Natural Features Inventory and Management Recommendations for Cannonsburg State Game Area

Prepared By:
Aaron P. Kortenhoven, Jesse M. Lincoln, Yu Man Lee, Peter J. Badra, Logan M. Rowe, Joshua G. Cohen, Nicole J. Smith, Ashley Cole-Wick.

Michigan Natural Features Inventory
Michigan State University Extension
P.O. Box 30444
Lansing, MI 48909-7944

Prepared For:
Michigan Department of Natural Resources; Wildlife Division

September 2024

MNFI Document Number 2024-15

Michigan Natural Features Inventory
MICHIGAN STATE UNIVERSITY | Extension
DEPARTMENT OF NATURAL RESOURCES DNR MICHIGAN

Suggested Citation:

Aaron P. Kortenhoven, Jesse M. Lincoln, Yu Man Lee, Peter J. Badra, Logan M. Rowe, Joshua G. Cohen, Nicole J. Smith, Ashley Cole-Wick. Natural Features Inventory and Management Recommendations for Cannonsburg State Game Area. Michigan Natural Features Inventory, Report Number 2024-15, 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: Eastern Box Turtle (*Terrapene carolina carolina*) recorded in Cannonsburg State Came Area. 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, Dan Kennedy, Ann LeClaire, Steve Chadwick, John Niewoonder, James Miller, Jesse Bramer, Guntis (Nik) Kalejs, Brian Maki, Nick Dohm, and Nathan Poley.

For their support and assistance throughout this project, we thank our MNFI colleagues Rebecca Rogers, Courtney Ross, Helen Enander, Mike Monfils, Michael Sanders, David Cuthrell, Ashley Adkins, Kraig Korroch, Sarah Carter, Clay Wilton, and Brian Klatt. Thank you to AmeriCorps Servicemembers Nathan Hilbrands and Marta Springer who assisted with field work.

EXECUTIVE SUMMARY

Cannonsburg State Game Area (SGA) is 1,360 acres of semi-contiguous public land in the southwest Lower Peninsula of Michigan in Kent County

Cannonsburg SGA provides critical habitat for a myriad of game and non-game species in a rapidly developing suburban area. The game area supports 113.1 acres of high-quality natural communities and the natural cover within the game area supports a diversity of rare herptiles (reptiles and amphibians), birds, insects, and snails

Michigan Natural Features Inventory (MNFI) conducted Stage 1 Michigan Forest Inventory (MiFI) in 2016 and surveys for high-quality natural communities and rare animal surveys were conducted in 2023 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 that will aid sustainable management of those important areas.

MNFI scientists documented three new community EOs, one box turtle EO update, one new fowler's toad EO, one new pickerel frog EO, three new watercress EOs, one hooded warbler EO update, and one new Louisiana watertrush EO, one old blanchard's cricket frog EO.

Two high-quality dry southern forests and one high-quality southern hardwood swamp were documented in Cannonsburg SGA in 2023. Together, these high-quality areas represent 8.3% of the game area and provide critical habitat for the species found within the game area.

MNFI scientists conducted visual encounter surveys for rare herptiles. Three rare herptile species were documented including eastern box turtle (*Terrapene carolina carolina*, State Threatened), pickerel frog (*Lithobates palustris*, State Special Concern) and Fowler's toad (*Anaxyrus fowleri*, State Special Concern).

Aquatic surveys were performed at Cannonsburg SGA and watercress snail (*Fontigens nickliniana;* State Special Concern) was documented along the Egypt Creek.

Rare bird surveys included point-counts for raptors and forest songbirds. We documented 12 singing hooded warbler (*Setophaga citrina*, State Special Concern) and updated an existing EO for this species. In addition, Louisiana waterthrush (*Parkesia motacilla*, State Threatened) was recorded in the game are for the first time as a new EO.

Considering the concentrations of rare herptiles and birds 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 provide the following management recommendations to protect native biodiversity and ecosystem integrity in order of importance: 1) minimize forest fragmentation adjacent to high-quality natural communities identified in this report; 2) implement prescribed fire in oak-dominated forests; 3) control invasive species within high-quality natural communities, and 4) prevent the establishment of new bike trails and minimize erosion of current bike trails.

The upland and lowland forests in Cannonsburg provide critical habitat for neotropical migrants like this hooded warbler. Photo by Aaron Kortenhoven.

Table of Contents

ACKNOWLEDGMENTS iii

EXECUTIVE SUMMARY. iv

INTRODUCTION 1
Ecoregions 2
Vegetaton Circa 1800 3
Changes in Land Cover 6

METHODS. 9
Natural Community Surveys 9
Rare Amphibian and Reptile Surveys 10
Rare Snail and Mussel Surveys. 12
Rare Insect Surveys. 14
Rare Bird Surveys 18

RESULTS 20
Natural Communities 22
Cannonsburg Woods 22
Dursum Woods. 26
Egypt Creek Swamp 29
Rare Amphibians and Reptiles 32
Rare Snails and Mussels 35
Rare Insects 38
Rare Birds. 40

DISCUSSION 43
Natural Community Discussion and Recommendations 43
Forest Fragmentation 43
Fire as an Ecological Process Fragmentation 43
Controlling Invasive Species 44
Ecological Impact of Recreational Use 46
Rare Amphibians and Reptiles 47
Rare Snail and Mussel Surveys. 48
Rare Insects 49
Rare Birds. 50

CONCLUSION 52

LITERATURE CITED 53

APPENDICIES 57

List of Figures

Figure **Page**

1. Imagery of Cannonsburg SGA. 2
2. Ecoregions of Southern Michigan. 3
3. Surficial geology of Cannonsburg SGA. 4
4. Vegetation of Cannonsburg SGA circa 1800. 5
5. Michigan Forest Inventory stand data of Cannonsburg SGA. 7
6. Mosaic of 1938 aerial photographs of Cannonsburg SGA 8
7. Location of rare Amphibians and Reptiles 11
8. Rare Snail and Mussel Surveys. 13
9. Location of rare insect surveys 15
10. Location of songbird and raptor surveys 19
11. Natural Community element occurence locations in Cannonsburg SGA 21
12. Location of Cannonsburg Woods Dry Southern Forest 22
13. Statewide distribution of Dry Southern Forest. 23
14. The location of Dursum Woods Dry Southern Forest 26
15. The location of Egypt Creek Swamp Southern Hardwood Swamp 29
16. Statewide distribution of Southern Hardwood Swamp 30
17. Location of Amphibians and Reptiles EOs in Cannonsburg SGA 32
18. Location of watercress snail in Cannonsburg SGA 35
19. Historic frosted elfin EO locations. 38
20. Survey points where target bird species were documented during 2023 surveys. 41
21. Prescribed fire needs assessment of Cannonsburg SGA 46
22. Invasive species prioritization model output for Cannonsburg SGA 45

List of Tables

Table	Page
1. Locations of mussel and watercress snail survey sites	13
2. Natural community element occurrences for the Cannonsburg Game Area	20
3. Amphibian and reptile element occurences that have been documented in Cannonsburg SGA	34
4. Watercress snail EO data	34
5. Locations where watercress snail were documented	36
6. Locations of mussel survey sites	37
7. Incidental finds at mussel survey sites	37
8. Percentage of each substrate particle size class estimated visually at each mussel survey site	37
9. Physical habitat characteristics recorded at mussel survey sites	37
10. Unlisted butterflies observed during insect surveys	39
11. Bird species documented during surveys	42

List of Appendicies

Appendix **Page**

Ia. Floristic Quality Assessment for Cannonsburg Woods Dry Southern Forest 57

Ib. Floristic Quality Assessment for Dursum Woods Dry Southern Forest 60

Ic. Floristic Quality Assessment for Egypt Creek Swamp Southern Hardwood Swamp 63

INTRODUCTION

Cannonsburg State Game Area (SGA) is 1,360 acres of semi-contiguous public land in the southwest Lower Peninsula of Michigan in Kent County (Figure 1). The land is owned and managed by the Wildlife Division of Michigan's Department of Natural Resources (DNR) and was purchased with funds secured by the Pittman-Robertson Federal Aid in Wildlife Restoration Act and is administered through the DNR's Wildlife Division (WLD).

