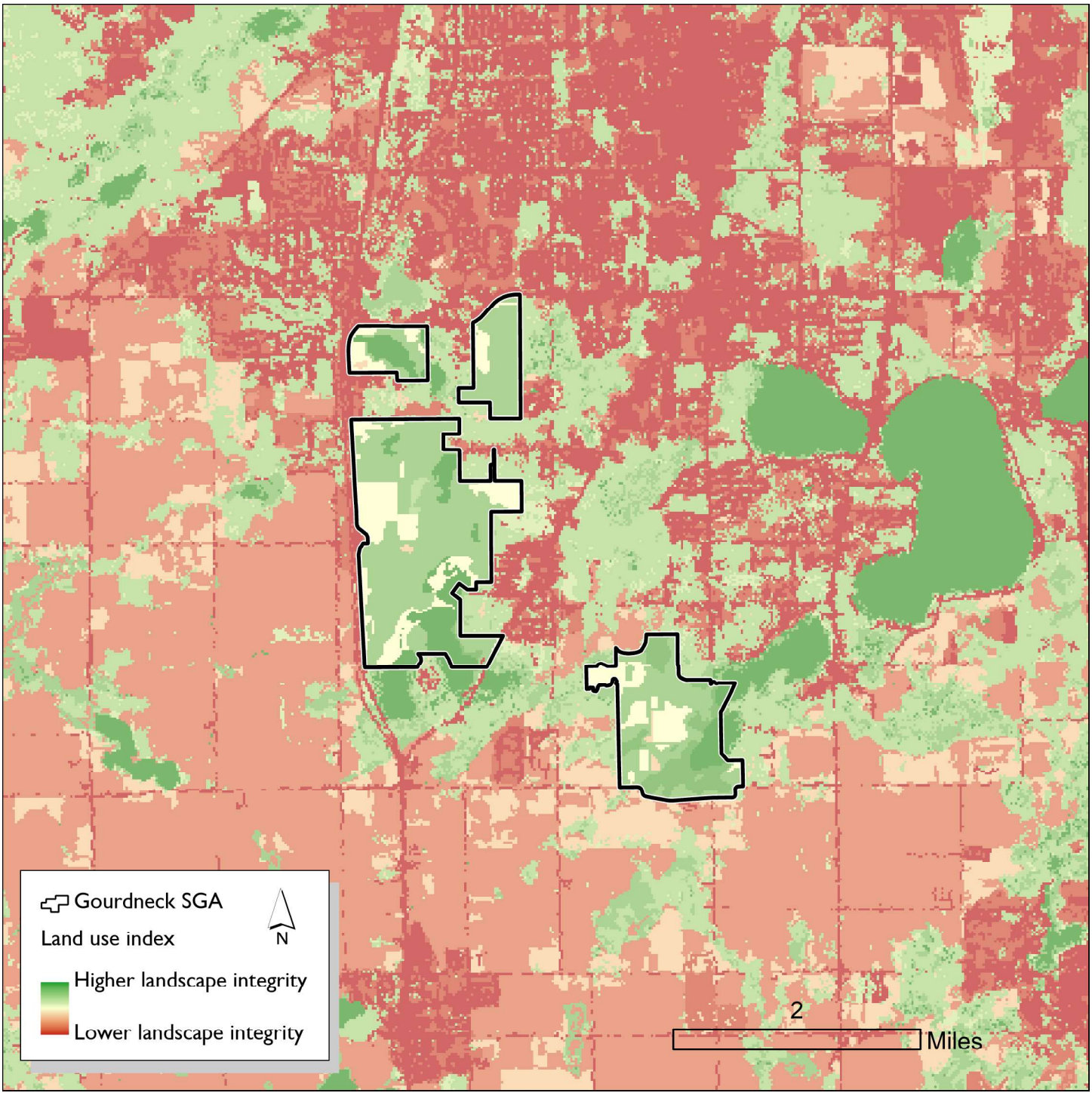


Figure 6. A land use index of Gourdneck State Game Area. The land use index is based on the proportion of land use and natural cover surrounding an area of interest. Gourdneck SGA is characterized by high land use index scores across the game area and especially in contrast to the city of Portage and private lands away from nearby lakes.

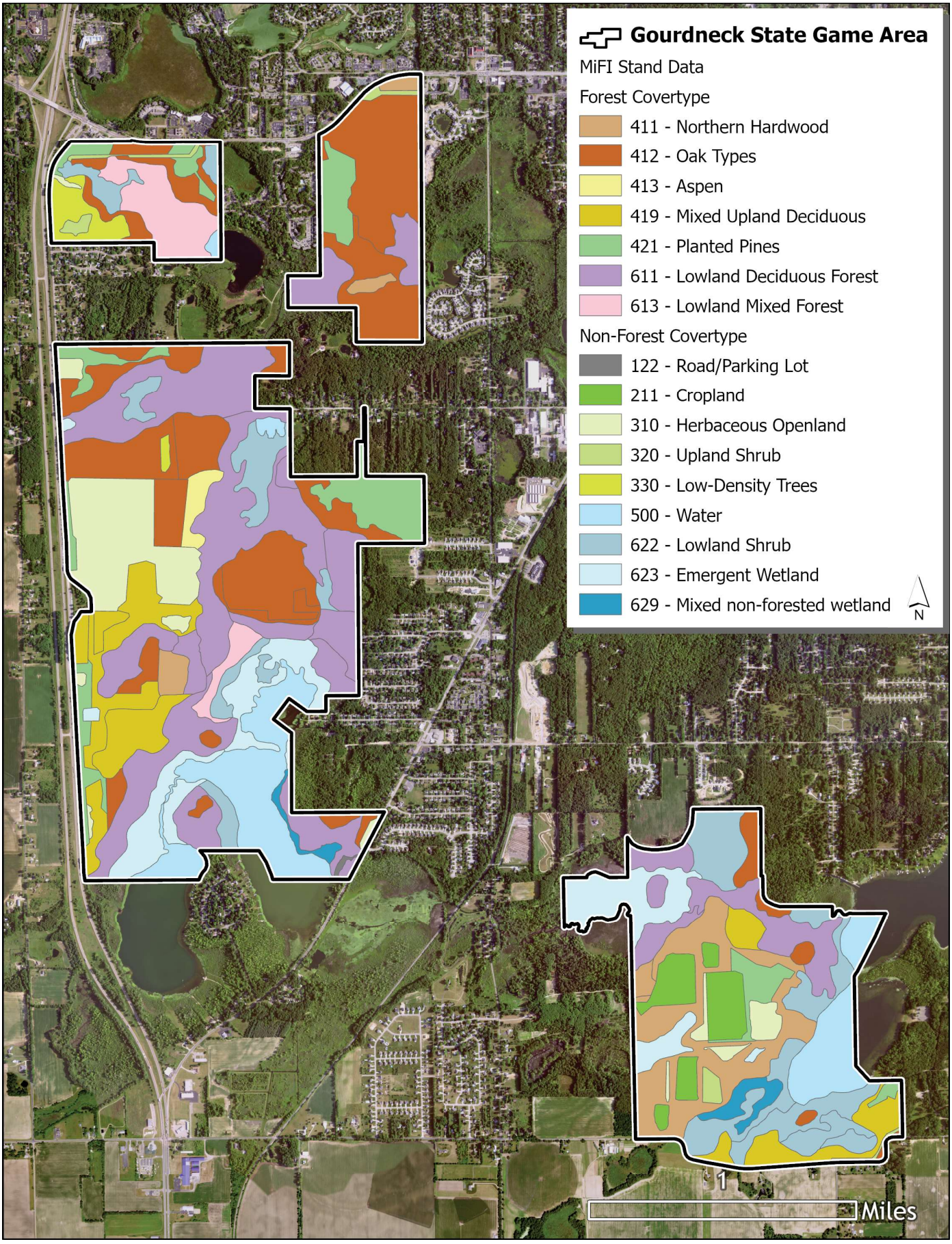


Figure 7. Michigan Forest Inventory (MiFI) stand data for Gourdneck State Game Area.

METHODS

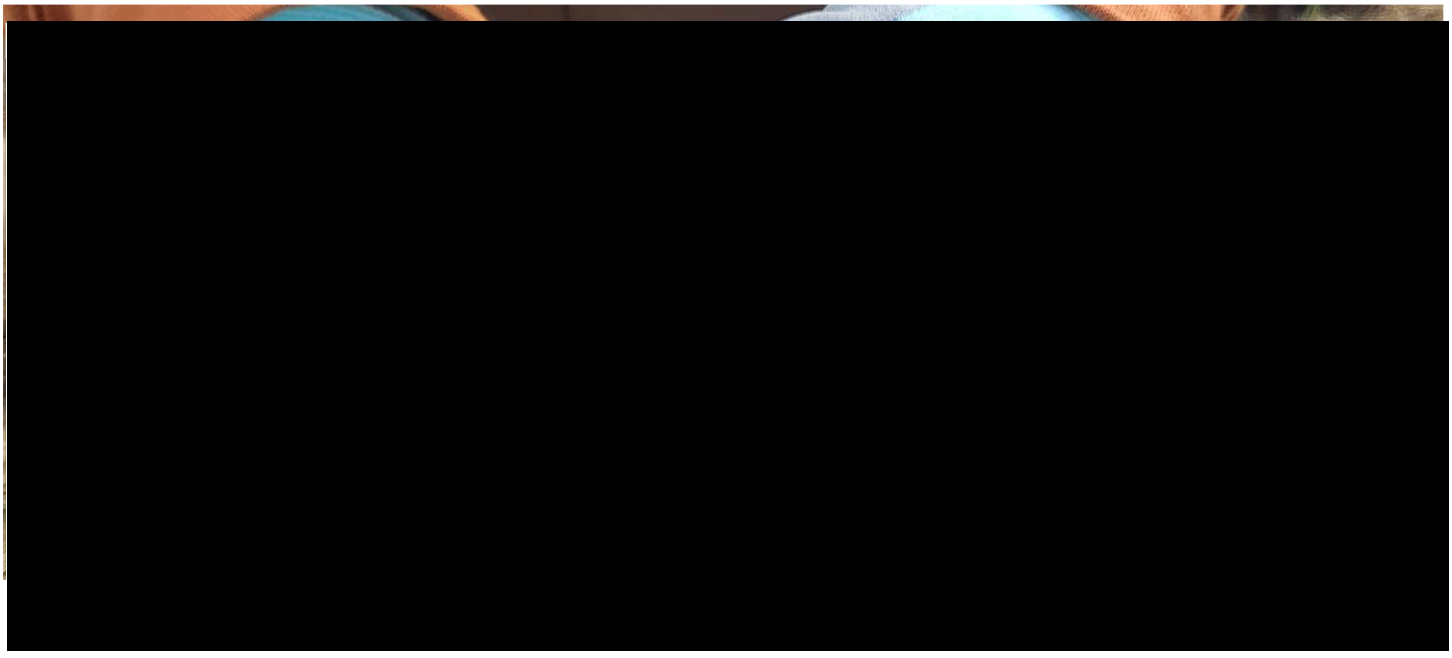
Throughout this report, natural community types and rare species are referred to as “elements” and their documented occurrences at specific location are referred to as element occurrences or “EOs”. Ecological and rare species surveys relied on a variety of data resources to determine if potential habitat occurs within the game area, including existing natural community EOs, MiFI cover types, aerial photography, and on-the-ground observations. The documentation of new high-quality natural communities was especially dependent on areas identified during the 2016 MiFI surveys and the combination of MiFI surveys and targeted natural community surveys helped inform subsequent rare species surveys and the formulation of management recommendations.

Target species for rare animal surveys were identified using historical distribution within Michigan, past occurrences in or near Gourdneck SGA, and the presence of potential habitat as determined by MiFI and natural community surveys. Based on these criteria, rare animal surveys focused on reptiles and amphibians; unionid mussels; several insect groups; and woodland raptors, forest interior songbirds, and grassland birds. Surveys for target animal species were conducted in appropriate potential habitats during time periods when targeted elements were expected to be most active and detectable (e.g., breeding season). Surveys were conducted to identify new occurrences, update or expand existing occurrences, and revisit historical occurrences of select rare species. Michigan’s Wildlife Action Plan (Derosier et al. 2015) identifies species of greatest conservation need (SGCN) and observations of these species were recorded when encountered.

Natural Community Surveys

MNFI’s natural community classification recognizes 77 natural community types in Michigan (Kost et al. 2007, Cohen et al. 2015). A natural community is defined as an assemblage of interacting plants, animals, and other organisms that repeatedly occurs under similar environmental conditions across the landscape and is predominantly structured by natural processes rather than modern anthropogenic disturbances, such as timber harvest, alterations to hydrology, and fire suppression. Historically, Indigenous Peoples were an integral part of natural communities throughout the Great Lakes region with many natural communities being maintained by native management practices such as cultural fire, wildlife management, and planting and harvesting plants. The interactions between Indigenous cultures and their landscape were widespread, sophisticated, and central to maintaining historical abundances of biodiversity (Stewart 2009).

The natural community EOs were 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. MNFI scientists utilized a combination of field surveys, aerial photographic interpretation, and Geographic Information System (GIS) analysis to assess natural community size and landscape context.



Natural community surveys detailed the vegetative structure and composition, ecological boundaries, and landscape and abiotic context of exemplary natural communities. These surveys also assessed the current ranking, classification, and delineation of these occurrences. Ecological field surveys of Gourdneck SGA were implemented over the growing season of 2022.

Qualitative meander surveys were conducted to assess the natural community classification, ecological boundaries, and ranking of the target sites. Vegetative structure and composition, soils, landscape and abiotic context, threats, management needs, and restoration opportunities were all assessed. This information is critical for informing landscape-level planning efforts, facilitating site-level decisions about prioritizing management objectives to conserve native biodiversity, and evaluating the success of restoration actions.

Methods employed during this survey followed the methodology developed during the initial evaluation of Ecological Reference Areas on State Forest land by MNFI ecologists (Cohen et al. 2008; Cohen et al. 2009).

The ecological field surveys involved:

- compiling comprehensive plant species lists and noting dominant and representative species and opportunistically documenting rare plant populations
- 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 and hydrology
- noting anthropogenic disturbances
- evaluating potential threats to ecological integrity
- ground-truthing aerial photographic interpretation using GPS
- taking digital photos and GPS points at significant locations
- evaluating the natural community classification and mapped ecological boundaries
- assigning or updating element occurrence ranks
- noting management needs and restoration opportunities or evaluating past and current restoration activities

During natural community surveys, MNFI scientists note community structure and composition, as well as threats and past disturbances. A portion of Greenspire Bog (above) was impacted by excavation of the peat and continuing runoff from Centre Ave. and the clearing of the adjacent uplands. Photo by T.J. Bassett.

Following completion of the field surveys, the collected data were analyzed and transcribed to create new EO records in MNFI's statewide biodiversity conservation database (MNFI 2023). Natural community boundaries were modified or established and information from these surveys was used to develop site descriptions, threat assessments, and management recommendations.

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

We calculated FQI for each natural community occurrence as:

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

where $\bar{C}$ = *mean C-value* and n = *species richness*. Michigan sites with an FQI of 35 or greater possess sufficient conservatism and richness that they are considered floristically important from a statewide perspective (Herman et al. 2001). FQI scores greater than 50 indicate exceptional sites with extremely high conservation value (Herman et al. 2001). Mean C values may represent a less biased indicator of relative conservation value and are provided with conservation metrics in the Appendices (Matthews et al. 2005, Slaughter et al. 2015). Tracking changes to the FQI or Mean C of a site following biodiversity stewardship is a useful means of evaluating the success of management. Species lists for each natural community EO are provided in the Appendices.

Natural community surveys involve compiling a comprehensive list of plant species and description of community structure and composition. Photo by J.M. Lincoln.

Rare Plant Surveys

We conducted a desktop assessment of rare plant species currently or historically occurring within Gourdneck SGA by querying the Natural Heritage Database (MNFI 2023). First, we compiled new data from recent surveys to ensure that data associated with each EO reflected the most up-to-date observations. New data was obtained from formal MNFI surveys (e.g., Paskus et al. 2019, Bassett et al. 2022b) as well as incidental observations made by MNFI staff, DNR staff, and other biologists. Observations by Todd Barkman, WMU Biology Professor, and Russ Schipper, local naturalist, were helpful. We then assessed the status of each rare plant EO. We revised the EO Rank when new data was available, and examined the last observed date and the last survey date to determine the likelihood that that EO persists at Gourdneck SGA. When a recent survey failed to find an EO, we assessed whether that survey was sufficient (i.e., comprehensive in extent and seasonally appropriate) to detect the species in question.

Finally, we classified each EO as either *recently documented as extant* at, *potentially extirpated* from, or *likely extirpated* from Gourdneck SGA. We classified EOs as recently documented as extant if they were observed in the last 25 years, and no sufficient survey failed to find that species since the most recent observed date. EOs classified as potentially extirpated were observed in the past 40 years but not documented in recent surveys, although appropriate habitat persists. Alternately, potentially extirpated species have not been observed in at least 40 years but are easily overlooked or have not been the target of recent surveys. For example, narrow-leaved reedgrass (*Calamagrostis stricta* var. *stricta*, State Threatened) is similar in appearance to the common blue-joint grass (*C. canadensis*), and whorled pogonia (*Isotria verticillata*, State Threatened) is similar in appearance to the common Indian cucumber-root (*Medeola virginica*). EOs classified as likely extirpated have not been observed in at least 40 years and meet at least one additional criterion: 1) have been targeted during sufficient surveys, 2) occurred in a site that no longer supports appropriate habitat, or 3) were documented in a vague locality that may not currently occur within Gourdneck SGA.

The State Endangered orange-fringed orchid (*Platanthera ciliaris*, left) was historically found in the Hampton Creek Wetland complex but has not been documented since 1979 and is presumed extirpated from the game area. A population of the State Threatened rosinweed (*Silphium integrifolium*, right) persists within Hampton Creek Fen. Photos by J.M. Lincoln.

Rare Reptile and Amphibian Surveys

Surveys for rare amphibian and reptile species (i.e., herptiles) in the Gourdneck SGA in 2022 focused primarily on the following species: spotted turtle (*Clemmys guttata*, State Threatened), Blanding's turtle (*Emydoidea blandingii*, State Special Concern), eastern box turtle (*Terrapene carolina carolina*, State Threatened), eastern massasauga (*Sistrurus catenatus,* Federally Threatened and State Threatened), and Blanchard's cricket frog (*Acris blanchardi,* State Threatened). These species also have been identified as Species of Greatest Conservation Need (SGCN) in Michigan's updated Wildlife Action Plan (Derosier et al. 2015). [redacted] Surveys also had potential for detecting several additional rare amphibian and reptile species and/or SGCN. These included the pickerel frog (*Lithobates palustris*, State Special Concern), smooth greensnake (*Opheodrys vernalis*, State Special Concern), Kirtland's snake (*Clonophis kirtlandii*, State Endangered), gray ratsnake (*Pantherophis spiloides*, State Special Concern), blue racer (*Coluber constrictor foxii*), northern ribbonsnake (*Thamnophis sauritus septentrionalis*), northern ring-necked snake (*Diadophis punctatus edwardsii*), and eastern musk turtle (*Sternotherus odoratus*) (Derosier et al. 2015). We also compiled information on sightings of rare amphibians and reptiles in Gourdneck SGA from other researchers conducting surveys in the game area and other external sources (i.e., Michigan Herptile Atlas, John Ball Zoo, Grand Valley State University, and Central Michigan University).

[redacted]

Visual encounter, aquatic funnel trapping, and breeding frog call or auditory surveys were conducted in areas with suitable or potential habitat for the target herptile species (Figure 8). Surveys were conducted from April 18 through September 14 using standard methods for surveying amphibians and reptiles (Campbell and Christman 1982, Corn and Bury 1990, Crump and Scott 1994, Graeter et al. 2013). Visual encounter surveys were conducted within and/or along the edge of open wetlands and waterbodies, vernal pools, adjacent open uplands, and upland and lowland forest stands (Figure 8). Surveys consisted of one or two surveyors walking slowly through areas with suitable habitat for target species, overturning cover objects (e.g., logs/woody debris, rocks, etc.), inspecting retreats, and looking for basking, resting, or active individuals on the surface or under cover objects (Campbell and Christman 1982, Corn and Bury 1990, Crump and Scott 1994, Glaudus 2013, Figure 8).

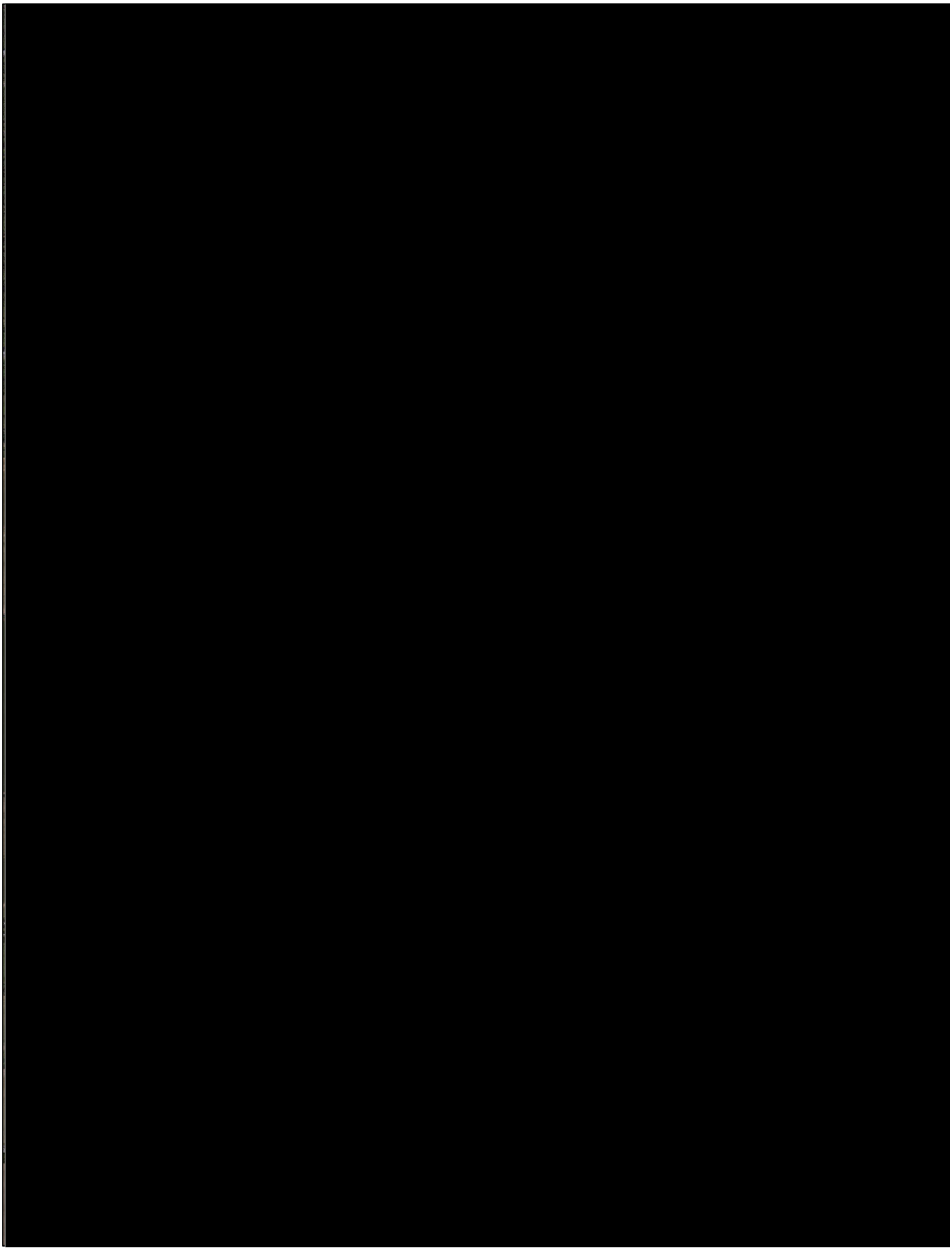


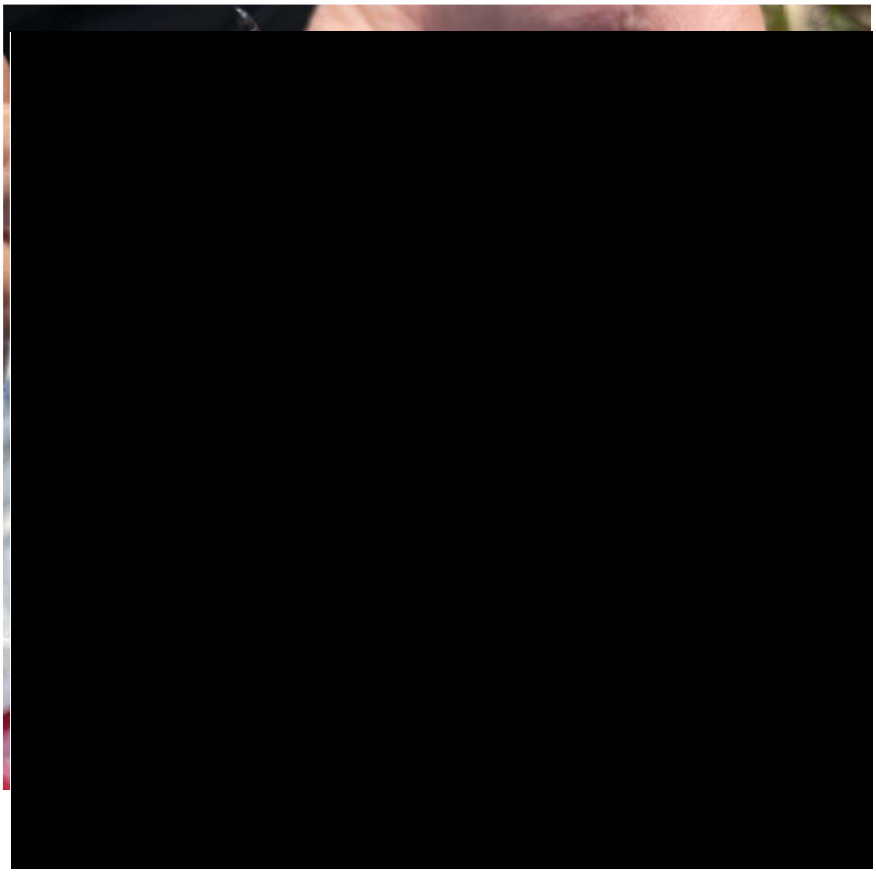
Figure 8. Location of rare herptile surveys in Gourdneck State Game Area.

Visual surveys were conducted under appropriate weather conditions when target species were expected to be active and/or visible [i.e., generally between 60-80°F (16-27°C), wind less than 15 mph, no or light precipitation]. Survey sites were visited one to five times during the field season.

Aquatic funnel trapping was conducted to document the presence and assess the abundance and demographics of spotted turtles and Blanding's turtles within Gourdneck SGA. Trapping surveys consisted of deploying up to 10 Promar minnow traps (i.e., 10, 9, and 7 traps) in each of three reference plots or areas (Figure 8) for four consecutive nights from April 18 through 22 (Willey and Jones 2014, Northeast Spotted Turtle Working Group 2019), which resulted in a total of 104 trap nights. As part of a Competitive State Wildlife Grant project focused on assessing the status and ecology of spotted and Blanding's turtles in Michigan and Ohio, MNFI and John Ball Zoo collaborated to conduct two additional weeks of trapping surveys in the game area in 2022 to obtain more information about spotted turtle population abundance and demographics, following the spotted turtle demographic assessment monitoring protocol developed by the Northeast Spotted Turtle Working Group (2019). These additional surveys consisted of deploying 7 to 10 minnow traps in 1 to 2 reference plots in the Vanderbilt Fen for four consecutive nights from April 27 through 30 and May 9 through 13, resulting in 108 additional trap nights and an overall total of 212 trap nights across all three weeks of trapping surveys. Visual encounter surveys for spotted and Blanding's turtles also were conducted while setting and checking traps. Turtles captured in the traps were measured, weighed, sexed, aged based on visible annuli or growth rings on the turtle shell and age class (adult, subadult/juvenile, hatchling), photographed, and examined for general health condition, injuries, and abnormal shell characteristics. Individual turtles captured in the traps also were marked by notching the outer scutes of the carapace (top turtle shell) with a unique notch code using the Nagle et al. (2017) notching system (except for snapping turtles). Other herptile species and other animal species captured in the traps also were recorded. Traps were checked every day during the trapping period, and animals captured in the traps were released after processing was completed.

Auditory or breeding frog call surveys for the Blanchard's cricket frog were conducted at seven sites within Gourdneck SGA on June 24 (Figure 8). Survey sites were comprised of permanent lakes, ponds, and streams and surrounding open wetlands. Surveys consisted of listening along roads in the evening or at night (17:30 – 01:00 EDT) for breeding calls of cricket frogs emanating from nearby wetlands or bodies of water. Species, call index values, location, time, and weather conditions were recorded during the surveys. Call indices were defined in the following manner: 1 = individuals can be counted, space between calls (1-5 individuals); 2 = individual calls can be distinguished but some overlapping calls (6-12 individuals); and 3 = full chorus, calls are constant, continuous and overlapping (unable to count individuals) (Sargent 2000). All frog species heard calling during the surveys were recorded.

Survey data forms were completed for all herptile surveys using the ArcGIS Survey123 mobile application. Survey locations and routes and locations of rare herptile species were recorded using the ArcGIS Survey123 and Field Maps mobile applications on a smartphone or tablet. We documented all reptiles and amphibians and other animals encountered during surveys. The species, number of individuals, age class, location, general habitat, behavior, and time of observation were noted. Weather conditions and survey times also were recorded. Whenever possible, we took photos of observed species for supporting documentation. All rare species observations were entered into the Michigan Natural Heritage Database.



Rare Mollusk and Fish Surveys

Rare native mussels were the primary target of aquatic surveys. Although there were no previously documented occurrences of rare native mussels with Gourdneck SGA, snuffbox (*Epioblasma triquetra*, Federally Endangered) and round pigtoe (*Pleurobema sintoxia*, State Special Concern) were documented in Gourdneck Creek approximately 5 miles downstream of Gourdneck SGA and suitable habitat for mussels in general was expected within the game area. Records for spotted gar (*Lepisosteus oculatus*, State Special Concern) were documented in 2005 and 1981 within Little Sugarloaf Lake, Sugarloaf Lake/Mud Lake, and Gourdneck Lake.

The State Endangered pugnose shiner (*Notropis anogenus*) was recorded in the northeast part of Kalamazoo County in 2002. It occurs in clear vegetated lakes and vegetated pools and runs of low gradient streams and rivers. Hogset Lake and Gourdneck Creek were targeted for fish sampling effort in this survey. Surveys for watercress snail (*Fontigens nickliniana*, State Special Concern) were also made when appropriate habitat was encountered. Surveys for native mussels were performed in wadable habitats (less than approximately 70cm deep) at 11 survey sites (Table 1, Figure 9, Sites 1-11). The search area at each site was measured to standardize sampling effort among sites and allow unionid mussel density estimates to be made. Live unionid mussels and shells were located with a combination of visual and tactile search methods. Glass bottom buckets were used to facilitate visual detection. Frequent tactile searches through the substrate were made to help ensure that buried individuals were being detected, including smaller sized unionid mussels. Live individuals were identified to species and placed back into the substrate anterior end down (siphon end up) in the immediate vicinity of where they were found. Shells were also identified to species. The number of live individuals was determined for each unionid mussel species at each site.

Aquatic survey Site 11 in Gourdneck Creek where live slippershell (*Alasmidonta viridis*, State Threatened) was found. Photo by P.J. Badra.

The number of shells of listed species and species of Special Concern found were counted and recorded. The riverbanks were scanned visually for mussel shell middens created by muskrats or other mammalian predators. Aquatic snails, fish, and non-native bivalves including zebra mussels (*Dreissena polymorpha*) and Asian clams (*Corbicula fluminea*) were identified and noted when encountered during mussel surveys. Sphaeriid clams were noted as present or absent as a group. A visual meander search for native mussels was made by canoe from Hogset Lake boat ramp (42.149154, -85.590332) to Gourdneck Creek (42.155343, -85.587622) and from site 7 upstream approximately 200m (to 42.19544, -85.64233).

Latitude and longitude of each survey site was recorded with a handheld Garmin GPS unit (Table 1). Habitat data were recorded to describe and document stream conditions at the time of the surveys. Substrate within each search area was characterized by estimating percent composition of each of six particle size classes as described in Hynes 1970 (Table 3). Woody debris, aquatic vegetation, exposed solid clay substrate, and eroded banks were noted when observed. The percentage of the search area with pool, riffle, and run habitat, and a rough characterization of current water speed were estimated visually (Table 5). At select sites, conductivity and pH of water were recorded with an Oakton handheld meter, and alkalinity and hardness were measured with LaMotte kits (models 4491-DR-01 and 4824-DR-LT-01) (Table 4).

Surveys for watercress snail were made at three sites (Table 1, Figure 9, Sites 1, 12, and 13). Watercress snail habitat, consisting of groundwater seeps with watercress (*Nasturtium officinale*), was noted and surveyed while hiking the headwaters of Portage Creek just west of Hampton Lake and 400m south of Vanderbilt Road within Gourdneck SGA.

Table 1. Locations of mussel and watercress snail survey sites in Gourdneck SGA, 2022. Sites 1-11 were surveyed for native mussels. Site 1 was surveyed for mussels and watercress snails, and sites 12 and 13 were surveyed for watercress snails.

Site	Waterbody	Access	Latitude (N)	Longitude (W)
1	Portage Creek	Hike west from apartments	42.192063	-85.635549
2	"	"	42.193391	-85.637201
3	"	Hike southwest from condominiums	42.186019	-85.621454
4	"	Hike west from condominiums	42.186613	-85.622378
5	Portage Creek headwaters	Vanderbilt Ave.	42.183677	-85.635612
6	"	"	42.183322	-85.633960
7	Portage Creek	Angling Rd. parking lot	42.19498	-85.64088
8	Gourdneck Creek	Hogset Lake boatramp	42.15492	-85.59209
9	"	"	42.15597	-85.59478
10	"	"	42.15542	-85.59381
11	"	"	42.15519	-85.59236
12	Portage Creek headwaters	Vanderbilt Ave.	42.182853	-85.633833
13	"	"	42.182849	-85.631334

* Hogset Lake boatramp is located at 42.149154, -85.590332

Table 2. Locations of fish sampling sites in Gourdneck SGA, 2022.

Site	Waterbody	Access	Latitude (N)	Longitude (W)
Fish-1	Hogset Lake	Hogset Lake boatramp**	42.14974	-85.58958
Fish-2*	"	"	42.15071	-85.58903
Fish-3	"	"	42.15318	-85.58750
Fish-4	"	"	42.15147	-85.58781
Fish-5	"	"	42.15524	-85.58713
Fish-6	Gourdneck Creek	"	42.15527	-85.58820
Fish-7	"	"	42.15540	-85.58952
Fish-8	"	"	42.15503	-85.59193
Fish-9	"	"	42.15550	-85.59245

* Spotted gar, a species of special concern, was seen near site Fish-2.

** Hogset Lake boatramp is located at 42.149154, -85.590332

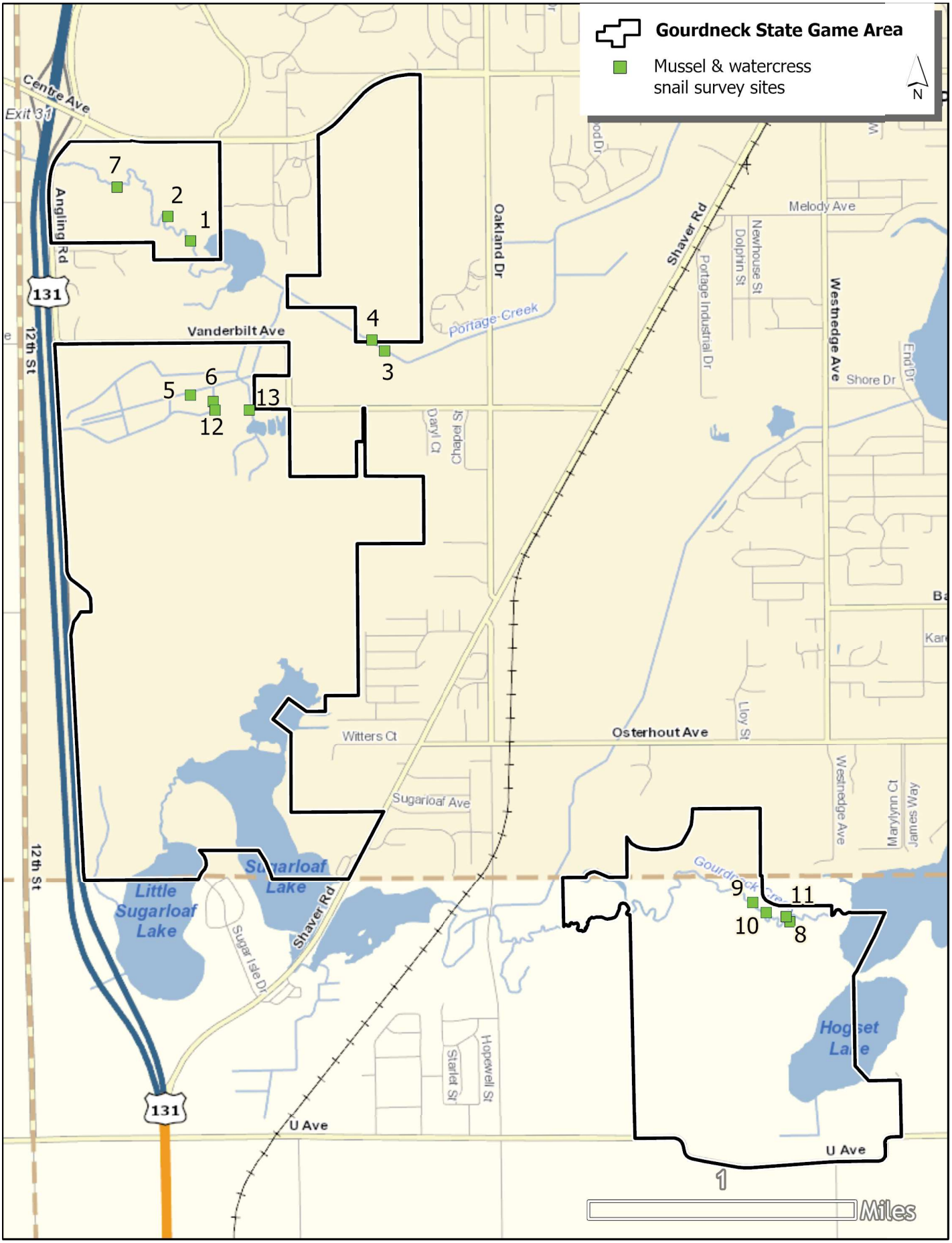


Figure 9. Location of aquatic survey sites in Gourdneck State Game Area.

Watercress snails are found in springs and spring fed headwater streams and have a strong association with the plant watercress (Berry 1943, Baker 1902). When spring or seep habitat with watercress was found, the stems and leaves of watercress plants and the shallow water areas around the plants was visually searched for snails. Live individuals and shells of small sized snails appearing to be watercress snail were placed in a labeled bottle or polyethylene bag with ethanol. Population density was estimated by counting the number of watercress snails within a small area (e.g. 0.125m^2) and extrapolating based on the area of occupied habitat. Photographs were taken of the micro-habitat and surrounding habitat where snails were found. Location of survey sites was recorded with a handheld GPS unit. Snails were photographed and identified to species in the lab under 7x to 63x magnification using shell characters. A visit was made to the University of Michigan Museum of Zoology Mollusk Collection to corroborate identification of watercress snails with museum specimens of this and similar species such as New Zealand mudsnail (*Potamopyrgus antipodarum*), Boreal marstonia (*Marstonia lustrica*), and Brown walker (*Pomatiopsis cincinnatiensis*).

In addition to incidentals finds during mussel surveys, minnow traps and visual searches were used to sample fish along the western side of Hogset Lake and in Gourdneck Creek. Five traps were baited with Cheeze-It crackers and distributed along the shore of the Lake at a depth ranging from 0.5m to 2m, and four traps were placed in Gourdneck Creek. All traps were set, checked, and removed from the water the same day using a canoe. Fish were photographed, identified, and returned to the spot they were found. Calm, clear water in Hogset Lake during the time of fish surveys facilitated visual detection and identification of fish. Latitude and longitude of each trap location was recorded with a handheld Garmin GPS unit (Table 2, Figures 9 and 10).

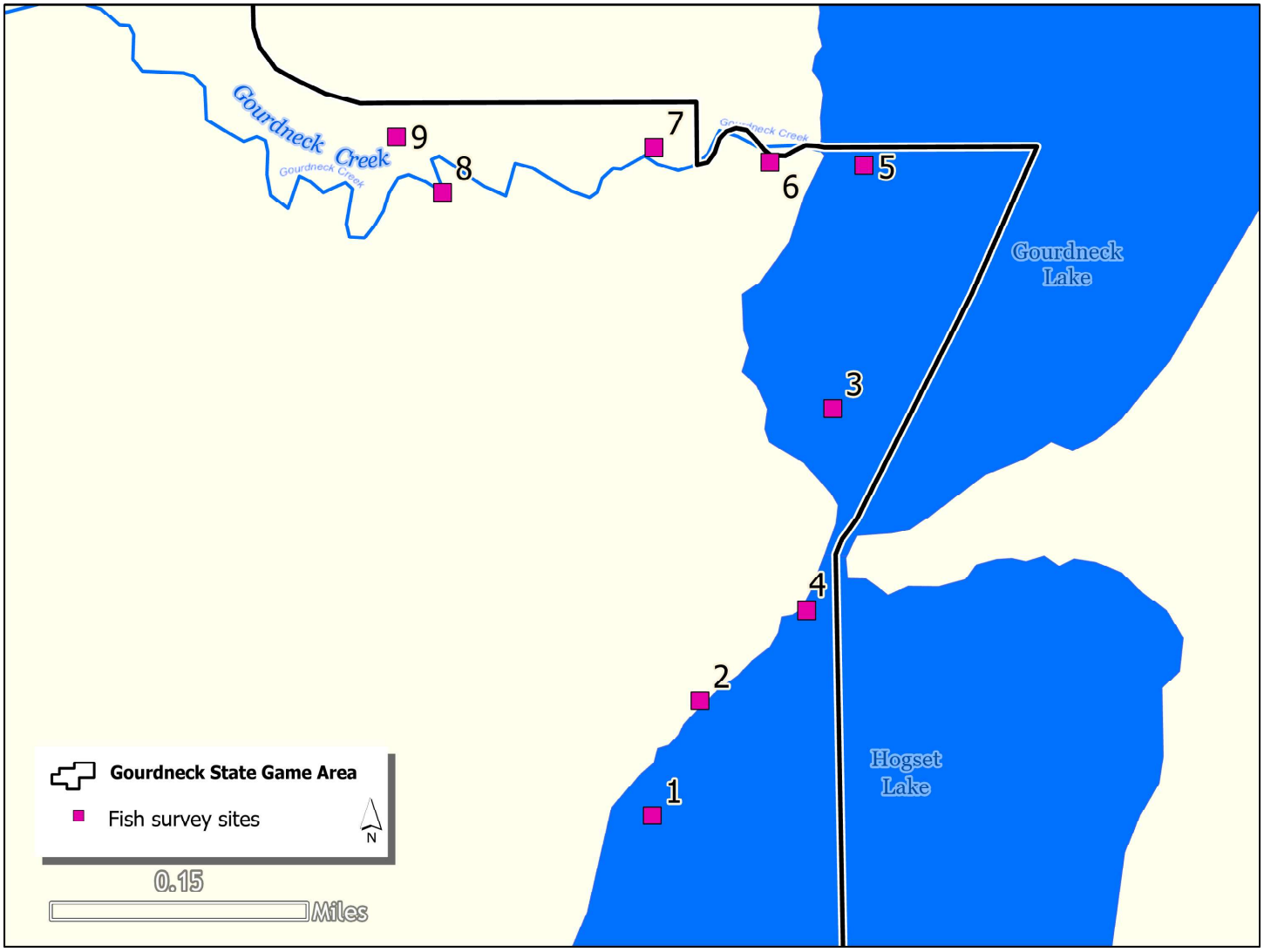


Figure 10. Location of fish survey sites in Gourdneck State Game Area.

Table 3. Percentage of each substrate particle size class estimated visually at each mussel survey site. Diameter of each size class: boulder (>256mm), cobble (256-64mm), pebble (64-16mm), gravel (16-2mm), sand (2-0.0625mm), silt/clay (<0.0625mm).

Site #	Boulder	Cobble	Pebble	Gravel	Sand	Silt
1					70	30
2					80	20
3			1	2	80	17
4					80	20
5						*
6						*
7					80	20
8				50	50	
9				10	60	30
10				10	20	70
11					60	40

* 100% fine organic muck substrate

Table 4. Water chemistry measures taken at select mussel survey sites.

Site #	pH	Conductivity (µS)	Alkalinity (mg/l CaCO3)	Hardness (mg/l)	Water temp. (C)
7	8.07	628	168	-	21.3
9	8.04	537	176	200	26.3
10	7.98	538	188	200	26.9
11	8.05	443	176	188	24.7

Table 5. Physical habitat characteristics recorded at mussel survey sites.

Site #	Current speed (m/second)	Aquatic vegetation?	Woody debris?	Eroded banks?	Dredged?	%Pool	%Riffle	%Run
1	0.20	Y	Y	N	N	20		80
2	0.25	Y	Y	N	N		10	90
3	0.25	N	Y	Y	N	20		80
4	0.25	N	Y	Y	Y	10		90
5	0	N	Y	N	N	100		
6	0	N	Y	N	N	100		
7	0.22	Y	Y	N	N			100
8	0.20	Y	Y	N	N			
9	0.33	Y	Y	N	N			100
10	0.20	Y	Y	N	N			
11	0.25	Y	Y	N	N	30		70

Rare Insect Surveys

We conducted rare insect surveys for three insect groups: butterflies, borer moths (*Papaipema* spp.), and tamarack tree cricket. We selected three sites at Gourdneck SGA to survey for rare butterflies based on the availability of nectar sources and presence of host plants: Centre Ave. Powerline (Compartment 1, Stand 3), Hampton Lake Fen (Compartment 1, Stand 14), and Vanderbilt Road Fen (Compartment 2, Stand 15) (Figure 11). To capture the full suite of common and rare lepidopteran species present in these sites, we visited each site four times in 2022 between May and August.

Butterfly meander surveys were limited to periods when the temperature was above 15° C (60° F), there was no rain, and with low winds (≤ 25 km/h; 15 mph). If temperatures were 15 - 21° C (60 - 70° F), surveys were only conducted when cloud cover was ≤ 50% of the sky. There was no cloud cover restriction if the temperature was above 21° C (70° F). Surveys were conducted between 10:00 AM and 6:00 PM (EDT). We conducted modified Pollard-Yates (Pollard and Yates 1993) surveys in which we followed a meander through habitat, focusing on areas with nectar sources. We walked at a steady, slow speed of approximately 35 meters per minute. We identified all butterflies to species, when possible.