Cannonsburg SGA provides critical habitat for a myriad of game and non-game species in a rapidly developing suburban area. The landscape surrounding Cannonsburg has high concentration of new sub-division developments, which have increased over the last few decades. Many forested and agricultural areas adjacent to the game area are disappearing due to the expanding urbanization of the greater Grand Rapids area. This urban sprawl highlights the significance of the natural areas of Cannonsburg SGA, which currently provide habitat and refuge for the fauna and flora of Kent County.

Michigan Natural Features Inventory (MNFI) is Michigan's natural heritage program and maintains a geospatial database of populations of rare and declining species and of 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 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. Surveys for high-quality natural communities and rare animals were conducted in 2023. The goal of this survey effort is to provide resource managers and planners with baseline information on natural community and rare species occurrences and identify the most critical places on state lands for biodiversity stewardship.

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.

This report focuses on native biodiversity with an emphasis on rare species and high-quality ecosystems. Biodiversity stewardship considerations are included in the report, and we acknowledge that the DNR manages for multiple values including wildlife management, hunting, and other wildlife

Cannonsburg Woods is a dry southern forest element occurence documented in 2023. Photo by Aaron Kortenhoven.

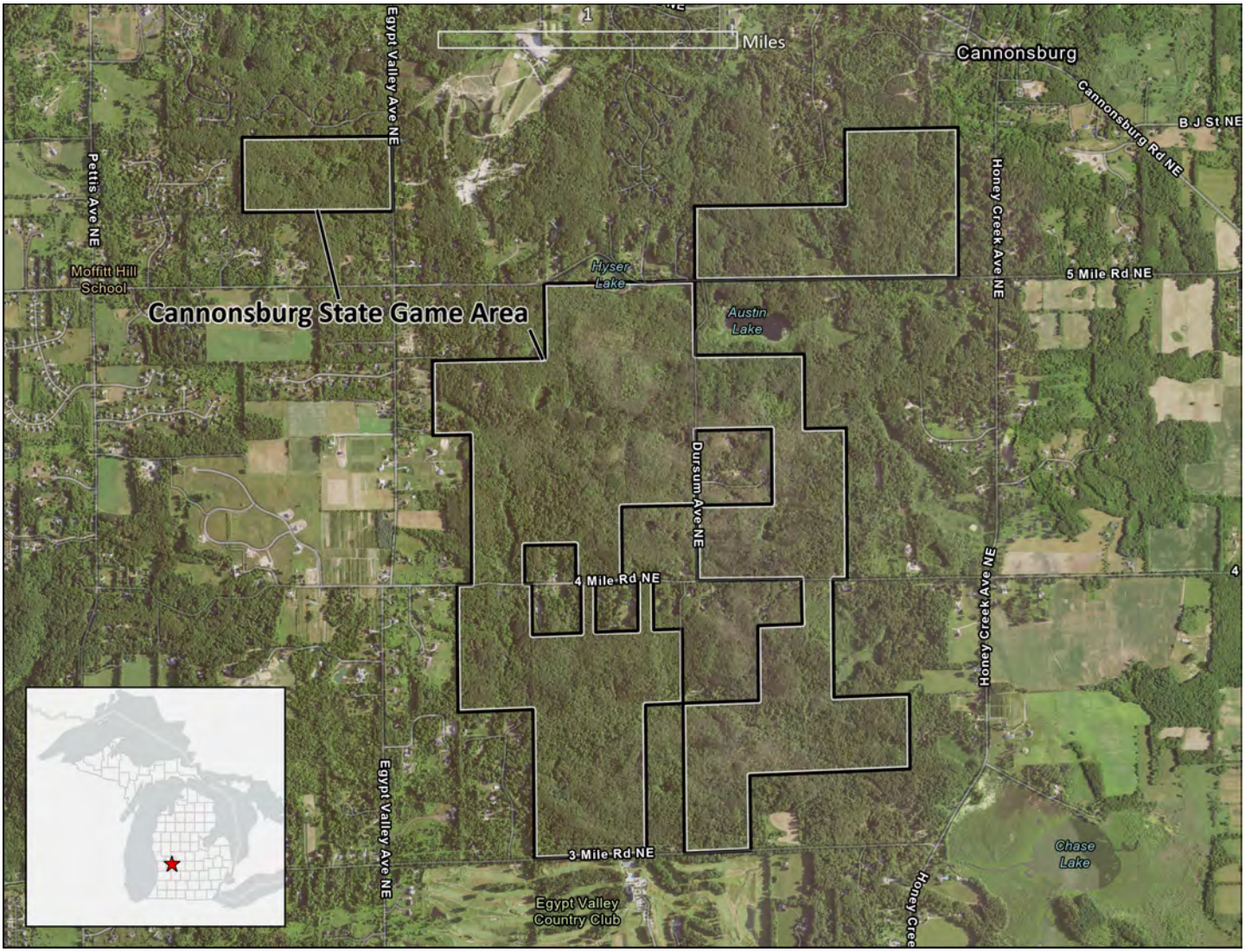


Figure 1. Imagery of Cannonsburg State Game (ESRI 2024).

related recreation, as well as biodiversity, and that the report does not necessarily reflect the planned management actions of the DNR. Specific management recommendations are provided for rare species and groups of rare species and for each natural community element occurence found within the game area.

We provide an overview of the landscape and historical context of Cannonsburg SGA, summarize the findings of MNFI's surveys for high-quality natural communities and rare animal species, and identify stewardship priorities in the game area. Cannonsburg SGA supports several rare plant, avian, snail, reptile, amphibian, and insect species. During the natural features inventory of this game area we documented or updated element occurrences of three natural communites, two rare bird species, three rare herptiles, and one snail species.

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. Cannonsburg SGA occurs in southern lower Michigan in Section VI within the Greenville Sub-Subsection (VI.4.2) of the Ionia Subsection (VI.4) (Albert 1995, Figure 2).

The Greenville Sub-Subsection is primarily hilly end and ground moraines dissected by outwash channels with well to excessively well drained soils (Figure 3, Albert 1995).

This Subsection historically supported extensive beech-maple forest in the north and oak-hickory forest in the south, with white pine locally common in dry upland sites. Lowland forested areas were a mix of hardwood-conifer and conifer swamps. The ecological processes in upland natural communities in this Sub-section were driven by periodic landscape-scale fire (Albert 1995).

Circa 1800 Vegetation

Interpretations of the General Land Office (GLO) surveyor notes by MNFI ecologists indicated that the Cannonsburg SGA and the surrounding area contained several distinct vegetation assemblages in the 1800s (Comer et al. 1995) (Figure 4). The GLO surveyors recorded information on tree species composition, tree size, and general condition of the lands within and surrounding Cannonsburg SGA. The prevalent cover types included Oak Hickory Forest (49%), Mixed Oak Forest (29%), Mixed Conifer Swamp (12%), Black Oak Barren (19%), and Mixed Conifer Swamp (2%).

GLO surveyors described most of the SGA as comprised of white oak (*Quercus alba)*, black oak (*Q. velutina*), with several areas of the game area being recently burned and containg oak grubs.