Survey sites for borer both species (*Papaipema* spp.) were selected by assessing the available landcover and host plant presence data recorded by MNFI Ecologists in MiFI and within the natural community EOs. Sites were selected based on the following criteria: 1) landcover class associated with occurrences of target species in other regions of Michigan, 2) the presence of host plant, and 3) approximate ecological integrity of target stands.

Prior to 2022, the Michigan Natural Heritage database did not contain any information of rare borer moth species at Gourdneck SGA. Two survey sites were selected in 2022 (one for Blazing star borer and 1 for Royal fern borer). Surveys were conducted using standardized methodology developed by MNFI to document the moth community at a local site. During each *Papaipema* survey event in 2022, abundance data was collected for each species of *Papaipema* encountered and *Papaipema* species richness at each survey site was determined. For each *Papaipema* survey in 2022, associated environmental and weather data was collected.

Black light surveys were conducted for rare *Papaipema spp.* under the powerline right of way near Centre Avenue. Photo by L.M. Rowe.

Moth surveys utilized the technique of blacklighting, which consisted of standard mercury-vapor and UV lights powered by a portable generator. A large white sheet was used as a collecting surface. This frame was placed in a central location with larval host plants on all sides to maximize the likelihood of collecting adults. Surveys were generally conducted between the hours of 8:00 PM and 12:00 AM.

In 2022, we surveyed two main locations within Gourdneck SGA for tamarack tree cricket (scientific name, state status). The first location contained a known EO in the Natural Heritage Database (42.1569, -85.6488), which was last surveyed in 2000. The second location was throughout the rich tamarack swamp east of Angling Road and south of W. Centre Avenue (42.1941, -85.6390). Meander surveys were conducted throughout the suitable habitat. When a tamarack tree was encountered along the transect, we used a sweep net with a 4 ft extension handle to sweep the tamarack branches and collect any crickets on the tree. Each tree was swept for approximately 10 seconds, or until all reachable branches were surveyed. Both locations were surveyed on 08/12/2022, in sunny weather and with low wind.

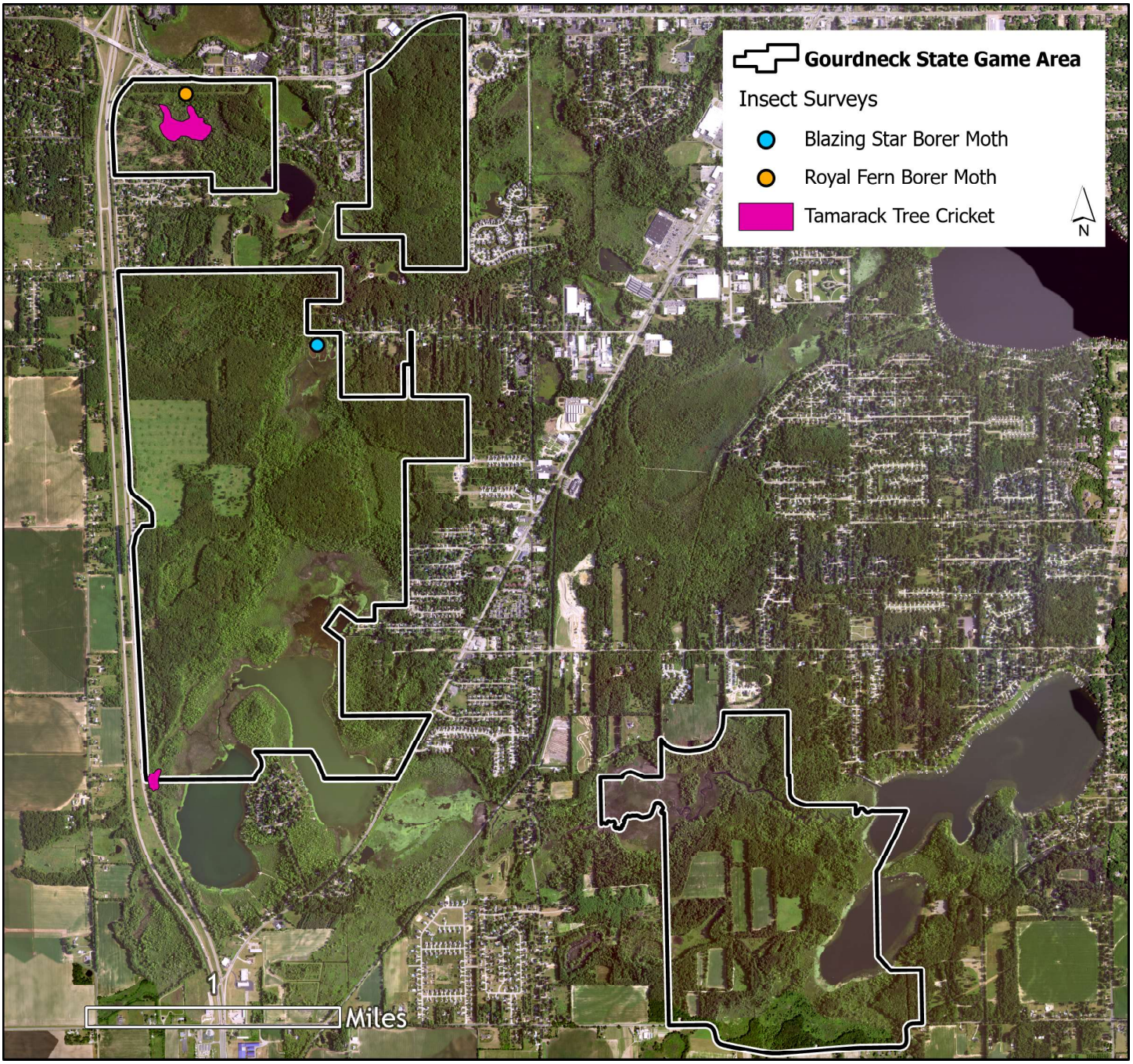


Figure 11. Location of insect surveys in Gourdneck State Game Area.

Rare Bird Surveys

Given the presence of mature forest and managed grassland within Gourdneck SGA we focused bird surveys on rare songbirds and raptors. Rare raptor surveys targeted red-shouldered hawk (*Buteo lineatus*, State Threatened), a DNR featured species. Rare songbirds were broken into two groups: forest songbirds and grassland songbirds. Rare forest songbird surveys targeted cerulean warbler (*Setophaga cerulea*, State Threatened) and hooded warbler (*Setophaga citrina*, State Special Concern). Rare grassland songbird surveys targeted grasshopper sparrow (*Ammodramus savannarum*, State Special Concern), Henslow's sparrow (*Ammodramus henslowii*, State Endangered) and dickcissel (*Spiza americana*, State Special Concern).

For raptors and forest songbirds forested stands covering at least 4 hectares (10 acres) were considered potential habitat for target species. Grassland bird surveys were conducted within the 102-acre warm season grass planting. We generated a 250 m X 250 m grid of points overlaid on the survey area. Points were assigned unique identification numbers and uploaded to tablet computer for field location. Points falling within the survey stands were visited during raptor and songbird surveys. During field surveys some points were deemed "non-suitable" habitat and surveys did not occur at these points. We did not survey points falling within pine plantations, young aspen stands, or farmstead forests.

We conducted two-minute raptor surveys at systematically located point count stations (Figure 12; Mosher et al. 1990, Anderson 2007, Bruggeman et al. 2011). Each two-minute point count consisted of one-minute broadcasts of red-shouldered hawk calls and one minute of silent listening. Surveys were conducted in May, 2022. At each station the following data were recorded: whether a red-shouldered hawk was detected; all other raptor sightings or vocalizations; other bird observations; and other rare animal species detections or potential habitats. If a

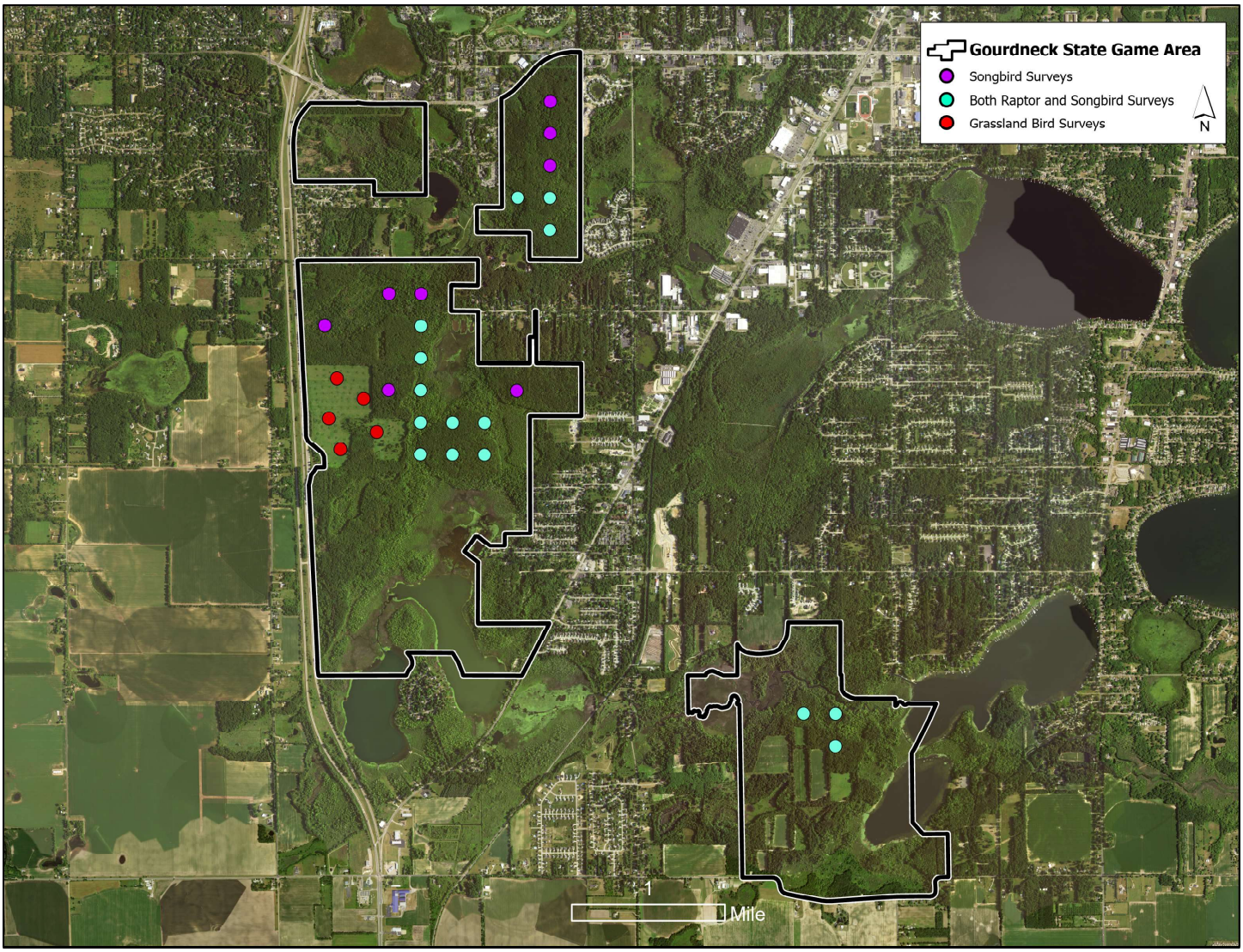


Figure 12. Location of songbird, raptor, and grassland bird surveys in Gourdneck State Game Area.

rare raptor was observed, the vicinity surrounding the point was searched for potential nests. While walking and driving between station locations, we also visually inspected trees for stick nests.

Forest bird point counts were conducted at systematically located points within suitable habitat (Figure 12). Ralph et al. (1995) noted that it is usually more desirable to increase the number of independent point-count stations than to conduct repeated surveys at a smaller number of locations, so we visited each point only once. Surveys were conducted from June 6 to June 10, 2022, from sunrise to 6 hours after sunrise, or until weather condition made it unlikely to detect birds. We avoided conducting surveys during weather conditions that could reduce bird detectability, such as strong winds (≥ 20 km/hr or 13 mph) and moderate to heavy precipitation. In addition to documenting observations of the targeted rare species, we collected data on all birds seen or heard during each 10-minute point count. We recorded the species and number of individuals observed during three independent periods (2 minutes, 3 minutes, and 5 minutes) for a total of 10 minutes at each station (Ralph et al. 1995). Use of the three survey periods provides flexibility in making comparisons with other surveys (e.g., North American Breeding Bird Surveys) which adhere to these survey protocols. Each bird observation was assigned to one of four distance categories (0-25 m, 25-50 m, 50-100 m, and >100 m) based on the estimated distance of the bird from the observer to facilitate future distance analyses and refinement of density and population estimates. At each point-count station, we noted if the site appeared suitable for cerulean or hooded warbler.

During grassland bird surveys, stations (i.e., points) were surveyed twice between May 12 and July 15, 2022 from sunrise to four hours after sunrise (Ralph et al. 1995). We employed the same survey protocol for grassland birds as we did for forest songbirds.

A Henslow's sparrow (*Ammodramus henslowii*; State Endangered)was observed during grassland bird surveys. Photo by A.P. Kortenhoven.

RESULTS

MNFI conservation scientists have documented 66 element occurrences (EOs) from Gourdneck SGA. Of those EOs, 34 were newly documented or updated during the course of the 2022 surveys. These new or updated element occurrences are composed of six natural community and 28 rare species. During surveys completed for the Integrated Inventory project at Gourdneck SGA, MNFI scientists documented or updated six natural community EOs (Table 6, Figure 13), nine rare plant EOs (Table 7, Figure 22), ten herptile EOs (Table 10, Figures 25-28), five new rare mollusk EOs (Table 11, Figure 29), 1 new fish EO (Table 11, Figure 29), two insect EOs (Table 14, Figure 30) and updated one rare bird EO (Table 16, Figure 31). Data compiled on these EOs were entered into MNFI's Natural Heritage Database (MNFI 2022).

Natural Communities

MNFI ecologists documented four new high-quality natural communities and updated two existing natural community EOs in the Gourdneck SGA including a bog, a hardwood-conifer swamp, two prairie fens, a rich tamarack swamp, and a southern hardwood swamp (Table 6, Figure 13). These high-quality natural communities cover 225 acres or 9.8 % of the game area. The following site summaries contain a detailed discussion for each of the six natural community EOs organized alphabetically by natural community type.

Table 6. Natural community element occurrences in the Gourdneck State Game Area.

Site Name	EO ID	Rank	Size (Ac)	First Recognized as EO	Last Visited	Compartment	Stands
Bog							
Greenspire Bog	26549	CD	17.5	2019	2022	1	1
Hardwood-Conifer Swamp							
Sugarloaf Swamp	26460	C	44	2022	2022	2	53 and 58
Prairie Fen							
Hampton Creek Fen	9117	D	5.8	1979	2022	1	14
Vanderbilt Fen	12497	C	22.8	2002	2022	2	15
Rich Tamarack Swamp							
Hampton Creek Swamp	26458	D	29	2022	2022	1	16
Southern Hardwood Swamp							
Vanderbilt Swamp	26616	C	106.2	2022	2022	2	13, 36, and 43

The Sugarloaf Lake wetland complex features areas of high-quality southern hardwood swamp and hardwood-conifer swamp. Photo by J.M. Lincoln.

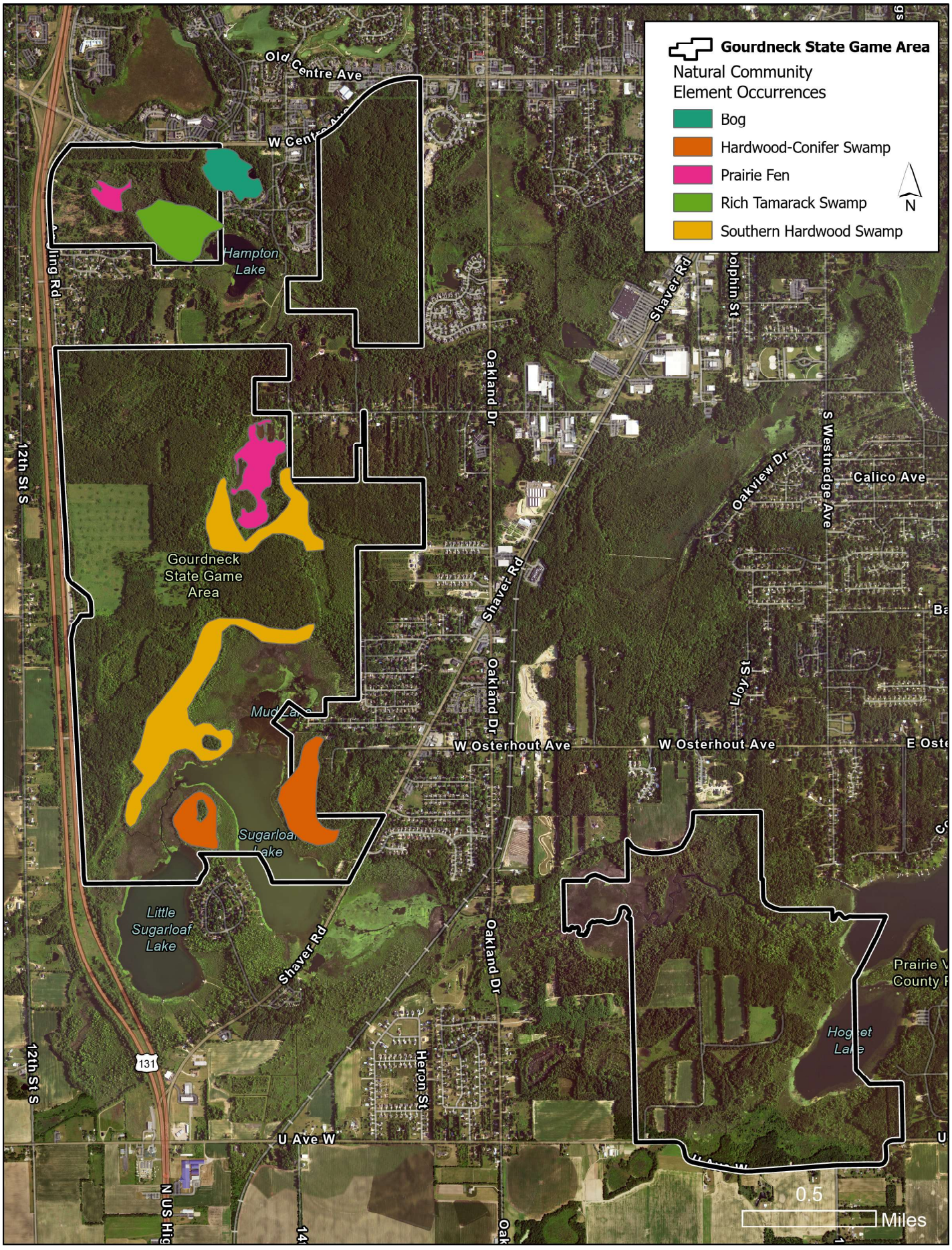


Figure 13. Natural community element occurrences in Gourdneck State Game Area.

Natural Community Descriptions

1. Greenspire Bog
Natural Community Type: Bog
Rank: G3G5 S4, vulnerable to secure globally and secure within the state
Element Occurrence Rank: CD
Size: 17.5 acres
Location: Compartment 1; Stand 1
Element Occurrence Identification Number: 26549

Greenspire Bog occurs in a deep kettle hole in a sandy outwash plain. Bogs are ombrotrophic systems, fed by rainwater and feature very acidic substrates. In contrast, fens are strongly influenced by groundwater seepage and have a circumneutral or alkaline pH. This bog features an extensive, continuous mat of Sphagnum ringed by a moat of open water and floating aquatic vegetation. The organic soils are composed of saturated peat with partially decomposed sphagnum mosses and fragments of sedges and wood. The top 40 to 45 cm of the organic soils was saturated loose Sphagnum and the bottom 5 to 10 cm was partially decomposed hemic to fibric peat. The presence of hemic and fibric peat in the top layers of substrate indicates that the site is a mature bog, having supported typical bog vegetation for several centuries. The pH of all soil strata was consistently very acidic at 4.5, suggesting relatively undisturbed hydrology.

The site consists of several zones typical of southern Michigan bogs. An open moat ranging from 3 to 5 meters in width surrounds the entire bog. The upland side of the moat is characterized by black gum (*Nyssa sylvatica*), red maple (*Acer rubrum*), red oak (*Quercus rubra*), highbush blueberry (*Vaccinium corymbosum*), glossy buckthorn (*Frangula alnus*), and white pine (*Pinus strobus*).

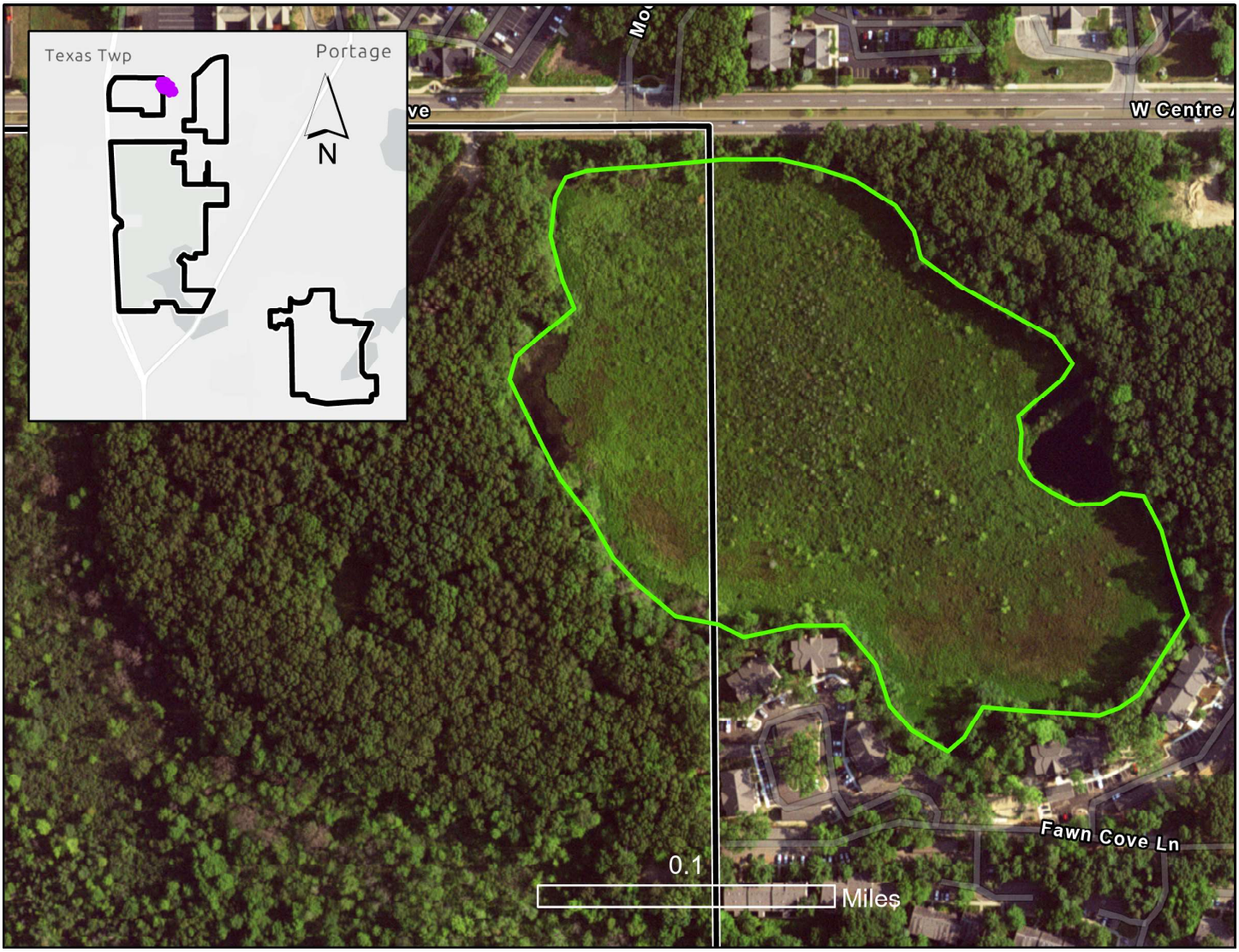


Figure 14. Location of Greenspire Bog (ESRI 2022).

The moat consists of deep muck soils and primarily shallow, open water. Adjacent to the moat is a zone of shrubs and forbs, dominated by highbush blueberry and swamp loosestrife (*Decodon verticillatus*).

Immediately beyond this area is a saturated zone of ferns, graminoids and shrubs. This zone is dominated by Virginia chainfern (*Woodwardia virginica*), with some scattered pockets of few-seeded sedge (*Carex oligosperma*). The primary zone of the bog features a continuous mat of floating Sphagnum, dominated by leatherleaf (*Chamaedaphne calyculata*) and several tall shrubs, including highbush blueberry (*Vaccinium corymbosum*), mountain holly (*Ilex mucronata*), and winterberry (*I. verticillata*). Other species found here included: few-seeded sedge and tawny cotton grass (*Eriophorum virginicum*). In the middle of the bog was a tall shrub and tree zone dominated by mountain holly, glossy buckthorn (*Frangula alnus*), red maple (*Acer rubrum*), tamarack (*Larix laricina*) and very robust leatherleaf. Of special note is that a significant percentage of the tamarack trees were either dead or almost dead. This may be an indication of recent high-water levels within the bog from direct runoff and precipitation.

The northwest corner of the bog showed acute signs of disturbance, likely due to the influence of stormwater inflows from Centre Ave. and adjacent developed areas. This portion of the bog was characterized by an expanded mat of floating vegetation and a concentration of purple loosestrife (*Lythrum salicaria*). There was also potentially historical peat mining in localized areas along the eastern border of the bog.

Invasive, non-native species were typically occasional or infrequent. Glossy buckthorn was found throughout the bog and was particularly well established and abundant within the inner tall shrub zone of the bog. Purple loosestrife was also established in parts of the moat surrounding the bog, particularly in the broad area of emergent vegetation and open water in the northwest corner of the bog, where runoff from Centre Ave. may be a consistent source of disturbance.

The moat of the bog is dominated by whorled loosestrife (foreground). Photo by T.J. Bassett.

Hybrid cat-tail (*Typha* x *glauca*) and purple loosestrife are very low in abundance and restricted to the margins of the bog and could be managed with relative ease.

Greenspire Bog was visited in August 2019 and October 2022. Twenty-four plant species were observed with 21 native species and 3 non-native species recorded. The total FQI was 23.0 and the Total Mean C was 4.7. Conservation metrics for Greenspire Bog and the comprehensive species list are available in Appendix 2.

Threats and Management Recommendations

The site is adjacent to Centre Ave., a major east-west road, scattered residential structures to the east, and a large apartment complex to the south. It appears that runoff from Centre Ave. may have already impacted the northern portion of the bog, and the new apartment complex has replaced a significant natural forested buffer with impervious surfaces that are likely to contribute to nutrient and sediment-laden runoff into the bog. One of the biggest issues facing the long-term health of the Greenspire bog may be the polluted runoff from both of these sources. We recommend that management efforts focus on maintaining an extensive natural buffer, preventing alterations to hydrology, reducing runoff from roads and apartment complexes, and treating invasive species – especially glossy buckthorn, purple loosestrife, and hybrid cat-tail.

The central portion of the bog features a mat of floating Sphagnum moss which is dominated by leatherleaf, Virginia chain fern, and sparse tamarack. Photo by T.J. Bassett.

A portion of Greenspire Bog was impacted by historical excavation. Nutrient rich runoff from surrounding land clearing and apartment complexes is likely impacting water quality, potentially exacerbating infestations of invasive species such as narrow-leaved cat-tail and glossy buckthorn. Photo by T.J. Bassett.

Greenspire Bog is being impacted by runoff from Centre Avenue and surrounding apartment complexes. Photo by J.M. Lincoln.

2. Sugarloaf Swamp
Natural Community Type: Hardwood-conifer swamp
Rank: G4 S3, apparently secure globally and vulnerable within the state
Element Occurrence Rank: C
Size: 44 acres
Location: Compartment 2; Stands 53 and 58
Element Occurrence Identification Number: 26460

This swamp is situated at the margins of a Sugarloaf Lake and is bordered by floating mats of poor fen along the lake and oak forests on the adjacent sandy outwash uplands. Historically, the surrounding landscape was characterized by oak savanna and influenced by frequent fires. However, due to constant seepage of cold, minerotrophic groundwater, fire was not a significant disturbance factor within the swamp. The canopy of the swamp is dominated by deciduous species with a supercanopy of white pine throughout. The site features hummock and hollow microtopography. The hummocks are composed of ancient rotting stumps. The hollows are characterized by deep, stagnant sapric mucks that remain inundated or saturated for most of the year. Soil samples from the hummocks showed alkaline pH (7.5-8.0), fine organics with embedded coarse woody debris, and a fine network of roots. The hollows were characterized by alkaline pH (8.0), fine, saturated sapric mucks that extend to a depth of more than one meter.

The majority of trees and shrubs are growing on hummocks composed of debris from rotting stumps of former trees. The location of these historical stumps appears to determine the canopy structure and niches for canopy associates. The gradual transition from poor fen to forested wetland is a part of the lake-filling process. Anthropogenic fluctuations in the lake levels and disease outbreaks have had a detrimental impact on the distribution and composition of canopy species, most recently with the loss of ash and elm.

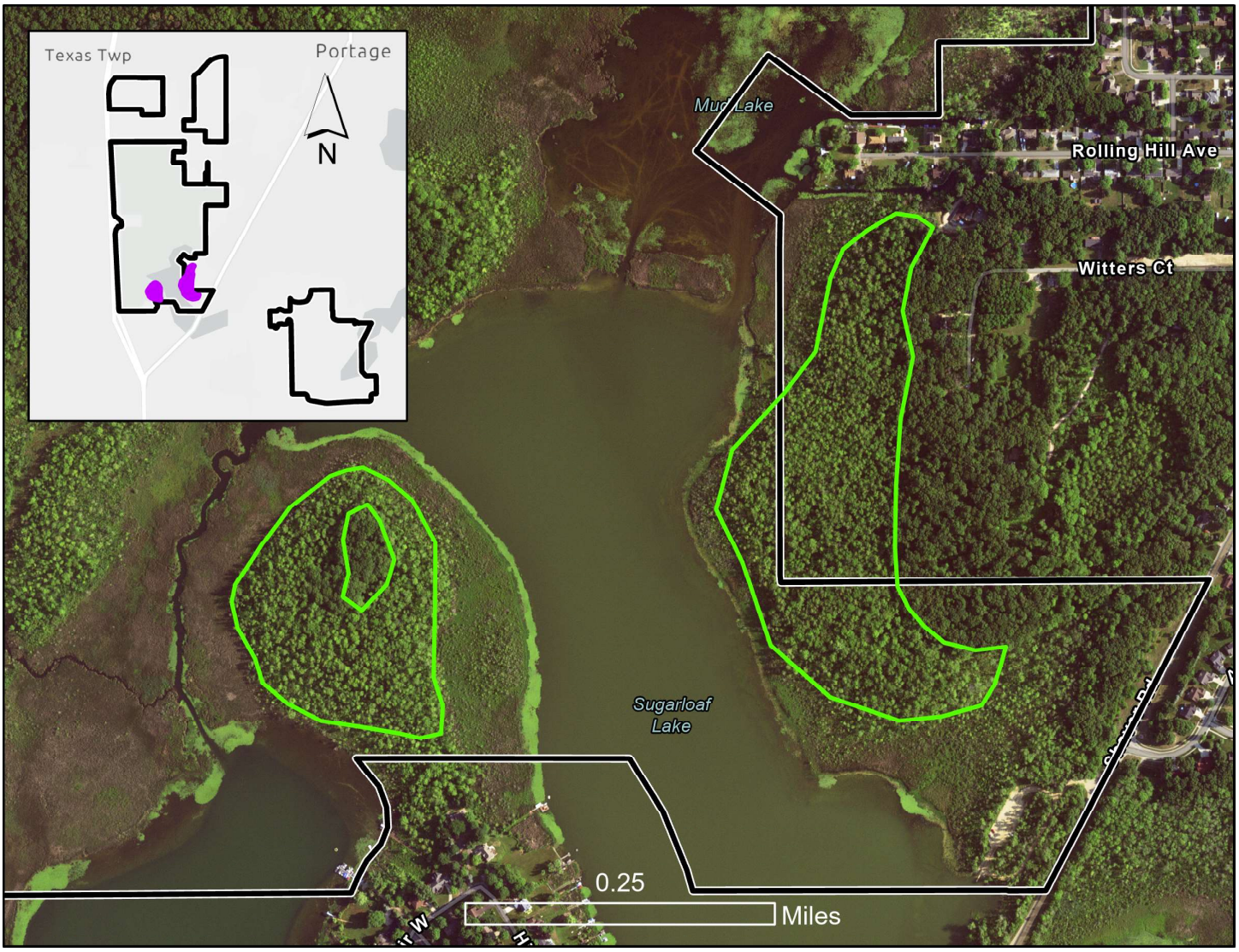


Figure 15. Location of the two polygons of Sugarloaf Swamp hardwood-conifer swamp (ESRI 2022).

Sugarloaf Swamp features a supercanopy of white pine. Photo by J.M. Lincoln.

The hardwood-conifer swamp community type is more prevalent in the northern portions of the state and is relatively rare in the southern half of Michigan's lower peninsula. This is one of three hardwood-conifer swamps in the southern two tiers of Michigan counties. This swamp is in relatively good condition with a high proportion of native species and few invasive species within the swamp. The forest is dominated by second-growth trees but has composition and structure similar to historical conditions although ash borer and Dutch elm disease have eliminated important components of the canopy. Ash was likely around 10 % of the canopy with areas close to 25% of the canopy. Hydrologic alterations are influencing the level of the lake, causing increased water levels and canopy mortality towards the lake edge. Yellow birch seems to be dying and it might be due to fluctuations in water level or climate change as the species is much less common this far south in Michigan. Deer herbivory was obvious throughout, especially on blueberry and huckleberry as observed during the 2022 survey.

The swamp is characterized by a sparse canopy (60 to 70%) of deciduous trees with a supercanopy of white pine (*Pinus strobus*). Dominant deciduous trees include red maple (*Acer rubrum*), basswood (*Tilia americana*), and tulip tree (*Liriodendron tulipifera*). Silver maple (*Acer saccharinum*), American elm (*Ulmus americana*), yellow birch (*Betula alleghaniensis*), black gum (*Nyssa sylvatica*), tamarack (*Larix laricina*), and red oak (*Quercus rubra*) are occasional canopy associates. There were several dead standing and down green and black ash. These appear to have occupied around 10 to 20% of the canopy. Elm was also likely more abundant historically. Canopy trees range in size from 25 to 75 cm diameter. Most trees are likely around 100 years old but one white pine had a ring count of 133 years and a red maple had a ring count of 138 years.

The subcanopy and understory both range from 20 to 30%. The subcanopy consists of American elm, red maple, white pine, black gum, yellow birch, and tulip tree. Within the understory, muscle wood (*Carpinus*

Sugarloaf Swamp is characterized by hummock-hollow microtopography. Photo by J.M. Lincoln.

caroliniana), black ash (*Fraxinus nigra*), green ash (*Fraxinus pennsylvanica*), elm (*Ulmus sp.*), white pine, red maple, poison sumac (*Toxicodendron vernix*), and Michigan holly (*Ilex verticillata*) are relatively prevalent. Beech (*Fagus grandifolia*), red oak , flowering dogwood (*Cornus florida*), and bitternut hickory (*Carya cordiformis*) are rare in the subcanopy and understory.

The low shrub layer has 20 to 30% coverage and is dominated by spicebush (*Lindera benzoin*), pussy willow (*Salix discolor*), silky dogwood (*Cornus amomum*), glossy buckthorn (*Frangula alnus*), highbush blueberry (*Vaccinium corymbosum*), Michigan holly (*Ilex verticillata*), swamp rose (*Rosa palustris*), autumn olive (*Elaeagnus umbellata*), and multiflora rose (*Rosa multiflora*) are typical species. Huckleberry (*Gaylussacia baccata*) and witch-hazel (*Hamamelis virginiana*) are less common and restricted to the driest hummocks.

The herbaceous layer is typically dense and continuous, except for the wettest hollows between hummocks. Ferns are common to dominant with cinnamon fern (*Osmunda cinnamomea*), sensitive fern (*Onoclea sensibilis*), and royal fern (*Osmunda regalis*) as the most abundant. Skunk cabbage (*Symplocarpus foetidus*), white grass (*Leersia virginica*), fowl manna grass (*Glyceria striata*), floating manna grass (*Glyceria septentrionalis*), sedges (*Carex stipata*, *C. crinata*, and *C. pseudo-cyperus*), tufted loosestrife (*Lysimachia thyrsiflora*), cursed crowfoot (*Ranunculus sceleratus*), and marsh-marigold (*Caltha palustris*) are typical species in the mucky hollows. The elevated hummocks are more diverse with goldthread (*Coptis trifolia*), wood anemone (*Anemone quinquefolia*), partridge-berry (*Mitchella repens*), sedges (*C. disperma*, *C. leptalea*, *C. grayi*), long-awned wood grass (*Brachyelytrum erectum*), wood reedgrass (*Cinna arundinacea*), and jack-in-the-pulpit (*Arisaema triphyllum*).

The large trees of Sugarloaf Swamp tend to grow on hummocks composed of decaying stumps of former trees. These hummocks also support a diversity of shrubs, including huckleberry. Photo by J.M. Lincoln.

Sugarloaf Swamp was visited in June 2022. One hundred and seventeen plant species were observed with 111 native species and 6 non-native species recorded. The total FQI was 46.5 and the Total Mean C was 4.3. Conservation metrics for Sugarloaf Swamp and the comprehensive species list are available in Appendix 3.

Threats and Management Recommendations

The primary threats to the swamp are alterations to lake levels, land clearing on private lands, invasive species, and deer herbivory. Invasive species pose a serious threat to the system and include narrow-leaf cat-tail (*Typha angustifolia*), glossy buckthorn, autumn olive, multiflora rose, and reed canary grass (*Phalaris arundinacea*). We recommend evaluating ideal lake levels for stabilizing the lake margins and preventing mortality of trees in the swamp. Problematic invasive species within the swamp in order of concern are glossy buckthorn, autumn olive, and multiflora rose. At the lakeward margins of the swamp, narrow-leaved cat-tail and reed canary grass are serious threats. We recommend treating invasive species beginning with glossy buckthorn, autumn olive, and multiflora rose within the swamp. Once those shrubs are controlled, we recommend addressing the narrow-leaf cat-tail and reed canary grass at the margins, but acknowledge that this is an extremely difficult task. Finally, we recommend evaluating options for purchasing the adjacent private property, which supports a substantial amount of the high-quality hardwood-conifer swamp.

Multiflora rose and other invasive species are locally problematic within Sugarloaf Swamp. Photo by J.M. Lincoln.

Canopy species within Sugarloaf Swamp have died towards the lakeward portion of the swamp (bottom). This is likely due to fluctuations of lake levels but canopy mortality could also be influenced Dutch elm disease, emerald ash borer, and potentially climate change. The resulting loss of canopy and increased lake level has led to a dramatic expansion of the non-native invasive narrow-leaved cat-tail at the edges of the swamp (top). Photos by J.M. Lincoln.

3. Hampton Creek Fen
Natural Community Type: Prairie Fen
Rank: G3 S3, vulnerable globally and vulnerable within the state
Element Occurrence Rank: D
Size: 5.8 acres
Location: Compartment 1; Stand 14.
Element Occurrence Identification Number: 9117

This fen occurs along Hampton Creek within a small drainage basin between lobes of sandy outwash upland. The drainage empties into the kettle depression that forms Hampton Lake to the southeast. The fen is kept open by constant, cold groundwater from the surrounding uplands to the south. Soils are alkaline (pH 7.0-7.5) sapric peats over marl (pH 7.5). Around the stream and areas of seepage, sapric peats are greater than 1 m. The system transitions to fire-suppressed oak savanna along the uplands. Within the drainage, the fen transitions to degraded southern shrub-carr and rich tamarack swamp.

Beaver were historically likely part of a long disturbance cycle where the site would be inundated by flooding and then transition to submergent and emergent wetland, then prairie fen, shrub-carr, and rich tamarack swamp over long periods of time. The conversion of more closed-canopy rich tamarack swamp would have been interrupted by infrequent fire, periodic insect outbreaks, and zones of groundwater seepage, creating a dynamic, diverse, and complex system within the drainage. There was a known Indigenous settlement on the north side of the stream. Since Euro-colonization, the broader wetland complex has been impacted by land clearing, channelizing of Hampton Creek, localized ditching, invasive species, fire suppression, and the overabundance of deer.

The fen was ditched in the early 20th century, though the impacts to native vegetation appear to have been relatively minor. Invasive shrubs are most dominant

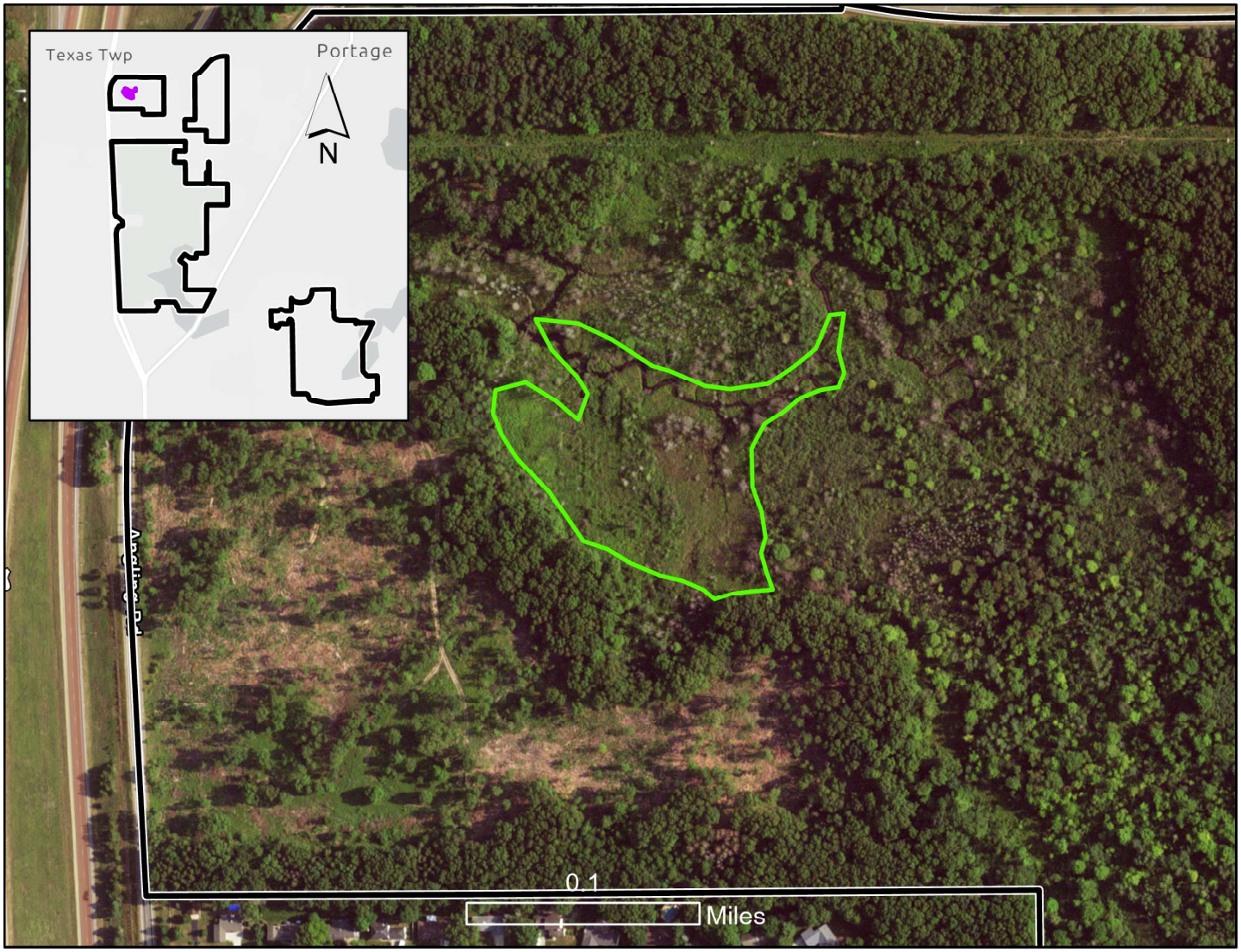


Figure 16. Location of Hampton Creek Fen prairie fen (ESRI 2022).

in areas along ditching. The system was flooded by beaver in 2017 which has caused a substantial shift in species composition and vegetative structure. Following the flooding from beaver and subsequent removal of the dam in 2020, there has been a dramatic increase in purple loosestrife and narrow-leaf cattail. Glossy buckthorn has also increased, eliminating characteristic vegetation.

The prairie fen is diverse with areas dominated by tall shrubs, zones of open fen meadow dominated by sedges, and areas of seepage feeding the small stream. Within the fen meadow, dominant graminoids include sedges (*Carex stricta*, *Cx*. *lasiocarpa*, *Cx*. *stipata*, *Cx*. *sterilis*, and *Cx*. *bebbii*), cut grass (*Leersia oryzoides*), blue-joint (*Calamagrostis canadensis*), rush (*Juncus brachycephalus*), and fowl manna grass (*Glyceria striata*). The native broad-leaved cat-tail (*Typha latifolia*) is locally abundant but the invasive narrow-leaf cat-tail (*Typha angustifolia*) is locally dominant and appears to be increasing in abundance following inundation from the beaver dam. Forbs in this fen meadow zone include joe-pye-weed, wild mint (*Mentha canadensis*), southern blue flag (*Iris virginica*), purple loosestrife (*Lythrum salicaria*), bedstraw (*Galium asprellum, G. trifidum*), goldenrods (*Solidago rugosa* and *S. patula*), New England aster (*Symphyotrichum novae-angliae*), arrow-leaved tear-thumb (*Persicaria sagitta*), great water dock (*Rumex orbiculatus*), and golden ragwort (*Packera aurea*). Ferns are common to locally dominant and include sensitive fern (*Onoclea sensibilis*), marsh fern (*Thelypteris palustris*), and royal fern (*Osmunda regalis*). Shrubs in this fen meadow zone include shrubby cinquefoil (*Dasiphora fruticosa*), poison sumac (*Toxicodendron vernix*), red-osier (*Cornus sericea*), meadowsweet (*Spiraea alba*), wild black currant (*Ribes americanum*), and Bebb's willow (*Salix bebbiana*).