We evaluated the notes that the land surveyors took within the game area and the immediate vicinity to provide a summary of the composition and structure of the land circa 1800. Within upland areas of the SGA, white oak and black oak were the most common canopy trees. Recorded diameters of trees ranged from 10 to 60 cm with an average of 36 cm (N = 13).

Several 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 rich tamarack swamps at the margins of wetlands and adjacent uplands. Where the surveyors noted canopy composition of these swamp

Figure 2. Cannonsburg State Game Area occurs in southern lower Michigan in Section VI within the Greenville Sub-Subsection (VI.4.2) of the Ionia Subsection (VI.4) (Albert 1995).

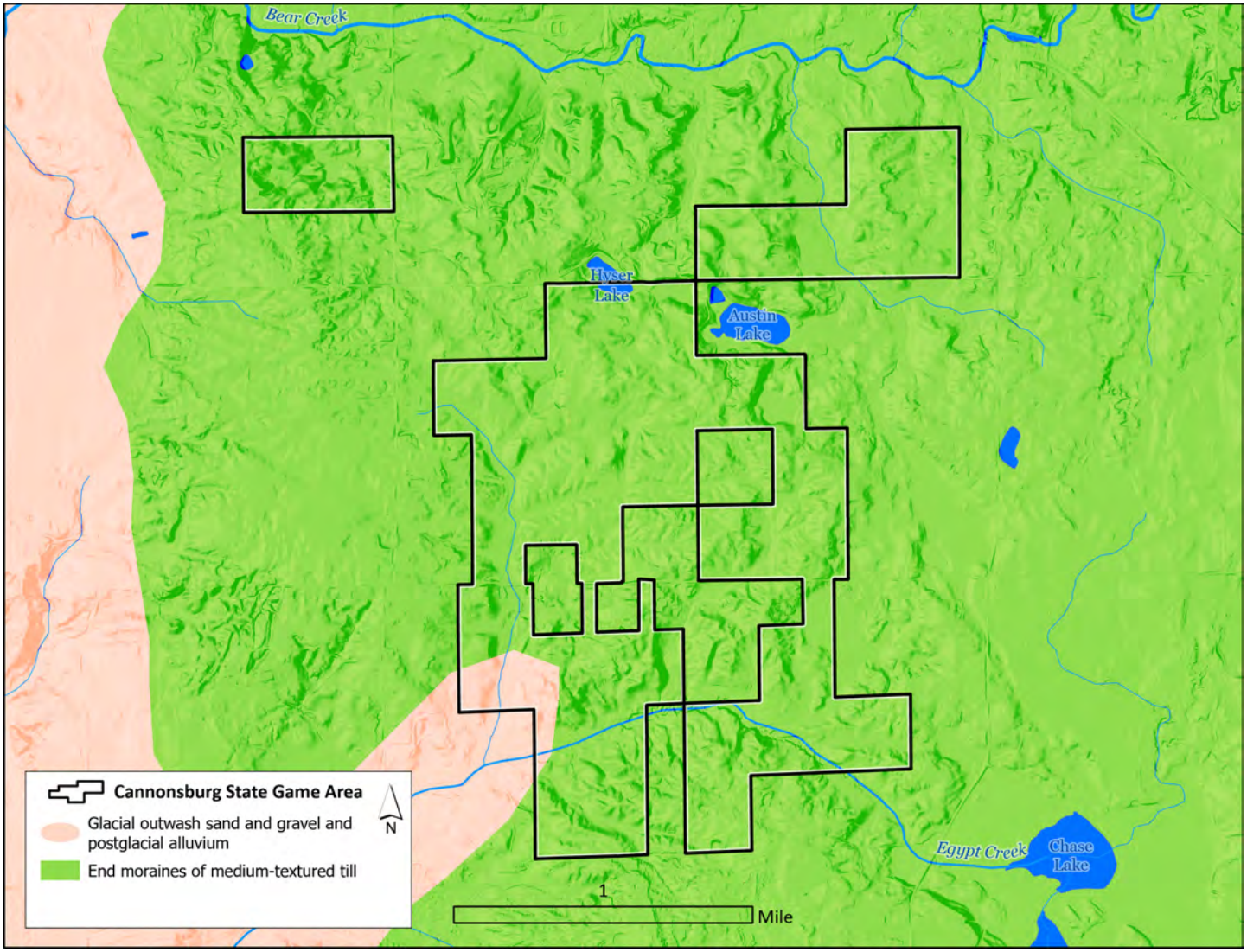


Figure 3. Surficial geology of Cannonsburg State Game Area.


Dursum Woods is a dry southern forest element occurence documented in 2023. This images shows a moraine-dominated landscape. Photo by Aaron Kortenhoven.

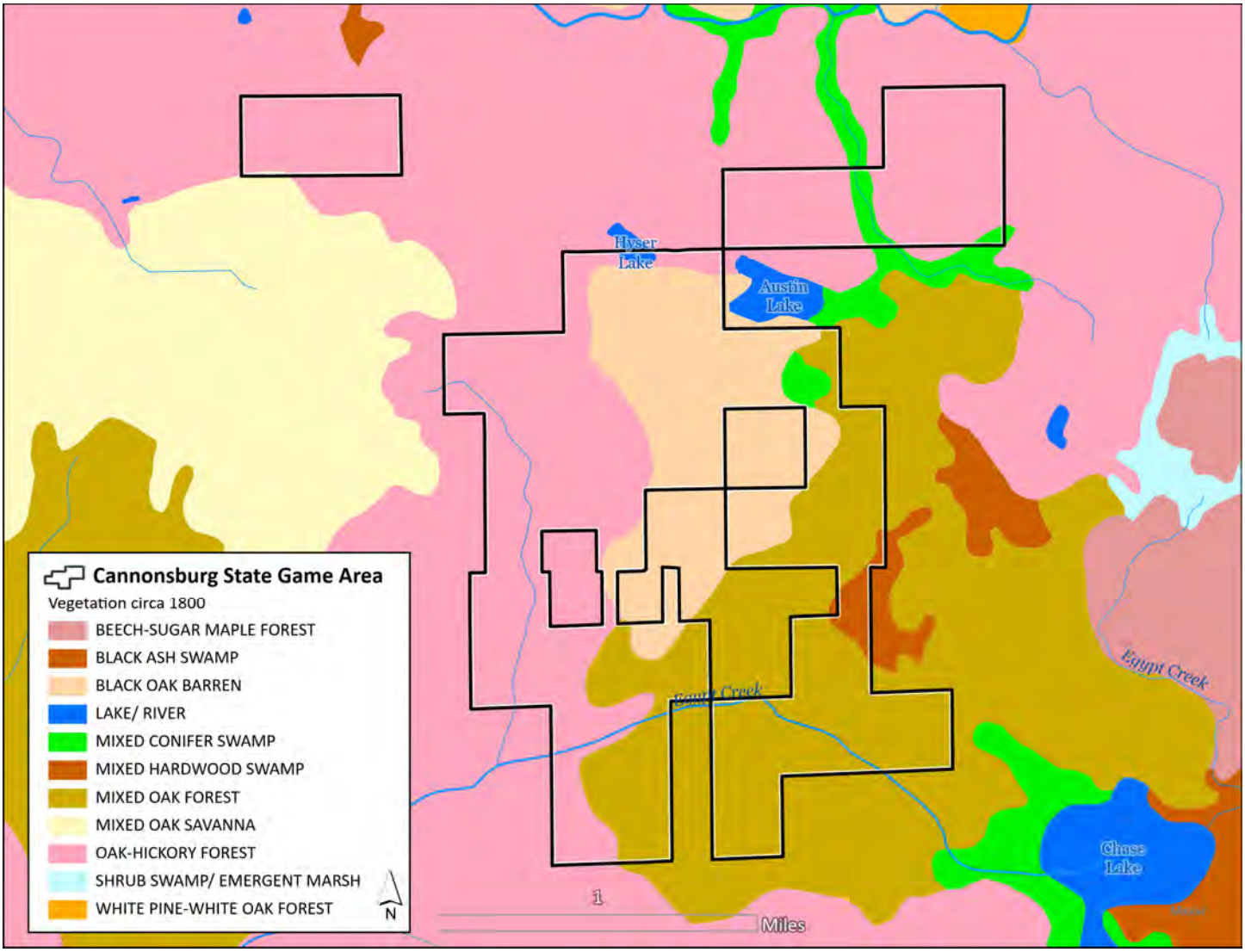


Figure 4. Vegetation of Cannonsburg State Game Area circa 1800 (Comer et al 1995).


Dursum Woods element occurence. Photo by Aaron Kortenhoven.

forests, tamarack was the dominant tree species. Average tree diameter for tamarack was 18 cm (N=4).

Changes in Land Cover

The landcover within and around Cannonsburg SGA has changed greatly since the early 1800s (Figures 4). The greatest change is due to logging, agriculture, fire suppression, tree disease, non-native insect outbreak, and invasive species infestations. Currently, mixed upland forest is the dominant land cover type in Cannonsburg SGA (86% of the game area; 1167 ac; Figure 5). 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-Hickory and Mixed Oak Forest. Much of this forest has converted to mixed deciduous forest with black locust (*Robinia pseudoacacia*) and black cherry (*Prunus serotina*) widespread throughout the SGA. These two species are early-successional trees that often colonize abandoned agricultural fields and are imparted a competitive advantage in fire-suppressed landscapes subject to high deer browse pressure.

The non-forested wetlands and lowland forest that have not been cleared have been significantly altered over the past 200 years by invasive disease, invasive species infestations, and fire suppression. Though the GLO notes did not document American elm (*Ulmus americana*) and ash (*Fraxinus spp.*) as significant components of the lowland forests, they are present now and were important components of the forested wetland communities. Dutch elm disease (*Ophiostoma ulmi*) has effectively eliminated elm as an overstory tree across Michigan. In 2002, the non-native invasive emerald ash borer (*Agrilus planipennis*), was identified in southeastern Michigan. This Asiatic beetle has killed millions of ash trees across Michigan and altered the species composition and structure of upland and lowland forests (USDA Forest Service 2002, Roberts 2003). Both ash and elm are now relegated to the understory of forests with canopy trees occurring infrequently.

Aerial photographs from 1938 show how logging and agriculture contributed to habitat fragmentation and ecological degradation across the SGA (Figure 6). In 1938 most of the uplands in the game area were agricultural fields. The land parcels that comprise the current boundaries of Cannonsburg SGA were acquired by the state between 1949 and 1952. Many of these agricultural parcels reverted to forest after state ownership. These reforested agricultural areas tend to have the greatest concentrations of invasive species. The imagery from 1938 is particularly useful for identifying forests that still retain native vegetation. Areas that were forested in the 1938 imagery, that have not since been logged, have the lowest proportion of invasive species, oldest trees, and greatest ecological restoration potential because the seedbank and soil biota have had minimal disturbance.

While 86% of Cannonsburg SGA is upland forest, only 8.84% (113.1 ac) is documented high-quality natural communities. The landscape around the SGA is mostly rural residential with new sub-developments being built continually, leading to high recreation pressure.

Dry southern forest; this image shows the black oak and white oak dominanted canopy. Photo by Jesse Lincoln.

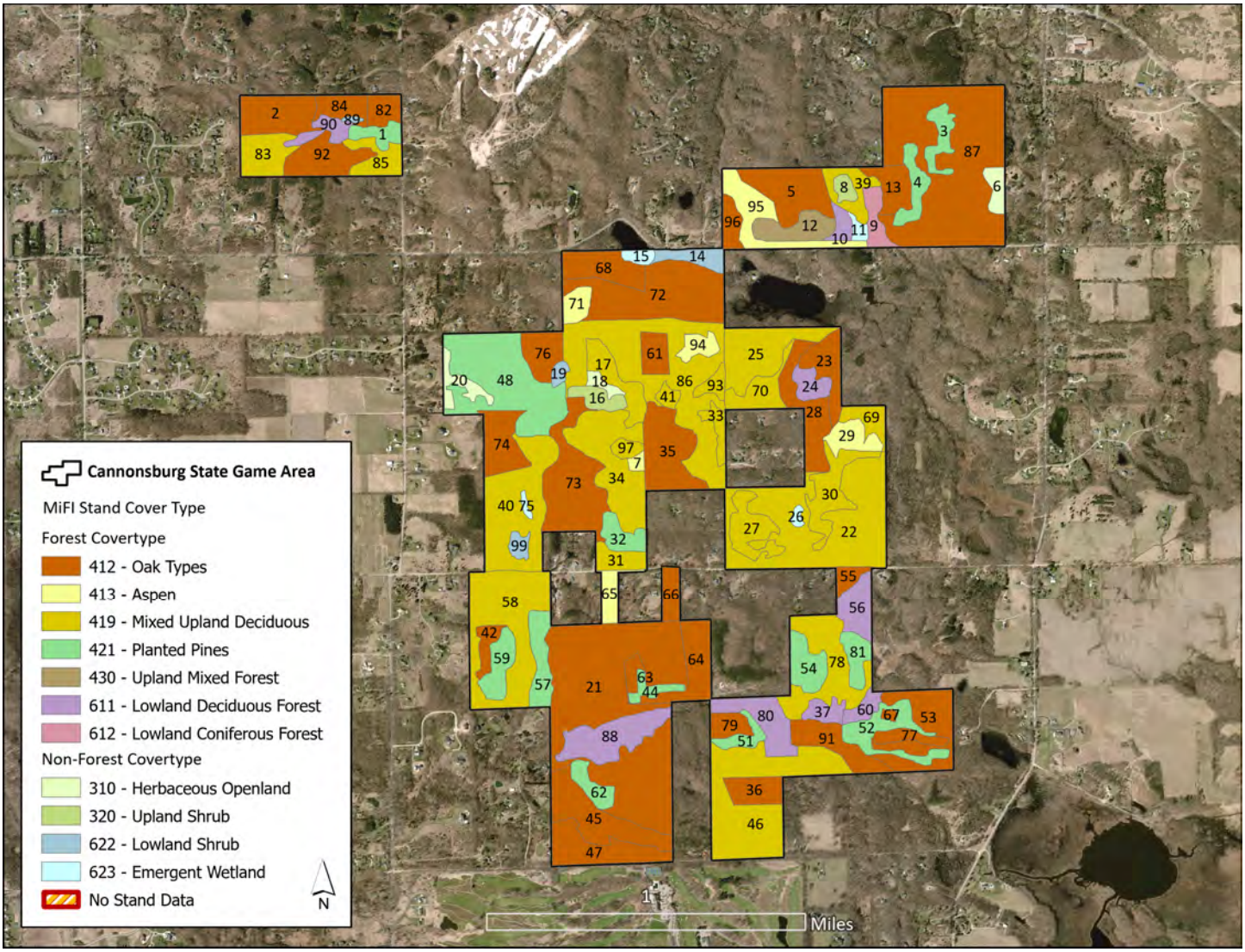


Figure 5. Michigan Forest Inventory (MiFI) stand data for Cannonsburg State Game Area.