Areas dominated shrubs feature silky dogwood (*Cornus amomum*), Poison sumac, nannyberry (*Viburnum lentago*), glossy buckthorn (*Frangula alnus*), Michigan holly (*Ilex verticillata*), hazelnut (*Corylus americana*), spicebush (*Lindera benzoin*), highbush blueberry (*Vaccinium corymbosum*), common buckthorn (*Rhamnus cathartica*), autumn olive (*Elaeagnus umbellata*), and multiflora rose (*Rosa multiflora*).

Hampton Creek Fen is influenced the seepage of nutrient-rich groundwater from adjacent uplands. This constant flow allows for the accumulation of peat over alkaline marl. Photo by J.M. Lincoln.

Areas along the stream and zones with seeping groundwater are characterized by hardstem bulrush (*Schoenoplectus acutus*), American bur-reed (*Sparganium americanum*), water-parsnip (*Berula erecta*, State Threatened), water hemlock (*Cicuta bulbifera*), purple-stemmed tickseed (*Bidens connata*), common water horehound (*Lycopus americanus*), creeping bent (*Agrostis stolonifera*), watercress (*Nasturtium officinale*), forget-me-not (*Myosotis scorpioides*), and common bladderwort (*Utricularia vulgaris*). Aquatic plants in the stream include sago pondweed (*Stuckenia pectinata*), common waterweed (*Elodea canadensis*), and Richardson's pondweed (*Potamogeton richardsonii*).

Hampton Creek Fen was visited in June and August 2022. One hundred and nine plant species were observed in the prairie fen with 96 native species and 13 non-native species recorded. The total FQI was 39.7 and the Total Mean C was 3.8. Conservation metrics for Hampton Creek Fen and the comprehensive species list are available in Appendix 4.

Threats and Management Recommendations

Invasive species pose a serious threat to the system and include narrow-leaf cat-tail, glossy buckthorn, purple loosestrife, common buckthorn, reed canary grass, and Canada thistle. These seem to have been exacerbated by recent inundation from beavers. Our primary management recommendations are to prevent beavers from forming dams along Hampton Creek, continue to treat invasive species, reduce woody encroachment at the ecotone where the fen transitions to upland, and include the fen with prescribed fires of the adjacent uplands. Additional areas of fen could likely be recovered, especially to the east along the stream, if invasive shrubs were addressed.

The invasive non-native narrow-leaved cat-tail is locally dominant, particularly in areas of Hampton Creek Fen that were impacted by inundation by beaver. Photo by J.M. Lincoln.

The composition of Hampton Creek Fen has been substantially altered by inundation from beaver flooding. The top photo was taken in 2016 when the fen was still dominated by native vegetation. The bottom photo from 2022 shows a dramatic expansion of the non-native invasive purple loosestrife. Photos by J.M. Lincoln.

4. Vanderbilt Fen
Natural Community Type: Prairie Fen
Rank: G3 S3, vulnerable globally and vulnerable within the state
Element Occurrence Rank: C
Size: 22.8 acres
Location: Compartment 2; Stand 15.
Element Occurrence Identification Number: 12497

This fen occurs within a glacial drainage basin between lobes of sandy outwash uplands. The entire wetland complex around Sugarloaf Lake to the south, continuing up to this fen is a heterogenous mix of submergent and emergent marsh, floating poor fen lake margins, prairie fen where peat grows over marl, rich tamarack swamp on deep organic mucks, southern hardwood swamp on saturated sands, and hardwood-conifer swamp where there is substantial groundwater influence from adjacent sandy moraines. The northern portion of the drainage flows north, the southern portion flows south such that even though there is a continuous wetland complex, the wetland system feeds different streams (Figure 18).

Soils within the fen are alkaline (pH 7.5) sapric peats over marl (pH 7.5 to 8.0). Around the zones of open water in the center of the fen, there is extensive floating Sphagnum peat moss and the system trends towards poor fen. Here, the fibric peats are slightly acidic (pH 6.5 to neutral) and the decaying fibric and sapric peats below are alkaline (pH 7.5-8.0). The area of floating peat seems to have dramatically expanded since 2016 due to a beaver dam at the outlet in the northernmost portion of the fen. It appears that much of the peat disassociated from the marl below such that the zone of poor fen dominated by wiregrass sedge, hardstem bulrush, and blue-joint dramatically expanded into areas that were recently dominated by shrubby cinquefoil (*Dasiphora fruticosa*).

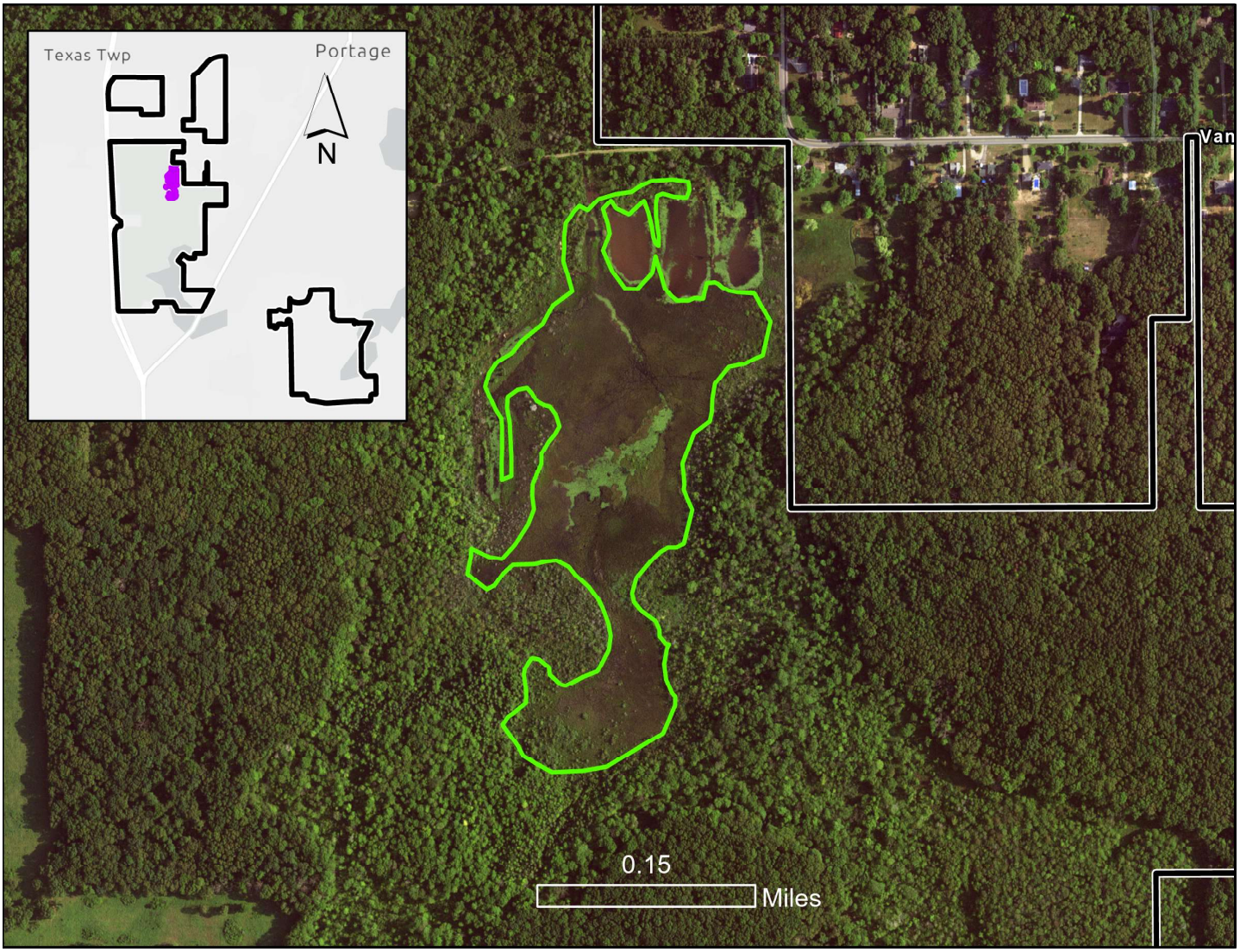


Figure 17. Location of Vanderbilt Fen prairie fen (ESRI 2022).

Along the open water, there are extensive zones of floating peat dominated by wiregrass sedge with pitcher-plant, marsh fern, and tamarack (top photo). Following flooding by the beaver, several diverse areas that once featured extensive shrubby cinquefoil hummocks had converted to a more uniform meadow of wiregrass sedge, bulrush, and blue-joint (bottom photo). Photos by Jesse M. Lincoln.

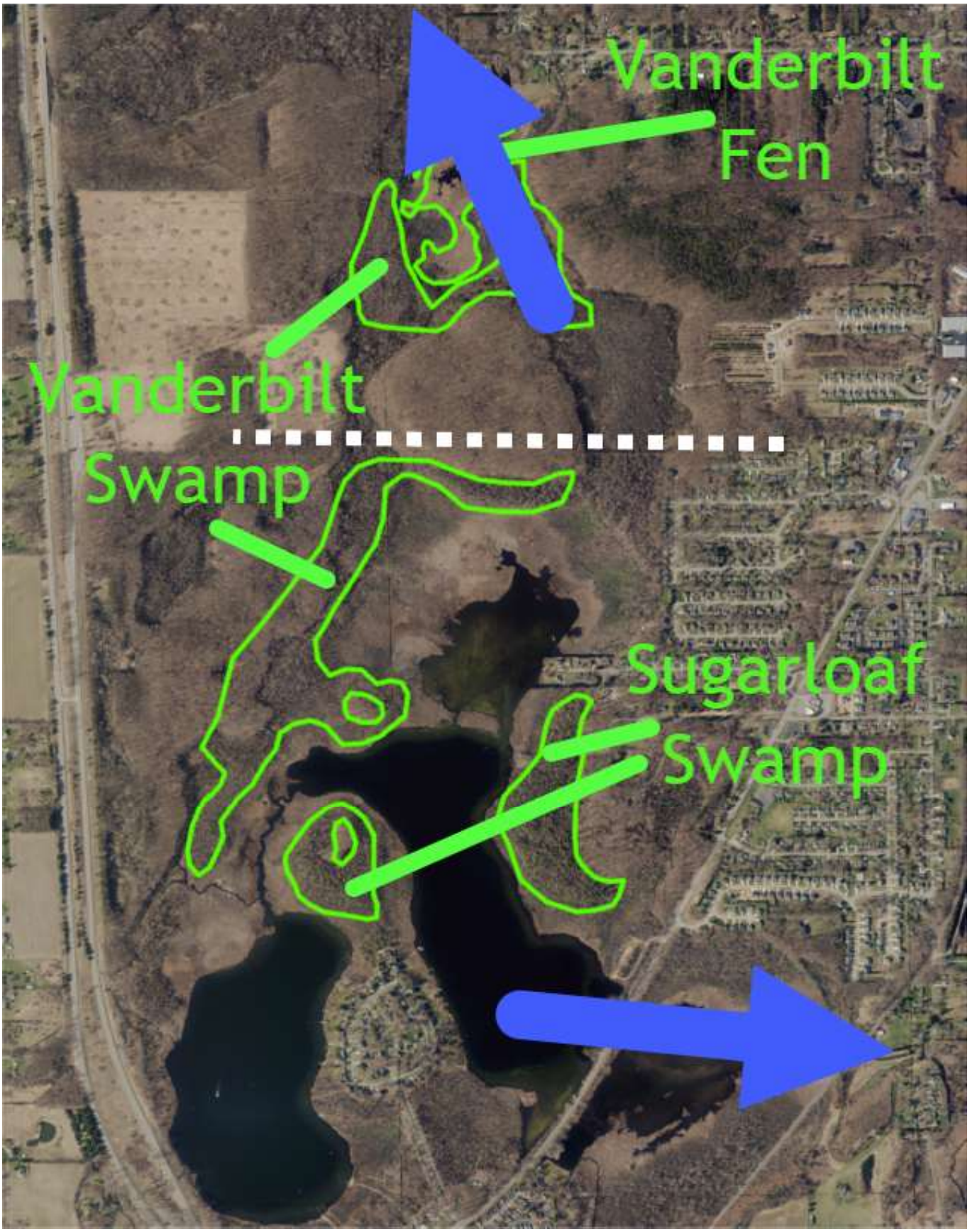


Figure 18. The drainage pathways of the wetland complexes around Sugarloaf Lake and Vanderbilt Fen. Vanderbilt Fen occurs in a large wetland complex that extends south to Sugarloaf Lake. Vanderbilt Fen drains to the north, eventually meeting with Portage Creek and converging with the Kalamazoo River. Sugarloaf Lake drains to the east and south through Gourdneck Creek and eventually converging with St. Joseph River. The apparent divide is indicated by the white dashed line, blue arrows indicate the direction of flow.

Beaver were historically doubtless part of a long disturbance cycle within this wetland complex. The site would be inundated by flooding and then during prolonged periods of drawdown would transition to submergent and emergent wetland, then prairie fen, shrub-carr, and rich tamarack swamp. The conversion of more closed-canopy rich tamarack swamp would have been interrupted by infrequent fire, periodic insect outbreaks, and zones of groundwater seepage, creating a dynamic, diverse, and complex wetland system within the drainage that varied in both space and time.

The margins of the fen are diverse with prairie grasses and likely burned in concert with the adjacent uplands, which were historically oak savannas. Ditching of this wetland, the extraction of marl, and fire suppression have acted in concert to eliminate the open ecotone between the fen and the oak uplands. Imagery from 1938 is especially useful for visualizing the elimination of the ecotone (Figure 19). The ecotone was likely important habitat for [redacted] rare reptiles in the system. These fen margins and tamarack swamp ecotones are also particularly susceptible to invasion by glossy buckthorn and the non-native shrub forms extensive thickets throughout the complex.

The system has had some areas where marl extraction severely modified the margins of the fen prior to state ownership. There are five obvious pits that were excavated and some minor ditching where the wetland flows out of the basin at the northern end. There has also been some ditching along the pits, potentially to drain the complex. There is also a serious problem with narrow-leaved cat-tail at the southern portion of the system and glossy buckthorn is locally abundant. Despite these problems, management by the state has substantially reduced glossy buckthorn around the marl pits and non-native Phragmites at various locations throughout the fen system.

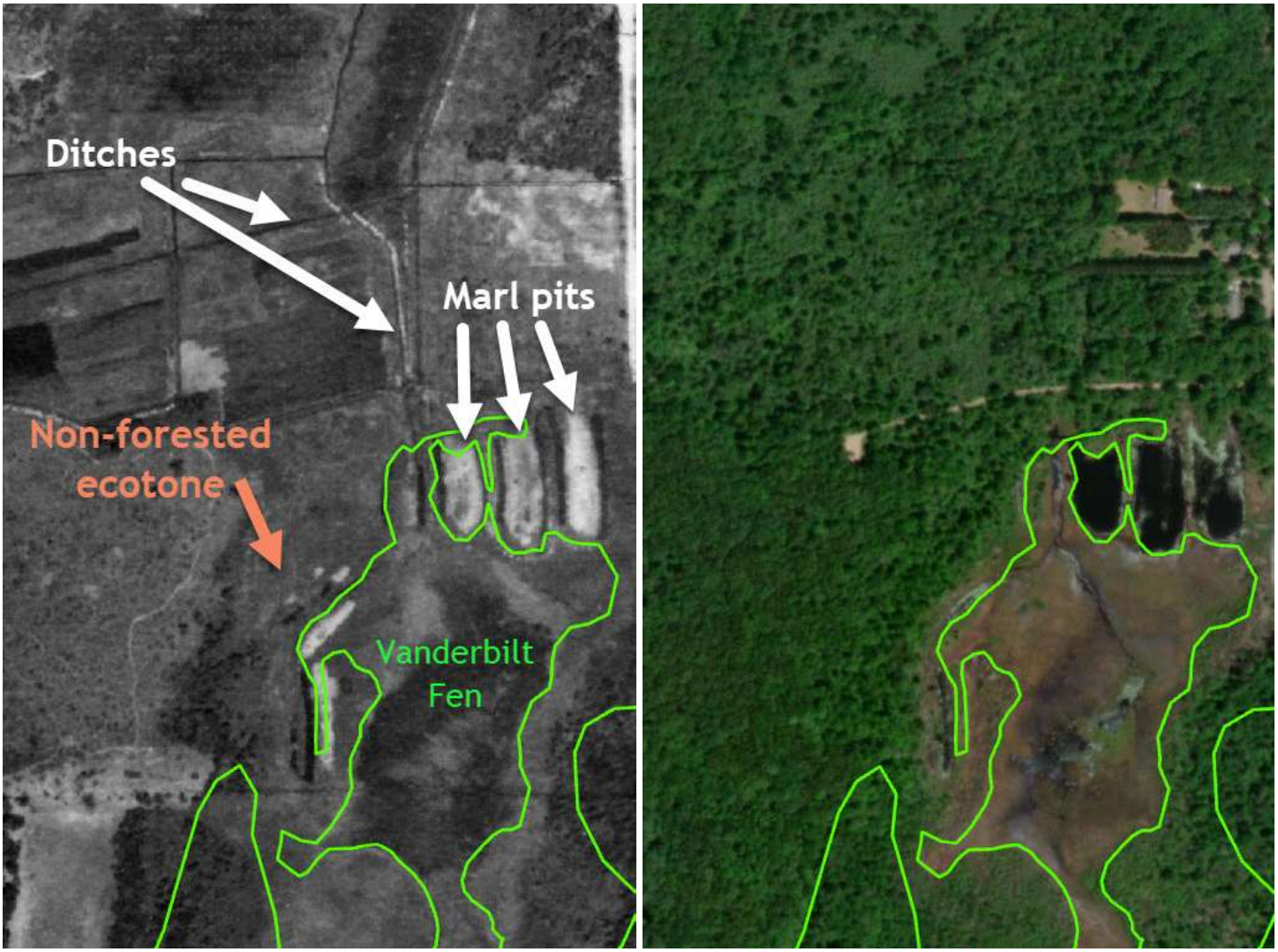
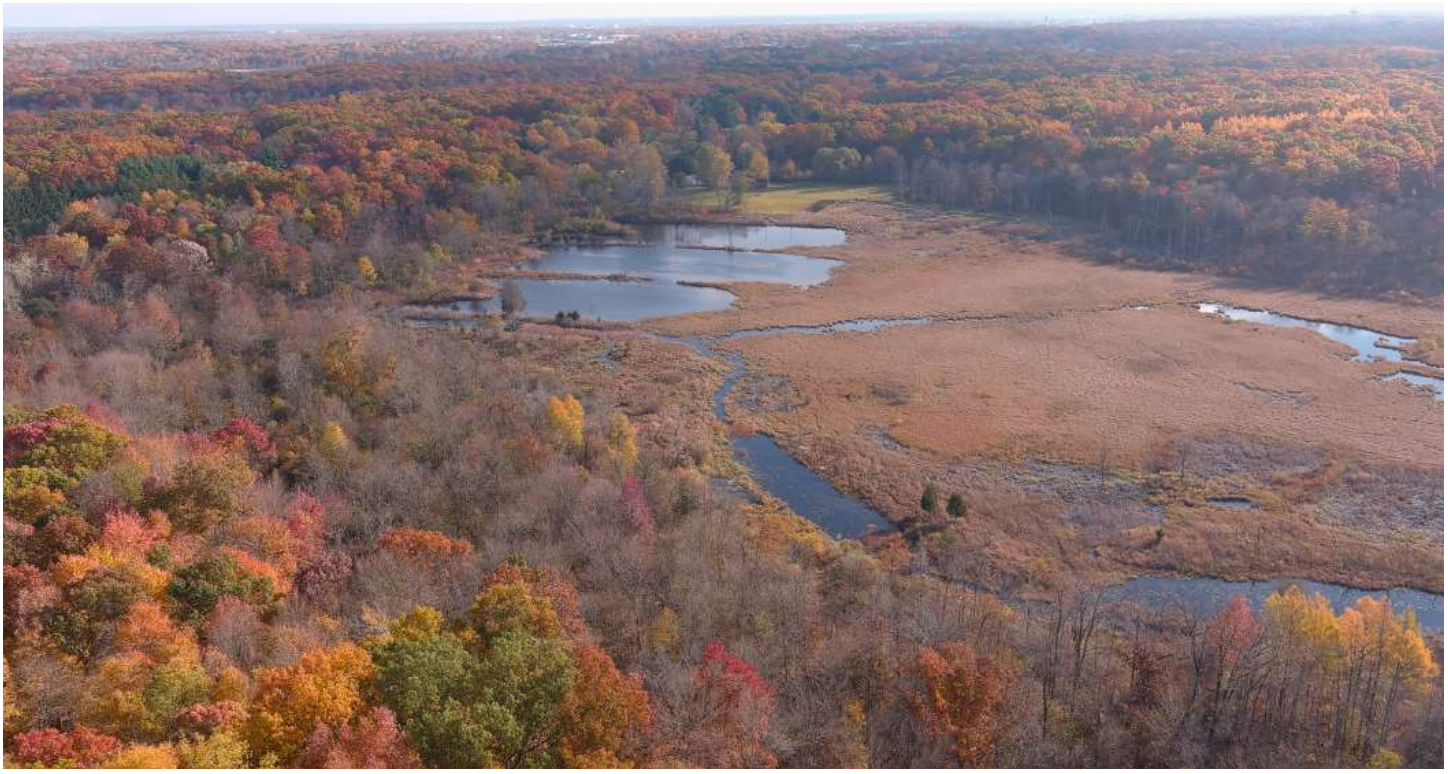


Figure 19. Imagery of the Vanderbilt Fen wetland complex from 1938 (left) and now (right). The imagery shows the marl pits and extensive ditching throughout the wetland complex around Vanderbilt Fen. Additionally, the ecotone between the fen and surrounding uplands is non-forested in the early 20th century. Ditching and fire suppression have caused areas of ecotones and open wetlands to transition to forest.



Marl was extracted from Vanderbilt Fen prior to state ownership. Five ponds were dug for this purpose and are still apparent. Photo by J.M. Lincoln.

Areas adjacent to the excavated marl pits support a high diversity of native prairie fen vegetation, including marsh blazing-star, Ohio goldenrod, big bluestem, and shrubby cinquefoil. Photo by L.M. Rowe.

This prairie fen is characterized by a floating sphagnum/sedge mat flanking areas of open water, and a sloping fen margin with deep peats over marl. The open water area features yellow pond-lily (*Nuphar lutea*), whorled loosestrife (*Decodon verticillatus*), hardstem bulrush (*Schoenoplectus acutus*), pondweed (*Potamogeton gramineus*), water smartweed (*Persicaria amphibia*), marsh cinquefoil (*Comarum palustre*), and mermaid-weed (*Proserpinaca palustris*).

The floating sphagnum/sedge mat, or poor fen zone, is overwhelmingly dominated by wiregrass sedge (*Carex lasiocarpa*), blue-joint (*Calamagrostis canadensis*), hardstem bulrush, and marsh fern (*Thelypteris palustris*). Extensive areas of the floating mat have low diversity but several areas are extremely diverse. The more diverse zones of the poor fen feature bog lobelia (*Lobelia kalmii*), common arrowhead (*Sagittaria latifolia*), tickseed-sunflower (*Bidens trichosperma*), northern bog aster (*Symphyotrichum boreale*), false nettle (*Boehmeria cylindrica*), twig-rush (*Cladium mariscoides*), nodding ladies-tresses (*Spiranthes cernua*), threesquare (*Schoenoplectus pungens*), bog willow (*Salix pedicellaris*), pitcher-plant (*Sarracenia purpurea*), broad-leaved cat-tail (*Typha latifolia*), native phragmites (*Phragmites australis* subs. *amercanus*), beak-rush (*Rhynchospora alba*), yellow flat sedge (*Cyperus flavescens*), and swamp milkweed (*Asclepias incarnata*).

Towards the margin and along the marl pits, the site more closely resembles typical prairie fen with sphagnum development over marl. These areas were impacted by marl extraction and some ditching and feature the greatest concentration of glossy buckthorn (*Frangula alnus*). Despite the disturbance and encroachment from woody species, the prairie fen margins are very diverse. Species include big bluestem (*Andropogon gerardii*), Ohio goldenrod (*Solidago ohioensis*), marsh blazing star (*Liatris spicata*), purple meadow rue (*Thalictrum dasycarpum*), Indian grass (*Sorghastrum nutans*), black-eyed susan (*Rudbeckia hirta*), purple loosestrife (*Lythrum salicaria*), common mountain mint (*Pycnanthemum virginianum*), rush (*Juncus brachycephalus*), boneset (*Eupatorium perfoliatum*), twig-rush (*Cladium mariscoides*), tussock sedge (*Carex stricta*), fringed brome (*Bromus ciliatus*),

A population of white lady-slipper (*Cypripedium candidum*, State Threatened) was relocated in Vanderbilt Fen in 2022 after not being observed since 1980. This species is frequently browsed by deer and is declining across its range due to herbivory and fire suppression. Photo by J.M. Lincoln.

tall coreopsis (*Coreopsis tripteris*), and purple false foxglove (*Agalinis purpurea*). Shrubs in this zone include shrubby cinquefoil, poison sumac (*Toxicodendron vernix*), dogwoods (*Cornus amomum, C. foemina,* and *C. sericea*), swamp rose (*Rosa palustris*), and black raspberry (*Rubus occidentalis*). Trees are very infrequent and include tamarack (*Larix laricina*), big-tooth aspen (*Populus grandidentata*), red-cedar (*Juniperus virginiana*), black cherry (*Prunus serotina*), and American elm (*Ulmus americana*).

Vanderbilt Fen was visited in August 2022. Eighty plant species were observed with 74 native species and 6 non-native species recorded. The total FQI was 41.1 and the Total Mean C was 4.6. Conservation metrics for Vanderbilt Fen and the comprehensive species list are in Appendix 5.

Threats and Management Recommendations

The site is extremely diverse with numerous rare plant and animal species documented within the wetland complex. [redacted] protecting the integrity of the wetland complex should be a top priority for game area managers. The primary threats to Vanderbilt Fen are alterations to hydrology, especially from beaver, invasive species, and woody encroachment at the margins of the fen, likely due to fire suppression and the legacy of ditching. We recommend continuing to treat invasive species, particularly narrow-leaved cat-tail south of the open pond and glossy buckthorn and autumn olive at the margins. We also urge managers to investigate repairing hydrology issues that may have been caused by historical ditching (visible in the 1938 imagery). The system was historically much less forested, particularly at the northwestern zones and ditching and fire suppression likely caused a conversion of the ecotone from open prairie to degraded rich tamarack swamp. This ecotone is important habitat for numerous reptiles. We recommend including this ecotone in prescribed fire plans to maintain the open condition of the ecotone and increase floristic continuity from the upland to the wetland.

Areas adjacent to the excavated marl pits have been treated for invasive species, such as glossy buckthorn. These areas continue to support a high diversity of native prairie fen vegetation. Photo by J.M. Lincoln.

Following the beaver flooding, a patch of non-native invasive narrow-leaved cat-tail rapidly expanded in the southern portion of the fen (location indicated by the green arrow in the bottom photo). This infestation is a serious threat to the integrity of the fen and treating it should be a top priority. Photos by J.M. Lincoln.

5. Hampton Creek Swamp
Natural Community Type: Rich Tamarack Swamp
Rank: GU S4, globally unrankable and secure within the state
Element Occurrence Rank: D
Size: 29 acres
Location: Compartment 1; Stand 16.
Element Occurrence Identification Number: 26458

Hampton Creek Swamp is part of a larger wetland complex along Hampton Creek and Hampton Lake. The swamp occurs in an area of poorly drained outwash deposits between lobes of sandy outwash uplands. Previous surveys describe the mapped polygon as two large patches of rich tamarack swamp separated by southern shrub-carr, with southern hardwood swamp on the upland margins (Sytsema and Pippen 1981). An additional patch of rich tamarack swamp occurred to the west, upstream on Hampton Creek, but major tamarack mortality occurred in response to recent beaver flooding. Portions of the stream have been straightened, apparently during the construction of Highway 131 (Sytsema and Pippen 1981). Soils within the rich tamarack swamp are circumneutral (pH 6.5 to 7.0) sapric mucks of varying depths (15 cm to > 1 m) over fine circumneutral (pH 7.0) sands.

The swamp is highly variable with concentrations of tamarack along seeps and natural stream channels. The rich tamarack swamp locally intergrades with southern wet meadow, southern shrub-carr, and southern hardwood swamp. Community structure is heterogenous, with canopy ranging from 30 to 75% and tree sizes ranging from 12 to 40 cm. The canopy is generally dominated by tamarack (*Larix laricina*), especially along seeps and stream channels. Red maple (*Acer rubrum*), American elm (*Ulmus americana*), southern pin oak (*Quercus palustris*), and red oak (*Q. rubra*) are interspersed in the canopy.

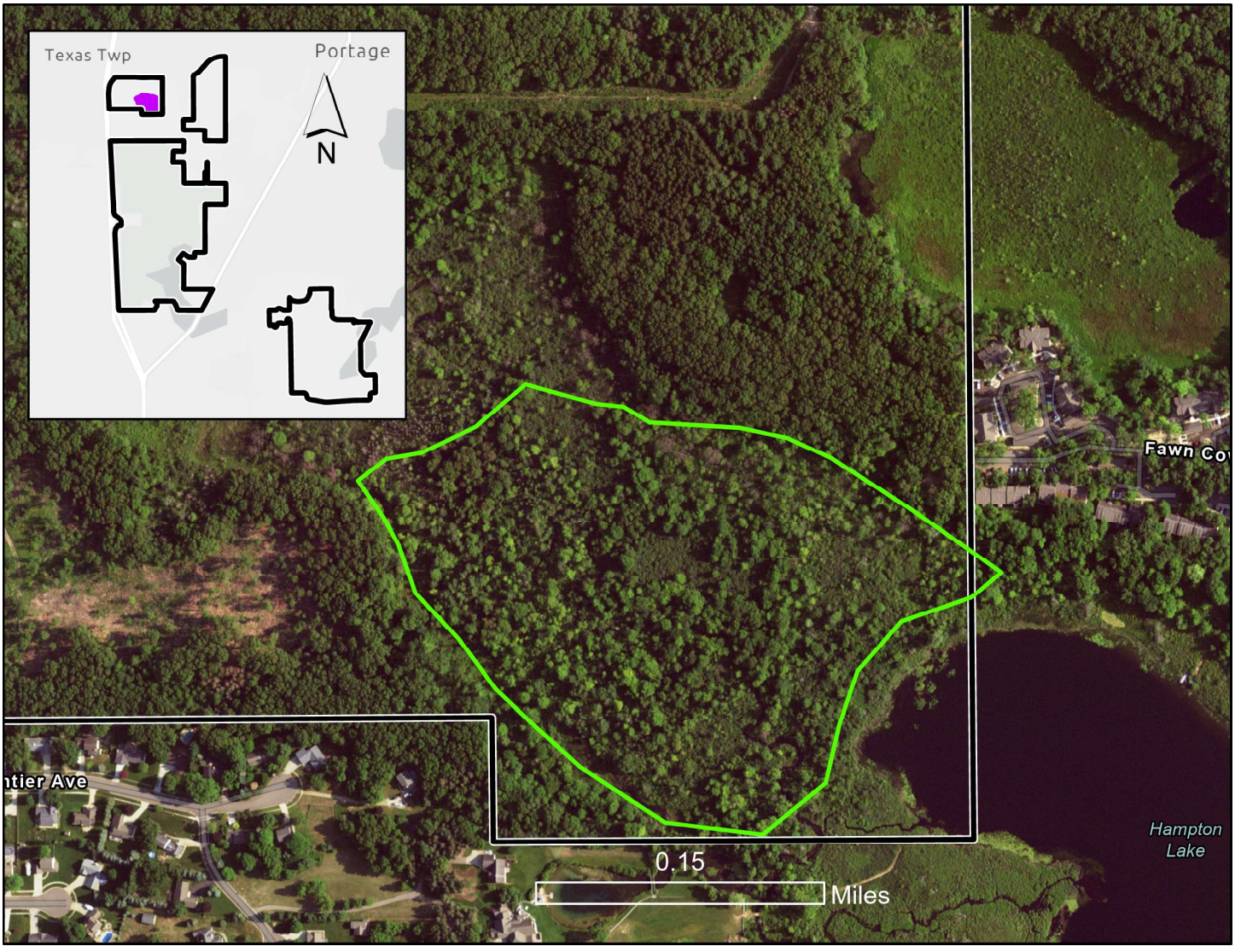
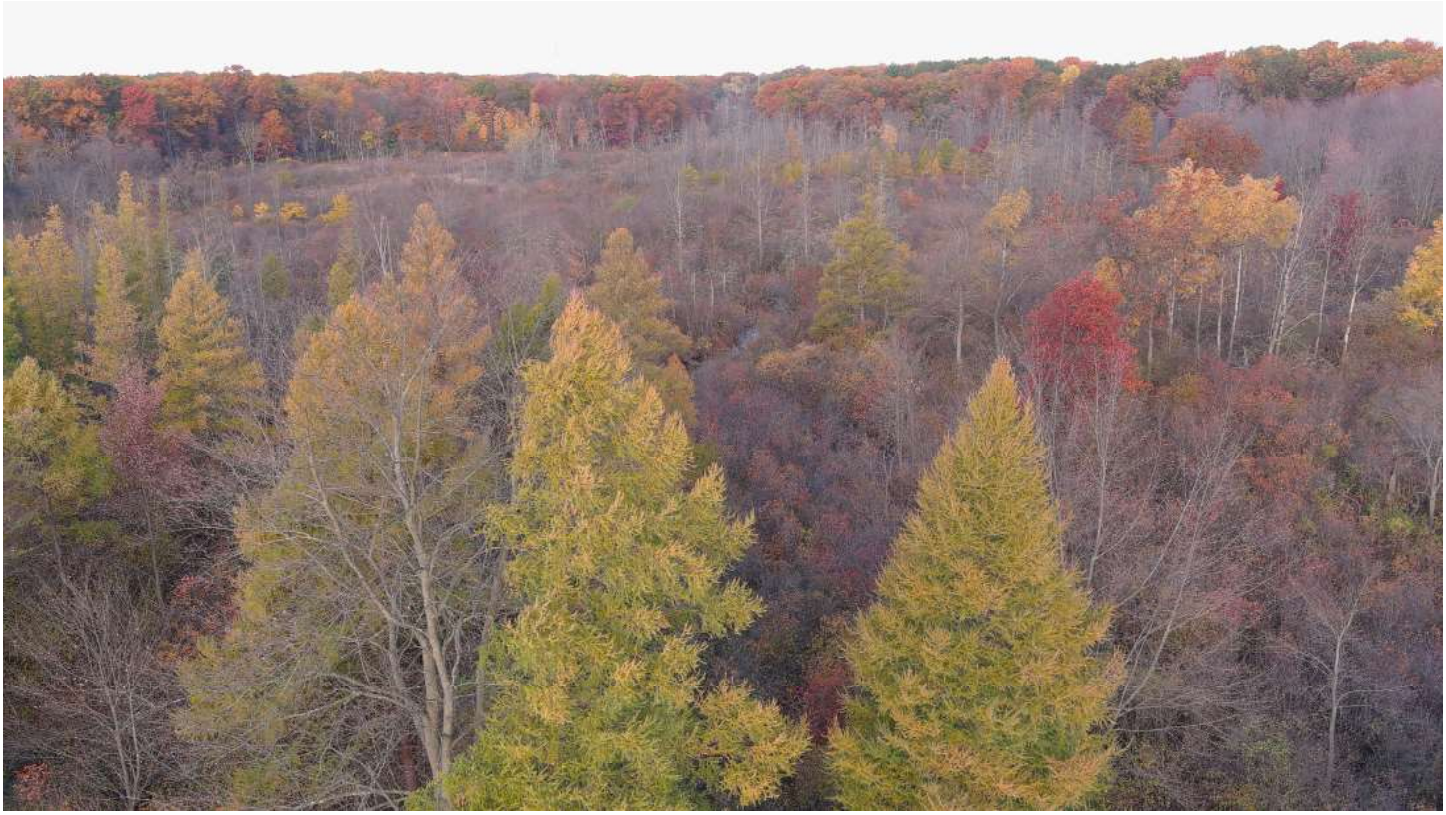


Figure 20. Location of Hampton Creek Swamp rich tamarack swamp (ESRI 2022).



Hampton Creek Swamp is characterized by a sparse canopy of tamarack and red maple with an understory locally dominated by glossy buckthorn. Photo by J.M. Lincoln.

Areas along Hampton Creek are especially diverse. Photo by J.M. Lincoln.

Black cherry (*Prunus serotina*) is prevalent in areas where the stream was straightened, and the spoils piled on the stream banks. Open canopy gaps are common and dominated by shrubs or occasionally graminoids. Tamarack in the canopy was aged at 60 to 115 years. The understory is dense and frequently dominated by glossy buckthorn (*Frangula alnus*), poison sumac (*Toxicodendron vernix*), alder (*Alnus incana*), highbush blueberry (*Vaccinium corymbosum*), spicebush (*Lindera benzoin*), grey dogwood (*Cornus foemina*), and common buckthorn (*Rhamnus cathartica*). The herbaceous layer is extremely variable and diverse, though often becoming shaded out by the extraordinarily dense glossy buckthorn. Common species include golden ragwort (*Packera aurea*), tussock sedge (*Carex stricta*), rough-leaved goldenrod (*Solidago patula),* sensitive fern (*Onoclea sensibils*), skunk cabbage (*Symplocarpus foetidus*), crested woodfern (*Dryopteris cristata*), slender sedge (*Carex leptalea*), rice cutgrass *(Leersia oryzoides),* and dwarf red raspberry (*Rubus pubescens*).

Cut-leaved water parsnip (*Berula erecta*, Special Concern) is the only extant rare plant species in this swamp and it is common in seeps and scattered along the stream margins. Several historical EOs are considered extirpated or likely extirpated from this swamp, including prairie Indian-plantain (*Arnoglossum plantagineum*, Special Concern), white lady's-slipper (*Cypripedium candidum*, State Threatened), and climbing fern (*Lygodium palmatum*, State Endangered).

Hampton Creek Swamp was visited once in July of 2019 and once in June of 2022. One hundred and thirty-four plant species, including 119 native (88.8%) and 15 non-native were recorded. The total FQI was 50.9 and the Total Mean C was 4.5. Conservation metrics for Hampton Creek Swamp and the comprehensive species are in Appendix 6.

There are inclusions of southern hardwood swamp at the eastern edge of Hampton Creek Swamp. These areas are locally dominated by red maple. Photo by T.J. Bassett.

Threats and Management Recommendations
Hampton Creek Swamp has been severely degraded by glossy buckthorn and other non-native shrubs such as common buckthorn (*Rhamnus cathartica*), Autumn olive (*Elaeagnus umbellata*), multiflora rose (*Rosa multiflora*), Japanese barberry (*Berberis thunbergii*), common privet (*Ligustrum vulgare*), and Morrow's honeysuckle (*Lonicera morrowii*). Narrow-leaved cat-tail (*Typha angustifolia*) hybrid cat-tail (*T.* x *glauca*), and purple loosestrife (*Lythrum salicaria*) are widespread and locally dominant. Our primary management recommendations are to treat invasive species (particularly glossy buckthorn), investigate restoring the natural stream channel morphology, and limit the impacts of beaver on the stream hydrology. The treatment of invasive species, especially glossy buckthorn, multiflora rose, and autumn olive, is a high priority but will be especially challenging and time intensive due to the saturated soils and density of poison sumac.

Hampton Creek Swamp is locally dominated by glossy buckthorn. This infestation is substantially reducing native vegetation and altering the successional trajectory of much of the swamp and broader wetland complex. Treating the invasive shrub will improve the composition of the swamp but will be very difficult.
Photo by J.M. Lincoln.

6. Vanderbilt Swamp
Natural Community Type: Southern Hardwood Swamp
Rank: G3 S3, vulnerable globally and vulnerable within the state
Element Occurrence Rank: D
Size: 106.2 acres
Location: Compartment 2; Stands 13, 36, 43
Element Occurrence Identification Number: 26616

This southern hardwood swamp occurs as two polygons within a large wetland complex. The southern polygon is situated at the margins of a small lake and occurs between floating mats of poor fen and uplands on lobes of sandy outwash. Historically, the surrounding uplands were characterized by oak savanna and influenced by frequent fires. However, due to constant seepage of cold, minerotrophic groundwater, fire was not a significant disturbance factor within the swamp. The canopy of the swamp is dominated by deciduous species, particularly red maple (*Acer rubrum*), yellow birch (*Betula alleghaniensis*), silver maple (*A. saccharinum*), and American elm (*Ulmus americana*). Towards the margins where the swamp transitions to poor fen, the canopy is dominated by tamarack and the system trends towards rich tamarack swamp. These inclusions of rich tamarack swamp are relatively small and species composition is generally constant, though black ash (*Fraxinus nigra*), royal fern (*Osmunda regalis*), and native phragmites (*Phragmites australis var. americanus*) become more dominant in the open areas. Soils of the hardwood swamp are saturated mucks (pH 7.0) to depths between 10 and 20 cm over fine, circumneutral (pH 7.0-7.5) saturated sands.

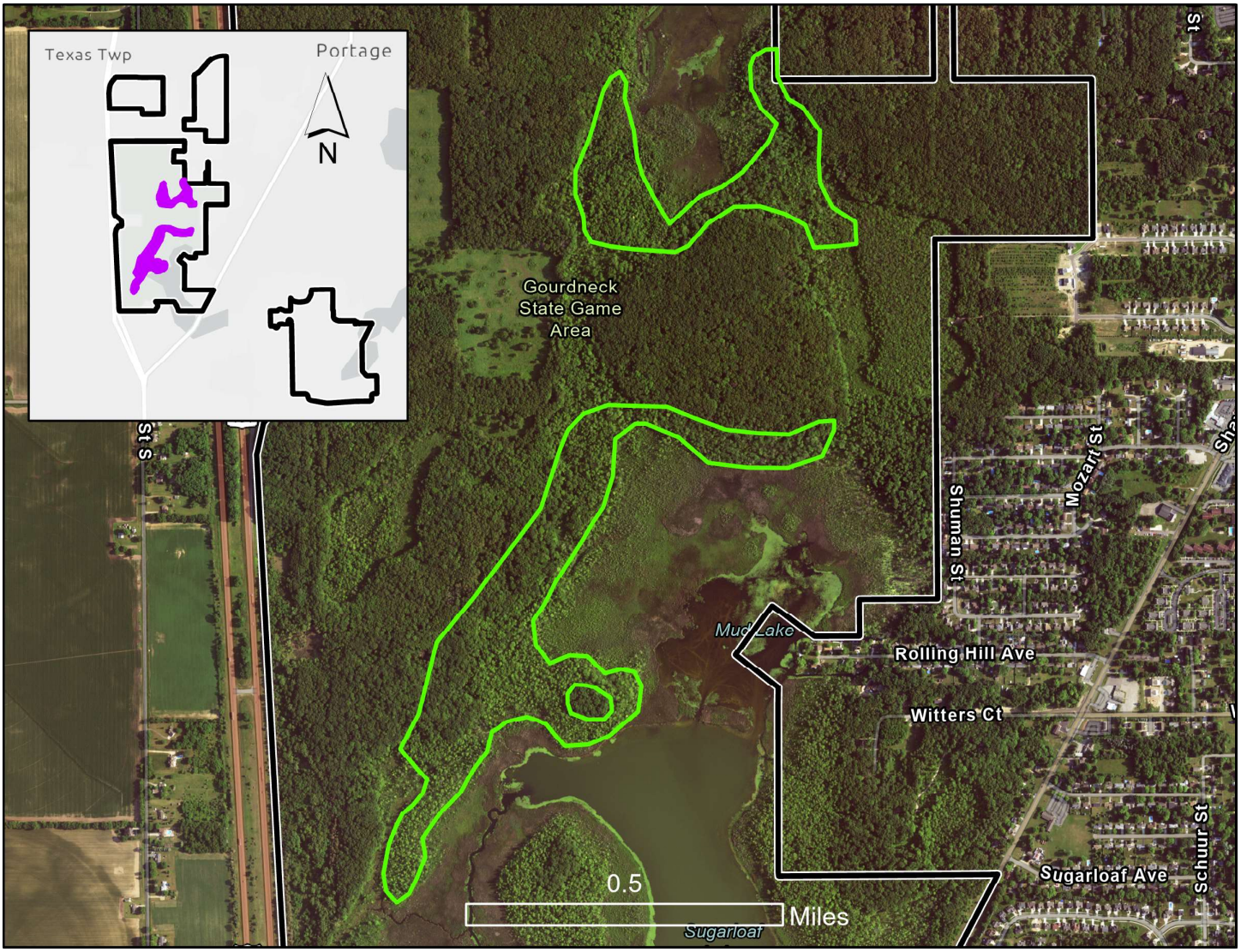


Figure 21. Location of Vanderbilt Swamp southern hardwood swamp (ESRI 2022).

Vanderbilt swamp is characterized by a canopy dominated by red and silver maple, an understory dominated by musclewood and spicebush, and a diverse herbaceous layer locally dominated by cinnamon fern.
Photo by J.M. Lincoln.

Vanderbilt Swamp occurs between oak-dominated uplands and the margins of Sugarloaf Lake.
Photo by J.M. Lincoln.

Tip-ups are creating a subtle hummock-hollow microtopography that is much less pronounced than in the hardwood-conifer swamp along the lake margin. Where the system transitions to rich tamarack swamp, large sphagnum hummocks form at the base of tamaracks and deep pools occur between the trees. Anthropogenic fluctuations in the lake levels and disease outbreaks have had a detrimental impact on the distribution and composition of canopy species, most recently with the loss of ash and elm.

This swamp is in fair condition with a high proportion of native species within the swamp. The forest is dominated by second-growth trees but has composition and structure similar to historical conditions. Ash borer and Dutch elm disease have eliminated important components of the canopy. Ash formerly occupied approximately 10% of the crown cover of the canopy. Hydrology alterations are influencing the level of the lake, causing increased water levels and canopy mortality towards the lake edge. Yellow birch seems to be dying and it might be due to fluctuations in water level or climate change as the species is much less common this far south in Michigan.

The swamp is characterized by a moderate canopy coverage (70 to 80%) of deciduous trees. Dominant trees include red maple (*Acer rubrum*), yellow birch (*Betula alleghaniensis*), silver maple (*Acer saccharinum*), and American elm (*Ulmus americana*). Swamp white oak (*Quercus bicolor*), southern pin oak (*Q. palustris*), and black gum (*Nyssa sylvatica*), are occasional canopy associates. Where the swamp transitions to open poor fen and cat-tail marsh, the canopy is dominated by tamarack (*Larix laricina*).

Silver maple and yellow birch are locally dominant in the canopy. Black and green ash are common in the understory and beech occurs infrequently throughout the swamp. Photo by J.M. Lincoln.

Here, the canopy becomes much sparser (around 50%). Elm was also likely more abundant historically. Canopy trees range in diameter from 35 to 60 cm. Many of the largest trees are likely around 100 years old. A 40.6 cm red maple had an estimated ring count of 104 but was difficult to read. Another 38 cm red maple had a ring count of 67 with some rot in the center. A 43.9 cm dbh red maple had a ring count of 88 but it was also difficult to read. A 17.8 cm dbh tamarack had a ring count of 98.

The subcanopy and understory both range from 10 to 20%. The subcanopy consists of American elm (*Ulmus americana*), red maple (*Acer rubrum*), yellow birch (*Betula alleghaniensis*), black gum (*Nyssa sylvatica*), swamp white oak (*Quercus bicolor*), southern pin oak (*Q. palustris*), and beech (*Fagus grandifolia*). Within the understory, muscle wood (*Carpinus caroliniana*), black ash (*Fraxinus nigra*), green ash (*Fraxinus pennsylvanica*), elm (*Ulmus sp.*), red maple, poison sumac (*Toxicodendron vernix*), and Michigan holly (*Ilex verticillata*) are prevalent. Beech (*Fagus grandifolia*), basswood (*Tilia americana*) red oak (*Quercus rubra*), and pawpaw (*Asimina triloba*) are rare in the subcanopy and understory.

The low shrub layer has 20 to 30% coverage and is dominated by spicebush (*Lindera benzoin*), highbush blueberry (*Vaccinium corymbosum*), Michigan holly (*Ilex verticillata*), wild black currant (*Ribes americanum*), gray dogwood (*Cornus amomum*), glossy buckthorn (*Frangula alnus*), swamp rose (*Rosa palustris*), autumn olive (*Elaeagnus umbellata*), Japanese barberry (*Berberis thunbergia*), and multiflora rose (*Rosa multiflora*).

Yellow birch is locally abundant in Vanderbilt Swamp. Many birch appeared to be dying during the 2022 surveys, potentially due to fluctuations in levels of Sugarloaf Lake. Photo by J.M. Lincoln.

The herbaceous layer is typically dense and continuous though locally sparse in the most saturated areas. Cinnamon fern (*Osmunda cinnamomea*) and sensitive fern (*Onoclea sensibilis*), are common to dominant. Other common species include skunk cabbage (*Symplocarpus foetidus*), sedges (*Carex stipata*, *C. crinata*, and *C. pseudo-cyperus*), tear-thumb (*Persicaria arifolia*), clearweed (*Pilea pumila*), swamp buttercup (*Ranunculus hispidus*), dwarf raspberry (*Rubus palustris*), calico aster (*Symphyotrichum lateriflorum*), white grass (*Leersia virginica*), fowl manna grass (*Glyceria striata*), marsh-marigold (*Caltha palustris*), wood reedgrass (*Cinna arundinacea*), and poison ivy (*Toxicodendron radicans*).

Vanderbilt Swamp was visited once in August of 2022. Seventy-eight plant species were observed in the southern hardwood swamp with 71 native species (91%). The Total FQI was 37.1 and the Total Mean C was 4.2. Conservation metrics for Vanderbilt Swamp and the comprehensive species are in Appendix 7.

Threats and Management Recommendations

Deer herbivory was obvious throughout. Invasive species pose a serious threat to the system and include glossy buckthorn, autumn olive, multiflora rose, and barberry. As with Sugarloaf Swamp, we recommend evaluating ideal lake levels for stabilizing the lake margins and preventing mortality of trees in the swamp. We recommend treating invasive species beginning with Japanese barberry, glossy buckthorn, autumn olive, and multiflora rose within the swamp. Once those shrubs are controlled, we recommend addressing the narrow-leaf cat-tail and reed canary grass at the margins towards the lake.

Red maple is generally the most dominant tree in Vanderbilt Swamp. Photo by J.M. Lincoln.

Rare Plants

Several populations of rare plants have been documented prior to the MiFI surveys. Over the course of the project, several known populations were opportunistically revisited during the course of initial vegetation mapping surveys and subsequent natural community surveys. There are 37 EOs of 23 rare plant species associated with Gourdneck SGA (Tables 7, 8, and 9; MNFI 2023). Of these 37 EOs, 15 EOs of 9 species were recently documented as extant (Table 7), 8 EOs of 7 species were potentially extirpated (Table 8), and 14 EOs of 13 species were likely extirpated (Table 9). Of the rare plant populations that have been documented in the game area, 59.5% have probably or potentially been extirpated.

A larger proportion of wetland plant EOs were documented as extant (12; 50%), when compared to potentially (5; 21%) and likely extirpated (7; 29%) EOs (Tables 7, 8, and 9). Many extant EOs were found in prairie fen and a small zone of wet-mesic sand prairie in the Hampton Creek Wetlands complex and in Vanderbilt Fen, which have been the target of more recent focused rare plant surveys (Paskus et al. 2019). In contrast, a larger proportion of upland EOs were likely extirpated (7; 54%), when compared to potentially extirpated (3; 23%) and extant (3; 23%). Recent survey effort has likely been more even across upland areas, and the smaller proportion of extant EOs is probably due to more extensive anthropogenic modifications (e.g., logging and tillage) in uplands when compared to wetlands.

A population of white false indigo (*Baptisia lactea*, State Threatened) persists along E U Avenue at the southern boundary of the game area. This species was historically associated with prairies and oak savannas but is now relegated to artificial open habitats such as roadsides and powerline corridors. Several documented populations have been lost during recent decades. Photo by J.M. Lincoln.

Table 7. Extant rare plant element occurrences within Gourdneck State Game Area or nearby. Status abbreviations are as follows: E, State Endangered; T, State Threatened; and SC, Species of Special Concern. EO rank abbreviations are as follows: AB, excellent to good estimated viability, B, good estimated viability; C, fair estimated viability; CD, fair to poor estimated viability; and H, historic record.

Scientific Name	Common Name	Status	G/S Rank	EO ID	Last Observed	Survey Date	EO Rank
			Compartment 1				
Amorpha canescens	Leadplant	SC	G5/S3	12380	2022	2019	CD
Berula erecta	Cut-leaved water parsnip	SC	G4G5/S2	1685	2016	2016	B
Calamagrostis stricta ssp. *stricta*	Narrow-leaved reedgrass	T	G5T5/S1	3313	2004	2019	B
Eryngium yuccifolium	Rattlesnake-master	E	G5/S2	2854	2022	2022	D
Lechea minor	Least pinweed	T	G5/S1	26385	2019	2019	D
Scleria triglomerata	Tall nut rush	SC	G5/S3	23640	2019	2019	CD
Silphium integrifolium	Rosinweed	T	G5/S2	12505	2019	2019	CD
			Compartment 2				
Berula erecta	Cut-leaved water parsnip	SC	G4G5/S2	13390	2003	2003	C
Calamagrostis stricta ssp. *stricta*	Narrow-leaved reedgrass	T	G5T5/S1	1195	2002	2002	A
Cypripedium candidum	White lady slipper	T	G4/S2	1856	2022	2022	D
			Compartment 3				
Amorpha canescens	Leadplant	SC	G5/S3	13386	2014	2014	CD
Baptisia lactea	White false indigo	T	G4Q/S3	4380	2022	2022	C
Berula erecta	Cut-leaved water parsnip	SC	G4G5/S2	3899	2022	2022	B
Calamagrostis stricta ssp. *stricta*	Narrow-leaved reedgrass	T	G5T5/S1	13384	2003	2003	BC
Cypripedium candidum	White lady's-slipper	T	G4/S2	2750	1997	1997	D

A few individuals of leadplant (*Amorpha canescens*, State Special Concern) were found under the powerline corridor the northern portion of the game area during the surveys of 2022. Individuals that had been documented nearby were not able to be relocated and were presumed extirpated. Photo by J.M. Lincoln.

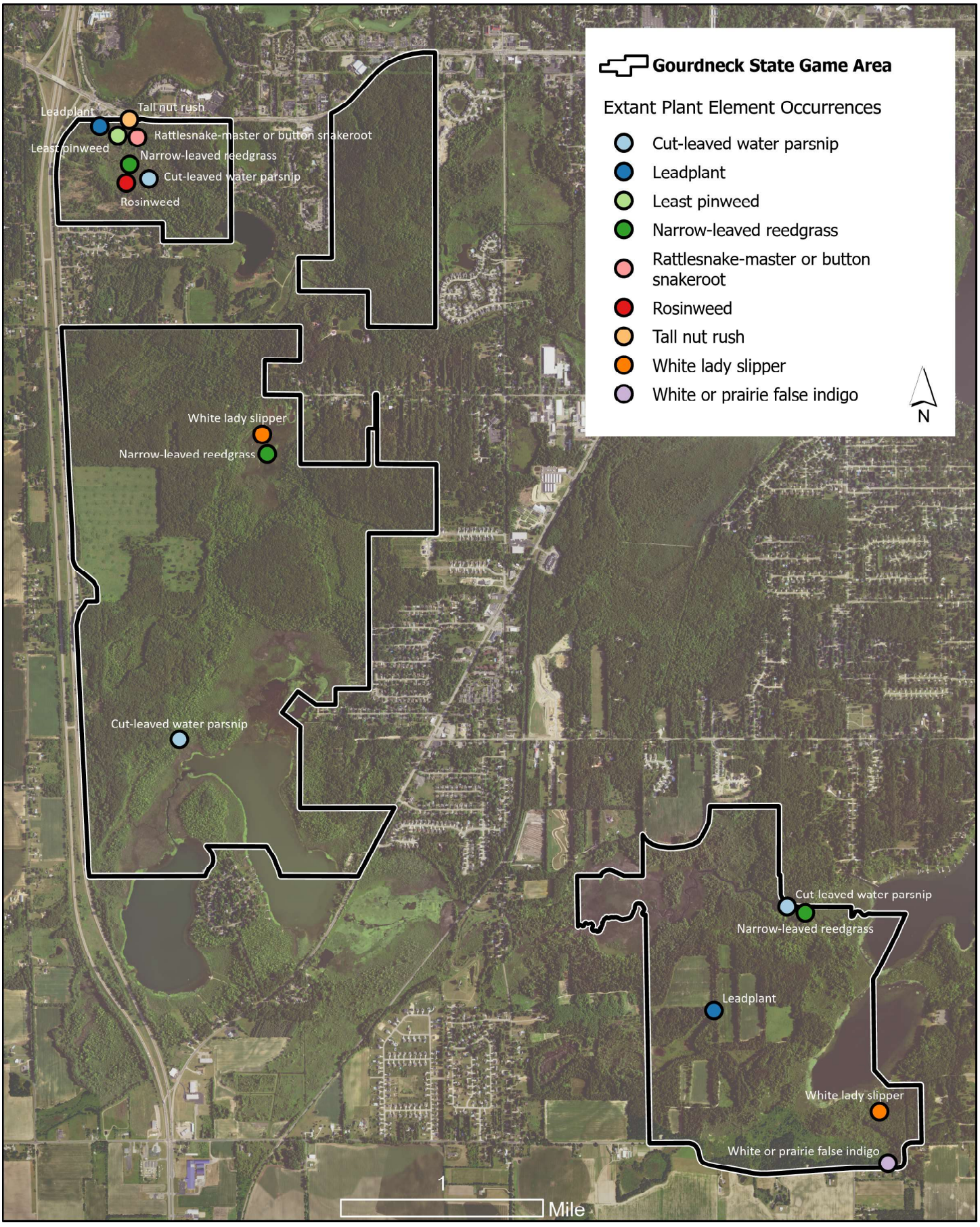


Figure 22. Location of extant rare plant element occurrences in Gourdneck State Game Area.

Table 8. Potentially extirpated rare plant element occurrences within Gourdneck State Game Area or nearby. Status abbreviations are as follows: E, State Endangered; T, State Threatened; and SC, Species of Special Concern. EO rank abbreviations are as follows: AB, excellent to good estimated viability, B, good estimated viability; C, fair estimated viability; CD, fair to poor estimated viability; and H, historic record.

Scientific Name	Common Name	Status	G/S Rank	EO ID	Last Observed	Survey Date	EO Rank
			Compartment 1				
Arnoglossum plantagineum	Prairie indian-plantain	SC	G4G5/S3	5873	2003	2019	D
Cypripedium candidum	White lady's-slipper	T	G5/S2	739	2003	2019	CD
			Compartment 2				
Calamagrostis stricta ssp. *stricta*	Narrow-leaved reedgrass	T	G5T5/S1	11498	1937	1937	H
Cuscuta pentagona	Dodder	SC	G4G5/S1	11141	1937	1937	H
Isotria verticillata	Whorled pogonia	T	G5/S2	5682	1935	2022	H
Isotria verticillata	Whorled pogonia	T	G5/S2	12105	1934	1934	H
Scleria triglomerata	Tall nut rush	SC	G5/S3	12170	1947	1947	H
			Compartment 3				
Platanthera ciliaris	Orange-fringed orchid	E	G5/S1S2	6211	1990	1990	E

Whorled pogonia (*Isotria verticillata*; State Threatened) has not been documented from within or around Gourdneck SGA since 1935, though suitable habitat persists, particularly in Sugarloaf and Vanderbilt Swamps. This individual is from an extant population in Gratiot-Saginaw State Game Area. Photo by J.M. Lincoln.

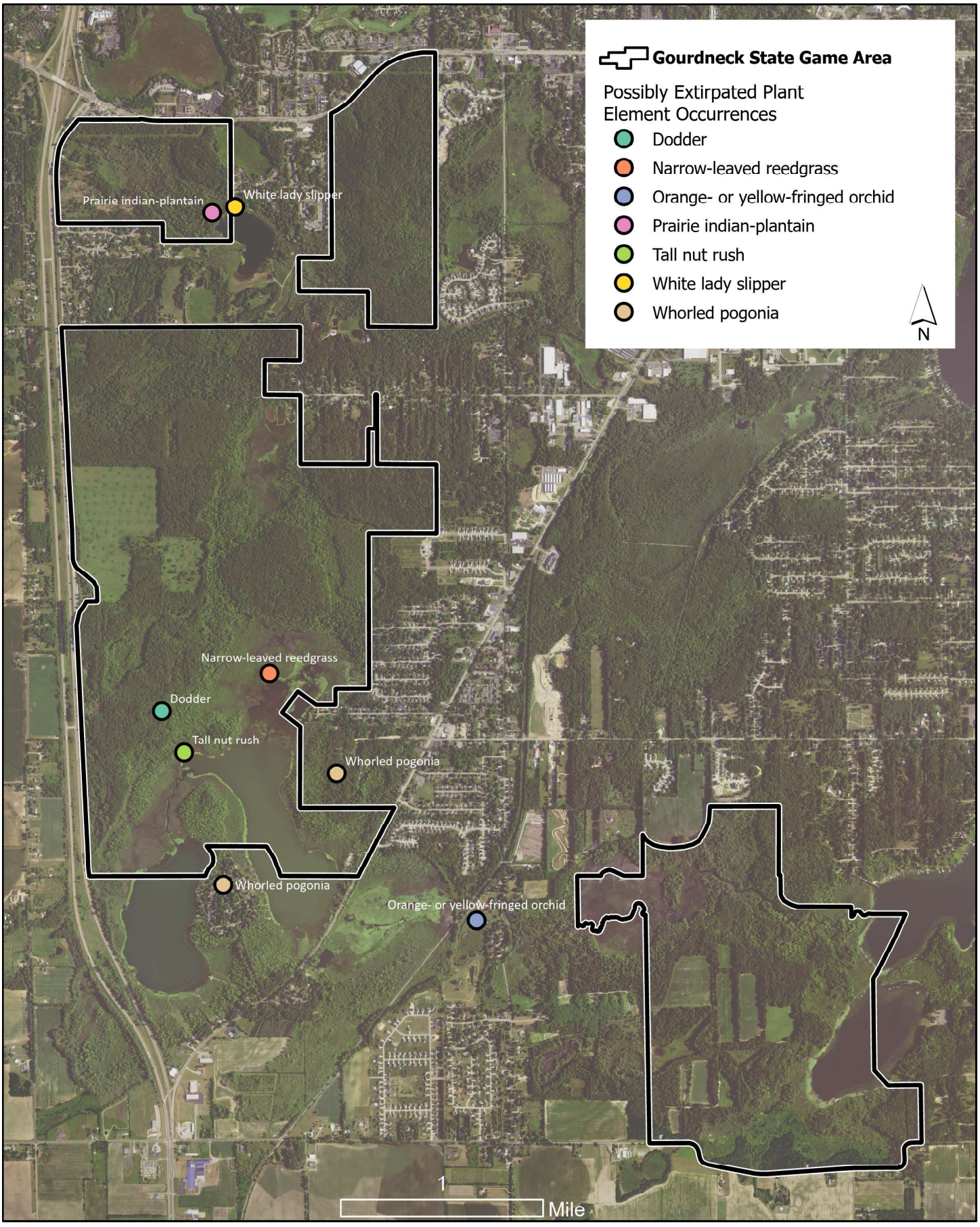


Figure 23. Location of potentially extirpated rare plant element occurrences in Gourdneck State Game Area.

Table 9. Probably extirpated rare plant element occurrences within Gourdneck State Game Area or nearby. Status abbreviations are as follows: E, State Endangered; T, State Threatened; and SC, Species of Special Concern. EO rank abbreviations are as follows: AB, excellent to good estimated viability, B, good estimated viability; C, fair estimated viability; CD, fair to poor estimated viability; and H, historic record.

Scientific Name	Common Name	Status	G/S Rank	EO ID	Last Observed	Survey Date	EO Rank
			Compartment 1				
Angelica venenosa	Hairy angelica	SC	G5/S3	7154	1934	2005	H
Boechera missouriensis	Missouri rock-cress	T	G5/S2	2607	1939	1939	H
Coreopsis palmata	Prairie coreopsis	E	G5/S2	4207	1947	2014	D
Lygodium palmatum	Climbing fern	E	G4/S1	5700	1979	2019	F
Platanthera ciliaris	Orange-fringed orchid	E	G5/S1S2	4693	1979	1997	X
			Compartment 2				
Boechera missouriensis	Missouri rock-cress	T	G5/S2	11462	1943	1943	H
Carex straminea	Straw sedge	E	G5/SH	6688	1934	1934	H
Panax quinquefolius	Ginseng	T	G3G4/S2 S3	483	1933	1933	H
Penstemon pallidus	Pale beard tongue	X	G5/SX	6757	1937	1937	H
			Compartment 3				
Carex albolutescens	Sedge	T	G5/S2	8206	1941	1941	H
Cypripedium candidum	White lady's-slipper	T	G4/S2	10502	1934	1934	H
Eryngium yuccifolium	Rattlesnake-master	E	G5/S2	1859	1947	1997	F
Gillenia trifoliata	Bowman's root	X	G4G5/SX	7195	1981	2022	X
Stellaria crassifolia	Fleshy stitchwort	E	G5/S1	11617	1947	1947	H

One population of rattlesnake-master (*Eryngium yuccifolium*; State Endangered) persists within Gourdneck SGA. Another population in the southeastern portion of the game area has not been documented since 1947. Photo by J.M. Lincoln.

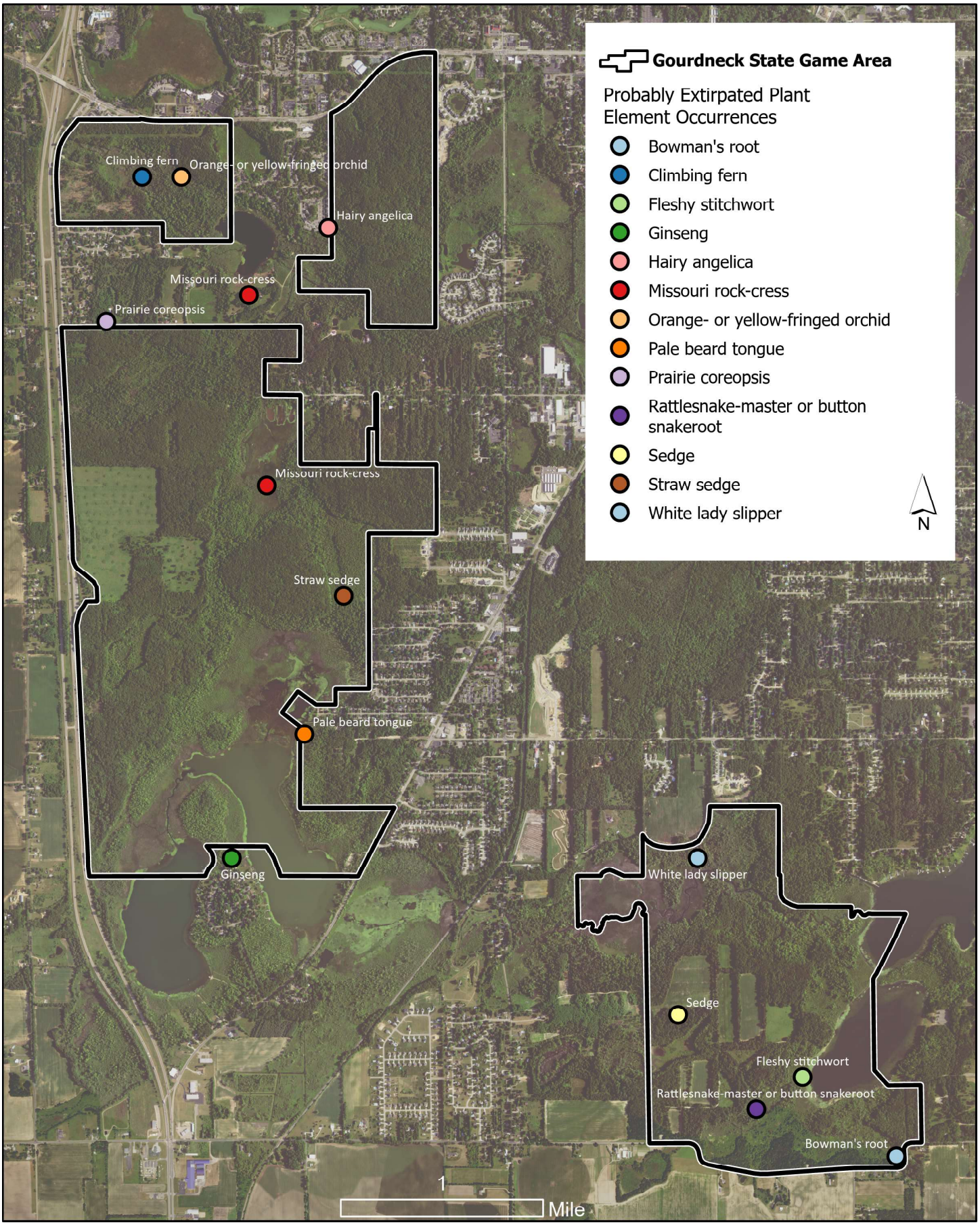


Figure 24. Location of probably extirpated rare plant element occurrences in Gourdneck State Game Area.

Rare Reptiles and Amphibians

Overall, ten element occurrences (EOs) of eight rare amphibian and reptile species were documented within Gourdneck SGA based on MNFI's surveys and information compiled from previous MNFI herptile surveys in the game area and external sources in 2022 (Table 10, Figures 25, 26, 27, 28). MNFI's surveys in 2022 documented five EOs or populations of three rare herptile species, and Blanchard's cricket frog, and one additional SGCN, the eastern musk turtle (Table 10). Previous MNFI surveys in the game area and surveys and observations compiled from other researchers and external sources also documented these three rare herptile species as well as five EOs of five additional rare herptile species in or near the game area, including pickerel frog (State Special Concern), and mudpuppy (*Necturus maculosus;* State Special Concern), and two additional herptile SGCN, the blue racer and northern ribbonsnake (Table 10, Figures 25, 26, 27, 28).

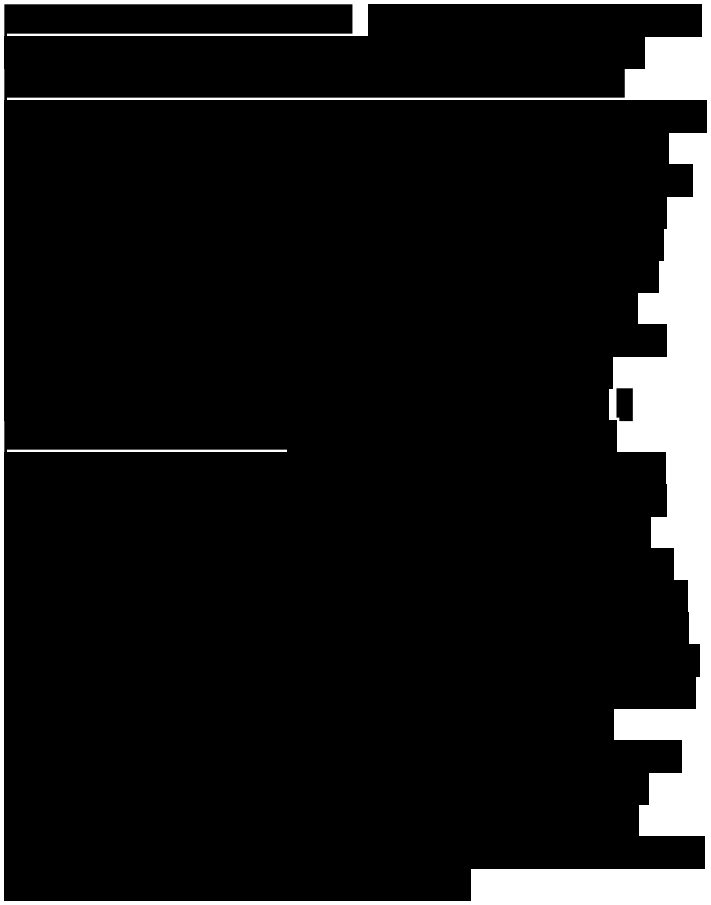


Table 10. Rare amphibian and reptile element occurrences within Gourdneck State Game Area. State and federal status abbreviations are as follows: E, State Endangered; T, State Threatened; and SC, State Special Concern; LT, Federally Threatened. EO rank abbreviations are as follows: A, excellent estimated viability; AB, excellent to good estimated viability; AC, excellent to fair viability; B, good estimated viability; BC, good to fair estimated viability; H, historical; and E, extant. "P" refers to parent EO, and "S" refers to sub-EO.

Common Name	Scientific Name	State Status	Federal Status	EO ID	EO Rank	Year First Observed	Year Last Observed
Blanchard's Cricket Frog	*Acris blanchardi*	T		3422	AB	1988	2022
Blanchard's Cricket Frog	*Acris blanchardi*	T		7997	AB	1996	2022
Pickerel Frog*	*Lithobates palustris*	SC		23300	E	2005	2016
Mudpuppy*	*Necturus maculosus*	SC		26479	E	2021	2021

*Indicates species that were documented in the vicinity of Gourdneck SGA and have potential to occur within the game area because of suitable habitat.

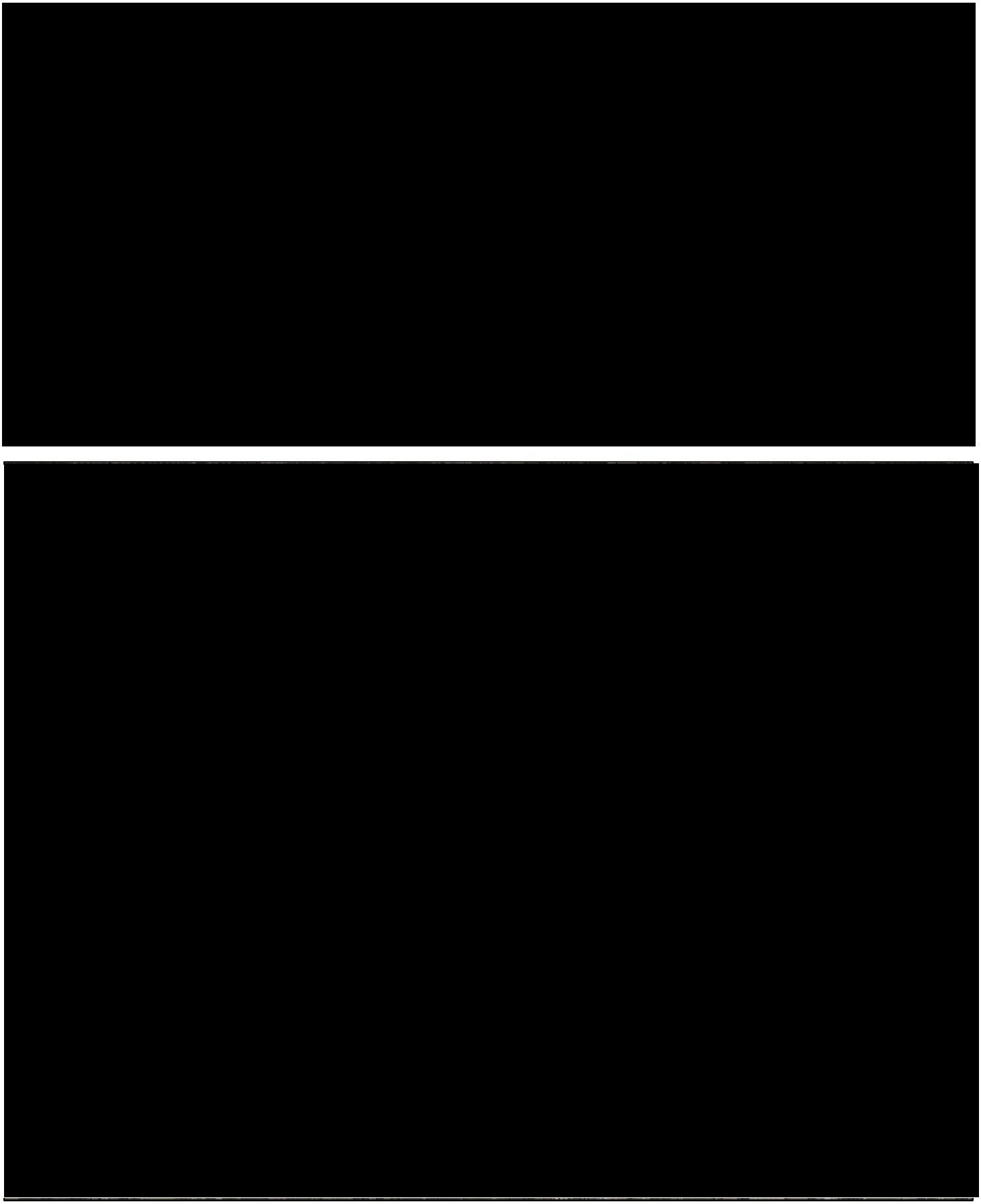


Figure 25. Locations of Blanchard's cricket frog (*Acris blanchardi*), [redacted] pickerel frog (*Lithobates palustris*), and mudpuppy (*Necturus maculosus*) element occurrences in or near Gourdneck State Game Area.

[redacted]

[redacted]

MNFI's breeding frog call/auditory surveys documented Blanchard's cricket frogs at two locations in the Gourdneck SGA on June 24, 2022. Four males were heard calling at the north end of Vanderbilt Fen, and a few frogs were heard calling in the distance to the south/southeast from the boat launch at Sugarloaf Lake (Figure 25. A graduate student researcher from Central Michigan University also documented cricket frogs calling at the north end of Vanderbilt Fen and in the southern and northern portions of Sugarloaf Lake between June 13 and17, 2022 (Rainey pers. comm.). He also collected tissue samples from 16 cricket frogs found along the southwest corner of Mud Lake and the northern end of Sugarloaf Lake between June 13 and 17, 2022 (Rainey pers. comm.).

[redacted]

A Blanchard's cricket frog (*Acris blanchardi*). Photo by Jessica Piispanen with USFWS.

All these observations updated two previously documented Blanchard's cricket frog EOs in the game area (EO IDs 3422 and 7997) (Table 10). Both these EOs have been ranked as having excellent to good estimated viability. Although only small numbers of frogs have been seen or heard calling at multiple locations within these EOs, these EOs have persisted for over 25 to 35 years, the sites are protected as part of the game area, and the sites are of sufficient size to sustain cricket frog populations for the long term as long as current conditions continue into the future.

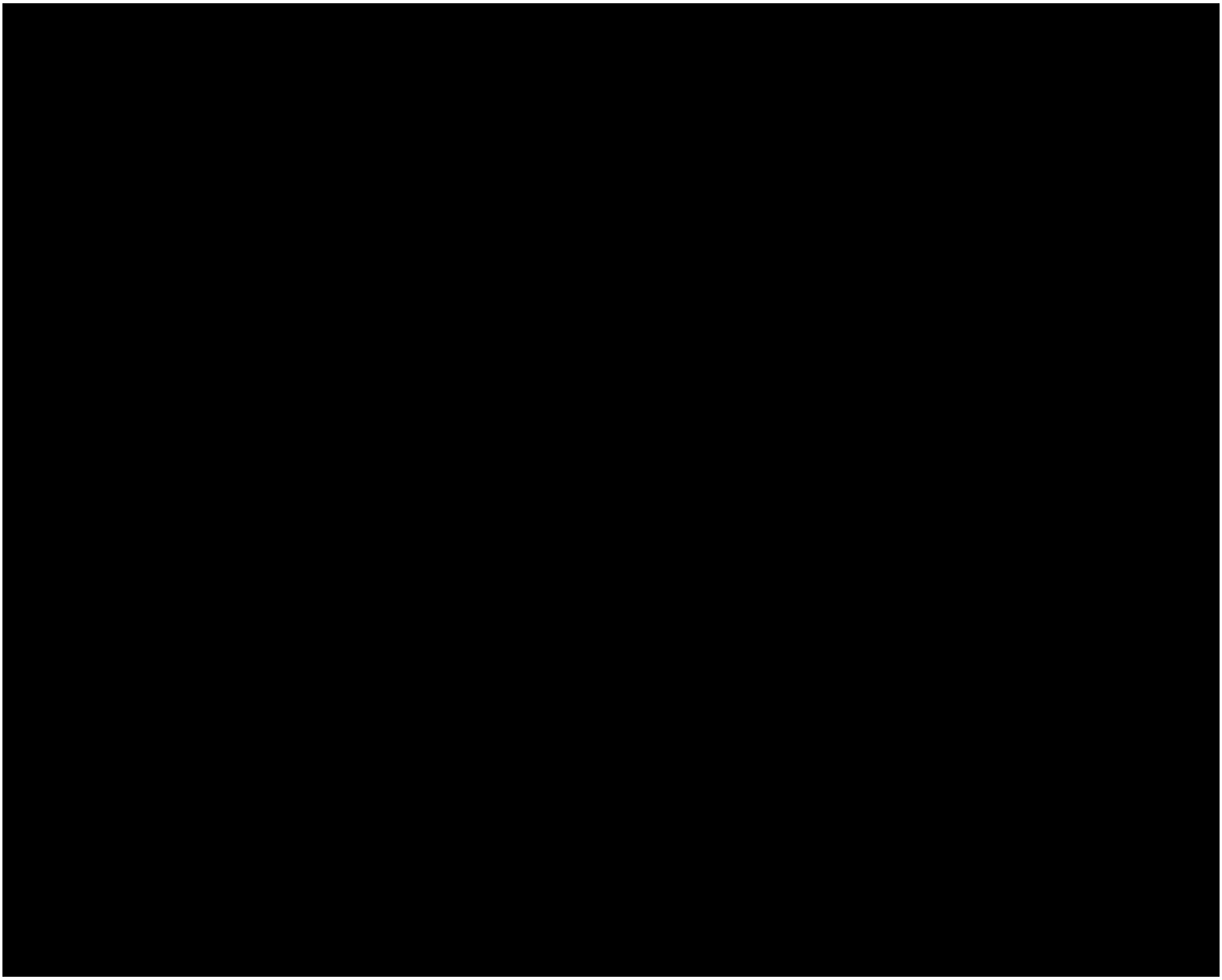
Five additional rare species were recently documented within or adjacent to the Gourdneck SGA.

[redacted] Two observations of pickerel frogs were reported in 2009 and 2016 in T04S R11W Section 9 which is southwest of Hogset Lake (Figure 25). These observations may have occurred in the game area on the north side of U Ave W. These observations updated a known EO of this species (EO ID 23300) which has been ranked as extant given lack of available information to estimate viability of this population/EO at this time (Table 10). Finally, a mudpuppy was observed on December 17, 2021 in a channel that flows into Gourdneck Creek south of Gourdneck Lake and northeast of Hogset Lake (Figure 25). This observation, represented a new EO of this species (EO ID 26479) (Table 10). This EO was outside the Gourdneck SGA but given that portions of Gourdneck Creek and Hogset Lake occur within the game area, this species has good potential to occur in the game area.

MNFI's amphibian and reptile surveys in 2022 documented an additional SGCN, an eastern musk turtle, and seven common amphibian and reptile species. Information compiled from earlier rare

[redacted]

herptile surveys conducted by MNFI from 2002 through 2006 documented two additional herp SGCN, the blue racer and northern ribbonsnake, and seven additional common species. The eastern musk turtle was captured in one of the turtle traps near the southern end of Sugarloaf Lake on May 11, 2022. Common amphibian and reptile species detected during herptile surveys in 2022 included the American bullfrog (*Lithobates catesbeianus*), green frog (*Lithobates clamitans*), northern spring peeper (*Pseudacris crucifer crucifer*), eastern red-backed salamander *(Plethodon cinereus*), snapping turtle (*Chelydra serpentina*), northern map turtle (*Graptemys geographica*), and painted turtle (*Chrysemys picta*). Painted turtles were the most abundant turtle species captured during aquatic funnel trapping surveys in the Gourdneck SGA, with 83 captures including adults and subadults or juveniles. Additional common herptile species and/or SGCN documented during previous rare herptile surveys conducted by MNFI in the game area, particularly Vanderbilt Fen, from 2002 through 2006 include the northern watersnake (*Nerodia sipedon sipedon*), eastern gray treefrog (*Hyla versicolor*), western chorus frog (*Pseudacris triseriata triseriata*), eastern American toad (*Anaxyrus americanus americanus*), eastern hog-nosed snake (*Heterodon platir*hinos), blue racer (*Coluber constrictor foxii*), eastern gartersnake (*Thamnophis sirtalis sirtalis*), northern ribbonsnake (*Thamnophis sauritus septentrionalis*), and Dekay's brown snake (*Storeria dekayi*).



Rare Mollusks and Fish

New EOs for three mussel species were documented within Gourdneck SGA (Table 11, Figure 29). Slippershell (*Alasmidonta viridis*) and rainbow (*Cambarunio iris*) were found in Gourdneck Creek and creek heelsplitter (*Lasmigona compressa*) was found in Portage Creek. Aquatic surveys were performed at 13 sites (Table 1, Figure 9). Sites 1 through 11 were surveyed for native mussels. Site 1 was surveyed for mussels and watercress snails, and sites 12 and 13 were surveyed for watercress snails only. Conditions for performing aquatic surveys were favorable with adequate water clarity. A total of seven native mussel species were found including one State Threatened species and two Species of Special Concern (Tables 11, 12, and 13). All three of these are Species of Greatest Conservation Need (SGCN). A single live individual was found for two of these species, slippershell (*Alasmidonta viridis*) and rainbow (*Cambarunio iris*). All other mussel species were represented by shells. The condition of most of the shells found was moderately to heavily worn. No live mussels or shell were seen in visual meander searches from Hogset Lake boat ramp (42.149154, -85.590332) to the confluence of Gourdneck Creek into Gourdneck Lake (42.155343, -85.587622) and from site 7 to approximately 200 m upstream (42.19544, -85.64233).

Two new EOs for watercress snail were documented (Figure 29). One EO corresponds to the population documented at site 1 and the second EO corresponds to the population occurring in both sites 12 and 13. Sites 12 and 13 were close enough to each other (200m apart) that they are considered one EO. Estimated density at site 1 was at least 10 live individuals per m^2 over a 10 m^2 area. Estimated

Table 11. Rare aquatic element occurrences documented in Gourdneck SGA, summer 2022. Status abbreviations are as follows: T, State Threatened; and SC, State Special Concern. Element occurrence (EO) rank abbreviations are as follows: E, verified extant; H, historical; CD, fair to poor estimated viability; and D, poor estimated viability.

Common Name	Scientific Name	State Status	Federal Status	EO ID	EO Num	EO Rank	Year First Observed	Year Last Observed	Survey Site #
Slippershell	*Alasmidonta viridis*	T	NA	26480	447	E	2022	2022	11
Rainbow	*Cambarunio iris*	SC	NA	26481	21	E	2022	2022	9
Watercress snail	*Fontigens nickliniana*	SC	NA	26483	42	D	2022	2022	1
Watercress snail	*Fontigens nickliniana*	SC	NA	26393	40	CD	2022	2022	12 & 13
Creek heelsplitter	*Lasmigona compressa*	SC	NA	26482	229	E	2022	2022	3
Spotted gar	*Lepisosteus oculatus*	SC	NA	26507	104	E	2022	2022	Fish-2

Table 12. Incidental finds at mussel survey sites, including aquatic snails (Gastropoda), fingernail clams (Sphaeriidae), crayfish, and fish.

Common Name	Species/Taxa	1	2	3	4	5	6	7	8	9	10	11	12	13
Snails	Gastropoda													
Pointed campeloma	*Campeloma decisum*								X	X	X	X		
Watercress snail (SC)	*Fontigens nickliniana*	X											X	X
Two-ridge rams-horn	*Helisoma anceps*		X	X				X				X		
Physa	*Physa sp.*		X					X			X			
Marsh rams-horn	*Planorbella trivolvis*			X				X	X	X	X	X		
Sharp hornsnail	*Pleurocera acuta*				X									
Banded mystery snail	*Viviparus georgianus*	X		X	X					X	X			
Fingernail clams	Sphaeriidae	X	X	X				X	X	X	X	X		
Crayfish	Decapoda	X												
Fish	Osteichthyes													
Bowfin	*Amia calva*										X			
Mottled sculpin	*Cottus bairdii*	X												
Northern pike	*Esox lucious*								X					
Johnny darter	*Etheostoma nigrum*	X												
Bluegill	*Lepomis macrochirus*								X					
Largemouth bass	*Micropterus salmoides*								X					

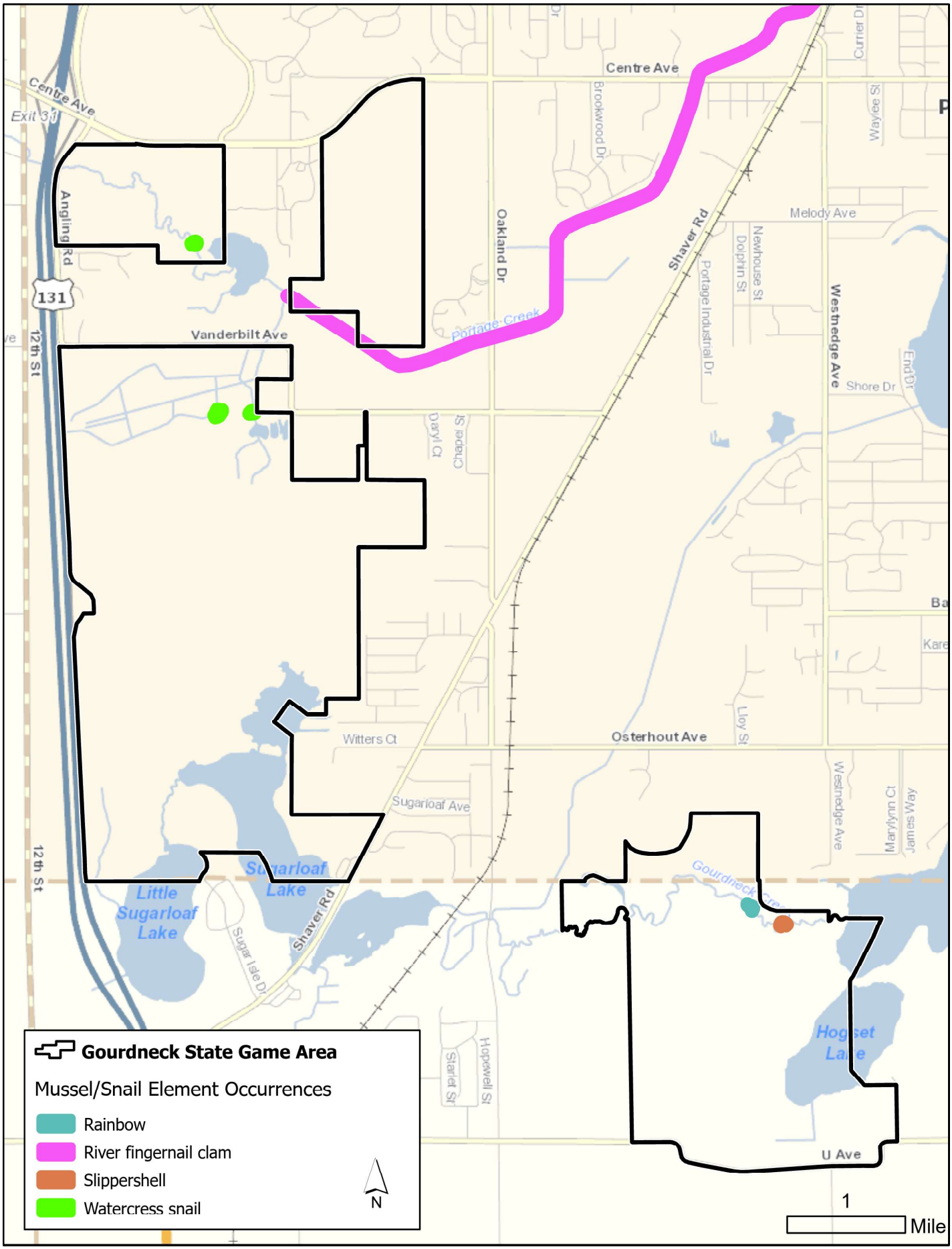
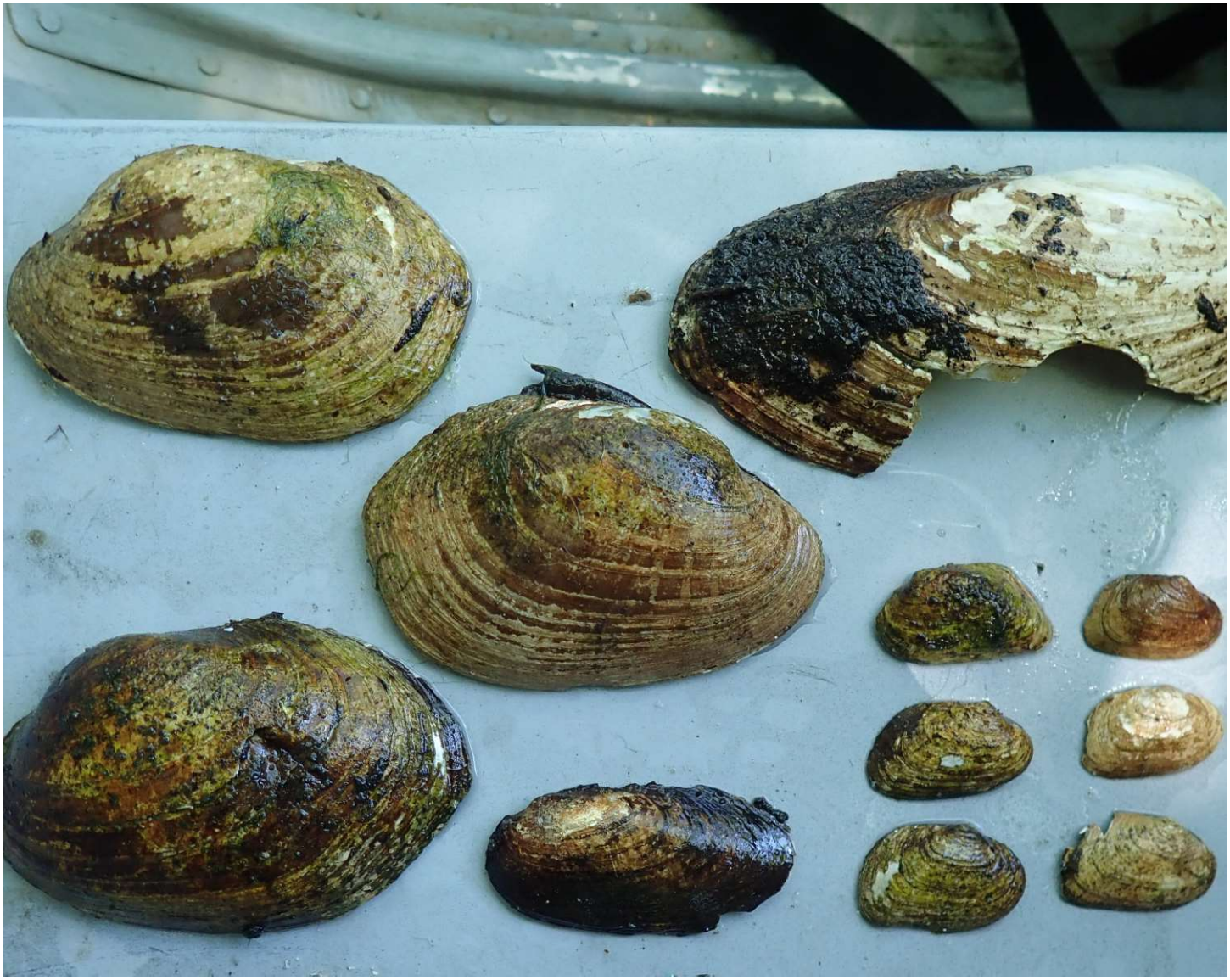


Figure 29. Location of rare mollusk element occurrences in Gourdneck State Game Area.

density at site 12 was 12 live individuals per m^2 over a 50 m^2 area and at site 13 was 0.2 live individuals per m^2 over a 15 m^2 area. The EO at site 1 was given an EO rank of D, due to its relatively low density and small patch of habitat. The EO at sites 12 and 13 was assigned a rank of CD. Two additional locations with groundwater seeps and the plant watercress were searched for watercress snail, but none where found. These were located in the headwaters of Portage Creek near survey sites 5 and 6, at 42.182853, -85.633833 and 42.182849, -85.631334.