Cannonsburg Woods dry southern forest; this image shows the black oak and white oak dominanted canopy. Photo by Aaron Kortenhoven.

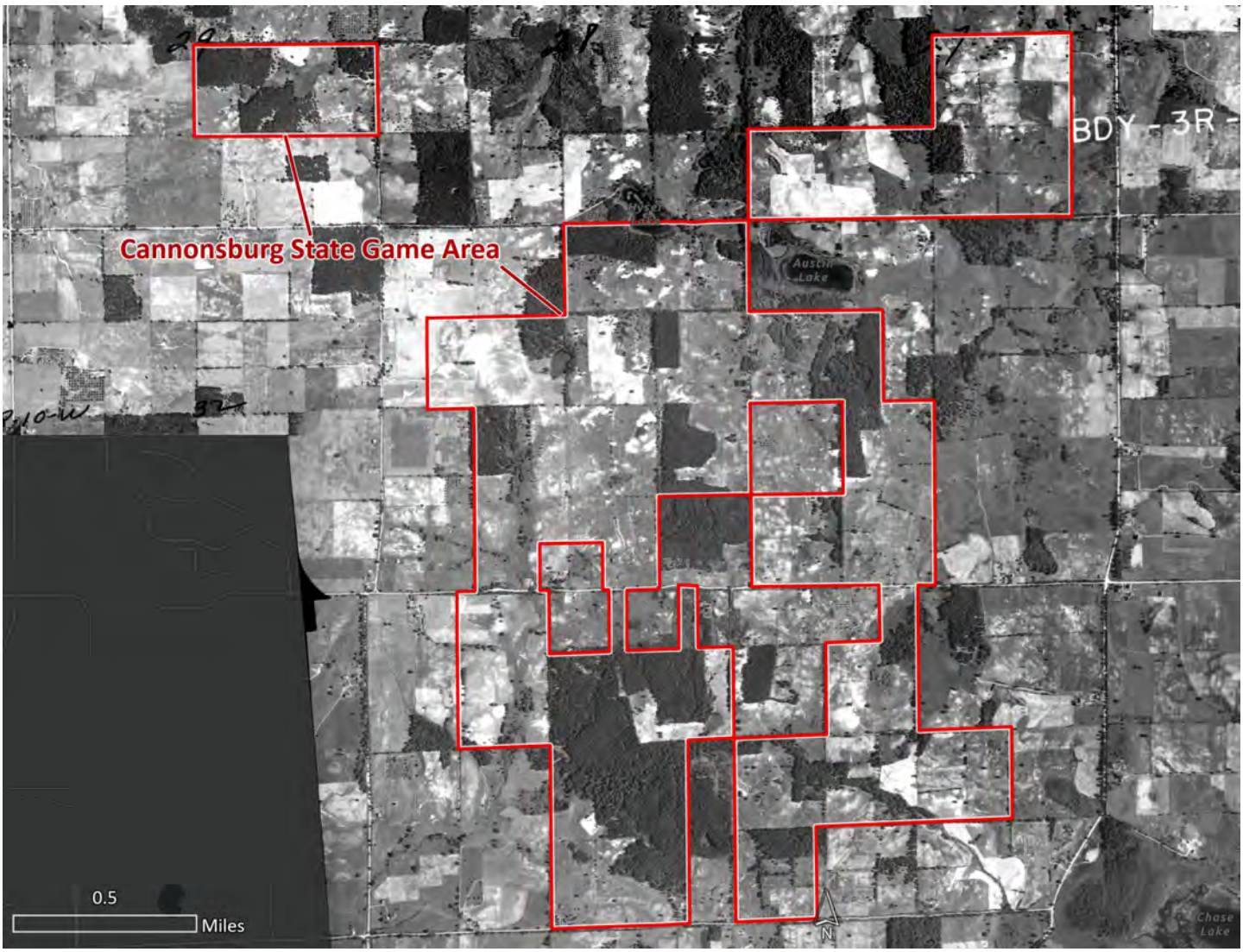


Figure 6. Mosaic of 1938 aerial photographs of Cannonsburg State Game Area. These images can inform managers on where high-quality forest occur. Areas that were forested in the picture (typically the darker hues) are often dominated by native vegetation, harbor old trees, and contain low levels of invasive species. These areas generally have the highest conservation value for native biodiversity.

Fire suppression in the Cannonsburg Woods has resulted in the prevalence of red maple in the forest understory. Photo by Aaron Kortenhoven.

METHODS

Throughout this report, natural community types and rare species are referred to as "elements" and their documented occurrences at specific locations 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 informed by areas identified during MiFI surveys. The combination of MiFI surveys, targeted natural community surveys and rare species surveys helped formulate management recommendations.

Target species for rare animal surveys were identified using their historical distribution in Michigan, past records in Cannonsburg SGA and vicinity, and the presence of habitat as determined by MiFI. Based on these criteria, rare animal surveys focused on herptiles, snails and mussels, several insect groups, raptors, and forest songbirds. Surveys for target animal species were conducted in the appropriate habitats during time periods when targeted species were 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 maintained by native land tending practices including cultural fire, wildlife harvest, 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: size, landscape context, and condition (Faber-Langendoen et al. 2015). If a site meets defined requirements for these three criteria (MNFI 1988), it is categorized as a high-quality example of that specific natural community type, entered into MNFI's database as an EO, and given a rank from A to D, based on how well it meets the above criteria. MNFI ecologists 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 Cannonsburg SGA were implemented during the growing season of 2023.

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

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
- taking photos and corresponding GPS points at representive 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

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

Floristic data from the natural community surveys were compiled and we used the Universal Floristic Quality (FQA) Assessment Calculator (Reznicek et al. 2014, Freyman et al. 2016) to calculate the Floristic Quality Index (FQI) for each natural community EO within the game area. The FQI is a 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 a 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:

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 have sufficient conservatism and species richness that they are considered floristically diverse areas in the state (Herman et al. 2001). FQI scores greater than 50 are considered exceptionally diverse sites with 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 (Appendix I; 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 measure of evaluating the success of management. Species lists and FQI for each natural community EO are provided in Appendix I.

Rare Amphibian and Reptile Surveys

Surveys for rare amphibian and reptile species in Cannonsburg SGA in 2023 focused on both previously documented species and new occurrences of rare species. We determined which species to survey for based on available habitat and known range of these species. We targeted: Blanchard's cricket frog (*Acris blanchardi,* State Threatened), Fowler's toad (*Anaxyrus fowleri*, State Special Concern), pickerel frog (*Lithobates palustris*, State Special Concern), Blanding's turtle (*Emydoidea blandingii*, State Special Concern), eastern box turtle (*Terrapene carolina carolina*, State Threatened), and gray rat snake (*Pantherophis spiloides*, State Special Concern). In addition to being rare, these species have been identified as Species of Greatest Conservation Need (SGCN) in Michigan's Wildlife Action Plan (Derosier et al. 2015). Surveys also had potential for detecting additional rare amphibian and reptile species or SGCN. These included the smooth green snake (*Opheodrys vernalis*, State Special Concern), blue racer (*Coluber constrictor foxii*), northern ribbon snake (*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 the game area from other MNFI surveys conducted in the game area and other external sources (MDNR staff, MNFI Rare Species Form, and Michigan Herp Atlas).