A spotted gar (*Lepisosteus oculatus*; State Special Concern) was observed in Hogset Lake, near site Fish-2 at the surface of the water. Fifteen bluegill (*Lepomis macrochirus*) and one bluntnose minnow (*Pimephales notatus*) were found in the five traps set in Hogset Lake. Only one bluegill was found in the four traps set in Gourdneck Creek. Six fish species were observed during mussel surveys (Table 4). No Asian clams or zebra mussels were found at any of the aquatic survey sites. No non-native aquatic snails were found at any of the survey sites. Habitat and substrate characteristics, and water chemistry measures are provided in Tables 5 through 7. Site 4 appeared to have been dredged/channelized in the past. Water temperature and chemistry measures were taken at aquatics survey site 7 in Portage Creek on June 20, 2022 and sites 9 through 11 in Gourdneck Creek, June 21 through 23, 2022. Chemistry measures were within ranges generally suitable for aquatic animal life.



Slippershell (*Alasmidonta viridis*, State Threatened) (six small shells bottom right), fatmucket (*Lampsilis siliquoidea*) (left), giant floater (*Pyganondon grandis*) (top right), and spike (*Eurynia dilatata*) (bottom center) from site 11 in Gourdneck Creek.

Table 13. Mussel species found at each aquatic survey site. Numbers of live native mussels and number shells of rare species are given in parentheses (S(#)). Presence/absence of non-native bivalves is noted. (T= State Threatened; SC= species of special concern).

		1	2	3	4	5	6
Common name	Species	#	#	#	#	#	#
Slippershell (T)	*Alasmidonta viridis*						
Rainbow (SC)	*Cambarunio iris*						
Spike	*Eurynia dilatata*				S		
Fatmucket	*Lampsilis siliquoidea*						
Creek heelsplitter (SC)	*Lasmigona compressa*			S(1)			
Giant floater	*Pyganodon grandis*				S		
Strange floater	*Strophitus undulatus*						
	# species live	0	0	0	0	0	0
	# species live or shell	0	0	1	2	0	0
	Area searched (m^2)	79	117	233	90	40	40
Asian clams	*Corbicula fluminea*						
Zebra mussels	*Dreissena polymorpha*						

		7	8	9	10	11
Common name	Species	#	#	#	#	#
Slippershell (T)	*Alasmidonta viridis*					1live (18 shells)
Rainbow (SC)	*Cambarunio iris*			1		
Spike	*Eurynia dilatata*				S	S
Fatmucket	*Lampsilis siliquoidea*		S			S
Creek heelsplitter (SC)	*Lasmigona compressa*					
Giant floater	*Pyganodon grandis*					S
Strange floater	*Strophitus undulatus*					S
	# species live	0	0	1	0	1
	# species live or shell	0	1	1	1	5
	Area searched (m^2)	113	*	90	104	223
Asian clams	*Corbicula fluminea*					
Zebra mussels	*Dreissena polymorpha*					

* Visual search from Hogset Lake boat ramp to Gourdneck Creek

Watercress snails (*Fontigens nickliniana*, State Special Concern) from site 12 in Gourdneck State Game Area. Shell length approximately 3 mm. Photo by P.J. Badra.

Rare Insects

New EOs for two insect species were documented within Gourdneck SGA and we updated records for one EO. We did not collect any *Papaipema* borer moths at the Vanderbilt Fen site in 2022. However, at the Centre Ave. powerline corridor near Hampton Creek Fen we collected three different *Papaipema* species during blacklight surveys, including a new record for royal fern borer (Papaipema speciosissima, State Special Concern, n=1, EOID 26235). This single specimen was collected on 10/05/2022 at 10:29 pm. In addition, we documented occurrences of common species including Aster borer (*P. impecuniosa*; n=2) and Sensitive fern borer (*P. inquesiata*; n=4).

We identified two locations with tamarack tree cricket (*Oecanthus laricis*, State Special Concern) in Gourdneck SGA. First, we re-confirmed that this species is present at the historic site along the western shoreline of Little Sugarloaf Lake (EOID 5775). At this location, we collected a single female specimen from a lower branch on a tamarack tree that was approximately 20 ft tall. At the second location in the Hampton Creek Swamp rich tamarack swamp, we collected a single male specimen from a middle branch on a tamarack tree approximately 12 ft tall. Tamarack tree cricket had not previously been documented from this site and this documentation represents a new EO for this species within the game area (EOID 26172).

We recorded 168 butterflies at three sites in 2022, comprising 37 species (Table 15). We also observed two unidentified skippers, which flew away before we could confirm the species identification. Although no listed nor special concern butterfly species were recorded during surveys, one notable species was the zebra swallowtail (*Protographium marcellus*), which we observed while surveying the Centre Ave. powerline. While not listed, this butterfly is uncommon in Michigan, where it feeds on pawpaw trees (*Asimina triloba*) as a caterpillar.

Table 14. Rare insect element occurrences documented in Gourdneck State Game Area, summer 2022. Status abbreviations are as follows: SC, State Special Concern. Element occurrence (EO) rank abbreviations are as follows: BC, good to fair estimated viability; CD, fair to poor estimated viability.

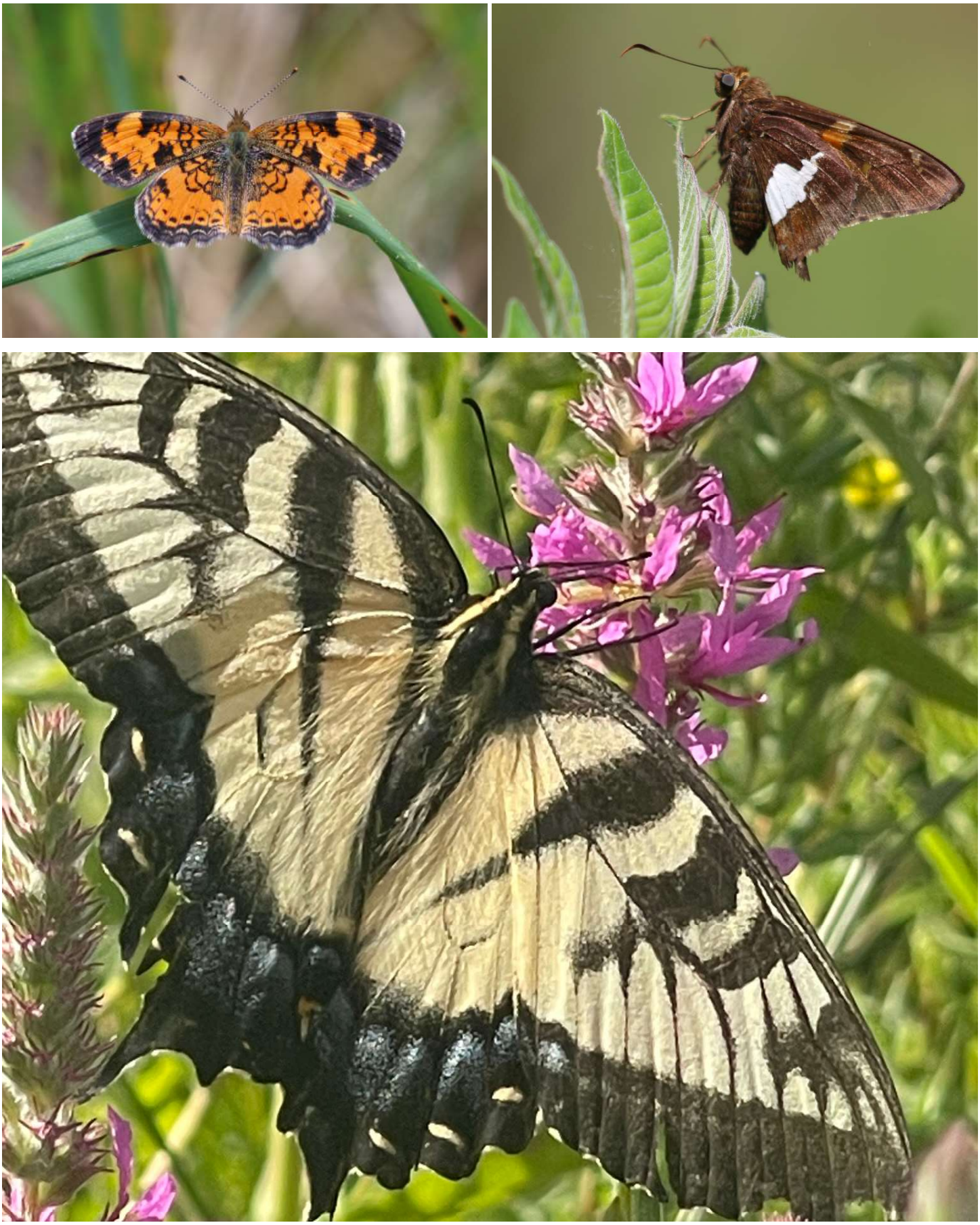
Common Name	Scientific Name	State Status	Federal Status	EO ID	EO Rank	Year First Observed	Year Last Observed
Royal fern borer	*Papaipema speciosissima*	SC	NA	26235	BC	2022	2022
Tamarack tree cricket	*Oecanthus laricis*	SC	NA	5775	CD	2000	2022
Tamarack tree cricket	*Oecanthus laricis*	SC	NA	26172	CD	2022	2022

A new record for tamarack tree cricket (*Oecanthus laricis*, State Special Concern) was documented during meander surveys. Photo by D.L. Cuthrell, MNFI.

Figure 30. Location of rare insect element occurrences in Gourdneck State Game Area.

Table 15. Incidental, unlisted non-target butterflies observed during insect surveys.

Common Name	Scientific Name	Center Ave. Powerline	Hampton Lake Fen	Vanderbilt Fen	Total
American Copper	*Lycaena phlaeas*	2	0	0	**2**
Appalachian brown	*Satyrodes appalachia*	2	1	2	**5**
Black dash	*Euphyes conspicua*	0	2	0	**2**
Black swallowtail	*Papilio polyxenes*	3	0	1	**4**
Broad-winged skipper	*Poanes viator*	0	0	1	**1**
Cabbage white	*Pieris rapae*	7	12	6	**25**
Clouded sulphur	*Colias philodice*	1	0	1	**2**
Common buckeye	*Junonia coenia*	1	0	0	**1**
Common checkered skipper	*Pyrgus communis*	0	1	0	**1**
Common roadside skipper	*Amblyscirtes vialis*	0	1	0	**1**
Eastern tailed blue	*Cupido comyntas*	3	0	0	**3**
Eastern tiger swallowtail	*Papilio glaucus*	1	1	2	**4**
Edwards' hairstreak	*Satyrium edwardsii*	1	0	0	**1**
European skipper	*Thymelicus lineola*	2	1	2	**5**
Eyed brown	*Satyrodes eurydice*	2	2	1	**5**
Giant swallowtail	*Papilio cresphontes*	1	0	1	**2**
Great spangled fritillary	*Speyeria cybele*	0	1	0	**1**
Hobomok Skipper	*Poanes hobomok*	3	0	0	**3**
Juvenal's Dusky Wing	*Erynnis juvenalis*	5	0	0	**5**
Least skipper	*Ancyloxpha numitor*	1	7	4	**12**
Little wood satyr	*Megisto cymela*	15	1	0	**16**
Monarch	*Danaus plexippus*	0	2	3	**5**
Mourning cloak	*Nymphalis antiopa*	1	0	1	**2**
Mulberrywing	*Poanes massasoit*	0	3	0	**3**
Mustard white	*Pieris oleracea*	0	1	0	**1**
Northern pearly-eye	*Enodia anthedon*	1	0	0	**1**
Orange suphur	*Colias eurytheme*	1	0	0	**1**
Pearl crescent	*Phyciodes tharos*	4	4	6	**14**
Pepper and Salt Skipper	*Amblyscirtes hegon*	3	0	0	**3**
Red-spotted purple	*Limenitis arthemis astyanax*	1	0	0	**1**
Silvery Blue	*Glaucopsyche lygdamus*	1	0	0	**1**
Silver-spotted skipper	*Epargyreus clarus*	7	0	3	**10**
Spicebush swallowtail	*Papilio troilus*	0	0	5	**5**
Spring azure	*Celastrina ladon*	1	0	2	**3**
Viceroy	*Limenitis archippus*	0	7	6	**13**
Zabulon skipper	*Poanes zabulon*	1	0	0	**1**
Zebra swallowtail	*Protographium marcellus*	1	0	0	**1**
Unidentified skipper	*NA*	0	1	1	**2**
Total		**72**	**48**	**48**	**168**



Non-target butterfly species observed during insect surveys: pearl crescent (top left, Photo by L.M. Rowe), silver-spotted skipper (top right, Photo by L.M. Rowe), and an eastern tiger swallowtail (Photo by A.A. Cole-Wick).

Rare Birds

We completed rare raptor surveys at 15 points within the game area (Figure 12). Red-shouldered hawks (RSHA) were not detected, and we did not record any active RSHA nests. We conducted forest songbird surveys at 23 points (Figure 12). No rare forest songbirds were detected. We conducted grassland bird surveys at five points and detected Henslow's sparrows at three survey points, all of which were in a single field being managed as prairie and savanna (Figure 12). We used these observations to update an existing element occurrence for Henslow's sparrow (EO ID 20415, Table 16).

We documented a total of 41 bird species during point counts at Gourdneck SGA (Table 17). Seventeen species were detected at 30% or more survey points including: tufted titmouse (*Baeolophus bicolor;* 70%), eastern wood-pewee (*Contopus virens;* 65%), American robin (*Turdus migratorius;* 57%), red-bellied woodpecker (*Melanerpes erythrocephalus*; 57%), northern cardinal (*Cardinalis cardinalis*; 52%), red-winged blackbird (*Agelaius phoeniceus;* 52%), white-breasted nuthatch (*Sitta carolinensis*; 43%), wood thrush (*Hylocichla mustelina*; 43%), yellow warbler (*Setophaga petechia*; 39%), blue jay (*Cyanocitta cristata*; 35%), common yellowthroat (*Geothlypis trichas*; 35%), ovenbird (*Seiurus aurocapilla*; 35%), Acadian flycatcher (*Empidonax virescens*; 30%), brown-headed cowbird (*Cyanocitta cristata*; 30%), downy woodpecker (*Picoides pubescens*; 30%), red-eyed vireo (*Vireo o*livaceus; 30%), yellow-throated vireo (*Vireo flavifrons*; 30%).

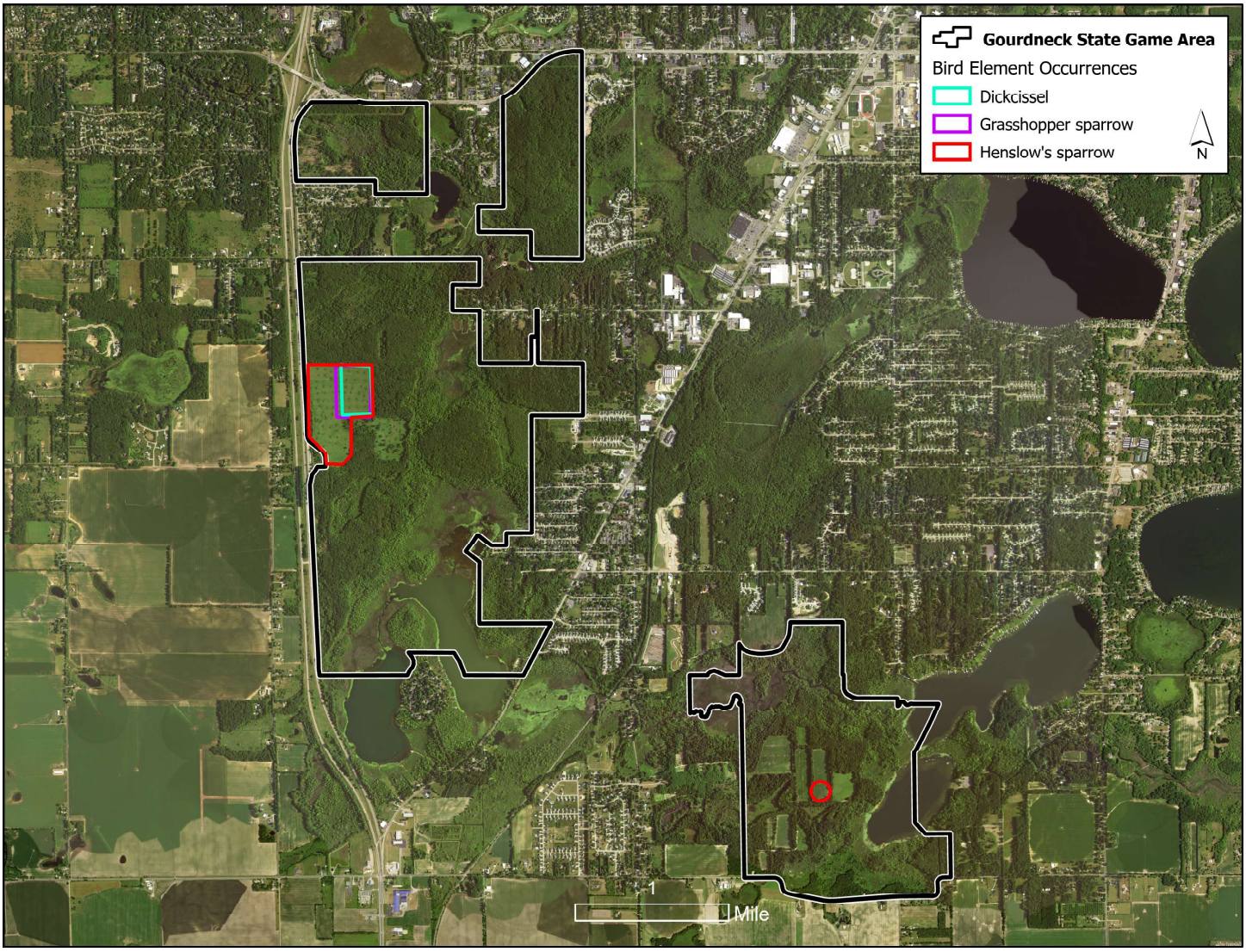


Figure 31. Location of rare bird element occurrences in Gourdneck State Game Area.

A white-eyed vireo was observed in Gourdneck SGA during MiFI surveys in 2016. This species was not documented during subsequent bird surveys in 2022. Photo by A.P. Kortenhoven.

The rare birds in Gourdneck SGA were documented from warm season grass plantings. Photo by J.M. Lincoln.

Henslow's sparrow was the only priority species detected at Gourdneck SGA in 2022 (Figure 31); however, occurrences for dickcissel and grasshopper sparrow are known from the area. Dickcissels were observed in 2013 and grasshopper sparrows in 2013 and 2014 during surveys conducted by MNFI (Table 16). Henslow's sparrow was recorded at three of the five points surveyed in 2022. Several bird species detected have special conservation status (Table 16). Three species are MDNR featured species for habitat management. These featured species are pileated woodpecker, wood thrush and wild turkey (*Meleagris gallopavo*). Red-bellied woodpecker and wood thrush are species of greatest conservation need (SGCN; Derosier et al. 2015). Wood thrush are also focal species for conservation efforts under the Landbird Habitat Conservation Strategy (Potter et al. 2007) of the Upper Mississippi River and Great Lakes Region Joint Venture.

Table 16. Rare birds and birds of special conservation status at Gourdneck State Game Area. Status abbreviations are as follows: E, State Endangered; and SC, State Special Concern. Element occurrence (EO) rank abbreviations are as follows: C, fair estimated viability; and D, poor estimated viability.

Common Name	Scientific Name	EO Rank	EO ID	State Status	Featured Species	SGCN	JV Focal Species	First Year Observed	Last Year Observed
Listed species									
Dickcissel	*Spiza americana*	D	20412	SC				2013	2013
Grasshopper sparrow	*Ammodramus savannarum*	C	20413	SC				2013	2014
Henslow's sparrow	*Ammodramus henslowii*	C	20415	E				2014	2023
Unlisted species									
Pileated woodpecker	*Dryocopus pileatus*				X			NA	2022
Red-bellied woodpecker	*Melanerpes erythrocephalus*					X		NA	2022
Wild turkey	*Meleagris gallopavo*				X			NA	2022
Wood thrush	*Hylocichla mustelina*				X	X	X	NA	2022

An eastern towhee documented during bird surveys at Gourdneck SGA. Photo by A.P. Kortenhoven.

Table 17. Bird species documented during surveys of Gourdneck State Game Area.

Common Name	Scientific Name	State Status	Featured Species	SGCN	JV Focal Species	Prop. of Points
Acadian flycatcher	*Empidonax virescens*					0.30
American crow	*Corvus brachyrhynchos*					0.09
American goldfinch	*Spinus tristis*					0.13
American robin	*Turdus migratorius*					0.57
Baltimore oriole	*Icterus galbula*					0.09
Barred owl	Strix varia					0.04
Black-billed cuckoo	*Coccyzus erythropthalmus*					0.09
Black-capped chickadee	*Poecile atricapillus*					0.17
Blue jay	*Cyanocitta cristata*					0.35
Blue-gray gnatcatcher	*Polioptila caerulea*					0.13
Brown creeper	*Poecile atricapillus*					0.04
Brown thrasher	*Cyanocitta cristata*					0.04
Brown-headed cowbird	*Molothrus ater*					0.30
Common yellowthroat	*Geothlypis trichas*					0.35
Downy woodpecker	*Picoides pubescens*					0.30
Eastern towhee	*Pipilo erythrophthalmus*					0.17
Eastern wood-pewee	*Contopus virens*					0.65
Field sparrow	*Spizella pusilla*					0.04
Gray catbird	*Dumetella carolinensis*					0.22
Great-crested flycatcher	*Myiarchus crinitus*					0.13
Hairy woodpecker	*Picoides villosus*					0.09
Henlow's sparrow	*Ammodramus henslowii*	E				0.60*
Indigo bunting	*Passerina cyanea*					0.04
Northern cardinal	*Cardinalis cardinalis*					0.52
Ovenbird	*Seiurus aurocapilla*					0.35
Pileated woodpecker	*Dryocopus pileatus*		x			0.13
Red-bellied woodpecker	*Melanerpes erythrocephalus*			x		0.57
Red-eyed vireo	*Vireo olivaceus*					0.30
Red-winged blackbird	*Agelaius phoeniceus*					0.52
Rose-breasted grosbeak	*Pheucticus ludovicianus*					0.22
Ruby-throated hummingbird	*Archilochus colubris*					0.04
Scarlet tanager	*Piranga olivacea*					0.26
Song sparrow	*Melospiza melodia*					0.17
Swamp sparrow	Melospiza georgiana					0.09
Tufted titmouse	*Baeolophus bicolor*					0.70
Veery	*Catharus fuscescens*					0.26
White-breasted nuthatch	Sitta carolinensis					0.43
Wild turkey	*Meleagris gallopavo*		x			0.04
Wood thrush	*Hylocichla mustelina*		x	x	x	0.43
Yellow warbler	*Setophaga petechia*					0.39
Yellow-billed cuckoo	*Coccyzus americanus*					0.04
Yellow-throated vireo	*Vireo flavifrons*					0.30

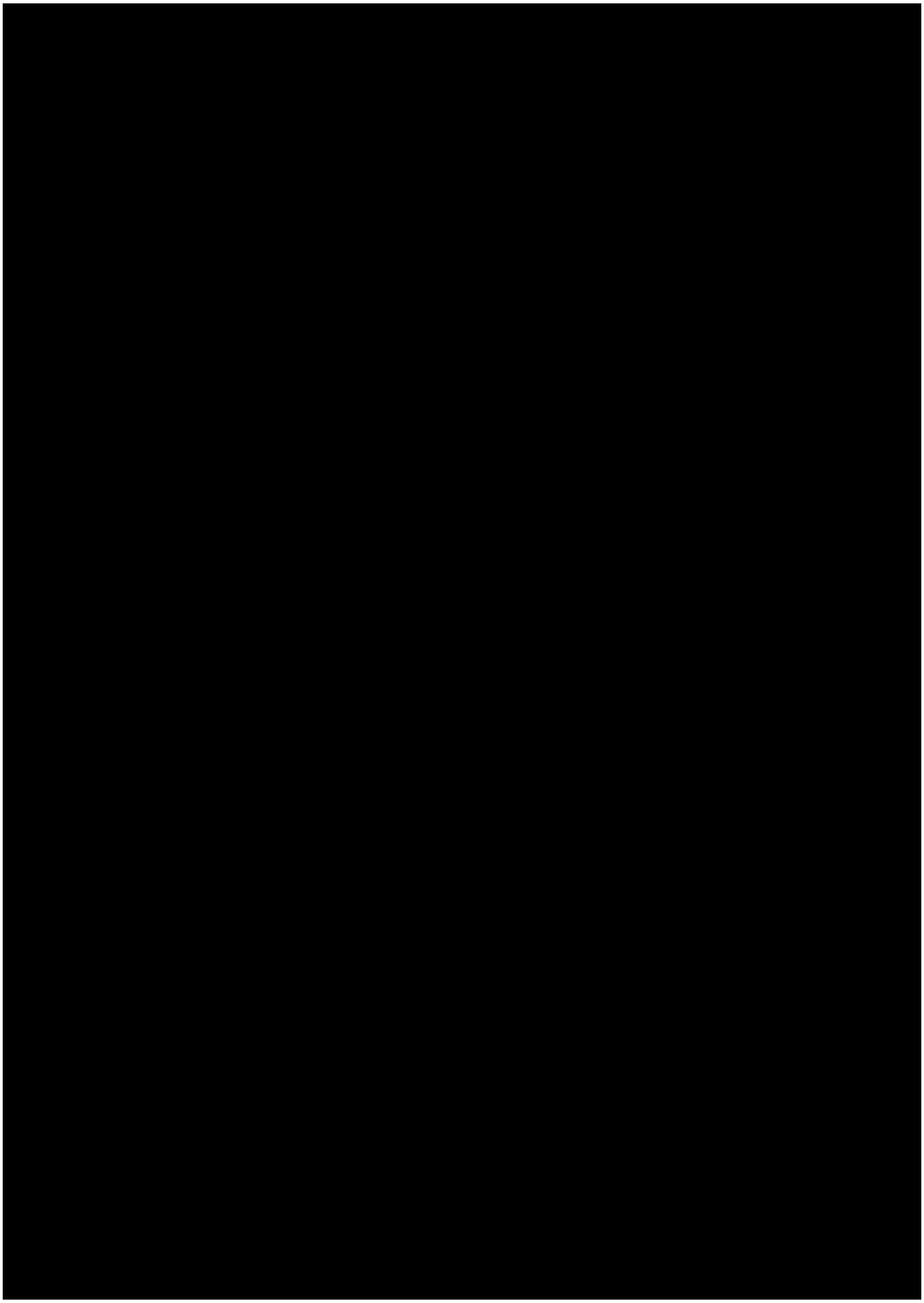
DISCUSSION

Gourdneck State Game Area (SGA) was established in 1941, making it one of the first game areas in Michigan. Game areas were acquired because wildlife habitat and hunting recreation are declining as urbanization, industrialization, and intensive farming have contributed to the loss of such habitats. The game area occurs almost entirely within the City of Portage and it is being featured by the DNR as the model for Urban State Game Areas. The game area is now effectively an island of natural cover in an expanse of urban and suburban development but despite the landscape context, Gourdneck SGA still supports several important natural communities, over one thousand acres of wetlands, and numerous populations of rare species. In addition, it offers a large variety of recreational opportunities including hunting, fishing, hiking, birdwatching, and foraging.

Gourdneck SGA is exceptionally notable as a hotspot for herptile diversity. The game area is an extremely important site for amphibian and reptile conservation in Michigan given the number and diversity of herptile species that have been documented in the game area. Twenty-five of the 56 amphibian and reptile species found in Michigan have been documented in or nearby the game area, including 8 of the 21 rare species currently listed in the state. This includes populations of [redacted] Blanchard's cricket frog (*Acris blanchardi*, State Threatened), Blanding's turtle (*Emydoidea blandingii*, State Special Concern), pickerel frog (*Lithobates palustris*, State Special Concern), and mudpuppy (*Necturus maculosus*, State Special Concern). Additionally, most populations of rare herptiles that have been documented in and around the game area have persisted in the area for several decades and have been estimated to have excellent, good, or fair viability.

While the game area supports populations of several rare species, many of these species are in serious decline across their range and are at risk due to habitat degradation and fragmentation. [redacted]

Gourdneck State Game Area is surrounded by suburban development and transportation infrastructure such as Highway-131. Photo by J.M. Lincoln.



[redacted] The high concentration of rare herptiles in Gourdneck SGA is especially unusual for southern Michigan, particularly relative to the game area's small size, degraded and fragmented nature of the surrounding landscape, and impacts of Euro-colonization over the past two centuries. The populations of rare herptiles in the game area represent important genetic material for the long-term health of these species because they are in decline across their range. Therefore, protecting the rare herptiles and the habitats upon which they rely are especially important conservation goals.

Gourdneck SGA also supports populations of several species of rare plants. A total of 37 populations of rare plants have been documented from within Gourdneck SGA or the vicinity. Early collections were conducted by Florence and Clarence Hanes in the 1930s and 1940s and they documented numerous populations of rare plants (Hanes and Hanes 1947). Over time, habitats within the game area have become increasingly degraded and the surrounding landscape more fragmented. Of the rare plant species that have been documented in the vicinity of the game area, only 40.5% have been relocated and recently confirmed extant. The remainder are likely extirpated.

Prioritizing stewardship of representative natural communities is critical to biodiversity conservation because native organisms are best adapted to environmental and biotic forces with which they have survived and evolved over millennia. Biodiversity is most easily and effectively protected by preventing high-quality sites from degrading, and invasive plants are much easier to eradicate when their populations are small and not yet well-established. Stewardship actions within the game area should focus on the highest quality examples of the rarest natural community types and the largest sites. Generally, we recommend that management efforts to maintain ecological integrity and native biodiversity be focused within natural communities and areas of natural cover that are recoverable to a better condition as these areas provide the best habitat for the numerous rare plant and animal species.

One of the locations adjacent to the game area where leadplant (*Amorpha canescens*, State Special Concern) had occurred was eliminated during the construction of this apartment complex. Photo by T.J. Bassett.

To that end, we provide the following management recommendations for your consideration.
We believe the main management needs in order of importance are to: 1) establish conservation priority areas around the highest quality wetlands, populations of rare taxa, and forested uplands that have the greatest potential for recovery to oak savanna; 2) protect hydrology of wetlands within those corridors; 3) develop and prioritize stewardship actions within those corridors, especially controlling invasive species and applying prescribed fire; and 4) monitor populations of rare taxa and the effectiveness of stewardship actions.

Fundamentally, our primary recommendations are to minimize fragmentation around conservation priorities, protect wetlands that support rare taxa, address serious infestations of invasive species, recover fire-dependent systems with the application of prescribed fire, and monitor the effectiveness of the stewardship actions. The following discussion section has been organized around these management recommendations. In addition, based on our experience researching and surveying this game area, we provide recommendations for future survey and monitoring needs.

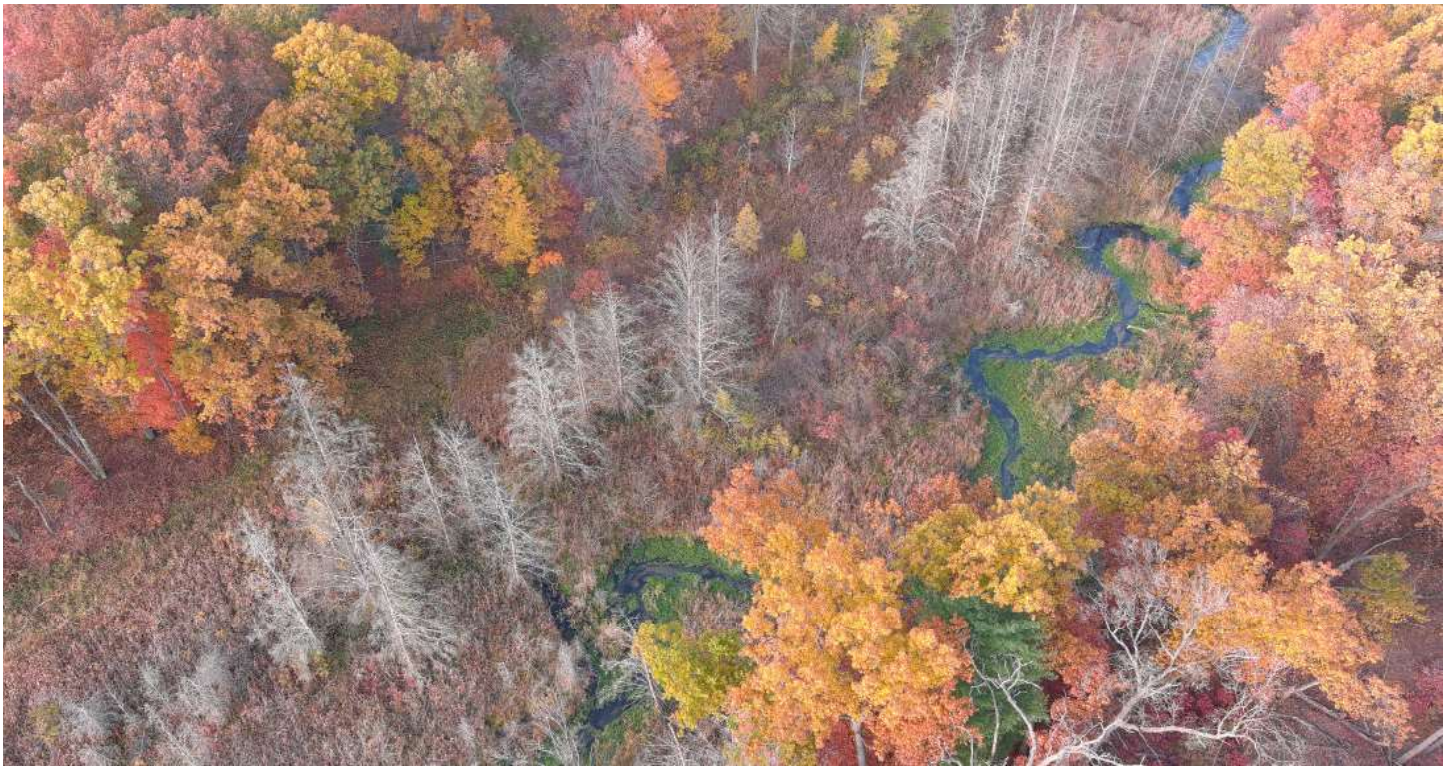
A severe infestation of the invasive glossy buckthorn has degraded much of the Hampton Creek wetland complex. The remaining areas of high-quality habitat that persist are in serious jeopardy from this and other invasive species. Photo by J.M. Lincoln.

Establishing Conservation Priority Areas

Landscape fragmentation is the process by which natural habitats are divided into smaller, isolated fragments due to agriculture, urbanization, and infrastructure development. The effects of fragmentation on native plants and animals and ecosystem processes are drastic (Heilman et al. 2002). Fragmentation reduces the size and quality of suitable habitat, which can lead to the loss of rare species that require specific habitat conditions. The small and insular nature of fragmented habitats may make them too small to support the full array of species formerly found in the landscape (Rooney and Dress 1997). The process isolates populations of rare species by eliminating connectivity between areas of suitable habitats, which can impede the movement of animals and plants and disrupt important ecological processes such as pollination and seed dispersal thereby limiting gene flow.

Local population extinctions within fragments are accelerated by reduced habitat and population size. Within fragmented landscapes, herptile population viability and diversity are reduced by the prevalence of mesopredators (e.g., raccoons, skunks, and opossums). Numerous neotropical migrant songbirds are dependent on interior forest habitat and are highly susceptible to nest parasitism and predation (Robinson et al. 1995, Heilman et al. 2002). Native plant diversity within forested fragments is threatened by low seedling survivorship, infrequent seed dispersal, high levels of herbivory, and growing prevalence of invasive species and native weeds, which thrive along the increasing edges and disperse throughout fragmented landscapes along roads and trails (Brosofske et al. 2001, Heilman et al. 2002, Hewitt and Kellman 2004). As a result of the cumulative, degrading factors from fragmentation, the rare species within Gourdneck SGA are likely declining at an accelerating rate, and are at risk of becoming locally extinct.

Remaining unfragmented natural spaces are becoming increasingly important to populations of rare species because of the scarcity of large blocks of unfragmented habitat and the continually increasing pressures from urban development. Some herptile species [redacted] often move among different wetlands throughout the active season and typically require large wetland complexes (Compton 2007). Local impacts from beaver can reduce the suitability of some habitats for [redacted] which require stable hydrologic conditions for hibernation. Providing suitable habitat and maintaining connectivity among and between wetland and upland habitats could make populations of herptiles more resilient to local habitat disruptions and improve their long-term viability. Natural spaces such as Gourdneck SGA serve as important refuges for species that are struggling to survive in the fragmented landscape. Protecting and restoring natural habitats and promoting connectivity between them are essential for maintaining healthy ecosystems and conserving local native biodiversity.



Connectivity of wetland and upland ecosystems is critical for populations of rare herptiles that utilize Gourdneck SGA Photo by J.M. Lincoln.

Within Gourdneck SGA we have identified four categories of land that are included in Conservation Priority Areas: 1) documented high-quality natural communities; 2) areas that provide critical habitat for rare species; 3) wetlands that provide important ecosystem services, and 4) areas that can be recovered to an improved condition with stewardship intervention. We have delineated the Conservation Priority Areas and provide a potential conservation buffer to improve connectivity between these Conservation Priority Areas (Figure 32). The Conservation Priority Areas include high-quality natural communities with an added 150 ft buffer to minimize fragmentation. Within the Conservation Priority Areas we have also included the oldest forested stands that have mature trees and limited invasive species but do not meet MNFI standards for inclusion as natural communities. Our top recommendation is to focus ecosystem stewardship efforts in the highest quality natural communities within the Conservation Priority Areas and minimize intensive forestry prescriptions in those zones. Considerable attention should be afforded the populations of rare species and long-term planning should be built around protecting and enhancing their populations through holistic ecosystem management and the reduction of mesopredators. The approach for conserving rare species should be centered around reducing threats to natural communities and maximizing connectivity between areas of high-quality natural communities. The primary degrading factors are destabilized hydrology, invasive species, and the suppression of fire in fire-dependent uplands. Because of the extremely high concentration of rare reptiles, we also recommend reducing the levels of mesopredators such as raccoons that predate reptiles and their nests, particularly turtles, as well as amphibians.

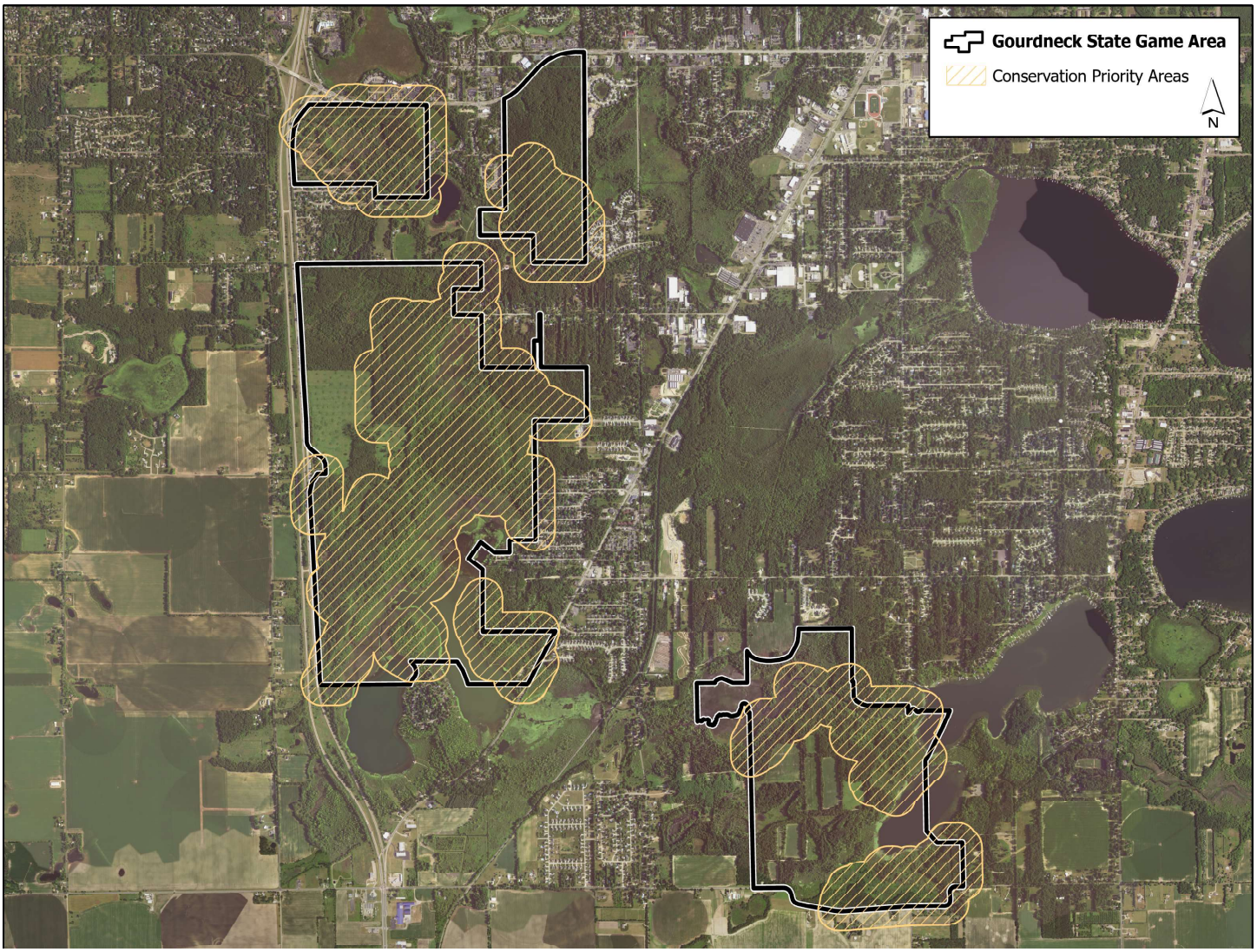


Figure 32. Proposed Conservation Priority Areas for Gourdneck State Game Area. To prevent habitat fragmentation, protect ecological integrity of the highest quality forests, limit impacts to wetlands, and protect populations of rare species, we suggest that land managers establish management goals based on improving ecological integrity within the Conservation Priority Areas through the treatment of invasive species, application of prescribed fire, and implementing forestry actions that avoid negatively impacting soils and maintain long-lived canopy species.

Ecosystem management to reverse habitat degradation should generally have positive impacts on the viability of rare plant species and habitats used by rare herptiles. Reducing the abundance and limiting the spread of invasive species will reduce competitive pressures that limit the viability of rare plant species populations. Avoiding hydrological disruptions will maintain ecological processes (e.g., groundwater flows, nutrient cycling) to which rare plants, herptiles, and mollusks are adapted. Reintroducing fire to the fire-dependent natural communities at Gourdneck SGA has the potential to have the largest impact, as fire stimulates germination and growth in many rare plant species and has the added benefit of controlling many invasive species and native species that compete with rare, fire-adapted plant species.

Turtle nest predation rates in highly fragmented landscapes and anthropogenically disturbed habitats can be very high (Lee 2007, Lee and Monfils 2008, Lincoln et al. 2019). Suitable nesting habitats, especially those that are safe from nest predators, may be limited in the Gourdneck SGA given the level of habitat fragmentation and disturbance within and adjacent to the game area. Restoring and maintaining open upland areas near wetlands and away from roads would provide suitable turtle nesting habitat that is potentially safe from predators. Control of mesopredators (e.g., raccoons) around nesting areas, particularly during the turtle nesting season, would help reduce predation of turtle nests and enhance reproductive success and population recruitment but would need to be conducted over the long term to be effective. Other methods for reducing turtle nest predation also can be investigated (e.g., nest cages, electric fences/enclosures). Maintaining or providing downed woody debris (e.g., hollow logs, rotting stumps, rootwads), brush piles, decaying leaf litter/piles, compost piles, and wood chip piles would provide microhabitats in which snakes could deposit their eggs or give birth to their young as well as provide refuge for turtles (Ernst and Ernst 2003, Harding and Mifsud 2017). Kingsbury and Gibson (2012) and Mifsud (2023) provide best management practices for conserving wetland and upland habitats for amphibians and reptiles.

As part of a holistic approach to improving conditions of ecosystems and rare species habitat, we suggest avoiding clearcutting upland forests within the Conservation Priority Areas. Selective timber harvest could still be a part of recovering savanna conditions, but clearcutting within and around high-priority forests and wetlands should be avoided. Management objectives for priority upland forests within the Conservation Priority Areas would ideally prioritize removing weedy tree species such as red maple and black cherry that are dominating the subcanopies of oak forests, thereby competing for water and nutrients

Populations of several herptiles in the state, such as box turtles (*Terrapene carolina carolina,* State Threatened), are rapidly declining due to dramatically increasing populations of mesopredators such as raccoons. Photo by J.M. Lincoln.

with canopy oaks, limiting recruitment of oak saplings in the understory, and suppressing herbaceous vegetation characteristic of oak savannas. During the process of recovering savannas with mechanical intervention, retain bur oak, white oak, dwarf chinquapin oak and other long-lived, fire-adapted tree species characteristic of oak savannas. Generally, we suggest eliminating intensive timber harvest in and around wetlands to protect aquatic systems and limit forest fragmentation around the highest quality forests to most effectively protect native biodiversity – especially the numerous rare animal and plant species.

The structure and processes of riparian ecosystems are determined by their interface with adjacent ecosystems (Tepley et al. 2004). Biodiversity refugia potential of riparian corridors within fragmented landscapes can be predicted based on width and contiguity of the natural cover (Goforth et al. 2002). Wider, more contiguous riparian corridors will provide the greatest benefits to long-term biodiversity conservation in fragmented landscapes (Goforth et al. 2002). We therefore stress the importance of minimizing fragmentation within the game areas riparian areas. Adjacent land use can negatively impact stream habitat and rare native mussel species. Increases in sedimentation or sediment load from timber harvest can lead to changes in abundance of invertebrates (Noel et al. 1986, Brown et al. 1997) and fish (Broadmeadow and Nisbet 2004, Nislow and Lowe 2006), including fish species that rare mussels rely on as hosts. Rare native mussels are intolerant of high levels of siltation. Changes in the amount of instream coarse woody debris caused by timber harvest can impact stream habitat (Smokorowski and Pratt 2007) and aquatic animal communities (Bilby and Ward 1991). Maintaining vegetated riparian buffers along streams is a common and important practice to mitigate impacts to aquatic species and ecosystems (Olson et al. 2007). Allowing for naturally vegetated buffers of 100 m or more from rivers, streams, headwaters, ponds, and lakes can help to minimize impacts of timber harvest on rare mussels. Due to the downstream cumulative effect of river ecosystems, buffers protecting headwaters and smaller river habitats contribute to the maintenance of habitat quality in the entire waterway downstream of these areas. Rare mussels in lakes and ponds also benefit from natural vegetation buffers at the margins of waterbodies.

We recommend implementing major habitat improvement projects within Gourdneck SGA within the Conservation Priority Areas. Habitat management efforts in upland systems within the Conservation Priority Areas should focus on recovering oak savanna conditions with fire and improving habitat for rare species, primarily by reducing invasive species, applying prescribed fire at a relatively high return interval, and improving connectivity between uplands and wetlands. Treating invasive species within the Conservation Priority Areas and applying prescribed burns are management tools that are recommended for enhancing ecosystem services and promoting native biodiversity within the highest quality natural communities within the Conservation Priority Area (Figure 32). We also encourage continued investigation into the purchase of private lands adjacent to the highest quality habitats (such as Vanderbilt Fen and Sugarloaf Swamp) and partnering with nearby conservation groups like Southwest Michigan Land Conservancy and the City of Portage Parks and Recreation Department to expand and connect nearby areas of natural cover so that the impacts of the conservation corridors are maximized.

Watercress snail habitat is extremely sensitive to changes in adjacent habitat. Small seeps that support populations of snails can easily be degraded by intensive forest management. Photo by P.J. Badra.

Protecting Wetlands

Wetlands and open water constitute 63.6% of Gourdneck SGA. All of the high-quality natural communities documented in the game area are wetland types. Many of the rare plants and animals found in the game area rely on wetlands during their life stages. Fish and mussel species rely on barrier free streams. Vegetated wetland buffers surrounding riparian areas help maintain the integrity of streams and support healthy populations of fish and mussels that utilize them. Relative to uplands, these features also contribute disproportionately to ecosystem services such as protecting water quality and nutrient cycling. Because of the value of wetlands, we recommend managers focus on protecting and stabilizing wetland systems.

All wetlands within the game area have been altered through ditching, road construction, or impoundments. Sugarloaf Lake drains through Gourdneck Creek and the creek was altered in the early 20th century through construction of Shaver Road. The stream was then redirected from the natural channel and into a ditch before resuming its semi-natural course towards Gourdneck Lake. Sugarloaf Drain is a ditch that was dug from Gourdneck Creek where it is crossed by Oakland Drive. It continues to the northeast where it cuts through Bishop's Bog, adding substantial flow and nutrient-laden runoff into a wetland community type that is typically fed by precipitation (i.e., rain and snow). Additionally, a beaver has recently created a dam along the altered waterways that drain the Sugarloaf Lake complex, causing increased lake levels. The results are most apparent at the margins of the lake where diverse areas of poor fen have been replaced by a near monoculture of non-native invasive hybrid cat-tail (*Typha x. glauca*). There were many areas of open poor fen that were identified in the 2016 MiFI surveys that were unable to be relocated in 2022 due to the expanding non-native cat-tail that outcompetes native vegetation as a result of the fluctuating water levels and associated nutrient flux. Additionally, there were several dead trees in the lakeward portions of Sugarloaf Swamp where the swamp was most impacted by fluctuating water levels. This has led to the zone of invasive cat-tail expanding into the swamp, eliminating extremely diverse assemblages of native vegetation.

Canopy species within Sugarloaf Swamp have died towards the lake, likely due to fluctuations of lake levels. The resulting loss of canopy and increased lake level has led to a dramatic expansion of the non-native invasive narrow-leaved cat-tail at the edges of the swamp. Photo by J.M. Lincoln.

Several areas of high-quality poor fen were identified along the margins of Sugarloaf, Mud, and Little Sugarloaf Lakes during the 2016 MiFI surveys (top photo, Stand 40; Compartment 2). By 2022, many of these areas had been completely subsumed by an advancing front of invasive narrow-leaved cat-tail (bottom photo). It is unclear if this was a result of fluctuating lake levels caused by a beaver dam impounding the outlet, but alterations to hydrology have serious consequences in a landscape with high background levels of invasive species. Photos by J.M. Lincoln.

Similar processes of fluctuating water levels have negatively impacted the two areas of prairie fen in the game area. Both Vanderbilt Fen and Hampton Creek Fen have recently been impacted by beavers. As a result, water levels and the amount of non-native cattails in the Vanderbilt Fen have been increasing for a number of years which may reduce habitat availability and suitability for [redacted] and other herptile species that occupy the fen. Beavers are ecosystem engineers and while they can have positive impacts on wetlands, there can be severe negative consequences on the condition of high-quality natural communities and populations of rare species, particularly in fragmented landscapes with high background levels of non-native invasive plant species. Beavers can alter the hydrology of wetlands by building dams, which can flood areas with populations of rare species and exacerbate the effects of habitat fragmentation.

For animals like [redacted], the stability of the wetlands is critical, especially because the fragmented nature of the landscape often prevents them from finding additional suitable habitat. Dramatic and sudden alterations to the hydrology of wetland and aquatic habitats should be avoided, especially significantly lowering the water table during late fall and winter as this could lead to mortality of overwintering amphibians and reptiles. Flooding or significantly increasing water levels for long periods of time during the active season or the overwintering period also can lead to habitat loss, temporary or permanent displacement of individuals, and mortality of eastern massasaugas (Seigel et al. 1998, Smith 2009, Ontario Ministry of Natural Resources and Forestry 2016). For assemblages of plants, the disturbance initiated by beaver flooding results in a dramatic shift in composition, often leading to infestations of non-native invasive species to the exclusion of native plants, as was the case in Hampton Creek Fen.

Beavers are native species and historically played a critical role as keystone species on the landscape. They were nearly eliminated from Michigan and have only recently begun to return to the local landscape in a substantial way. They provide important ecosystem services, such as the creation of wetland habitats and the improvement of water quality and can be beneficial for some species in fragmented landscapes. Locally, systems like rich tamarack swamp and prairie fen along streams were temporary expressions in a long continuum of natural community types that were influenced by beaver flooding.

A beaver dam along Hampton Creek killed several tamarack and inundated Hampton Creek Fen, leading to a dramatic increase in the abundance of invasive species. Photo by L.M. Rowe.

The presence of beavers in the modern landscape around Gourdneck SGA is destabilizing to wetlands and a risk to populations of rare species. The near absence of beaver over the past 200 years, the long periods of relative hydrologic stability, the abundance of invasive species, the elimination of several wetlands in the area, and the rapidly increasing fragmentation of the landscape around Gourdneck SGA mean that once flooded by beaver, the systems will be overrun with invasive plant species, and the rare animals have no alternative suitable habitats to seek. Unfortunately, in the modern landscape, the return of beavers to Gourdneck SGA poses a serious threat to native biodiversity.

The risks and benefits of beavers in wetlands with rare species need to be carefully considered in the context of the specific landscape and conservation goals, and management strategies should be tailored to minimize negative impacts. Because MNFI is an organization that focuses on the conservation of rare species and the protection of high-quality examples of natural communities, our management recommendations emphasize the protection of rare species and the habitat upon which they rely. Game area managers incorporate several factors when developing prioritization framework for decisions, but we urge careful consideration to minimizing the impacts of beavers and urge their removal as soon as they are detected.

Controlling beaver is becoming increasingly difficult and is not practical across the entire region. However, routinely surveying choke points that impact critical wetlands for beaver is important for maintaining the high-quality natural communities and populations of rare species. It may be prudent to partner with neighboring landowners, conservation districts, and the drain commissioner to develop a plan for monitoring critical areas for beavers, improving stream crossings with infrastructure that are less prone to beaver dams, and inventorying local infrastructure to minimize blockages and understanding potential points of control.

We also recommend investigating removing barriers within streams to improve connectivity of populations of mussels and fish. Alteration of stream flow with dams or other in-stream structures can lead to scouring of substrates used by mussels and should be avoided. Poor stream crossings, such as culverts that are too small or that are perched above stream water level, can also interfere with fish passage. Native mussels rely on transport by fish hosts while in the larval stage. These fish hosts allow for mussel migration to new habitats and transportation of between mussel populations. Barriers to fish passage between mussel populations can cause negative impacts to mussels from inbreeding and genetic isolation of populations (Watters 1996, Haag 2012). Though a relatively large population of the Federally Endangered snuffbox was documented in Gourdneck Creek in 2020, none were found during our 2022 surveys of Gourdneck SGA. This snuffbox population is one of the largest in Michigan and is located eight river kilometers downstream of Gourdneck SGA below the Sunset Lake impoundment and dam. The dam prevents the migration of snuffbox and other native mussels to upstream habitats. The high density of snuffbox found on the downstream side of the dam is likely an effect of the dam being a barrier to the movement of fish hosts. Fish tend to congregate below the dam since they cannot pass. Native mussel glochidia (larvae) attached to fish hosts deposit onto substrates below the dam where fish are congregated.

Watercress snails depend on the particular temperature regime, water chemistry, and physical structure of microhabitats found in springs and groundwater seeps on the margins of streams and lakes where watercress plants grow. Avoiding hydrologic alterations, such as draining and filling, near occupied springs can help to maintain groundwater flow that creates this habitat type. Retaining or restoring naturally vegetated buffers around springs, streams, and lakes with watercress snail provides shade, moderate temperatures, and reduces potential for erosion. Sedimentation of fine particles and erosion along the banks of streams where watercress snails occur can be reduced by maximizing the amount of naturally vegetated landcover and minimizing impervious surfaces in the watershed. Higher proportions of impervious and non-naturally vegetated landcover types can lead to flashier stream flows and increased erosion of stream banks. Forms of pollution the species may be most susceptible to are road salt, metals (e.g. copper, mercury, and zinc), and excess nutrients from agricultural runoff (Johnson et al. 2013, Lydeard et al. 2004).

Our management recommendations for protecting wetlands include 1) evaluating appropriate levels of Sugarloaf Lake to stabilize the wetland communities at its margins; 2) preventing beavers from forming dams, especially in areas that would impact the highest quality natural communities; 3) avoiding impacts to wetlands from timber harvest by providing large forested buffers along wetlands; 4) promoting natural vegetation along the margins of waterbodies; and 5) eliminating barriers along streams and repairing stream morphology to promote fish passage and improve habitat connectivity for mussels and aquatic species.

Controlling Invasive Species

Biological invasions are a critical driver of ecosystem degradation and the global decline of biodiversity (Vitousek et al. 1996, Kennedy et al. 2002). Invasive plants affect ecosystem processes through their patterns of resource acquisition and degrade native biodiversity by altering the fundamental structure and function of ecosystems (Ehrenfield 2010). Non-native invasive species often have no natural predators and can therefore spread aggressively. By outcompeting and replacing native species, invasive species can change floristic composition of natural communities, alter vegetative structure, and reduce native species diversity; often causing local or even complete extinction of some native species (Harty 1986).

Invasive species can also upset delicately balanced ecological processes such as trophic relationships, interspecific competition, nutrient cycling, soil erosion, hydrologic balance, and disturbance regimes (Bratton 1982). In addition, invasive species compromise pollinator services, change microclimates, despoil recreational resources, and degrade the economy of the Great Lakes states (Zavaleta 2000, Pimentel et al. 2005, Huang and Asner 2009, Ehrenfeld 2010). Environmental damages and losses caused by invasive species within the United States were estimated to be over $120 billion per year (Pimentel et al. 2005). Invasive infestations are projected to increase as the landscape continues to be fragmented (Vila and Ibanez 2011) and the climate changes.

MNFI has developed a model for prioritizing invasive species treatment (Cohen et al. 2019). This model identifies stands within the Gourdneck SGA that have the highest ecological need for invasive species management (Figure 33). Invasive species in Gourdneck SGA pose an extreme threat to populations of rare plant species, are altering

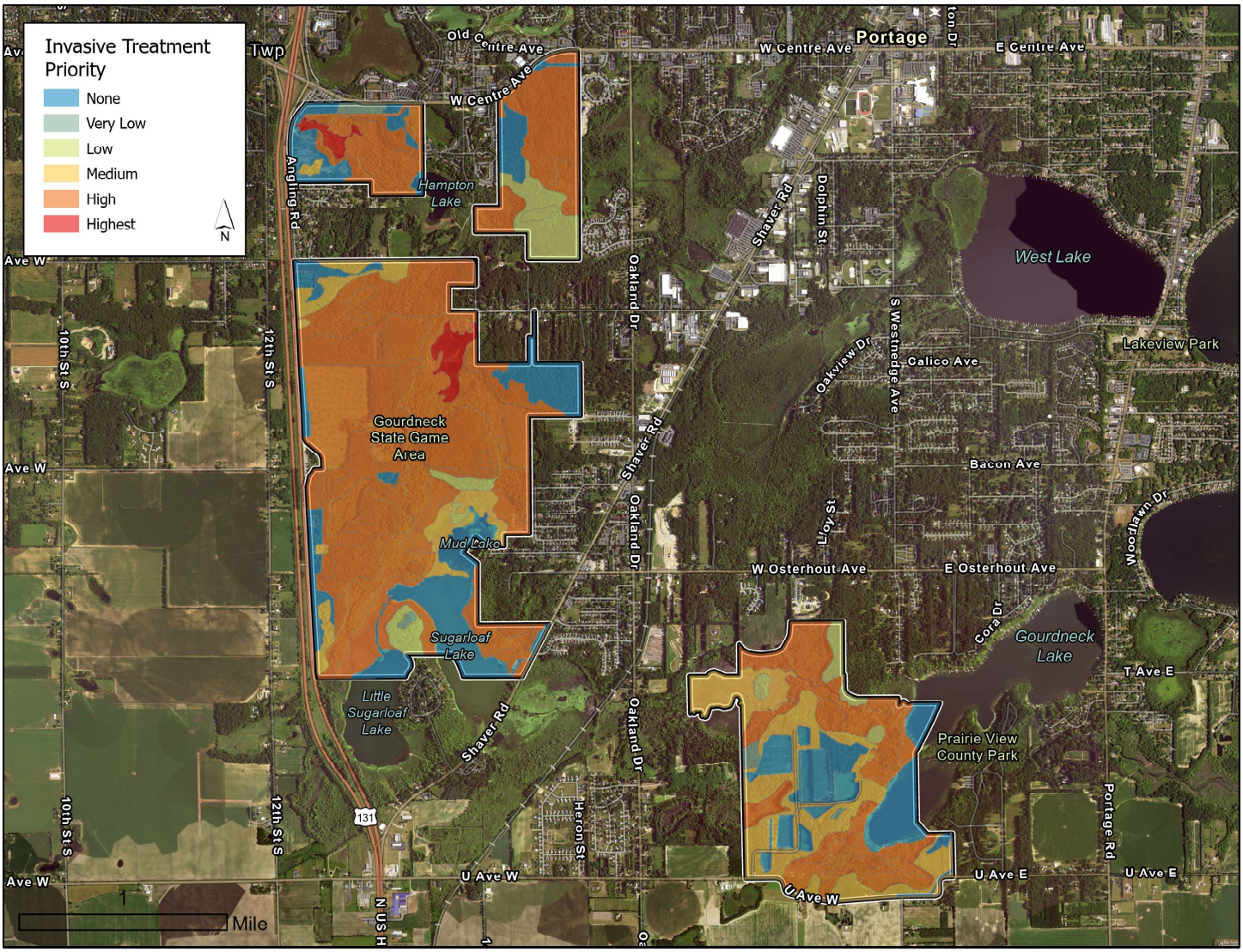


Figure 33. MNFI's invasive species treatment prioritization model identified the Vanderbilt and Hampton Creek prairie fens as having the highest priority for invasive species control efforts in the Gourdneck SGA. These stands are characterized by rare natural community types that support high biodiversity and numerous rare species populations, provide numerous ecosystem services, and are threatened by populations of invasive species that jeopardize long-term integrity and resilience of these important wetlands.

critical habitat for rare animals, and degrading composition of the most important natural communities. Reducing the negative impacts of invasive species to wetlands within the game area's wetlands can be achieved by preventing additional alterations to hydrology and minimizing habitat fragmentation around high-quality natural communities. Minimizing hydrologic disruption is an important part of reducing ongoing risk to natural communities. The treatment of invasive species in Gourdneck SGA should be a top priority for land managers. We encourage a multi-faceted approach to invasive species control and emphasize that improving the landscape context surrounding the high-quality natural areas is critical. Initial treatment of widespread invasive species should be focused in the highest quality wetlands, priority areas with rare plants, and upland forests that will be included in oak savanna management efforts. Addressing priority invasive species in the highest quality natural communities will ideally focus on the most problematic species, such as narrow-leaved cat-tail and non-native reed in the Vanderbilt Fen; glossy and common buckthorns in the Hampton Creek wetland complex; and buckthorns, autumn olive, Japanese barberry, and multiflora rose within Sugarloaf and Vanderbilt Swamps.

In upland areas where timber harvest is going to be implemented, we recommend treating invasive species in forests before modifying the canopy structure especially where invasive shrubs are prevalent and threaten to outcompete native vegetation following canopy release. Similar to hydrologic disruptions facilitating invasion of wetlands, timber harvest in fragmented landscapes can significantly increase populations of invasive species, especially oriental bittersweet, autumn olive, multiflora rose, Japanese barberry, garlic mustard, burdock, and mullein. Forest management in the absence of addressing invasive species can detrimentally affect attributes of regenerating forest ecosystems. The rapid expansion of invasive species following logging operations can decrease biological diversity, forest productivity, water and soil quality, and contributions to the carbon cycle (Pimentel et al. 2000).

Newly establishing invasive species should be removed as rapidly as possible before they infest additional areas. Treating invasive species is difficult and expensive, and severe infestations can take several years to control. Treatments should be implemented by someone trained on the identification of rare species and the location of the populations of rare species should be clearly communicated prior to control. Control measures should be enacted by someone familiar with applying herbicides in sensitive areas and wetlands. Partnerships with organizations such as SW x SW Corner Cooperative Invasive Species Management Area (CISMA) will be important for reducing existing populations and addressing new populations within the game area and in nearby natural areas.

In the past, autumn olive, multiflora rose, and other non-native species now understood to be highly invasive were historically planted on game areas because of a perceived benefit to wildlife. However, the negative impacts of these invasive shrubs have proven to be more detrimental than any potential benefits. To reduce the risk of introducing problematic species in the future, we recommend the DNR immediately instate a policy to plant only species known to be native to the region, particularly focusing on Michigan genotypes when available.

Sericea lespedeza (*Lespedeza cuneata*) is a serious invasive pest and there are nascent populations within Gourdneck SGA. Stopping this species before it becomes uncontrollable should be a top priority.
Photo by J.M. Lincoln.

Applying Prescribed Fire

The upland communities within Gourdneck SGA were historically fire-dependent oak savanna communities. These systems have been degraded by invasive species, an overabundance of deer, and especially by the lack of fire. Two prescribed fires have occurred on the game area, one in 2018 and another in 2021. While this is an encouraging start, we believe that broadening the application of fire to include additional high value uplands and increasing the frequency of prescribed fire for the purpose of recovering oak savanna community types is a top conservation priority. These fire-dependent natural community types serve as critical habitat for many of the rare plants and animals within the game area. Fire is the best tool to promote the open structure and floristic composition of oak savannas that provides critical habitat for so many species.

Within Michigan, more than 99.9% of oak savannas have been destroyed. Oak savanna ecosystems once covered over 1 million acres in the southern portion of the state (Comer et al 1995). Historically, all of the uplands within the boundaries of the Gourdneck State Game Area, 41% of the overall game area, were oak savanna. These historical savannas now exist as abandoned agricultural land or have converted to low-diversity, closed-canopy forest in the absence of fire. Today the primary threats to rare plant species in the upland habitats at Gourdneck SGA are fire suppression and deer browse. Lack of fire, and the resulting increase in density of trees and shrubs, threatens species such as leadplant, white wild indigo, and prairie coreopsis. For example, one population of leadplant decreased by almost half between 2003 and 2019, from an estimated 40 to 23 individuals (MNFI 2023). The viability of many of the remaining individuals is threatened by shade from encroaching shrubs and trees. Historically, oak savannas adjacent to wetlands would have provided suitable nesting habitat for turtles and gestation habitat for massasauga rattlesnakes. Because oak savannas have become so rare, numerous rare species are threatened by the lack of fire, and because the maintenance of oak savannas in Gourdneck SGA is a management objective of the DNR, we recommend management of target areas for savanna restoration, especially through the application of prescribed fire at a high-frequency return interval of around 3 to 5 burns per decade.

Many oak forests still support oak savanna indicator species and could be recovered to an improved condition with the application of prescribed fire. Photo by J.M. Lincoln.

In the absence of fire, areas of oak savanna have converted to closed-canopy oak forest (top, photo by J.M. Lincoln). These forests have understories dominated by fire-sensitive species such as red maple, which intercepts light and contributes to the elimination of characteristic herbaceous vegetation. By contrast, healthy oak savannas, such as this remnant in Wisconsin (bottom, photo by Dan Carter), feature widely spaced canopy oaks, minimal understory, and an extremely diverse herbaceous layer. Though returning the upland systems of Gourdneck SGA to such a state would be a substantial effort, implementing the return of fire to more of the game area at a higher frequency is a worthy goal and would benefit several populations of rare species.

The ecological benefits of returning fire to landscapes historically dominated by fire-dependent are evident. At nearby Fort Custer Training Center and Fort Custer Recreation Area in eastern Kalamazoo County, for example, frequent fire has dramatically increased the viability of several rare plant populations and the integrity of numerous high-quality natural communities. In addition, several new populations of rare plants were also documented following the reintroduction of frequent fire, either because fire stimulated seed germination or increased the viability of populations, increasing detectability (Cohen et al. 2009, Bassett et al. 2022a, MNFI 2023).

The best areas to target for oak savanna restoration and the application of prescribed fire are areas that have not been tilled or areas that may have been disturbed but still support savanna vegetation (Figure 34). In the absence of consistent fire, these areas have converted to closed-canopy oak forest, often with extremely dense understory of red maple. Competition from mesophytic species, such as red maple and invasive shrubs that thrive with fire suppression, acting in concert with high deer browse pressure has led to the failure of oak regeneration. While no longer resembling the historical condition of oak savanna, these areas with mature oaks that have not been tilled are critical for recovery of savannas in the game area as they often support remnant populations of savanna species in the ground cover.

Fire is a critical management tool for maintaining an open canopy, promoting high levels of grass and forb diversity, and deterring the encroachment of woody vegetation and some invasive species. Areas that retain concentrations of oak savanna indicator species such, as the opening under the powerline in Compartment 1, are important components of restoration and these areas should be prioritized for inclusion in prescribed fires.

The Centre Ave. powerline corridor in Compartment 1 is extremely diverse and supports a concentration of naturally occurring oak savanna indicator species within the game area as well as populations of rare plants (species list provided in Appendix 8). It is currently managed primarily with herbicide which has severely impacted native vegetation in the past. We suggest managing powerline corridor surrounding forested stands with prescribed fire to recover oak savanna and bolster conservative species. Photo by J.M. Lincoln.

Lupine and several other wildflower species that thrive in response to fire support numerous pollinators such as the two-spotted bumble bee. Photo by L.M. Rowe.

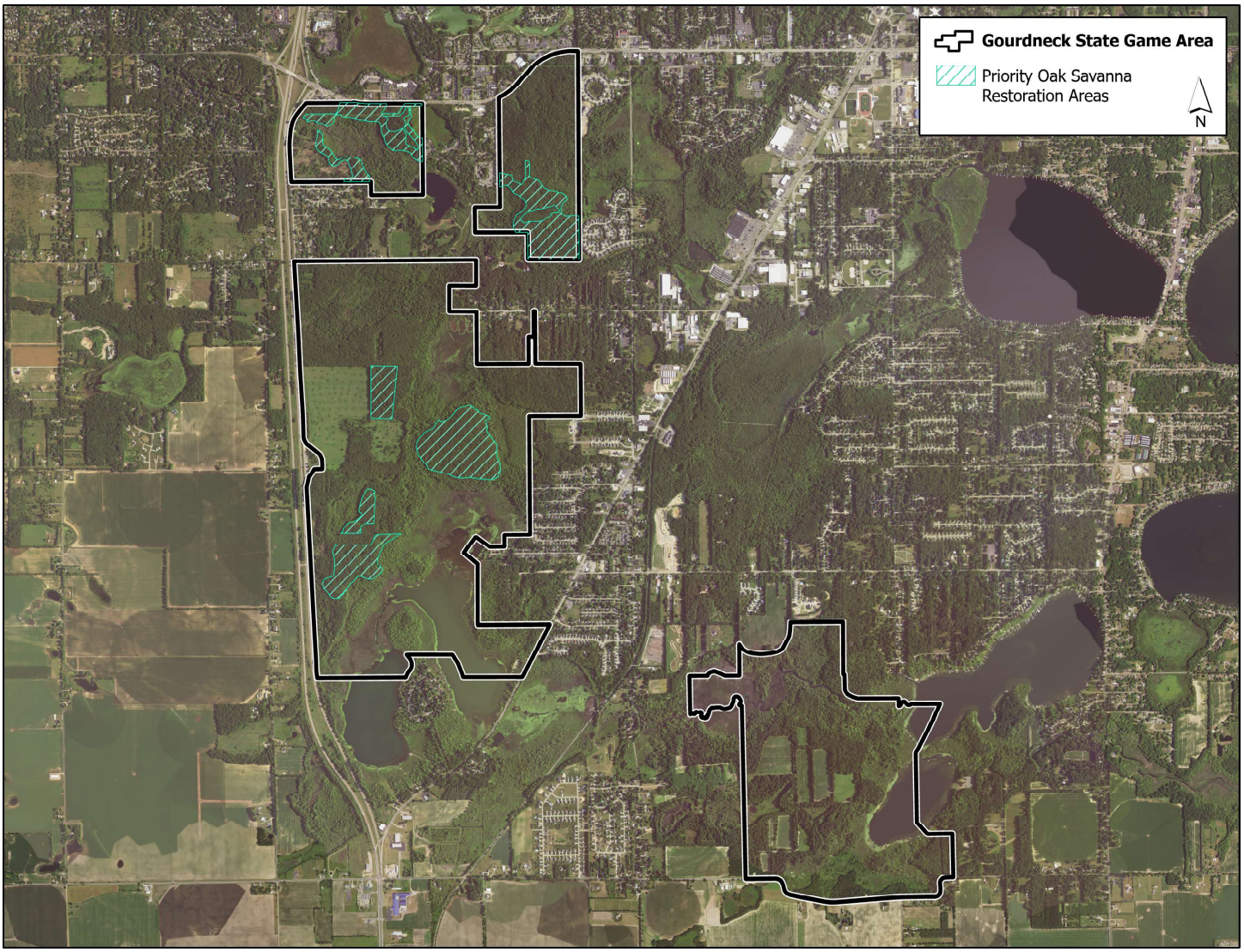
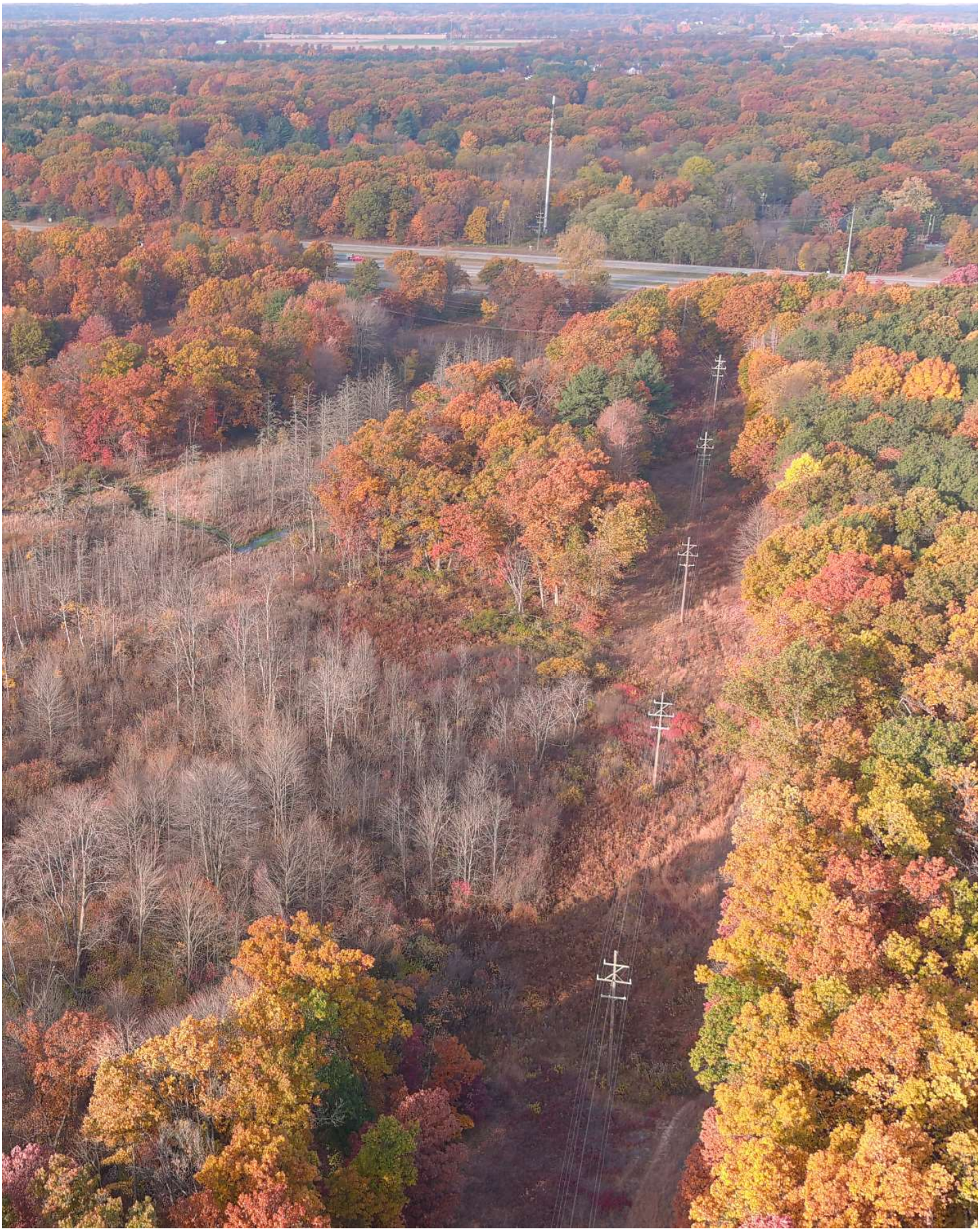


Figure 34. Priority oak savanna restoration areas. These forested stands were historically oak savanna and have converted to closed-canopy forest due to fire suppression. These areas were untilled and typically support indicator species and are therefore most recoverable. We especially recommend prioritizing Vanderbilt Island, the powerline corridor in Compartment 1, and the oak forest in the northeastern portion of the game area.

Several relatively conservative oak savanna indicator species persist at Gourdneck SGA. Common frostweed (top left), common spiderwort (middle left), clasping milkweed (bottom left), and American columbo indicate the past prevalence of fire in uplands within the game area. Populations of these species are facing threats from fire suppression, deer herbivory, and habitat degradation. Photos by J.M. Lincoln.



The powerline corridor supports numerous oak savanna indicator species and is part of a landscape that historically experienced frequent fire. This area should be prioritized for the application of prescribed burns and extreme care should be afforded the populations of native species that persist. Photo by J.M. Lincoln.

The persistence of characteristic vegetation is an important signal that the site was historically savanna and additional characteristic vegetation may be expressed through restoration. Fire intervals of one to three years bolster graminoid dominance, increase overall grass and forb diversity, and remove woody cover of saplings and shrubs.

MNFI has developed a model for assessing prescribed fire needs on state lands (Cohen et al. 2021). This model identifies fire-dependent ecosystems within Gourdneck SGA that have the highest ecological need for fire management (Figure 35). Resources for burning are limited and should be prioritized for targeted project areas. Vanderbilt Fen in Compartment 2 and the surrounding forested uplands to the west is a top priority area for implementing prescribed burns. Other project areas include the prairie fen within the Hampton Creek wetland complex and adjacent uplands; a relatively high-quality oak forest in the eastern portion of Compartment 1; Vanderbilt Island, south of Vanderbilt Fen; and forested stands along the western margin of the Sugarloaf Lake wetland complex (Figure 34). We recommend application of frequent prescribed fire in these areas with the goals of reducing dominance of mesophytes like red maple in the subcanopy, increasing herbaceous vegetation, and promoting oak recruitment.

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 the river that can act as burn breaks to facilitate burning across ecotones and avoid creating new burn breaks near sensitive areas. Developing large, permanent burn units that include younger forests adjacent to the highest quality natural communities can also provide forests with various age classes, a common goal of wildlife managers that is often achieved through timber harvest alone.

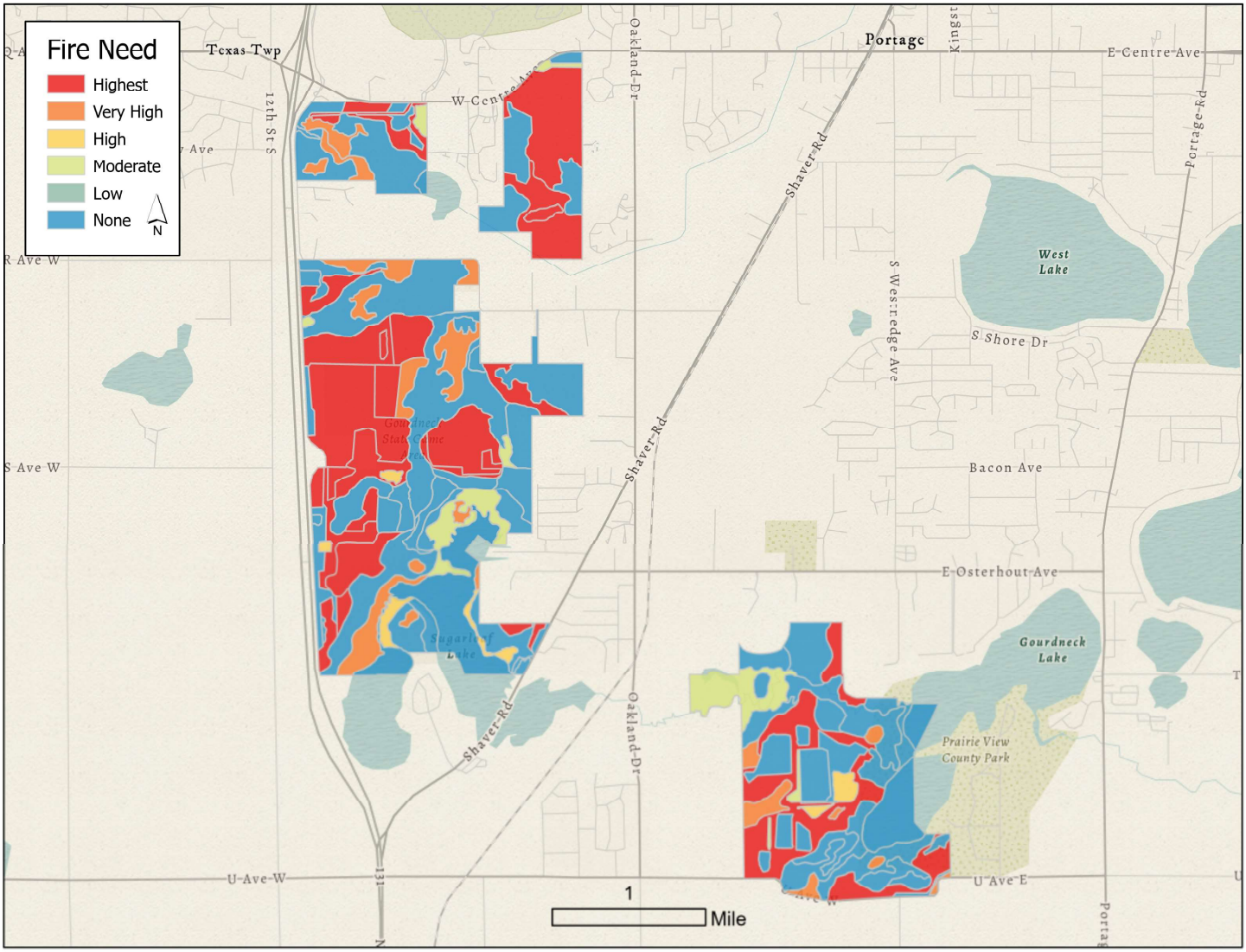


Figure 35. Prescribed fire needs assessment of Gourdneck State Game Area. Most of the uplands within the game area have a “very high” or “high” need for prescribed fire. Some areas that have a fire need of “none” are areas of planted pine, agricultural openings, plantings, or are generally degraded.

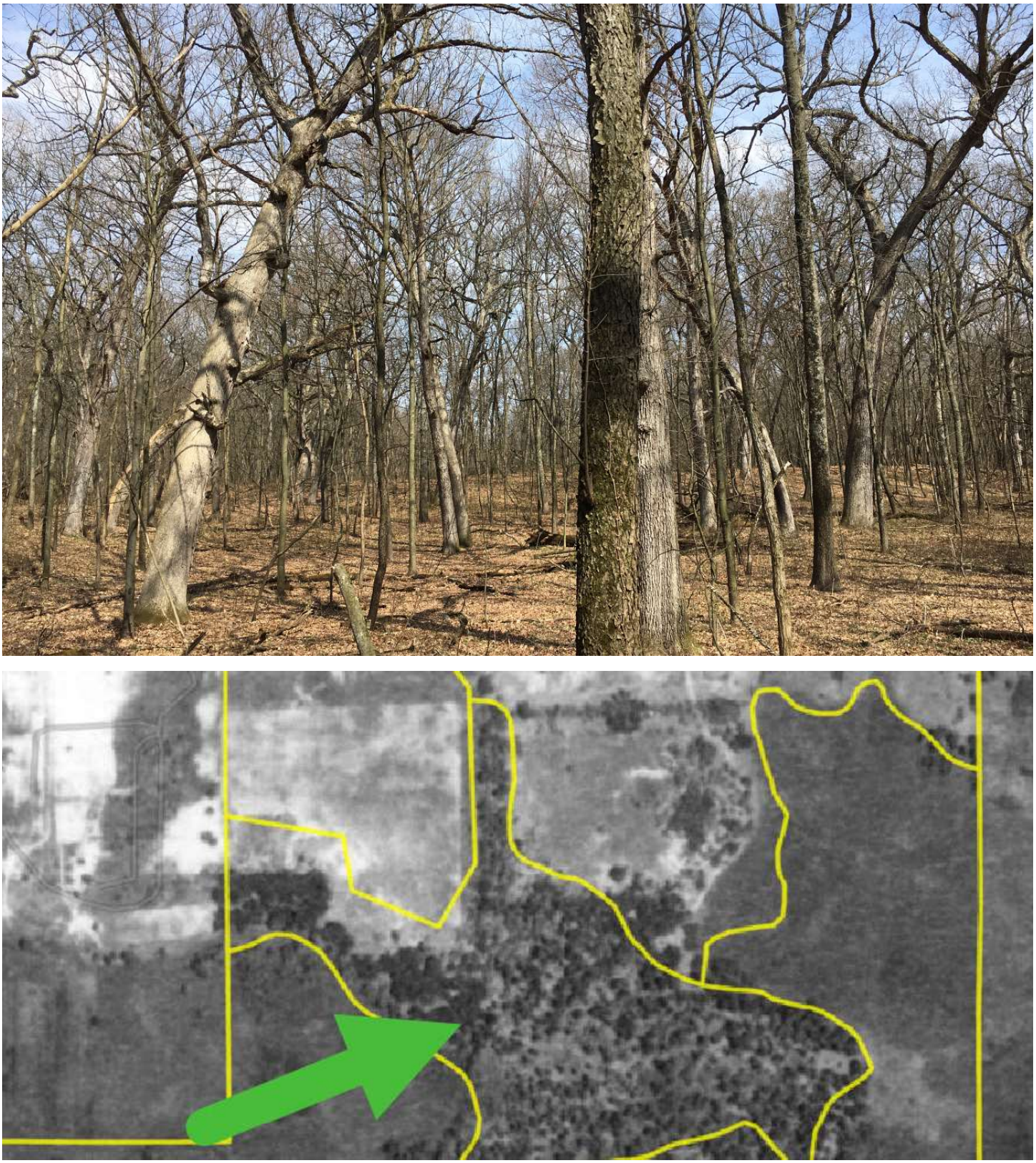
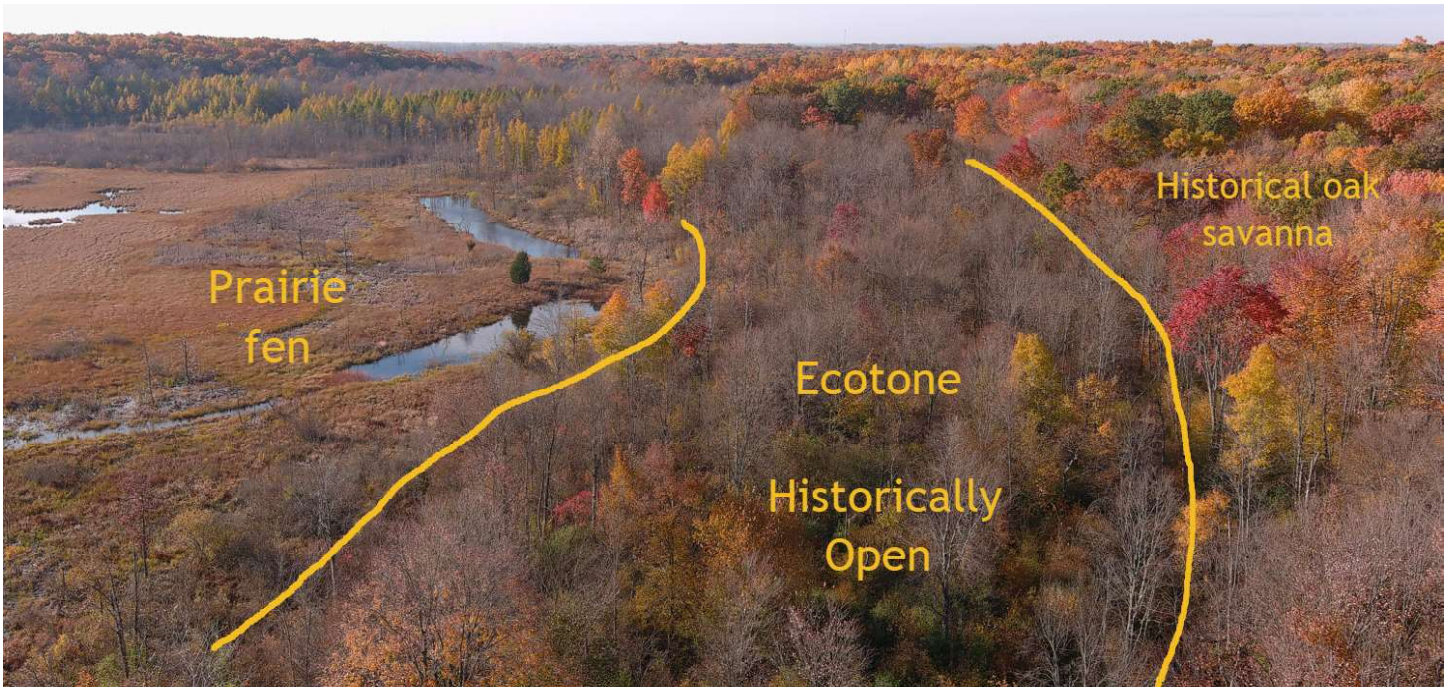


Figure 36. Aerial imagery from 1938 is useful for identifying areas of recoverable savanna. The green arrow shows an area that was not cleared that has wide spacing of trees the potentially reflect savanna conditions. Nearby stands were cleared for agriculture and have little potential for recovering to oak savanna. The area indicated by the green arrow now features a closed canopy forest (above, photo by J.M. Lincoln) with several ancient white oaks that have limb scars where the lower limbs were self-pruned as the open savanna conditions deteriorated. The subcanopy is now dominated by red maple with only a few characteristic savanna species. This is Stand 20 in eastern Compartment 1 and is a top priority for returning frequent prescribed fire. The large white oak in the left of the picture was aged and estimated to be 249 years old, the oldest found in the game area.