Visual encounter, aquatic funnel trapping, and auditory surveys were conducted in areas with suitable habitat for the target species (Figure 7). Surveys were conducted from July 8 to October 28 during active seasons using standard methods for surveying amphibians and reptiles (Campbell and Christman 1982). Visual encounter surveys were conducted within open wetlands and waterbodies, vernal pools, adjacent open uplands, and upland and lowland forest stands (Figure 7). Surveys consisted of

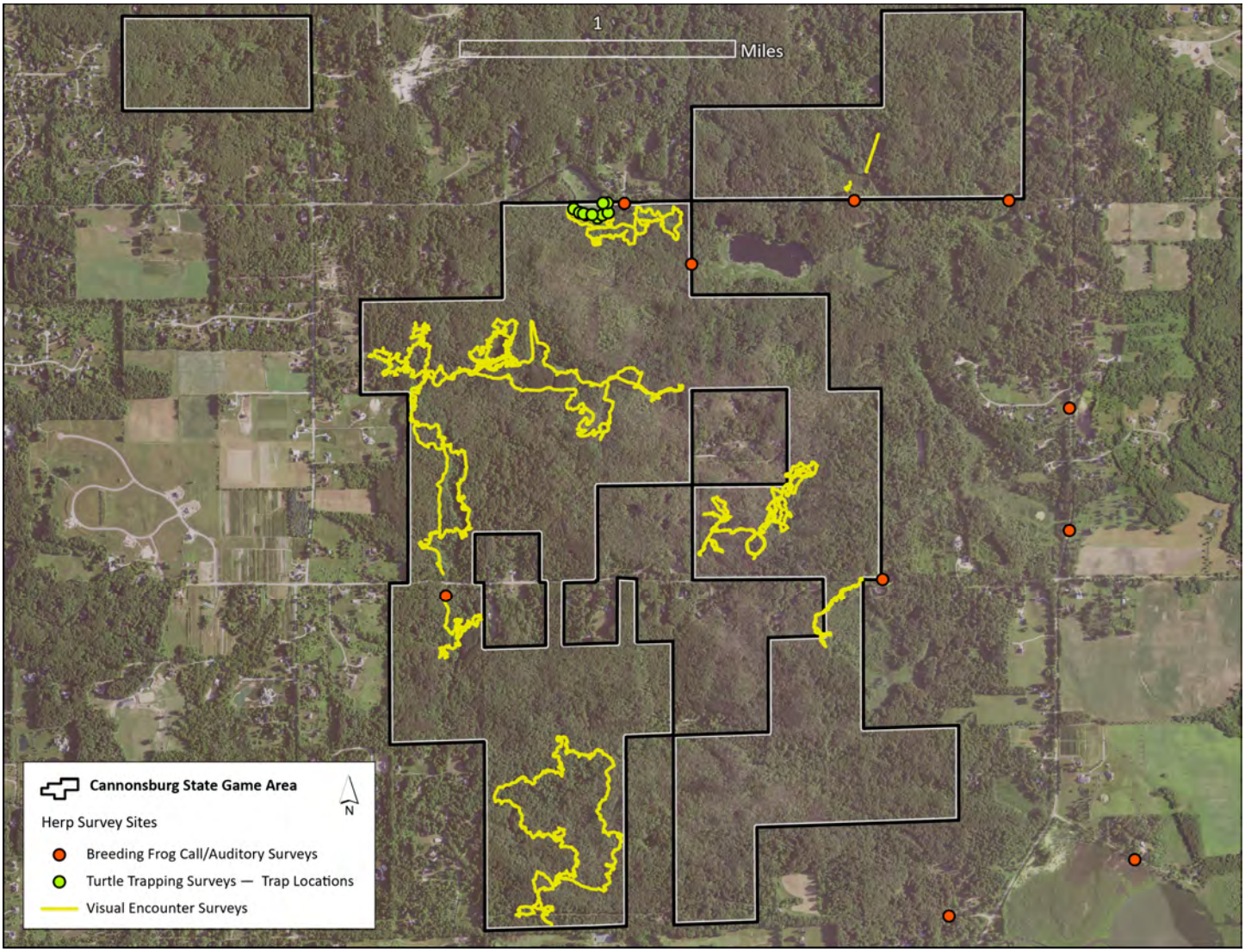


Figure 7. Location of amphibian and reptiles surveys in Cannonsburg State Game Area

Herptile survey site at Hyser Lake in Cannonsburg SGA. Photo by Yu Man Lee.

walking slowly through suitable habitat for target species, overturning cover objects (e.g., logs/woody debris, rocks, etc.), inspecting retreats, and looking for basking, resting, and active individuals on the surface or under cover objects. Visual surveys were conducted under appropriate weather conditions when target species were expected to be active and visible (between 16-27^{o}C, wind less than 20 kph, no or light precipitation).

We used aquatic funnel traps to capture turtles to document presence, abundance and demographics of Blanding's turtles in the Cannonsburg SGA. These surveys consisted of deploying nine Promar minnow traps within suitable habitat over four consecutive nights from August 12 through 16. These surveys followed a standard monitoring protocol for Blanding's turtles (Willey and Jones 2014, American Turtle Observatory 2017, Cross et al. 2023). All species of captured turtles were measured, weighed, sexed, aged, photographed, and examined for general health condition, injuries, and abnormal shell characteristics. Other herptile species and animal species captured in the traps were recorded. Traps were checked every day and captured animals were released after processing.

Breeding frog call surveys for the Blanchard's cricket frog were conducted between 17:30 and 01:00 EDT at six wetland sites within Cannonsburg SGA and four sites adjacent to the game area on July 8 (Figure 7). 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 an 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 tablet. We documented all amphibians and herptile during surveys. The species, number of individuals, age class, location, general habitat, behavior, and time of observation were noted. Weather conditions and survey times were recorded. When possible, we took photos of species for documentation. All rare species observations were entered into the Michigan Natural Heritage Database.

Rare Snail and Mussel Surveys

Watercress Snail Surveys

Watercress snail (*Fontigens nickliniana*) is a species of Special Concern in Michigan, however, its status in the state is not well known. There has been relatively little documented survey effort for watercress snail in Michigan in recent decades. Watercress snail occurrences within Michigan are concentrated in the southwest part of the Lower Peninsula, especially in the Grand Rapids and Kalamazoo area, south to the Indiana boarder. Several occurrences are scattered across other parts of the Lower Peninsula (MNFI Natural Heritage Database 2024).

Watercress snails are found in springs and spring-fed headwater streams. The snails have a strong association with the plant watercress (*Nasturtium officinale*). They are often seen on the stems and leaves of watercress, and immediately adjacent at the water's edge where the plant grows. They can be found in isolated springs, springs within shaded riparian zones along the banks of larger streams, and rivers and around small lakes, as well as the edges of small spring-fed headwater streams (Berry 1943). The watercress snail's specific habitat requirements and small size make it likely to be overlooked during surveys following typical methodologies for aquatic and terrestrial snails. For this reason, surveys targeting its particular habitat type, and snails of small size are needed to efficiently detect the species.

MNFI searched for potential watercress snail habitat along Egypt Creek, the North Branch of Egypt Creek, and two small tributaries of Bear Creek (Figure 8). Areas with watercress plants were targeted for watercress snail surveys. Visual searches for the snails were conducted on the stems and leaves of watercress plants and within the shallow wet areas around the plants. Due to the small size of watercress snails (2-3 mm in length) and difficulty in confirming identifications without magnification, live individuals and shells of small-sized snails appearing to be watercress snail were placed in a labeled bottle or polyethylene bag with ethanol to be later identified in the lab. 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 handheld GPS units. Snails were identified to species in the lab under 7x to 63x magnification using shell characters.

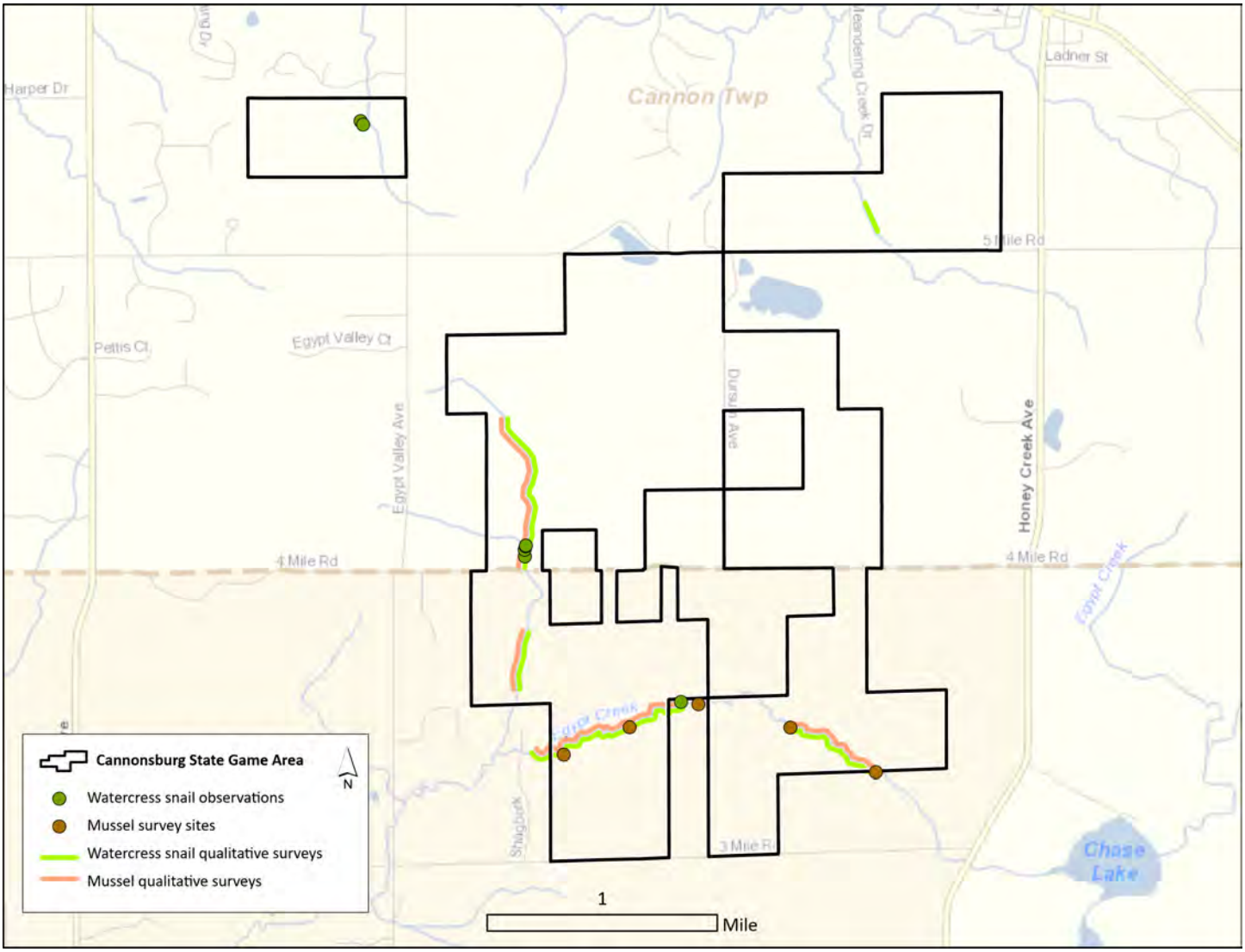


Figure 8. Locations of aquatic survey sites in Cannonsburg State Game Area.

Table 1. Locations of snail and mussel survey sites within Cannonsburg State Game Area.

Site	Waterbody	Access	Latitude (N)	Longitude (W)	Search Area (m^2)
1	Egypt Creek	Trailhead off 3 Mile Rd.	43.019824	-85.500376	130
2	"	"	43.021086	-85.496235	175
3	"	"	43.022141	-85.491915	133
4	"	"	43.021068	-85.486140	77
5	"	"	43.019024	-85.480768	128

Mussel Surveys

Cannonsburg SGA is just 4 km in river distance upstream of the lower Grand River, a system that supports several state listed and one federally listed mussel species and is one of the most species rich mussel communities in Michigan. Though medium to large rivers generally support the highest species richness in native unionid mussels, some species are commonly found in small headwater streams, such as Egypt Creek. These include the state threatened slippershell (*Alasmidonta viridis*) and Special Concern creek heelsplitter (*Lasmigona compressa*). Unionid mussels were chosen as a survey target because of the potential for new occurrences of these and other mussel species.

Stream habitat was surveyed for live unionid mussels and shells with a combination of visual and tactile means at each mussel survey site. 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. The search area at each mussel survey site was measured to standardize sampling effort among sites and allow estimates of mussel densities to be made. When live individuals were found they 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. 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. In addition to intensively searching discrete sites for mussels, longer reaches of Egypt Creek and the North Branch of Egypt Creek were waded and searched qualitatively for mussels (Figure 8).

Latitude and longitude of each survey site was recorded with a handheld Garmin GPS unit. 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. 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 described in Hynes 1970. 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 speed were estimated visually.

Rare Insect Surveys

Tamarack Tree Cricket

Surveys for tamarack tree cricket (*Oecanthus laricis*, State Special Concern) were completed in August, 2023 in a large tamarack swamp complex north of 5 Mile Road in Stands 9, 10, and 11 (Figure 9). Meander surveys were conducted throughout the suitable habitat. When a tamarack tree was encountered along the transect, we used a sweep net with a 4ft 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. A total of 42 tamarack trees were sampled for tamarack tree cricket at Cannonsburg SGA in 2023.

Karner Blue and Frosted Butterflies

Karner blue butterfly (*Plebejus samuelis,* State Endangered) and frosted elfin butterfly (*Callophrys irus,* State Threatened) are two species of butterflies associated with intact patches of wild lupine (*Lupinus perennis*) in oak barrens, oak openings, and oak-pine barrens in Michigan. For both species, eggs are deposited directly on wild lupine, and this plant serves as the exclusive larval host plant during larval development. Frosted elfin is univoltine (a single brood of offspring per year) and experiences the adult life stage from early May to June. Karner blue butterfly experiences two broods, resulting in adult flight from mid-May to mid-June and again from mid-July to mid-August.

Prior to this project, Cannonsburg SGA contained a single EO for frosted elfin (EO ID 6606) and no documentation of Karner blue butterfly. The population of frosted elfin at Cannonsburg SGA was first documented during surveys in 2002 and last documented in 2003. During both surveys populations of the species were presumed to be small, and the entire EO is represented by four butterflies. In 2003, the EO habitat was described as a cluster of several large, dense pockets of wild lupine that occurred in the forest openings and among the hardwood sub-canopy. In 2023, surveys for Karner blue butterfly and frosted elfin were conducted within the historic EO and adjacent habitats to determine if either species was present.