Because application of fire produces regrowth that is favored by deer, including areas of low-quality forest in the prescribed burn can help mitigate the most deleterious impacts of browse within high-quality forests after a burn.

Burn units that include high-quality wetlands adjacent to the targeted upland areas can provide continuity between uplands and lowlands. Maintaining suitable wetland and upland habitats that meet the needs of life history stages of the amphibian and reptile species that occur at Gourdneck SGA is critical for conserving these species, particularly rare and declining species. [redacted] and Blanchard's cricket frog have been documented in the Vanderbilt Fen and are typically associated with areas of open wetland with shallow water. These species also use adjacent shrubby or forested habitats if there are areas of open canopy where they can access sunlight for thermoregulation. Controlling woody encroachment and maintaining open conditions in the game area would maintain suitable habitat for these rare species and other herptile species. [redacted] Many herptiles depend on both fire-dependent upland and wetland habitat. Reptiles and amphibians utilize upland habitats for foraging, mating, thermoregulating, nesting, gestating, giving birth to young, aestivating, and overwintering (Harding and Mifsud 2017). Maintaining a diversity of upland habitats including open savanna, and forested habitats provides habitat for a range of herptiles in Gourdneck SGA. [redacted]

This transition zone or ecotone between uplands and lowlands is often very diverse and commonly used by herptiles at different times of the year for thermoregulation and nesting. Maintaining continuity between suitable wetland and upland habitats that meet the needs of life history stages of herptiles is critical for conserving these species, particularly rare and declining species. In the absence of fires and with ditching of many wetlands, ecotones have largely converted from diverse, open extensions of the oak savannas to dense shrub thickets dominated by invasive shrubs that function as a boundary between wetland and upland and are not useful for thermoregulation of herptiles. Because the gradient between upland and wetland was historically more open and critical for many rare reptiles, we recommend focusing on including these transition areas in prescribed burns. Modern burn practices often exclude these ecotones from prescribed fires and even use the area for burn breaks. We urge managers to avoid this approach and prioritize the inclusion of ecotones in burns, particularly around the high-quality fens.



A portion of the ecotone around Vanderbilt Fen has converted to a somewhat degraded rich tamarack swamp. We recommend implementation of prescribed fire across uplands and wetlands and the use of controlled burning to restore open conditions of the ecotones between wetlands and uplands. These ecotones provide valuable habitat for herptiles. Photo by J.M. Lincoln.

Many of the oak savannas that were not cleared for agriculture now exist as relatively degraded, low diversity oak forests. Photo by J.M. Lincoln.

Managers of this prairie fen and adjacent upland forest in Oakland County have cleared buckthorn and native shrubs from the ecotone in order to facilitate prescribed fire moving between uplands and lowlands to improve habitat for eastern massasauga rattlesnakes. Photo by J.M. Lincoln.

Restoration efforts that utilize fire may be accelerated with mechanical removal of target species, particularly by removing invasive species and red maple which generally dominate the understory and subcanopy of many historic savannas that have converted to closed-canopy forest in the absence of fire. Savannas are characterized by a sparse canopy coverage of 10 to 60%. This condition is best achieved through gradual canopy reduction through applying consistent prescribed fire. Combining the mechanical removal of understory red maple and the application of prescribed fire can accelerate the restoration process and dramatically increase the site's herbaceous vegetation and native insect populations (Lettow et al. 2014). As an initial target, we suggest that areas prioritized for oak savanna restoration should be burned using a fire-return interval of at least three burns per decade. Following the application of several burns, the effects of restoration should be assessed, and the timing and frequency of burns modified if necessary to improve community response.

Although prescribed fire typically improves the overall quality of habitat for many animal species, its impact on rare animals should be considered when planning a burn. Conducting these management practices in late winter or early spring before amphibian and reptile species emerge (typically March–April/early May depending on the species, latitude, and spring weather), in the fall after species have entered their hibernacula (e.g., late October/early November), or after the species have left a particular area or habitat would minimize the potential for adversely impacting these species. If prescribed burning needs to occur during spring and early summer, it is recommended that prescribed fires avoid the early spring emergence period (April to mid-May) or fall ingress period (October/early November) when herptiles may be lethargic or less active after emerging from or preparing to enter their winter hibernacula or overwintering sites. Instead, fires should be conducted later in the growing season when herps are fully active and may be able to evade slow-moving flames or find suitable refugia during prescribed fires (Melvin 2017). When these seasons cannot be avoided, conducting slow-moving fires such as backburns is recommended so individuals have time to avoid fire. In addition, we recommend dividing occupied habitat into multiple burn units and leaving at least one burn unit unburned at a time to serve as refugia for fire-sensitive species during fires. Other options for reducing the potential for adversely impacting herptiles during prescribed burns include surveying and temporarily removing target species from the treatment area prior to conducting prescribed burns and returning animals after the treatment. Similarly, limiting mowing, hydro-axing, and cultivation practices that involve the use of motorized vehicles

Managers in Gourdneck SGA have mechanically removed red maple from the understory of high-priority forests along the powerline corridor that supports numerous oak savanna indicator species. This is excellent stewardship intervention and will be especially effective when paired with prescribed fire.
Photo by J.M. Lincoln.

Prescribed burns should be patchy and conducted in a way to provide refugia for rare reptiles such as box turtles (*Terrapene carolina carolina*). Photo by Rachel Leightner, DNR.

or heavy equipment in occupied habitats during the active season (April-October) or following the same recommendations for prescribed burns would minimize potential for adversely impacting herptiles species. Raising mower decks to 15 – 20 cm (6-8 in) can help minimize potential for adversely impacting snakes. Kingsbury and Gibson (2012) and Mifsud (2023) provide additional general habitat management guidelines and recommendations for amphibians and reptiles.

Refugia, or unburned areas, are critical if prescribed burning needs to occur during spring and early summer. We suggest burning relatively large areas and striving for patchy burns by burning either when fuels are somewhat patchy or when weather conditions will not support hot, unbroken fire lines (such as can occur under atypically warm, dry weather and steady winds). Areas adjacent to where fire is applied can be burned in alternate years or seasons to protect populations of fire-sensitive species. This allows unburned units to serve as refugia for immobile invertebrates and slow-moving herptile species.

Prescribed fire is beneficial for many rare species and critical for the recovery of oak savannas in Gourdneck State Game Area. However, applying prescribed fire in urban environments requires careful planning and implementation due to the potential risks to human life and property. Fire management professionals must assess the surrounding built environment, including nearby structures, roads, and utilities, to ensure that the prescribed fire can be safely conducted without putting people or property at risk. Prescribed fire in urban environments may also cause respiratory irritation and other health issues. Therefore, the timing and location of prescribed fires must be carefully considered to minimize the exposure of nearby residents. Prescribed fire in urban environments may also face opposition from nearby residents who may be concerned about the risks to their health or property values. Fire managers must work closely with the community to address these concerns and communicate the benefits of prescribed fire for ecological health and reducing the risk of uncontrolled wildfires. Prescribed fire is critical for efforts to recover oak savannas and is already being applied in urban areas throughout the country and can be done carefully and with appropriate community engagement.

With respect to oak savanna restoration, we recommend 1) focusing efforts on the highest quality areas that can be recovered to a state more closely resembling historical oak savanna conditions (Figure 34); 2) creating permanent project boundaries with existing features such as trails and streams that function as burn breaks that excluded ecotones and wetlands and minimize disturbances associated with developing new burn breaks; 3) prioritizing the consistent application of fire at a rate of approximately three burns per decade within priority areas; 4) removing or treating mesophytic species – such as red maple, black cherry, and invasive shrubs – to accelerate the process of recreating savanna structure; 5) treating invasive species before and after burns; 6) applying slow-moving back burns or timing burns to avoid impacting rare herptiles; and 7) allowing seedbank expression by not supplementing restoration sites with additional plant species until reevaluating sites after several burns.

Monitoring

We strongly encourage the implementation of targeted monitoring of wetlands for changes in hydrology due to beaver dams, impacts of invasive species across the game area, and the health of populations of rare animal and plant species. Populations of plants are collapsing under heavy browse of white-tailed deer, fire suppression, expansion of invasive species, and isolation of populations. Rare reptiles and amphibians are facing decline from alterations to hydrology, water quality issues, and exponentially increasing populations of mesopredators like raccoons. We also suggest the implementation of continual monitoring within the high-quality natural communities and throughout actively managed areas to gauge the success of restoration activities at reducing invasive species populations. In addition, periodic early-detection surveys should be implemented to allow for the identification of invasive species that have yet to establish a stronghold within Gourdneck SGA.

Considering the potential for hydrologic alterations to negatively impact populations of rare herptiles, monitoring populations of rare herptiles should be continued. Additional surveys and monitoring are valuable for determining the status, distribution, and management needs of rare herptile species and other species of greatest concern (SGCN) that have been documented or have potential to occur within the Gourdneck SGA.

Many herptile species are cryptic and difficult to detect in the field, particularly if they are rare. Continuing targeted surveys will help determine if additional rare herptile species and SGCN occur in the game area, particularly gray ratsnakes, smooth greensnakes, northern ribbonsnakes, northern ring-necked snakes, and blue racers. Monitoring is especially valuable for clarifying the status, distribution, extent, and estimated viability of the [redacted] pickerel frog, [redacted], and mudpuppy populations within Gourdneck SGA to inform an adaptive management approach of these species. Surveys to identify areas with critical habitats for these species (e.g., nesting and overwintering areas) and assess threats to these populations and critical habitats will help to inform and guide ongoing management efforts for their conservation.

Surveys for rare plants are not frequently prioritized on public lands but their importance should not be discounted, especially considering the apparent and continual loss of populations from the region. Future surveys should target plant populations that have not been documented in recent years, particularly those classified here as “potentially extirpated” (Table 8). Many of these populations may not have been documented because there has not been sufficient survey effort. Others may exhibit traits that make detection difficult. For example, orchids such as whorled pogonia exhibit prolonged dormancy and may not produce above-ground growth in some years (Alahuhta et al. 2014).

Survey efforts over the last 25 years have resulted in documenting many populations of plants as still extant. These surveys have increased the certainty with which we can draw conclusions about the status of EOs at Gourdneck SGA. Targeted rare plant surveys occurred in the late 1990s and early 2000s throughout Gourdneck SGA (McKenna 2004, MNFI 2023), and in limited areas in the last ten years (Paskus et al. 2019, Bassett et al. 2022b, Slaughter and Bassett *in prep*). The lack of documentation of some other EOs may be due only to the absence of sufficient survey effort, and targeted surveys in additional areas of the game area may lead to observations of historical or new EOs. For example, tall nut rush (*Scleria triglomerata*, Special Concern) was collected by Hanes and Hanes (1947) from “NW of the [Sugarloaf] lake” within GOURDNECK SGA and least pinweed (*Lechea minor*, State Threatened) from near GOURDNECK SGA “Along railway ‘Island No. 2,’ SE of Sugarloaf Lake” (MNFI 2023). As a result of focused surveys in the Hampton Creek wetland complex in 2019, new EOs of both species were documented (Paskus et al. 2019; Table 7). Other species were always rare in Michigan and are less likely to be discovered with intensive survey efforts, including pale beard-tongue (*Penstemon pallidus*, State Extirpated), bowman’s root (*Gillenia trifoliata*, State Extirpated), straw sedge (*Carex straminea*, State Endangered), and fleshy stitchwort (*Stellaria crassifolia*, State Endangered).

Several rare plant species have been documented in the landscape surrounding Gourdneck SGA but have never been documented within the game area even though suitable habitat exists in the game area for these species (Table 9). In particular, species associated with upland savanna habitats may be discovered in future surveys, especially where management with prescribed fire is expanded. Additional species associated with bogs, fens, and swamps with EOs near Gourdneck SGA that should be the target of future surveys in the wetlands include gray birch (*Betula populifolia*, Special Concern), log fern (*Dryopteris celsa*, State Threatened), and bog bluegrass (*Poa paludigena*, Special Concern).

Orange-fringed orchid (*Platanthera ciliaris*) was historically found in the Hampton Creek wetland complex but has since been eliminated by habitat degradation. Nearby populations persist and it may be possible to recover the suitable habitat with stewardship intervention. Photo by J.M. Lincoln.

Within Fort Custer Training Center, MNFI has recently documented several new EOs, some of which had not been observed since they were first collected by Hanes and Hanes (1947). Some of these species have also been documented within or in the landscape surrounding Gourdneck SGA, including leadplant, dodder (*Cuscuta pentagona*, Special Concern), Virginia flax (*Linum virginianum*, State Threatened) and shining wedgegrass (*Sphenopholis nitida*, State Special Concern). There is suitable habitat within Gourdneck SGA for other species, including beaked agrimony (*Agrimonia rostellata*, Special Concern), upland boneset (*Eupatorium sessilifolium*, State Threatened), and pale avens (*Geum virginianum*, State Threatened).

There are active rare plant restoration efforts under way at Gourdneck SGA. Dr. Todd Barkman, Western Michigan University (WMU) Professor of Biology, and Chris Jackson, WMU greenhouse manager, are working with DNR staff to manage habitat along the powerline corridor in the north of Compartment 1 and expand the population of rattlesnake-master (*Eryngium yuccifolium*) found there. From 2021 through 2022, Dr. Barkman and his students collected seed from the existing population, germinated the seeds at WMU greenhouses, and planted 15 seedlings back out into the population. They will continue to monitor and attempt to expand this population.

The overabundance of white-tailed deer in the game area and in the surrounding landscape is having deleterious impacts on the landscape and especially rare plants. Natural communities are at risk of becoming functionally extinct as major components fail to recruit. Rare plants are becoming locally extinct and common plants are becoming rare. The overabundance of deer has a direct negative impact on many plant species due to over browsing and indirect effects such as the facilitation of invasive plant species (Augustine and Decalesta 2003, Knight et al. 2009, Frerker et al. 2014). Legumes such as leadplant and white wild indigo are among the plant species that

Deer herbivory was apparent on several species, including the State Threatened white false indigo (*Baptisia lactea*). Photo by J.M. Lincoln.

are especially favored by deer due to their high nitrogen content (Anderson et al. 2001). Many wetland species also occur in fire-dependent natural communities (e.g., prairie fen), and are threatened by fire suppression and also by deer browse because of their palatability, such as white lady's-slipper (*Cypripedium candidum*, State Threatened). It may be necessary to closely monitor deer browse and work to prevent the total loss of rare species by erecting deer exclusion fencing.

Many of the rare species of insect that we targeted are difficult to document in a single field season. Gourdneck SGA contains suitable habitat for the rare insect species that were surveyed for and these targets should continue to be surveyed for. Additionally, many rare species within the game area are facing serious decline and may increase in abundance following active stewardship of priority natural areas. Limiting habitat fragmentation, reducing populations of invasive species, and applying prescribed fires can increase populations of rare insect species.

The 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. Periodic surveys would also provide an opportunity to monitor the effects of management actions on these and other species of management interest.

Western Michigan University Botany Professor, Todd Barkman, surveys Hampton Creek Fen for rare species. Photo by T.J. Bassett.

CONCLUSIONS

Gourdneck State Game Area is colloquially known as Michigan's First Urban Game Area. Within the City of Portage, near Kalamazoo, and within a rapidly developing economic corridor, this relatively small block of natural cover is an especially valuable parcel for the conservation of rare biodiversity. Game areas are important for supporting biodiversity, promoting ecological resilience, maintaining ecological integrity, and providing ecosystem services. In this report, scientists from Michigan Natural Features Inventory provided detailed information about several important high-quality natural communities and populations of rare species documented during surveys in Gourdneck SGA. To maintain the game area's critical contribution to biodiversity protection, resilience, ecological integrity, and ecosystem services, we recommend that managers prioritize actions around sustaining the unique natural communities and populations of rare species by minimizing fragmentation around the highest quality wetlands; protecting hydrology of wetlands; continuing to control invasive species within the highest quality wetlands; applying prescribed fire to targeted areas of recoverable oak savanna; and monitoring populations of rare taxa.

The wetlands of Gourdneck State Game Area, such as the Hampton Creek complex, provide habitat for numerous rare species and offer important ecosystem services such as improving water quality and carbon sequestration. Despite its small size, the game area harbors significant biodiversity. Photo by J.M. Lincoln.

The Gourdneck State Game Area substantially contributes to the native biodiversity of the region, especially a high concentration of populations of rare reptiles and plants. The surrounding landscape has had an extreme loss of natural cover over the past two centuries and remaining networks of green infrastructure like the Gourdneck SGA are critical for the protection of native biodiversity. Because of the degree of development of the surrounding landscape and the numerous stakeholders interested in using the game area, we hope that the Michigan DNR continues to investigate partnering with regional conservation groups like Southwest Michigan Land Conservancy and City of Portage Parks and Recreation to expand and connect nearby areas of natural cover so that the impacts of the conservation corridors can be maximized. As natural cover of the surrounding landscape cover continues to decline and degrade in the context of private ownership, public lands such as Gourdneck State Game Area will have an ever-expanding role in the protection of Michigan's natural heritage and quality of life for its residents. It is big enough to protect native biodiversity, offer myriad recreational opportunities, and maintain the critical access to hunting, fishing, and trapping for which it was purchased. The importance of this and other game areas as both a reservoir of biodiversity and an entry point for citizens to experience that nature will only grow with the passage of time.

In April of 2023, the Michigan DNR partnered with the City of Portage Parks and Recreation Department to offer an event for local residents to visit the game area and learn about the various habitat requirements of reptile and amphibians. Photo by Annie Pryor, City of Portage Parks and Recreation Department.

LITERATURE CITED

Alahuhta, K., E. Crone, A. Ettinger, H. Hens, A. Jakalaniemi, and J. Tuomi. 2014. Instant death, slow death, and the consequences of assumptions about prolonged dormancy for plant population dynamics. Journal of Ecology 105: 471–483.

Albert, D.A. 1995. Regional landscape ecosystems of Michigan, Minnesota, and Wisconsin: A working map and classification. USDA, Forest Service, North Central Forest Experiment Station, St. Paul, MN.

Anderson, R.C., E.A. Corbett, M.R. Anderson, G.A. Corbett, and T.M. Kelley. 2001. High white-tailed deer density has negative impact on tallgrass prairie forbs. Journal of the Torrey Botanical Society 128:381–392.

Anderson, D.E. 2007. Survey Techniques in Raptor Research and Management Techniques, ed. D.M, Bird and K.L. Bildstein. Hancock House Publishers, Blaine, WA. Pp. 89-100.

Augustine, D.J. and D. DeCalesta. 2003. Defining deer overabundance and threats to forest communities: From individual plants to landscape structure. EcoScience 10: 472-486.

Bassett, T.J., A.A. Cole-Wick, P. Badra, D.L. Cuthrell, H.D. Enander, P.J. Higman, Y. Lee, C. Ross, and L.M. Rowe. 2022a. Natural Features Inventory of Fort Custer Training Center. Michigan Natural Features Inventory Report Number 2022-09, Lansing, MI. 91 pp. + xi, Appendices.

Bassett, T.J., E.A. Haber, L.N. May, and J.M. McLaughlin. 2022b. Conservation status update of whorled pogonia (Isotria verticillata) in Michigan. Michigan Natural Features Inventory Report Number 2022-32, Lansing, MI. 36 pp. + vi.

Berry, E.G. 1943. The Amnicolidae of Michigan: distribution, ecology, and taxonomy. Miscellaneous Publications of the Museum of Zoology, University of Michigan, 57: 1-68.

Bilby, R.E. and J.W. Ward. 1991. Characteristics and function of large woody debris in streams draining old-growth clear-cut, and second-growth forests in south-western Washington. Canadian Journal of Fisheries and Aquatic Sciences 48, 2499–2508.

Bratton, Susan P. 1982. The Effects Of Exotic Plant And Animal Species On Nature Preserves. Natural Areas Journal, vol. 2, no. 3, 1982, pp. 3–13.

Broadmeadow, S. and T.R. Nisbet. 2004. The effects of riparian forest management on the freshwater environment: a literature review of best management practices. Hydrology and Earth System Sciences 8, 286–305.

Brosofske, K.D., Chen, J., Crow, T.R. 2001. Understory vegetation and site factors : implications for a managed Wisconsin landscape. Forest ecology and management. Vol. 146:p 75-87

Brown, A.V., Y. Aguila, K.B. Brown, and W.P. Fowler. 1997. Responses of benthic macroinvertebrates in small intermittent streams to silvicultural practices. Hydrobiologia 347, 119–125.

Bruggeman, J.E., D.E. Andersen, and J.E. Woodford. 2011. Northern Goshawk monitoring in the western Great Lakes bioregion. Journal of Raptor Research, 45: 290-303.

Campbell, H.W., and S.P. Christman. 1982. Field techniques for herpetofaunal community analyses. Pages 193-200 *in* N.J. Scott, Jr., ed. Herpetological Communities, U.S. Department of Interior, Fish and Wildlife Service, Wildlife Research Report 13, Washington, D.C. 239 pp.

Cohen, J.G., B.S. Slaughter, and D.A. Albert. 2008. Natural Community Surveys of Potential Ecological Reference Areas on State Forest Lands. Michigan Natural Features Inventory, Report Number 2008-04, Lansing MI. 272 pp.

Cohen, J.G., B.S. Slaughter, and M.A. Kost. 2009. Natural Community Surveys and Stewardship Prioritization of Potential Ecological Reference Areas on State Forest Lands. Version 1.0. Michigan Natural Features Inventory, Report Number 2009-21, Lansing, MI. 526 pp

Cohen, J.G., M.A. Kost, B.S. Slaughter, and D.A. Albert. 2015. A Field Guide to the Natural Communities of Michigan. Michigan State University Press, East Lansing, MI. 362 pp.

Cohen, J.G., C.M. Wilton, H.D. Enander, and T.J. Bassett. 2021. Assessing the Ecological Need for Prescribed Fire in Michigan Using GIS-Based Multicriteria Decision Analysis: Igniting Fire Gaps. Diversity 13(3).

Comer, P.J., D.A. Albert, H.A. Wells, B.L. Hart, J.B. Raab, D.L. Price, D.M. Kashian, R.A. Corner, and D.W. Schuen. 1995. Michigan's presettlement vegetation, as interpreted from the General Land Office Surveys 1816-1856. Michigan Natural Features Inventory, Lansing, MI. Digital map.

Compton, B.W. 2007. Status Assessment for the Blanding's Turtle (Emydoidea blandingii) in the Northeast. Unpublished U.S. Fish and Wildlife Service report. 118 pp.

Corn, P.S., and R.B. Bury. 1990. Sampling methods for terrestrial amphibians and reptiles. U.S. Department of Agriculture, Forest Service, General Technical Report PNW-GTR-256. 34 pp.

Crump, M.L., and N.J. Scott. 1994. Visual encounter surveys. Pages 84-92 *in* W.R. Heyer, M.A.

Derosier, A.L., S.K. Hanshue, K.E. Wehrly, J.K. Farkas, and M.J. Nichols. 2015. Michigan's Wildlife Action Plan. Michigan Department of Natural Resources, Lansing, MI. http://www.michigan.gov/dnrwildlifeaction

Ehrenfeld, J.G. 2010. Ehrenfeld JG. Ecosystem consequences of biological invasions. Annu Rev Ecol Evol S. Annual Review of Ecology Evolution and Systematics. 41. 59-80. 10.1146/annurev-ecolsys-102209-144650.

Ernst, C.H. and E.M. Ernst. 2003. Snakes of the United States and Canada. Smithsonian Institution, Washington, D.C. 668 pp.

Faber-Langendoen, D., J. Rocchio, P. Comer, G. Kudray, L. Vance, E. Byers, M. Schafale, C. Nordman, E. Muldavin, G. Kittel, L. Sneddon, M. Pyne, and S. Menard. 2008. Overview of Natural Heritage Methodology for Ecological Element Occurrence Ranking based on Ecological Integrity Assessment Methods [Draft for Network Review]. NatureServe, Arlington, VA.

Faber-Langendoen, D., W. Nichols, J. Rocchio, J. Cohen, J. Lemly, and K. Walz. 2015. Ecological Integrity Assessments and the Conservation Value of Ecosystem Occurrences: General Guidance on Core Heritage Methodology for Element Occurrence Ranking. NatureServe, Arlington, VA.

Frerker, K., A. Sabo, and D. Waller. 2014. Long-term regional shifts in plant community composition are largely explained by local deer impact experiments. PLoS ONE 9: e115843.

Freyman, W.A., L.A. Masters, and S. Packard. 2016. The Universal Floristic Quality Assessment (FQA) Calculator: an online tool for ecological assessment and monitoring. Methods in Ecology and Evolution 7(3): 380-383

Glaudus, X.A. 2013. Visual encounter surveys. In: Graeter, G.L., K.A. Buhlmann, L.R. Wilkinson, and J.W. Gibbons (editors). 2013. Inventory and Monitoring: Recommended Techniques for Reptiles and Amphibians. pp. 73-74. Partners in Amphibian and Reptile Conservation Technical Publication IM-1, Birmingham, AL.

Goforth, R.R., D. Stagliano, Y.M. Lee, J.G. Cohen, and M. Penskar. 2002. Biodiversity Analysis of Selected Riparian Ecosystems within a Fragmented Landscape. Michigan Natural Features Inventory, Report Number 2002-26. Lansing, MI. 126 p.

Graeter, G.L., K.A. Buhlmann, L.R. Wilkinson, and J.W. Gibbons (editors). 2013. Inventory and Monitoring: Recommended Techniques for Reptiles and Amphibians. Partners in Amphibian and Reptile Conservation Technical Publication IM-1, Birmingham, AL. 321 pp.

Grimm, E.C. 1984. Fire and other factors controlling the Big Woods vegetation of Minnesota in the mid-nineteenth century. Ecological Monographs 54(3): 291-311

Haag, W.R. 2012. North American freshwater mussels: Natural history, ecology, and conservation. Cambridge University Press. New York.

Hanes, C.R. and F.N. Hanes. 1947. Flora of Kalamazoo County, Michigan. The Anthoensen Press, Portland, ME.

Harding, J.H. and D.A. Mifsud. 2017. Amphibians and Reptiles of the Great Lakes Region, Revised Edition. University of Michigan Press, Ann Arbor, MI. 408 pp.

Harty, F.M. 1986. Exotics and their ecological ramifications. Natural Areas Journal. 6(4): 20-26.

Heilman, Jr., G.E., J.R. Strittholt, N.C. Slosser, and D.A. Dellasala. 2002. Forest fragmentation of the conterminous United States: Assessing forest intactness through road density and spatial characteristics. BioScience 52(5): 411-422.

Herman, K.D., L.A. Masters, M.R. Penskar, A.A. Reznicek, G.S. Wilhelm, W.W. Brodovich, and K.P. Gardiner. 2001. Floristic Quality Assessment with wetland categories and examples of computer applications for the State of Michigan - Revised, 2nd Edition. Michigan Department of Natural Resources, Wildlife, Natural Heritage Program, Lansing, MI. 19 pp. + appendices.

Huang, C. and G.P. Asner. 2009. Applications of Remote Sensing to Alien Invasive Plant Studies. Applications of Remote Sensing 9(6): 4869-4889.

Hynes, H.B.N. 1970. The Ecology of Running Waters. Liverpool University Press, Liverpool. 24 pp.

Johnson, P., A. Bogan, K. Brown, N. Burkhead, J. Cordeiro, J. Garner, P. Hartfield, D. Lepitzki, G. Mackie, E. Pip, T. Tarpley, J. Tiemann, N. Whelan, and E. Strong. 2013. Conservation Status of Freshwater Gastropods of Canada and the United States. Fisheries. 38. 247. 10.1080/03632415.2013.785396.

Kennedy, T., Naeem, S., Howe, K. et al. Biodiversity as a barrier to ecological invasion. Nature 417, 636–638 (2002). https://doi.org/10.1038/nature00776

Kingsbury, B.A. and J. Gibson (editors). 2012. Habitat Management Guidelines for Amphibians and Reptiles of the Midwestern United States. Partners in Amphibian and Reptile Conservation Technical Publication HMG-1, 2nd Edition. 155 pp.

Knight, T.M., J.L. Dunn, L.A. Smith, J. Davis, and S. Kalisz. 2009. Deer facilitate invasive plant success in a Pennsylvania forest understory. Natural Areas Journal 29: 110-116.

Kost, M.A., D.A. Albert, J.G. Cohen, B.S. Slaughter, R.K. Schillo, C.R. Weber, and K.A. Chapman. 2007. Natural Communities of Michigan: Classification and Description. Michigan Natural Features Inventory Report Number 2007-21, Lansing, MI. 314 pp.

Lee, Y. 2007. Assessment of turtle use and mortality along the US-31 highway crossing of the Muskegon River: 2007 Year three final report. Michigan Natural Features Inventory Report Number 2007-25, Lansing, MI. 45 pp + appendices.

Lee, Y. and J.T. Legge. 2000 (Updated 2013). Special animal abstract for Sistrurus catenatus catenatus (eastern massasauga). Michigan Natural Features Inventory, Lansing, MI. 8 pp.

Lee, Y. and M.J. Monfils. 2008. Assessment of turtle use and mortality and evaluation of the turtle fence along the US-31 highway crossing of the Muskegon River: 2008 final report. Michigan Natural Features Inventory Report Number 2008-18, Lansing, MI. 60 pp + appendices.

Lee, Y. 2017. Developing Management Plans for Core Eastern Massasauga Populations in Michigan – Phase I. Michigan Natural Features Inventory Report No. 2017-08, Lansing, MI. 6 pp + appendices.

Lincoln, J.M., M.J. Monfils, Y. Lee, P.J. Badra, A.P Kortenhoven, H.D. Enander, B. Klatt, and J.G. Cohen. 2019. Natural Features Inventory and Management Recommendations for Muskegon State Game Area. Michigan Natural Features Inventory Report Number 2019-11, Lansing, MI. 94 pp.

Litzgus, J.D. 2006. Sex differences in longevity in the Spotted Turtle (Clemmys guttata). Copeia 2006(2): 281–288.

Lydeard, C., R.H. Cowie, W.F. Ponder, A.E. Bogan, P. Bouchet, S.A. Clark, K.S. Cummings, T.J. Frest, O. Gargominy, D.G. Herbert, R. Hershler, K.E. Perez, B. Roth, M. Seddon, E.E. Strong, F.G. Thompson. 2004. The global decline of nonmarine mollusks. Bioscience 54: 321-330.

Matthews, J.W., G. Spyreas, and C.M. Long. 2015. A null model test of Floristic Quality Assessment: Are plant species' Coefficients of Conservatism valid? Ecological Indicators 52:1-7.

McKenna, D. D. 2004. Flora and vegetation of Kalamazoo County. The Michigan Botanist, 43: 137-359.

Melvin, T.A. 2017. Prescribed fire effects on eastern box turtles in southwestern Michigan. M.S. Thesis, Michigan State University, East Lansing, MI. 105 pp.

Michigan Eastern Massasauga Working Group. 2020. Michigan's Recovery Implementation Strategy for Eastern Massasauga 2020-2025. Lansing, MI. 10 pp.

Michigan Natural Features Inventory (MNFI). 1988. Draft criteria for determining natural quality and condition grades, element occurrence size-classes and significance levels for palustrine and terrestrial natural communities in Michigan. Michigan Natural Features Inventory, Lansing, MI. 39 pp.

Michigan Natural Features Inventory. 2023. Michigan Natural Heritage Database, Lansing, MI.

Mifsud, D.A. 2023 Michigan Amphibian and Reptile Best Management Practices Second Edition. Herpetological Resource and Management Technical Publication 2023. 206 pp.

Moore, J.A. Personal communication. Associate Professor, Biology Department, Grand Valley State University, Allendale, MI.

Mosher, J.A., M.R. Fuller, and M. Kopeny. 1990. Surveying woodland hawks by broadcast of conspecific vocalizations. Journal of Field Ornithology 61: 453-461.

Nagle, R.D., O.M. Kinney, J.W. Gibbons, and J.D. Congdon. 2017. A simple and reliable system for marking hard-shelled turtles: The North American Code. Herpetological Review 48(2):327-330.

Nislow, K.H. and W.H. Lowe. 2006. Influences of logging history and riparian forest characteristics on macroinvertebrates and brook trout (*Salvelinus fontinalis*) in headwater streams (New Hampshire, U.S.A.). Freshwater Biology 51, 388–397.

Noel, D.S., C.W. Martin, and C.A. Federer. 1986. Effects of forest clearcutting in New England on stream macroinvertebrates and periphyton. Environmental Management 10, 661–670.

Northeast Spotted Turtle Working Group. 2019. Regional spotted turtle assessment protocol. 15 pp. [Available http://www.northeastturtles.org.]

O'Connor, R. 2006. A Land Managers Guide to Prairies and Savannas in Michigan: History, Classification and Management. Report 2006-18. Michigan Natural Features Inventory. Lansing, MI.

Olson, D.H., P.D. Anderson, C.A. Frissell, H.H. Welsh Jr., and D.F. Bradford. 2007. Bio-diversity management approaches for stream-riparian areas: perspectives for Pacific Northwest headwater forests, microclimates, and amphibians. Forest Ecology and Management 246, 81–107.

Ontario Ministry of Natural Resources and Forestry. 2016. Recovery Strategy for the Massasauga (Sistrurus catenatus) – Carolinian and Great Lakes – St. Lawrence Populations in Ontario. Ontario Recovery Strategy Series. Peterborough, ONT. V + 9 pp. + Appendix ix + 37 pp.

Paskus, J. J., T. J. Bassett and Y. Lee. 2019. Natural Features Assessment of Hampton Creek Wetlands. Michigan Natural Features Inventory, Report No. 2019-28, Lansing, MI. pp. 60 + Appendices.

Pimentel, D., L. Lach, R. Zuniga, and D. Morrison. 2000. Environmental and economic costs associated with non-indigenous species in the United States. BioScience. 50: 53–65.

Pimentel, D., R. Zuniga, and D. Morrison. 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological Economics 52(3): 273-288

Rainey, T. Personal communication. Graduate Student, Biology Department, Central Michigan University, Mt. Pleasant, MI.

Ralph, C.J., J.R. Sauer, and S. Droege (eds.). 1995. Monitoring bird populations by point counts. General Technical Report PSW-GTR-149. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, California. 187 pp.

Reznicek, A.A., M.R. Penskar, B.S. Walters, and B.S. Slaughter. 2014. Michigan Floristic Quality Assessment Database. Herbarium, University of Michigan, Ann Arbor, MI and Michigan Natural Features Inventory, Michigan State University, Lansing, MI. http://michiganflora.net

Roberts, D.L. 2003. The emerald ash borer: A threat to ash in North America. Michigan State University Extension, East Lansing, MI. Available: http://www.msue.msu.edu/reg_se/roberts/ash/eab_threat03.pdf.(Accessed: March 1, 2004). Robinson, S.K., F.R.

Robinson, S.K. Thompson, III, F.R., T.M. Donovan, D.R. Whitehead, and J. Faaborg. 1995. Regional Forest Fragmentation and the Nesting Success of Migratory Birds. Science v267 pp. 1987-1990

Rooney, T. P. 2001. Deer impacts on forest ecosystems: A North American perspective. Forestry 74:201208.

Rooney, T.P., and W.J. Dress. 1997. Patterns of plant diversity in overbrowsed primary and mature secondary hemlock-northern hardwood forest stands. Journal of the Torrey Botanical Society 124(1): 43-51.

Sargent, Lori G. 2000. Frog and toad population monitoring in Michigan. The Journal of the Iowa Academy of Science 107(3):195-199 [Available at: http://scholarworks.uni.edu/jias/vol107/iss3/25]

Seigel, R.A., C.A. Sheil, and J.S. Doody. 1998. Changes in a population of an endangered rattlesnake Sistrurus catenatus following a severe flood. Biological Conservation 83:127–131.

Slaughter, B.S., A.A. Reznicek, M.R. Penskar, and B.S. Walters. 2015. Notes on the Third Edition of the Floristic Quality Assessment of Michigan. Wetland Science & Practice.

Slaughter, B.S. and T.J. Bassett. In prep. Learning to say goodbye to Michigan's rare prairie flora. The Great Lakes Botanist.

Smith, C.S. 2009. Hibernation of the Eastern Massasauga Rattlesnake (Sistrurus c. catenatus) in Northern Michigan. M.S. Thesis, Department of Biology, Purdue University, Lafayette, IN.

Smokorowski, K.E. and T.C. Pratt. 2007. Effect of a change in physical structure and cover on fish and fish habitat in freshwater ecosystems—a review and meta-analysis. Environmental Reviews 15, 15–41.

Stewart, O. C. 2009. Forgotten Fires: Native Americans and the Transient Wilderness. University of Oklahoma Press; Illustrated edition. 384 pp.

Sytsma, K.J. and R.W. Pippen. 1981. The Hampton Creek Wetland Complex in Southwestern Michigan; I. History and Physical Features. The Michigan Botanist, Vol 20. p. 137-142.

Szymanski, J., C. Pollack, L. Ragan, M. Redmer, L. Clemency, K. Voorhies, and J. Jaka. 2016. Species Status Assessment for the Eastern Massasauga Rattlesnake (Sistrurus catenatus). Unpublished, U.S. Fish and Wildlife Service July 2016 (version 2).

Tepley, A.J., J.G. Cohen, and L. Huberty. 2004. Natural community abstract for floodplain forest. Michigan Natural Features Inventory, Lansing, MI.15 pp.

Thacker, A.J., E.T. Hileman, P. Keenlance, E.M. McCluskey, A. Swinehart, J. Kovach, and J.A. Moore. 2023. Modeling occupancy and detection probabilities to update the status of threatened eastern massasauga rattlesnake populations. Global Ecology and Conservation 43. e02422. 10.1016/j.gecco.2023.e02422.

USDS Forest Service. 2002. Pest Alert – Emerald Ash Borer. St Paul, MN. Available: http://www.na.fs.fed.us/spfo/pubs/pest_al/eab/ eab.htm.(Accessed: March 1, 2004).

USWFS. 2021. Recovery Plan for the Eastern Massasauga Rattlesnake (Sistrurus catenatus). USFWS Great Lakes Region (Region 3), Bloomington, MN. 15pp.

Vila, M. and I. Ibanez. 2011. Plant invasions in the landscape. Landscape Ecology 26: 461-472.

Vitousek, P.M., C.M. D'Antonio, L.L. Loope, and R. Westbrooks. 1996. Biological invasions as global environmental change. American scientist 84, no. 5: 468.

Watters, G.T. 1996. Small dams as barriers to freshwater mussels (Bivalvia, Unionoida) and their hosts. Biological Conservation 75: 79-85.

Willey, L.L. and M.T. Jones. 2014. Conservation plan for the Blanding's turtle and associated species of conservation need in the northeastern U.S. Report for New Hampshire Fish and Game Department and U.S. Fish and Wildlife Service New England Office. University of Massachusetts, Amherst, MA. 132 pp.

Zavaleta, E. 2000. The Economic Value of Controlling an Invasive Shrub. AMBIO: A Journal of the Human Environment 29(8). https://doi.org/10.1579/0044-7447-29.8.462

APPENDICES

Appendix 1. Notes from the General Land Office Surveyor Robert Clark, Jr., 1826 transcribed on to mylar topographic maps. These notes and maps serve as the basis for the circa 1800 vegetation maps.

Appendix 2. Floristic Quality Assessment for Greenspire Bog (EO ID 26549 pg 31).

Greenspire Bog
2019-08-19 and 2022-10-01
Gourdneck SGA
Practitioners: Tyler Bassett and Jesse Lincoln

Conservatism-Based Metrics:

Total Mean C:	4.7
Native Mean C:	5.4
Total FQI:	23
Native FQI:	24.7
Adjusted FQI:	50.5
% C value 0:	16.7
% C value 1-3:	20.8
% C value 4-6:	29.2
% C value 7-10:	33.3
Native Tree Mean C:	4
Native Shrub Mean C:	6.3
Native Herbaceous Mean C:	5.6

Species Richness:

Total Species:	24	
Native Species:	21	87.50%
Non-native Species:	3	12.50%

Species Wetness:

Mean Wetness:	-3.3
Native Mean Wetness:	-3.3

Physiognomy Metrics:

Tree:	6	25%
Shrub:	8	33.30%
Vine:	1	4.20%
Forb:	4	16.70%
Grass:	1	4.20%
Sedge:	3	12.50%
Rush:	0	0%
Fern:	1	4.20%
Bryophyte:	0	0%

Duration Metrics:

Annual:	1	4.20%
Perennial:	23	95.80%
Biennial:	0	0%
Native Annual:	1	4.20%
Native Perennial:	20	83.30%
Native Biennial:	0	0%

Appendix 2 (Continued). Floristic Quality Assessment for Greenspire Bog (EO ID 26549 pg 31).

Scientific Name	Common Name	Native?	C	W	Physiognomy
Acer rubrum	red maple	native	1	0	tree
Aronia prunifolia	chokeberry	native	5	-3	shrub
Carex oligosperma	sedge	native	10	-5	sedge
Chamaedaphne calyculata	leatherleaf	native	8	-5	shrub
Decodon verticillatus	whorled loosestrife	native	7	-5	shrub
Dulichium arundinaceum	three-way sedge	native	8	-5	sedge
Eriophorum virginicum	tawny cotton-grass	native	8	-5	sedge
Frangula alnus	**glossy buckthorn**	**non-native**	**0**	**0**	**shrub**
Ilex mucronata	mountain holly	native	7	-5	shrub
Ilex verticillata	michigan holly	native	5	-3	shrub
Larix laricina	tamarack	native	5	-3	tree
Lythrum salicaria	**purple loosestrife**	**non-native**	**0**	**-5**	**forb**
Nyssa sylvatica	black-gum	native	9	-3	tree
Persicaria punctata	smartweed	native	5	-5	forb
Phalaris arundinacea	reed canary grass	native	0	-3	grass
Pinus strobus	white pine	native	3	3	tree
Populus deltoides	cottonwood	native	1	0	tree
Salix nigra	black willow	native	5	-5	tree
Toxicodendron vernix	poison sumac	native	6	-5	shrub
Typha angustifolia	**narrow-leaved cat-tail**	**non-native**	**0**	**-5**	**forb**
Typha latifolia	broad-leaved cat-tail	native	1	-5	forb
Vaccinium corymbosum	highbush blueberry	native	6	-3	shrub
Vitis riparia	river-bank grape	native	3	0	vine
Woodwardia virginica	virginia chain-fern	native	10	-5	fern

Appendix 3. Floristic Quality Assessment for Sugarloaf Swamp hardwood-conifer swamp (EO ID 26460 pg 35).

Sugarloaf Hardwood-Conifer Swamp
06/14/2022
Practitioner: Jesse M. Lincoln

Conservatism-Based Metrics:

Total Mean C:	4.3
Native Mean C:	4.5
Total FQI:	46.5
Native FQI:	47.4
Adjusted FQI:	43.8
% C value 0:	6.8
% C value 1-3:	23.9
% C value 4-6:	55.6
% C value 7-10:	13.7
Native Tree Mean C:	4.8
Native Shrub Mean C:	4.8
Native Herbaceous Mean C:	4.4

Physiognomy Metrics:

Tree:	17	14.5%
Shrub:	15	12.8%
Vine:	8	6.8%
Forb:	48	41.0%
Grass:	8	6.8%
Sedge:	14	12.0%
Rush:	0	0.0%
Fern:	7	6.0%
Bryophyte:	0	0.0%

Species Richness:

Total Species:	117	
Native Species:	111	94.9%
Non-native Species:	6	5.1%

Duration Metrics:

Annual:	5	4.3%
Perennial:	112	95.7%
Biennial:	0	0.0%
Native Annual:	5	4.3%
Native Perennial:	106	90.6%
Native Biennial:	0	0.0%

Species Wetness:

Mean Wetness:	-1.7
Native Mean Wetness:	-1.8

Appendix 3 (Continued). Floristic Quality Assessment for Sugarloaf Swamp hardwood-conifer swamp (EO ID 26460 pg 35).

Scientific Name	Common Name	Native?	C	W	Physiognomy
Acer rubrum	red maple	native	1	0	tree
Acer saccharinum	silver maple	native	2	-3	tree
Actaea rubra	red baneberry	native	7	3	forb
Amphicarpaea bracteata	hog-peanut	native	5	0	vine
Anemone quinquefolia	wood anemone	native	5	3	forb
Apios americana	groundnut	native	3	-3	vine
Arisaema triphyllum	jack-in-the-pulpit	native	5	0	forb
Athyrium filix-femina	lady fern	native	4	0	fern
Betula alleghaniensis	yellow birch	native	7	0	tree
Betula papyrifera	paper birch	native	2	3	tree
Bidens cernua	nodding beggar-ticks	native	3	-5	forb
Boehmeria cylindrica	false nettle	native	5	-5	forb
Brachyelytrum erectum	long-awned wood grass	native	7	5	grass
Caltha palustris	marsh-marigold	native	6	-5	forb
Cardamine bulbosa	spring cress	native	4	-5	forb
Carex bebbii	sedge	native	4	-5	sedge
Carex comosa	sedge	native	5	-5	sedge
Carex crinita	sedge	native	4	-5	sedge
Carex disperma	sedge	native	10	-5	sedge
Carex grayi	sedge	native	6	-3	sedge
Carex hystericina	sedge	native	2	-5	sedge
Carex interior	sedge	native	3	-5	sedge
Carex lacustris	sedge	native	6	-5	sedge
Carex laxiculmis	sedge	native	8	3	sedge
Carex leptalea	sedge	native	5	-5	sedge
Carex pseudo-cyperus	sedge	native	5	-5	sedge
Carex rosea	curly-styled wood sedge	native	2	5	sedge
Carex stipata	sedge	native	1	-5	sedge
Carpinus caroliniana	blue-beech	native	6	0	tree
Carya cordiformis	bitternut hickory	native	5	0	tree
Chelone glabra	turtlehead	native	7	-5	forb
Cicuta bulbifera	water hemlock	native	5	-5	forb
Cinna arundinacea	wood reedgrass	native	7	-3	grass
Clematis virginiana	virgins bower	native	4	0	vine
Coptis trifolia	goldthread	native	5	-3	forb
Cornus amomum	silky dogwood	native	2	-3	shrub
Cornus florida	flowering dogwood	native	8	3	tree
Cryptotaenia canadensis	honewort	native	2	0	forb
Dioscorea villosa	wild yam	native	4	0	forb
Dryopteris carthusiana	spinulose woodfern	native	5	-3	fern
Dryopteris cristata	crested shield fern	native	6	-5	fern
Elaeagnus umbellata	autumn-olive	non-native	0	3	shrub
Elymus virginicus	virginia wild-rye	native	4	-3	grass
Equisetum arvense	common horsetail	native	0	0	fern
Eupatorium perfoliatum	boneset	native	4	-3	forb
Eutrochium maculatum	joe-pye-weed	native	4	-5	forb
Fagus grandifolia	american beech	native	6	3	tree
Festuca subverticillata	nodding fescue	native	5	3	grass
Frangula alnus	glossy buckthorn	non-native	0	0	shrub
Fraxinus nigra	black ash	native	6	-3	tree
Fraxinus pennsylvanica	red ash	native	2	-3	tree
Galium asprellum	rough bedstraw	native	5	-5	vine
Galium tinctorium	stiff bedstraw	native	5	-5	forb
Galium triflorum	fragrant bedstraw	native	4	3	forb

Appendix 3 (Continued). Floristic Quality Assessment for Sugarloaf Swamp hardwood-conifer swamp (EO ID 26460 pg 35).

Scientific Name	Common Name	Native?	C	W	Physiognomy
Gaylussacia baccata	huckleberry	native	7	3	shrub
Glyceria septentrionalis	floating manna grass	native	7	-5	grass
Glyceria striata	fowl manna grass	native	4	-5	grass
Hamamelis virginiana	witch-hazel	native	5	3	shrub
Ilex verticillata	michigan holly	native	5	-3	shrub
Impatiens capensis	spotted touch-me-not	native	2	-3	forb
Larix laricina	tamarack	native	5	-3	tree
Leersia virginica	white grass	native	5	-3	grass
Lindera benzoin	spicebush	native	7	-3	shrub
Liparis loeselii	loesels twayblade	native	5	-3	forb
Liriodendron tulipifera	tulip tree	native	9	3	tree
Lobelia siphilitica	great blue lobelia	native	4	-3	forb
Lycopus americanus	common water horehound	native	2	-5	forb
Lysimachia ciliata	fringed loosestrife	native	4	-3	forb
Lysimachia thyrsiflora	tufted loosestrife	native	6	-5	forb
Lythrum salicaria	purple loosestrife	non-native	0	-5	forb
Maianthemum canadense	canada mayflower	native	4	3	forb
Micranthes pensylvanica	swamp saxifrage	native	10	-5	forb
Mitchella repens	partridge-berry	native	5	3	forb
Monotropa uniflora	indian-pipe	native	5	3	forb
Nyssa sylvatica	black-gum	native	9	-3	tree
Onoclea sensibilis	sensitive fern	native	2	-3	fern
Osmunda cinnamomea	cinnamon fern	native	5	-3	fern
Osmunda regalis	royal fern	native	5	-5	fern
Packera aurea	golden ragwort	native	5	-3	forb
Parthenocissus quinquefolia	virginia creeper	native	5	3	vine
Peltandra virginica	arrow-arum	native	6	-5	forb
Phalaris arundinacea	reed canary grass	native	0	-3	grass
Physostegia virginiana	false dragonhead	native	8	-3	forb
Pilea pumila	clearweed	native	5	-3	forb
Pinus strobus	white pine	native	3	3	tree
Podophyllum peltatum	may-apple	native	3	3	forb
Polygonatum biflorum	solomon-seal	native	4	3	forb
Prenanthes altissima	tall white lettuce	native	5	3	forb
Quercus rubra	red oak	native	5	3	tree
Ranunculus hispidus	swamp buttercup	native	5	0	forb
Ranunculus sceleratus	cursed crowfoot	native	1	-5	forb
Ribes americanum	wild black currant	native	6	-3	shrub
Rosa multiflora	multiflora rose	non-native	0	3	shrub
Rosa palustris	swamp rose	native	5	-5	shrub
Rubus hispidus	swamp dewberry	native	4	-3	shrub
Rumex verticillatus	water dock	native	7	-5	forb
Salix discolor	pussy willow	native	1	-3	shrub
Sanicula odorata	black snakeroot	native	2	0	forb
Scirpus atrovirens	bulrush	native	3	-5	sedge
Smilax hispida	bristly greenbrier	native	5	0	vine
Solanum dulcamara	bittersweet nightshade	non-native	0	0	vine
Stellaria longifolia	long-leaved chickweed	native	5	-3	forb
Symphyotrichum lateriflorum	calico aster	native	2	0	forb
Symplocarpus foetidus	skunk-cabbage	native	6	-5	forb
Thalictrum dasycarpum	purple meadow-rue	native	3	-3	forb
Tilia americana	basswood	native	5	3	tree
Toxicodendron radicans	poison-ivy	native	2	0	vine
Toxicodendron vernix	poison sumac	native	6	-5	shrub

Appendix 3 (Continued). Floristic Quality Assessment for Sugarloaf Swamp hardwood-conifer swamp (EO ID 26460 pg 35).

Scientific Name	Common Name	Native?	C	W	Physiognomy
Trientalis borealis	star-flower	native	5	0	forb
Typha angustifolia	narrow-leaved cat-tail	non-native	0	-5	forb
Typha latifolia	broad-leaved cat-tail	native	1	-5	forb
Ulmus americana	american elm	native	1	-3	tree
Urtica dioica	stinging nettle	native	1	0	forb
Vaccinium angustifolium	low sweet blueberry	native	4	3	shrub
Vaccinium corymbosum	highbush blueberry	native	6	-3	shrub
Viola cucullata	marsh violet	native	5	-5	forb
Viola sororia	common blue violet	native	1	0	forb

Appendix 4. Floristic Quality Assessment for Hampton Creek Fen prairie fen (EO ID 9177 pg 41).

Gourdneck - Hampton Creek Fen
06/07/2022 and 08/31/2022
Practitioner: Jesse M. Lincoln

Conservatism-Based Metrics:

Total Mean C:	3.8
Native Mean C:	4.3
Total FQI:	39.7
Native FQI:	42.1
Adjusted FQI:	40.4
% C value 0:	13.8
% C value 1-3:	30.3
% C value 4-6:	45
% C value 7-10:	11
Native Tree Mean C:	1
Native Shrub Mean C:	4.3
Native Herbaceous Mean C:	4.4

Species Richness:

Total Species:	109	
Native Species:	96	88.1%
Non-native Species:	13	11.9%

Species Wetness:

Mean Wetness:	-2.8
Native Mean Wetness:	-3.1

Physiognomy Metrics:

Tree:	4	3.7%
Shrub:	22	20.2%
Vine:	7	6.4%
Forb:	51	46.8%
Grass:	7	6.4%
Sedge:	12	11.0%
Rush:	2	1.8%
Fern:	4	3.7%
Bryophyte:	0	0.0%

Duration Metrics:

Annual:	6	5.5%
Perennial:	101	92.7%
Biennial:	2	1.8%
Native Annual:	6	5.5%
Native Perennial:	88	80.7%
Native Biennial:	2	1.8%

Appendix 4 (Continued). Floristic Quality Assessment for Hampton Creek Fen prairie fen (EO ID 9177 pg 41).

Scientific Name	Common Name	Native?	C	W	Physiognomy
Agalinis tenuifolia	common false foxglove	native	5	-3	forb
Agrimonia parviflora	swamp agrimony	native	4	0	forb
Agrostis scabra	ticklegrass	native	4	0	grass
Agrostis stolonifera	**creeping bent**	**non-native**	**0**	**-3**	**grass**
Angelica atropurpurea	purplestem angelica	native	6	-5	forb
Apios americana	groundnut	native	3	-3	vine
Apocynum cannabinum	indian-hemp	native	3	0	forb
Asclepias incarnata	swamp milkweed	native	6	-5	forb
Berula erecta	water-parsnip	native	10	-5	forb
Betula pumila	bog birch	native	8	-5	shrub
Bidens connata	purple-stemmed tickseed	native	5	-3	forb
Boehmeria cylindrica	false nettle	native	5	-5	forb
Calamagrostis canadensis	blue-joint	native	3	-5	grass
Caltha palustris	marsh-marigold	native	6	-5	forb
Campanula aparinoides	marsh bellflower	native	7	-5	forb
Carex bebbii	sedge	native	4	-5	sedge
Carex interior	sedge	native	3	-5	sedge
Carex lasiocarpa	sedge	native	8	-5	sedge
Carex pseudo-cyperus	sedge	native	5	-5	sedge
Carex sterilis	sedge	native	10	-5	sedge
Carex stipata	sedge	native	1	-5	sedge
Carex stricta	sedge	native	4	-5	sedge
Carex vulpinoidea	sedge	native	1	-5	sedge
Cicuta bulbifera	water hemlock	native	5	-5	forb
Cicuta maculata	water hemlock	native	4	-5	forb
Cirsium arvense	**canada thistle**	**non-native**	**0**	**3**	**forb**
Cirsium muticum	swamp thistle	native	6	-5	forb
Cornus amomum	silky dogwood	native	2	-3	shrub
Cornus foemina	gray dogwood	native	1	0	shrub
Cornus sericea	red-osier	native	2	-3	shrub
Corylus americana	hazelnut	native	5	3	shrub
Dasiphora fruticosa	shrubby cinquefoil	native	8	-3	shrub
Elaeagnus umbellata	**autumn olive**	**non-native**	**0**	**3**	**shrub**
Eleocharis palustris	spike-rush	native	5	-5	sedge
Elodea canadensis	common waterweed	native	1	-5	forb
Epilobium ciliatum	willow-herb	native	3	-3	forb
Erechtites hieraciifolius	fireweed	native	2	3	forb
Eupatorium perfoliatum	boneset	native	4	-3	forb
Eutrochium maculatum	joe-pye-weed	native	4	-5	forb
Fallopia scandens	false buckwheat	native	2	0	vine
Frangula alnus	**glossy buckthorn**	**non-native**	**0**	**0**	**shrub**
Galium aparine	annual bedstraw	native	0	3	forb
Galium asprellum	rough bedstraw	native	5	-5	vine
Galium trifidum	small bedstraw	native	6	-3	forb
Gentiana andrewsii	bottle gentian	native	5	-3	forb
Geranium maculatum	wild geranium	native	4	3	forb
Glyceria striata	fowl manna grass	native	4	-5	grass
Ilex verticillata	michigan holly	native	5	-3	shrub
Impatiens capensis	spotted touch-me-not	native	2	-3	forb
Iris virginica	southern blue flag	native	5	-5	forb
Juncus brachycephalus	rush	native	7	-5	rush
Juncus effusus	soft-stemmed rush	native	3	-5	rush
Lathyrus palustris	marsh pea	native	7	-3	vine
Leersia oryzoides	cut grass	native	3	-5	grass
Lindera benzoin	spicebush	native	7	-3	shrub
Lobelia siphilitica	great blue lobelia	native	4	-3	forb

Appendix 4 (Continued). Floristic Quality Assessment for Hampton Creek Fen prairie fen (EO ID 9177 pg 41).

Scientific Name	Common Name	Native?	C	W	Physiognomy
Lycopus americanus	common water horehound	native	2	-5	forb
Lythrum salicaria	**purple loosestrife**	**non-native**	**0**	**-5**	**forb**
Malus baccata	**siberian crab**	**non-native**	**0**	**5**	**tree**
Mentha canadensis	wild mint	native	3	-3	forb
Micranthes pensylvanica	swamp saxifrage	native	10	-5	forb
Myosotis scorpioides	**forget-me-not**	**non-native**	**0**	**-5**	**forb**
Nasturtium officinale	watercress	native	4	-5	forb
Onoclea sensibilis	sensitive fern	native	2	-3	fern
Osmunda cinnamomea	cinnamon fern	native	5	-3	fern
Osmunda regalis	royal fern	native	5	-5	fern
Packera aurea	golden ragwort	native	5	-3	forb
Parthenocissus quinquefolia	virginia creeper	native	5	3	vine
Persicaria sagittata	arrow-leaved tear-thumb	native	5	-5	forb
Phalaris arundinacea	**reed canary grass**	**non-native**	**0**	**-3**	**grass**
Poa pratensis	**kentucky bluegrass**	**non-native**	**0**	**3**	**grass**
Populus tremuloides	quaking aspen	native	1	0	tree
Potamogeton richardsonii	richardsons pondweed	native	5	-5	forb
Potentilla simplex	old-field cinquefoil	native	2	3	forb
Pycnanthemum virginianum	common mountain mint	native	5	-3	forb
Rhamnus cathartica	**common buckthorn**	**non-native**	**0**	**0**	**tree**
Ribes americanum	wild black currant	native	6	-3	shrub
Rosa multiflora	**multiflora rose**	**non-native**	**0**	**3**	**shrub**
Rubus pubescens	dwarf raspberry	native	4	-3	shrub
Rubus strigosus	wild red raspberry	native	2	0	shrub
Rumex orbiculatus	great water dock	native	9	-5	forb
Salix bebbiana	bebbs willow	native	1	-3	shrub
Salix exigua	sandbar willow	native	1	-3	shrub
Sambucus canadensis	elderberry	native	3	-3	shrub
Schoenoplectus acutus	hardstem bulrush	native	5	-5	sedge
Scirpus atrovirens	bulrush	native	3	-5	sedge
Scirpus cyperinus	wool-grass	native	5	-5	sedge
Silphium integrifolium	rosin weed	native	10	0	forb
Solanum dulcamara	**bittersweet nightshade**	**non-native**	**0**	**0**	**vine**
Solidago canadensis	canada goldenrod	native	1	3	forb
Solidago patula	swamp goldenrod	native	6	-5	forb
Solidago rugosa	rough-leaved goldenrod	native	3	0	forb
Sparganium americanum	american bur-reed	native	6	-5	forb
Spiraea alba	meadowsweet	native	4	-3	shrub
Stuckenia pectinata	sago pondweed	native	3	-5	forb
Symphyotrichum firmum	smooth swamp aster	native	4	-3	forb
Symphyotrichum novae-angliae	new england aster	native	3	-3	forb
Thelypteris palustris	marsh fern	native	2	-3	fern
Toxicodendron vernix	poison sumac	native	6	-5	shrub
Triadenum fraseri	marsh st. johns-wort	native	6	-5	forb
Typha angustifolia	**narrow-leaved cat-tail**	**non-native**	**0**	**-5**	**forb**
Typha latifolia	broad-leaved cat-tail	native	1	-5	forb
Utricularia vulgaris	common bladderwort	native	6	-5	forb
Vaccinium corymbosum	highbush blueberry	native	6	-3	shrub
Verbena hastata	blue vervain	native	4	-3	forb
Viburnum dentatum	arrow-wood	native	6	0	shrub
Viburnum lentago	nannyberry	native	4	0	shrub
Viburnum opulus	**european highbush-cranberry**	**non-native**	**0**	**-3**	**shrub**
Vitis riparia	river-bank grape	native	3	0	vine

Appendix 5. Floristic Quality Assessment for Vanderbilt Fen prairie fen (EO ID 12497 pg 45).

Scientific Name	Common Name	Native?	C	W	Physiognomy
Agalinis purpurea	purple false foxglove	native	7	-3	forb
Ageratina altissima	white snakeroot	native	4	3	forb
Andropogon gerardii	big bluestem	native	5	0	grass
Apocynum cannabinum	indian-hemp	native	3	0	forb
Asclepias incarnata	swamp milkweed	native	6	-5	forb
Asparagus officinalis	**garden asparagus**	**non-native**	**0**	**3**	**forb**
Betula pumila	bog birch	native	8	-5	shrub
Bidens trichosperma	tickseed-sunflower	native	7	-5	forb
Boehmeria cylindrica	false nettle	native	5	-5	forb
Bromus ciliatus	fringed brome	native	6	-3	grass
Calamagrostis canadensis	blue-joint	native	3	-5	grass
Carex lasiocarpa	sedge	native	8	-5	sedge
Carex stricta	sedge	native	4	-5	sedge
Cladium mariscoides	twig-rush	native	10	-5	sedge
Clematis virginiana	virgins bower	native	4	0	vine
Comarum palustre	marsh cinquefoil	native	7	-5	forb
Coreopsis tripteris	tall coreopsis	native	7	0	forb
Cornus amomum	silky dogwood	native	2	-3	shrub
Cornus foemina	gray dogwood	native	1	0	shrub
Cornus sericea	red-osier	native	2	-3	shrub
Cyperus flavescens	yellow flat sedge	native	5	-5	sedge
Cypripedium candidum	white lady-slipper	native	10	-5	forb
Dasiphora fruticosa	shrubby cinquefoil	native	8	-3	shrub
Daucus carota	**queen-annes-lace**	**non-native**	**0**	**5**	**forb**
Decodon verticillatus	whorled or swamp loosestrife	native	7	-5	shrub
Doellingeria umbellata	flat-topped white aster	native	5	-3	forb
Erechtites hieraciifolius	fireweed	native	2	3	forb
Erigeron strigosus	daisy fleabane	native	4	3	forb
Eupatorium perfoliatum	boneset	native	4	-3	forb
Euthamia graminifolia	grass-leaved goldenrod	native	3	0	forb
Eutrochium maculatum	joe-pye-weed	native	4	-5	forb
Frangula alnus	**glossy buckthorn**	**non-native**	**0**	**0**	**shrub**
Juncus brachycephalus	rush	native	7	-5	rush
Juniperus virginiana	red-cedar	native	3	3	tree
Larix laricina	tamarack	native	5	-3	tree
Leersia oryzoides	cut grass	native	3	-5	grass
Liatris spicata	marsh blazing-star	native	8	0	forb
Lobelia kalmii	bog lobelia	native	10	-5	forb
Lycopus uniflorus	northern bugle weed	native	2	-5	forb
Lythrum salicaria	**purple loosestrife**	**non-native**	**0**	**-5**	**forb**
Monarda fistulosa	wild-bergamot	native	2	3	forb
Muhlenbergia mexicana	leafy satin grass	native	3	-3	grass
Nuphar advena	yellow pond-lily	native	8	-5	forb
Oxypolis rigidior	cowbane	native	6	-5	forb
Panicum dichotomiflorum	panic grass	native	0	-3	grass
Persicaria amphibia	water smartweed	native	6	-5	forb
Phalaris arundinacea	**reed canary grass**	**non-native**	**0**	**-3**	**grass**
Phragmites australis var. americanus	reed	native	5	-3	grass
Phragmites australis var. australis	**reed**	**non-native**	**0**	**-3**	**grass**
Populus grandidentata	big-tooth aspen	native	4	3	tree
Potamogeton gramineus	pondweed	native	5	-5	forb
Prenanthes racemosa	glaucous white lettuce	native	8	-3	forb
Proserpinaca palustris	mermaid-weed	native	6	-5	forb
Prunus serotina	wild black cherry	native	2	3	tree

Appendix 5 (Continued). Floristic Quality Assessment for Vanderbilt Fen prairie fen (EO ID 12497 pg 45).

Scientific Name	Common Name	Native?	C	W	Physiognomy
Pycnanthemum virginianum	common mountain mint	native	5	-3	forb
Rhynchospora alba	beak-rush	native	6	-5	sedge
Rosa palustris	swamp rose	native	5	-5	shrub
Rubus occidentalis	black raspberry	native	1	5	shrub
Rudbeckia fulgida	black-eyed susan	native	9	-5	forb
Sagittaria latifolia	common arrowhead	native	4	-5	forb
Salix discolor	pussy willow	native	1	-3	shrub
Salix pedicellaris	bog willow	native	8	-5	shrub
Sarracenia purpurea	pitcher-plant	native	10	-5	forb
Schoenoplectus acutus	hardstem bulrush	native	5	-5	sedge
Schoenoplectus pungens	threesquare	native	5	-5	sedge
Scirpus atrovirens	bulrush	native	3	-5	sedge
Solidago canadensis	canada goldenrod	native	1	3	forb
Solidago ohioensis	ohio goldenrod	native	8	-5	forb
Solidago rugosa	rough-leaved goldenrod	native	3	0	forb
Sorghastrum nutans	indian grass	native	6	3	grass
Spiranthes cernua	nodding ladies-tresses	native	4	-3	forb
Symphyotrichum boreale	northern bog aster	native	9	-5	forb
Thalictrum dasycarpum	purple meadow-rue	native	3	-3	forb
Thelypteris palustris	marsh fern	native	2	-3	fern
Toxicodendron vernix	poison sumac	native	6	-5	shrub
Triadenum fraseri	marsh st. johns-wort	native	6	-5	forb
Triglochin maritima	common bog arrow-grass	native	8	-5	forb
Typha angustifolia	**narrow-leaved cat-tail**	**non-native**	**0**	**-5**	**forb**
Typha latifolia	broad-leaved cat-tail	native	1	-5	forb
Ulmus americana	american elm	native	1	-3	tree

Appendix 5 (Continued). Floristic Quality Assessment for Vanderbilt Fen prairie fen (EO ID 12497 pg 45).

Vanderbilt Fen 08/31/2022
Practitioner: Jesse M. Lincoln
Gourdneck SGA

Conservatism-Based Metrics:

Total Mean C:	4.6
Native Mean C:	4.9
Total FQI:	41.1
Native FQI:	42.2
Adjusted FQI:	47.1
% C value 0:	10
% C value 1-3:	27.5
% C value 4-6:	36.3
% C value 7-10:	26.3
Native Tree Mean C:	3
Native Shrub Mean C:	4.5
Native Herbaceous Mean C:	5.2

Species Richness:

Total Species:	80	
Native Species:	74	92.5%
x	6	7.5%

Species Wetness:

Mean Wetness:	-2.7
Native Mean Wetness:	-2.8

Physiognomy Metrics:

Tree:	5	6.3%
Shrub:	12	15.0%
Vine:	1	1.3%
Forb:	42	52.5%
Grass:	10	12.5%
Sedge:	8	10.0%
Rush:	1	1.3%
Fern:	1	1.3%
Bryophyte:	0	0.0%

Duration Metrics:

Annual:	5	6.3%
Perennial:	74	92.5%
Biennial:	1	1.3%
Native Annual:	5	6.3%
Native Perennial:	69	86.3%
Native Biennial:	0	0.0%

Appendix 6. Floristic Quality Assessment for Hampton Creek Swamp rich tamarack swamp (EO ID 26458 pg 53).

Scientific Name	Common Name	Native?	C	W	Physiognomy
Acer rubrum	red maple	native	1	0	tree
Acer saccharinum	silver maple	native	2	-3	tree
Agrimonia parviflora	swamp agrimony	native	4	0	forb
Agrostis gigantea	**redtop**	**non-native**	**0**	**-3**	**grass**
Agrostis stolonifera	**creeping bent**	**non-native**	**0**	**-3**	**grass**
Alnus incana; a. rugosa	speckled alder	native	5	-3	shrub
Amphicarpaea bracteata	hog-peanut	native	5	0	vine
Anemone quinquefolia	wood anemone	native	5	3	forb
Angelica atropurpurea	purplestem angelica	native	6	-5	forb
Apios americana	groundnut	native	3	-3	vine
Asclepias incarnata	swamp milkweed	native	6	-5	forb
Athyrium filix-femina	lady fern	native	4	0	fern
Berberis thunbergii	**japanese barberry**	**non-native**	**0**	**3**	**shrub**
Berula erecta	water-parsnip	native	10	-5	forb
Betula alleghaniensis	yellow birch	native	7	0	tree
Betula pumila	bog birch	native	8	-5	shrub
Bidens cernua	nodding beggar-ticks	native	3	-5	forb
Boehmeria cylindrica	false nettle	native	5	-5	forb
Bromus ciliatus	fringed brome	native	6	-3	grass
Calamagrostis canadensis	blue-joint	native	3	-5	grass
Caltha palustris	marsh-marigold	native	6	-5	forb
Campanula aparinoides	marsh bellflower	native	7	-5	forb
Carex bebbii	sedge	native	4	-5	sedge
Carex comosa	sedge	native	5	-5	sedge
Carex diandra	sedge	native	8	-5	sedge
Carex hystericina	sedge	native	2	-5	sedge
Carex leptalea	sedge	native	5	-5	sedge
Carex pellita; c. lanuginosa	sedge	native	2	-5	sedge
Carex scabrata	sedge	native	4	-5	sedge
Carex stipata	sedge	native	1	-5	sedge
Carex stricta	sedge	native	4	-5	sedge
Celastrus orbiculatus	**oriental bittersweet**	**non-native**	**0**	**5**	**vine**
Chelone glabra	turtlehead	native	7	-5	forb
Cicuta bulbifera	water hemlock	native	5	-5	forb
Cinna arundinacea	wood reedgrass	native	7	-3	grass
Cirsium muticum	swamp thistle	native	6	-5	forb
Clematis virginiana	virgins bower	native	4	0	vine
Cornus sericea; c. stolonifera	red-osier	native	2	-3	shrub
Corylus americana	hazelnut	native	5	3	shrub
Cuscuta gronovii	common dodder	native	3	-3	vine
Dasiphora fruticosa; potentilla f.	shrubby cinquefoil	native	8	-3	shrub
Dioscorea villosa; dioscorea villosa	wild yam	native	4	0	forb
Dryopteris carthusiana	spinulose woodfern	native	5	-3	fern
Dryopteris cristata	crested shield fern	native	6	-5	fern
Elaeagnus umbellata	**autumn-olive**	**non-native**	**0**	**3**	**shrub**
Eleocharis palustris; e. smallii	spike-rush	native	5	-5	sedge
Eleocharis rostellata	spike-rush	native	10	-5	sedge
Elymus riparius	riverbank wild-rye	native	8	-3	grass
Epilobium coloratum	cinnamon willow-herb	native	3	-5	forb
Epilobium strictum	downy willow-herb	native	8	-5	forb
Eupatorium perfoliatum	boneset	native	4	-3	forb
Eutrochium maculatum; eupatorium m.	joe-pye-weed	native	4	-5	forb
Frangula alnus; rhamnus frangula	**glossy buckthorn**	**non-native**	**0**	**0**	**shrub**
Galium aparine	annual bedstraw	native	0	3	forb

Appendix 6 (continued). Floristic Quality Assessment for Hampton Creek Swamp rich tamarack swamp (EO ID 26458 pg 53).

Scientific Name	Common Name	Native?	C	W	Physiognomy
Galium asprellum	rough bedstraw	native	5	-5	vine
Galium trifidum	small bedstraw	native	6	-3	forb
Galium triflorum	fragrant bedstraw	native	4	3	forb
Glyceria striata	fowl manna grass	native	4	-5	grass
Ilex verticillata	michigan holly	native	5	-3	shrub
Impatiens capensis	spotted touch-me-not	native	2	-3	forb
Iris virginica	southern blue flag	native	5	-5	forb
Larix laricina	tamarack	native	5	-3	tree
Leersia oryzoides	cut grass	native	3	-5	grass
Ligustrum vulgare	**common privet**	**non-native**	**0**	**3**	**shrub**
Lindera benzoin	spicebush	native	7	-3	shrub
Lobelia siphilitica	great blue lobelia	native	4	-3	forb
Lonicera morrowii	**morrow honeysuckle**	**non-native**	**0**	**3**	**shrub**
Lythrum salicaria	**purple loosestrife**	**non-native**	**0**	**-5**	**forb**
Maianthemum canadense	canada mayflower	native	4	3	forb
Micranthes pensylvanica; saxifraga p.	swamp saxifrage	native	10	-5	forb
Muhlenbergia glomerata	marsh wild-timothy	native	10	-5	grass
Muhlenbergia mexicana	leafy satin grass	native	3	-3	grass
Myosotis scorpioides	**forget-me-not**	**non-native**	**0**	**-5**	**forb**
Nasturtium officinale	watercress	native	4	-5	forb
Nyssa sylvatica	black-gum	native	9	-3	tree
Onoclea sensibilis	sensitive fern	native	2	-3	fern
Osmunda cinnamomea	cinnamon fern	native	5	-3	fern
Osmunda regalis	royal fern	native	5	-5	fern
Oxypolis rigidior	cowbane	native	6	-5	forb
Packera aurea; senecio a.	golden ragwort	native	5	-3	forb
Parthenocissus quinquefolia	virginia creeper	native	5	3	vine
Pedicularis lanceolata	swamp-betony	native	8	-3	forb
Persicaria punctata; polygonum p.	smartweed	native	5	-5	forb
Persicaria sagittata; polygonum s.	arrow-leaved tear-thumb	native	5	-5	forb
Persicaria virginiana; polygonum v.	jumpseed	native	4	0	forb
Pilea pumila	clearweed	native	5	-3	forb
Pinus strobus	white pine	native	3	3	tree
Platanthera psycodes; habenaria p.	purple fringed orchid	native	7	-3	forb
Poa palustris	fowl meadow grass	native	3	-3	grass
Podophyllum peltatum	may-apple	native	3	3	forb
Populus tremuloides	quaking aspen	native	1	0	tree
Potamogeton robbinsii	pondweed	native	10	-5	forb
Prunus serotina	wild black cherry	native	2	3	tree
Pycnanthemum virginianum	common mountain mint	native	5	-3	forb
Quercus alba	white oak	native	5	3	tree
Quercus bicolor	swamp white oak	native	8	-3	tree
Quercus palustris	pin oak	native	8	-3	tree
Quercus rubra	red oak	native	5	3	tree
Rhamnus alnifolia	alder-leaved buckthorn	native	8	-5	shrub
Rhamnus cathartica	**common buckthorn**	**non-native**	**0**	**0**	**tree**
Rosa multiflora	**multiflora rose**	**non-native**	**0**	**3**	**shrub**
Rosa palustris	swamp rose	native	5	-5	shrub
Rumex orbiculatus	great water dock	native	9	-5	forb
Salix candida	hoary willow	native	9	-5	shrub
Salix discolor	pussy willow	native	1	-3	shrub
Salix nigra	black willow	native	5	-5	tree
Schoenoplectus acutus; scirpus a.	hardstem bulrush	native	5	-5	sedge
Scutellaria galericulata	marsh skullcap	native	5	-5	forb

Appendix 6 (continued). Floristic Quality Assessment for Hampton Creek Swamp rich tamarack swamp (EO ID 26458 pg 53).

Scientific Name	Common Name	Native?	C	W	Physiognomy
Scutellaria lateriflora	mad-dog skullcap	native	5	-5	forb
Solanum dulcamara	**bittersweet nightshade**	**non-native**	**0**	**0**	**vine**
Solidago patula	swamp goldenrod	native	6	-5	forb
Solidago rugosa	rough-leaved goldenrod	native	3	0	forb
Solidago uliginosa	bog goldenrod	native	4	-5	forb
Sparganium americanum	american bur-reed	native	6	-5	forb
Sparganium emersum; s. chlorocarpum	green-fruited bur-reed	native	6	-5	forb
Sphenopholis intermedia	slender wedgegrass	native	4	0	grass
Stuckenia pectinata; potamogeton p.	sago pondweed	native	3	-5	forb
Symphyotrichum firmum; aster puniceus	smooth swamp aster	native	4	-3	forb
Symphyotrichum lanceolatum; aster l.	panicled aster	native	2	-3	forb
Symphyotrichum puniceum; aster p.	swamp aster	native	5	-5	forb
Symplocarpus foetidus	skunk-cabbage	native	6	-5	forb
Thalictrum dasycarpum	purple meadow-rue	native	3	-3	forb
Thelypteris palustris	marsh fern	native	2	-3	fern
Toxicodendron vernix	poison sumac	native	6	-5	shrub
Triglochin palustris	slender bog arrow-grass	native	8	-5	forb
Typha x glauca	**hybrid cat-tail**	**non-native**	**0**	**-5**	**forb**
Typha angustifolia	**narrow-leaved cat-tail**	**non-native**	**0**	**-5**	**forb**
Ulmus americana	american elm	native	1	-3	tree
Utricularia gibba	humped bladderwort	native	8	-5	forb
Vaccinium corymbosum	highbush blueberry	native	6	-3	shrub
Vernonia missurica	missouri ironweed	native	4	0	forb
Veronica anagallis-aquatica	water speedwell	native	4	-5	forb
Viola cucullata	marsh violet	native	5	-5	forb
Zizia aurea	golden alexanders	native	6	0	forb

Appendix 6 (continued). Floristic Quality Assessment for Hampton Creek Swamp rich tamarack swamp (EO ID 26458 pg 53).

Practitioner: Jesse M. Lincoln, Tyler Bassett, John Paskus

Conservatism-Based Metrics:

Total Mean C:	4.4
Native Mean C:	5
Total FQI:	50.9
Native FQI:	54.5
Adjusted FQI:	47.1
% C value 0:	11.9
% C value 1-3:	20.1
% C value 4-6:	49.3
% C value 7-10:	18.7
Native Tree Mean C:	4.4
Native Shrub Mean C:	5.8
Native Herbaceous Mean C:	5

Physiognomy Metrics:

Tree:	15	11.20%
Shrub:	19	14.20%
Vine:	8	6%
Forb:	61	45.50%
Grass:	12	9%
Sedge:	12	9%
Rush:	0	0%
Fern:	7	5.20%
Bryophyte:	0	0%

Species Richness:

Total Species:	134	
Native Species:	119	88.80%
Non-native Species:	15	11.20%

Duration Metrics:

Annual:	8	6%
Perennial:	125	93.30%
Biennial:	1	0.70%
Native Annual:	8	6%
Native Perennial:	110	82.10%
Native Biennial:	1	0.70%

Species Wetness:

Mean Wetness:	-2.8
Native Mean Wetness:	-3.1

Appendix 7. Floristic Quality Assessment for Vanderbilt Swamp southern hardwood swamp (EO ID 26616 pg 57).

Scientific Name	Common Name	Native?	C	W	Physiognomy
Acer rubrum	red maple	native	1	0	tree
Acer saccharinum	silver maple	native	2	-3	tree
Apios americana	groundnut	native	3	-3	vine
Arisaema triphyllum	jack-in-the-pulpit	native	5	0	forb
Asimina triloba	pawpaw	native	9	0	tree
Berberis thunbergii	**japanese barberry**	**non-native**	**0**	**3**	**shrub**
Betula alleghaniensis	yellow birch	native	7	0	tree
Bidens cernua	nodding beggar-ticks	native	3	-5	forb
Boehmeria cylindrica	false nettle	native	5	-5	forb
Caltha palustris	marsh-marigold	native	6	-5	forb
Cardamine bulbosa	spring cress	native	4	-5	forb
Carex bebbii	sedge	native	4	-5	sedge
Carex crinita	sedge	native	4	-5	sedge
Carex grayi	sedge	native	6	-3	sedge
Carex leptalea	sedge	native	5	-5	sedge
Carex pseudo-cyperus	sedge	native	5	-5	sedge
Carex stipata	sedge	native	1	-5	sedge
Carpinus caroliniana	blue-beech	native	6	0	tree
Chelone glabra	turtlehead	native	7	-5	forb
Cicuta bulbifera	water hemlock	native	5	-5	forb
Cinna arundinacea	wood reedgrass	native	7	-3	grass
Coptis trifolia	goldthread	native	5	-3	forb
Cornus foemina	gray dogwood	native	1	0	shrub
Cryptotaenia canadensis	honewort	native	2	0	forb
Dioscorea villosa	wild yam	native	4	0	forb
Elaeagnus umbellata	**autumn-olive**	**non-native**	**0**	**3**	**shrub**
Equisetum arvense	common horsetail	native	0	0	fern
Fagus grandifolia	american beech	native	6	3	tree
Frangula alnus	**glossy buckthorn**	**non-native**	**0**	**0**	**shrub**
Fraxinus nigra	black ash	native	6	-3	tree
Fraxinus pennsylvanica	red ash	native	2	-3	tree
Galium asprellum	rough bedstraw	native	5	-5	vine
Glyceria septentrionalis	floating manna grass	native	7	-5	grass
Glyceria striata	fowl manna grass	native	4	-5	grass
Hamamelis virginiana	witch-hazel	native	5	3	shrub
Ilex verticillata	michigan holly	native	5	-3	shrub
Impatiens capensis	spotted touch-me-not	native	2	-3	forb
Larix laricina	tamarack	native	5	-3	tree
Leersia virginica	white grass	native	5	-3	grass
Ligustrum vulgare	**common privet**	**non-native**	**0**	**3**	**shrub**
Lindera benzoin	spicebush	native	7	-3	shrub
Liriodendron tulipifera	tulip tree	native	9	3	tree
Lobelia siphilitica	great blue lobelia	native	4	-3	forb
Lycopus americanus	common water horehound	native	2	-5	forb
Lysimachia thyrsiflora	tufted loosestrife	native	6	-5	forb
Maianthemum canadense	canada mayflower	native	4	3	forb
Mitchella repens	partridge-berry	native	5	3	forb
Nyssa sylvatica	black-gum	native	9	-3	tree
Onoclea sensibilis	sensitive fern	native	2	-3	fern
Osmunda cinnamomea	cinnamon fern	native	5	-3	fern
Osmunda regalis	royal fern	native	5	-5	fern
Packera aurea	golden ragwort	native	5	-3	forb
Parthenocissus quinquefolia	virginia creeper	native	5	3	vine
Persicaria arifolia	tear-thumb	native	7	-5	forb

Appendix 7 (continued). Floristic Quality Assessment for Vanderbilt Swamp southern hardwood swamp (EO ID 26616 pg 57).

Scientific Name	Common Name	Native?	C	W	Physiognomy
Persicaria virginiana	jumpseed	native	4	0	forb
Phalaris arundinacea	**reed canary grass**	**non-native**	**0**	**-3**	**grass**
Phragmites australis var. americanus	reed	native	5	-3	grass
Pilea pumila	clearweed	native	5	-3	forb
Quercus bicolor	swamp white oak	native	8	-3	tree
Quercus palustris	pin oak	native	8	-3	tree
Quercus rubra	red oak	native	5	3	tree
Ranunculus hispidus	swamp buttercup	native	5	0	forb
Ranunculus sceleratus	cursed crowfoot	native	1	-5	forb
Ribes americanum	wild black currant	native	6	-3	shrub
Rosa multiflora	**multiflora rose**	**non-native**	**0**	**3**	**shrub**
Rosa palustris	swamp rose	native	5	-5	shrub
Rubus pubescens	dwarf raspberry	native	4	-3	shrub
Solanum dulcamara	**bittersweet nightshade**	**non-native**	**0**	**0**	**vine**
Symphyotrichum lateriflorum	calico aster	native	2	0	forb
Symplocarpus foetidus	skunk-cabbage	native	6	-5	forb
Thelypteris palustris	marsh fern	native	2	-3	fern
Tilia americana	basswood	native	5	3	tree
Toxicodendron radicans	poison-ivy	native	2	0	vine
Toxicodendron vernix	poison sumac	native	6	-5	shrub
Typha angustifolia	**narrow-leaved cat-tail**	**non-native**	**0**	**-5**	**forb**
Ulmus americana	american elm	native	1	-3	tree
Vaccinium corymbosum	highbush blueberry	native	6	-3	shrub
Viola cucullata	marsh violet	native	5	-5	forb

Appendix 7 (continued). Floristic Quality Assessment for Vanderbilt Swamp southern hardwood swamp (EO ID 26616 pg 57).

Practitioner: Jesse M. Lincoln
Gourdneck SGA
06/30/2022

Conservatism-Based Metrics:

Total Mean C:	4.2
Native Mean C:	4.6
Total FQI:	37.1
Native FQI:	38.8
Adjusted FQI:	43.9
% C value 0:	11.5
% C value 1-3:	20.5
% C value 4-6:	53.8
% C value 7-10:	14.1
Native Tree Mean C:	5.6
Native Shrub Mean C:	5
Native Herbaceous Mean C:	4.2

Physiognomy Metrics:

Tree:	16	20.5%
Shrub:	14	17.9%
Vine:	5	6.4%
Forb:	26	33.3%
Grass:	6	7.7%
Sedge:	6	7.7%
Rush:	0	0.0%
Fern:	5	6.4%
Bryophyte:	0	0.0%

Species Richness:

Total Species:	78	
Native Species:	71	91%
Non-native Species:	7	9%

Duration Metrics:

Annual:	5	6.4%
Perennial:	73	93.6%
Biennial:	0	0.0%
Native Annual:	5	6.4%
Native Perennial:	66	84.6%
Native Biennial:	0	0.0%

Species Wetness:

Mean Wetness:	-2.1
Native Mean Wetness:	-2.4

Appendix 8. Floristic Quality Assessment for Centre Ave powerline corridor.

Scientific Name	Common Name	Native?	C	W	Physiognomy
Achillea millefolium	yarrow	native	1	3	forb
Agrostis hyemalis	ticklegrass	native	4	0	grass
Amorpha canescens	lead-plant	native	8	5	shrub
Andropogon gerardii	big bluestem	native	5	0	grass
Andropogon virginicus	broom-sedge	native	4	3	grass
Antennaria parlinii	smooth pussytoes	native	2	5	forb
Apocynum androsaemifolium	spreading dogbane	native	3	5	forb
Artemisia campestris	wormwood	native	5	5	forb
Asclepias amplexicaulis	clasping milkweed	native	8	5	forb
Asclepias exaltata	poke milkweed	native	6	5	forb
Asclepias syriaca	common milkweed	native	1	5	forb
Asclepias tuberosa	butterfly-weed	native	5	5	forb
Aureolaria flava	smooth false foxglove	native	8	5	forb
Blephilia ciliata	ohio horse mint	native	7	5	forb
Bromus inermis	**smooth brome**	**non-native**	**0**	**5**	**grass**
Carex muehlenbergii	sedge	native	7	5	sedge
Carex pensylvanica	sedge	native	4	5	sedge
Carex stricta	sedge	native	4	-5	sedge
Centaurea stoebe	**spotted knapweed**	**non-native**	**0**	**5**	**forb**
Clinopodium vulgare	wild-basil	native	3	5	forb
Comandra umbellata	bastard-toadflax	native	5	3	forb
Coreopsis lanceolata	sand coreopsis	native	8	3	forb
Coreopsis tripteris	tall coreopsis	native	7	0	forb
Cornus foemina	gray dogwood	native	1	0	shrub
Crocanthemum canadense	common frostweed	native	8	5	forb
Danthonia spicata	poverty grass; oatgrass	native	4	5	grass
Dichanthelium commonsianum	panic grass	native	6	3	grass
Dichanthelium depauperatum	panic grass	native	4	5	grass
Dichanthelium dichotomum	panic grass	native	7	0	grass
Dichanthelium oligosanthes	panic grass	native	5	3	grass
Doellingeria umbellata	flat-topped white aster	native	5	-3	forb
Elaeagnus umbellata	**autumn-olive**	**non-native**	**0**	**3**	**shrub**
Eryngium yuccifolium	rattlesnake-master	native	10	0	forb
Festuca trachyphylla	**sheep fescue**	**non-native**	**0**	**5**	**grass**
Frangula alnus	**glossy buckthorn**	**non-native**	**0**	**0**	**shrub**
Frasera caroliniensis	american columbo	native	10	5	forb
Galium pilosum	hairy bedstraw	native	6	5	forb
Gaultheria procumbens	wintergreen	native	5	3	shrub
Gaylussacia baccata	huckleberry	native	7	3	shrub
Helianthus occidentalis	western sunflower	native	8	3	forb
Hieracium gronovii	hairy hawkweed	native	5	5	forb
Hypericum perforatum	**common st. johns-wort**	**non-native**	**0**	**5**	**forb**
Hypericum punctatum	spotted st. johns-wort	native	4	0	forb
Krigia biflora	false dandelion	native	5	3	forb
Krigia virginica	dwarf dandelion	native	4	5	forb
Lechea minor	small pinweed	native	9	5	forb
Lechea mucronata; l. villosa	hairy pinweed	native	5	5	forb
Lespedeza capitata	round-headed bush-clover	native	5	3	forb
Liatris aspera	rough blazing-star	native	4	5	forb
Lupinus perennis	wild lupine	native	7	5	forb
Lysimachia quadrifolia	four-leaved loosestrife	native	8	3	forb
Monarda fistulosa	wild-bergamot	native	2	3	forb
Monarda punctata	horse mint	native	4	5	forb
Muhlenbergia mexicana	leafy satin grass	native	3	-3	grass

Appendix 8 (continued). Floristic Quality Assessment for Centre Ave powerline corridor.

Scientific Name	Common Name	Native?	C	W	Physiognomy
Piptochaetium avenaceum	black oatgrass	native	10	3	grass
Poa pratensis	**kentucky bluegrass**	**non-native**	**0**	**3**	**grass**
Poa trivialis	**bluegrass**	**non-native**	**0**	**-3**	**grass**
Potentilla simplex	old-field cinquefoil	native	2	3	forb
Pteridium aquilinum	bracken fern	native	0	3	fern
Quercus alba	white oak	native	5	3	tree
Quercus velutina	black oak	native	6	5	tree
Rhus copallina	winged sumac	native	3	5	shrub
Rosa carolina	pasture rose	native	4	3	shrub
Rubus flagellaris	northern dewberry	native	1	3	shrub
Rubus hispidus	swamp dewberry	native	4	-3	shrub
Salix humilis	prairie willow	native	4	3	shrub
Schizachyrium scoparium	little bluestem	native	5	3	grass
Scleria triglomerata	tall nut-rush	native	10	0	sedge
Solidago altissima	tall goldenrod	native	1	3	forb
Solidago nemoralis	old-field goldenrod	native	2	5	forb
Solidago rugosa	rough-leaved goldenrod	native	3	0	forb
Solidago speciosa	showy goldenrod	native	5	5	forb
Solidago ulmifolia	elm-leaved goldenrod	native	5	5	forb
Sorghastrum nutans	indian grass	native	6	3	grass
Tradescantia ohiensis	common spiderwort	native	5	3	forb
Vaccinium angustifolium	low sweet blueberry	native	4	3	shrub
Vernonia missurica	missouri ironweed	native	4	0	forb
Veronica officinalis	**common speedwell**	**non-native**	**0**	**3**	**forb**

Appendix 8 (continued). Floristic Quality Assessment for Centre Ave powerline corridor.

Gourdneck Powerline

06/07/2022

Practitioners: Jesse Lincoln and Tyler Bassett

Conservatism-Based Metrics:

Total Mean C:	4.4
Native Mean C:	5
Total FQI:	38.9
Native FQI:	41.5
Adjusted FQI:	47
% C value 0:	12.8
% C value 1-3:	17.9
% C value 4-6:	46.2
% C value 7-10:	23.1
Native Tree Mean C:	5.5
Native Shrub Mean C:	4.1
Native Herbaceous Mean C:	5.1

Physiognomy Metrics:

Tree:	2	2.60%
Shrub:	12	15.40%
Vine:	0	0%
Forb:	43	55.10%
Grass:	16	20.50%
Sedge:	4	5.10%
Rush:	0	0%
Fern:	1	1.30%
Bryophyte:	0	0%

Species Richness:

Total Species:	78	
Native Species:	69	88.50%
Non-native Species:	9	11.50%

Duration Metrics:

Annual:	1	1.30%
Perennial:	74	94.90%
Biennial:	3	3.80%
Native Annual:	1	1.30%
Native Perennial:	66	84.60%
Native Biennial:	2	2.60%

Species Wetness:

Mean Wetness:	3
Native Mean Wetness:	3.1

Michigan Natural Features Inventory

Discover. Define. Deliver.