Surveys sites for Karner blue and frosted elfin butterflies were determined by an initial phase of habitat assessment, during which surveyors visited potential survey locations and assessed the quality of the habitat (i.e. wild lupine presence). The full EO for frosted elfin as well as a secondary location where the habitat showed potential (Stand 77) were assessed during this initial stage. Timed meander surveys were implemented at two primary

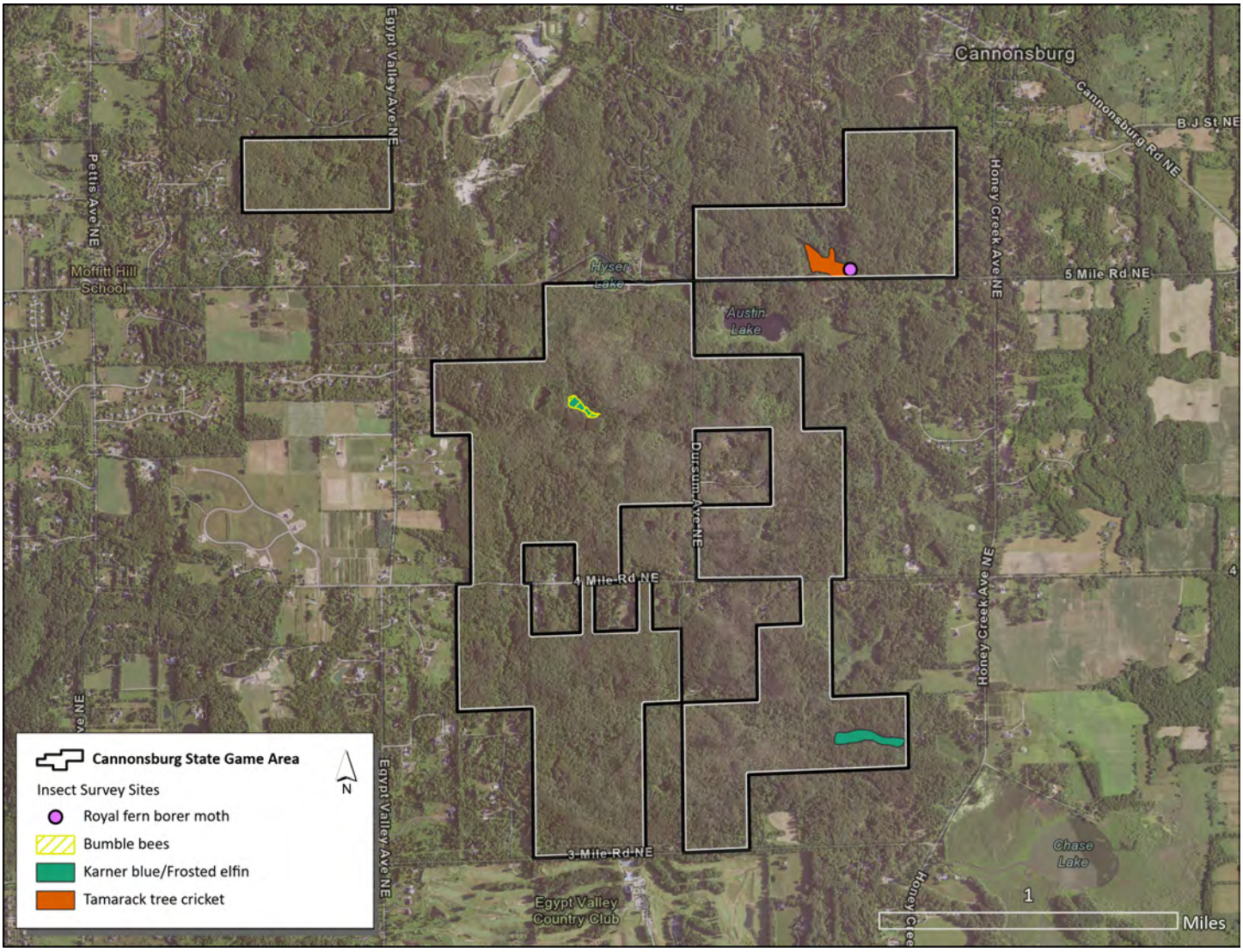


Figure 9. Locations of insect surveys in Cannonsburg State Game Area.


Survey site for Karner blue and frosted elfin butterflies. Photo by Ashley Cole-Wick.

locations (Location 1: Stand 17 and Stand 18, Location 2: stand 77, Figure 9). During each survey event, all butterfly species were recorded along survey transects. Karner blue and frosted elfin were surveyed on May 15th and 16th, 2023, and again on July 20th, 2023, to target the second brood adults.

Rare Bumble Bees

There are four state listed species of bumble bees which have current statewide distributions that overlap with Cannonsburg SGA. These include black and gold bumble bee (*Bombus auricomus*, State Special Concern), yellow bumble bee (*B. fervidus*, State Special Concern), American bumble bee (*B. pensylvanicus*, State Endangered), and Sanderson's bumble bee (*B. sandersoni*, State Special Concern). A fifth species, rusty patched bumble bee (*B. affinis*, State Endangered), hasn't been observed in Michigan since 1999, but historically would have occurred in Cannonsburg SGA. Each of these species inhabits areas with abundant floral resources and dense ground cover, which are necessary for forage and overwintering, respectively.

Royal fern (*Osmunda regalis*) at the survey site for royal fern borer moth. Photo by Logan Rowe.

We conducted standardized meander surveys for bumble bees. These surveys took place in Stand 18 on July 20th, 2023. The surveys consisted of a two-hour meander with aerial netting in an open field dominated by wildflowers and grasses in a mosaic of forest. The survey site was selected for its abundant floral resources, proximity to forest and wetlands, and the previously documented occurrences of state listed insect species (i.e., frosted elfin). During the survey, any bumble bee observed was collected, placed in a vial with the associated floral species, and stored until the end of the survey. After the survey, each bumble bee was identified to species. If a specimen was not accurately identified in the field we processed in the lab.

Royal Fern Borer Moth

The royal fern borer moth (*Papaipema speciossima*, State Special Concern) is restricted to the southern half of Michigan's Lower Peninsula and inhabits swamp forests but is occasionally found in several natural communities supporting royal fern (*Osmunda regalis*) and cinnamon fern (*Osmundastrum cinnamomeum*). The larval hosts are royal and cinnamon fern, and the larvae bore into the roots of these ferns during development. Given the limited presence if its host plant, only a single location was selected at Cannonsburg SGA for a royal fern borer moth surveys in 2023.

We conducted surveys along the western edge of Stand 9 on October 5th, 2023 (Figure 9) using standardized

Black lighting setup used during royal fern moth surveys. Photo by Logan Rowe.

methodology developed by MNFI to document the moth communities. During moth surveys in 2023 we collected data on abundance and *Papaipema* diversity at each survey site. We also collected associated environmental and weather data. We used blacklighting for moth surveys which consisted of standard mercury-vapor and UV lights powered by a portable generator. A large white sheet was used as a collecting surface. We placed the frame in a central location with royal fern on all sides to maximize the likelihood of collecting adults. We carried out surveys between the hours of 19:00 and 12:30 EDT.

Rare Bird Surveys

Given the presence of mature forest and results of previous surveys, we focused bird surveys in the game area on raptors and rare forest songbirds. Rare raptor surveys targeted red-shouldered hawk (*Buteo lineatus*, State Threatened), which is also DNR featured species. Rare songbird surveys targeted cerulean warbler (*Setophaga cerulea*, State Threatened), hooded warbler (*Setophaga citrina*, State Special Concern), and Louisiana waterthrush (*Parkesia motacilla*, State Threatened).

Forest stands covering at least 4 hectares (10 acres) were considered potential habitat for target species. 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 standsm, or farmstead forests. In addition to surveying for rare raptors and songbirds, point-count sampling was used to gather baseline information about the forest bird community, including relative avian abundance and species richness.

We conducted two-minute raptor surveys at systematically located point count stations (Figure 10; 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 between March 27 and May 1, 2023. 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 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 songbird point counts were conducted at the same systematically located points used for raptor surveys (Figure 10). 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 May 24 to June 1, 2023, from sunrise to 6 hours after sunrise, or until weather condition made it unlikely to detect birds. 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 warbler, hooded warbler, and Louisiana waterthrush.

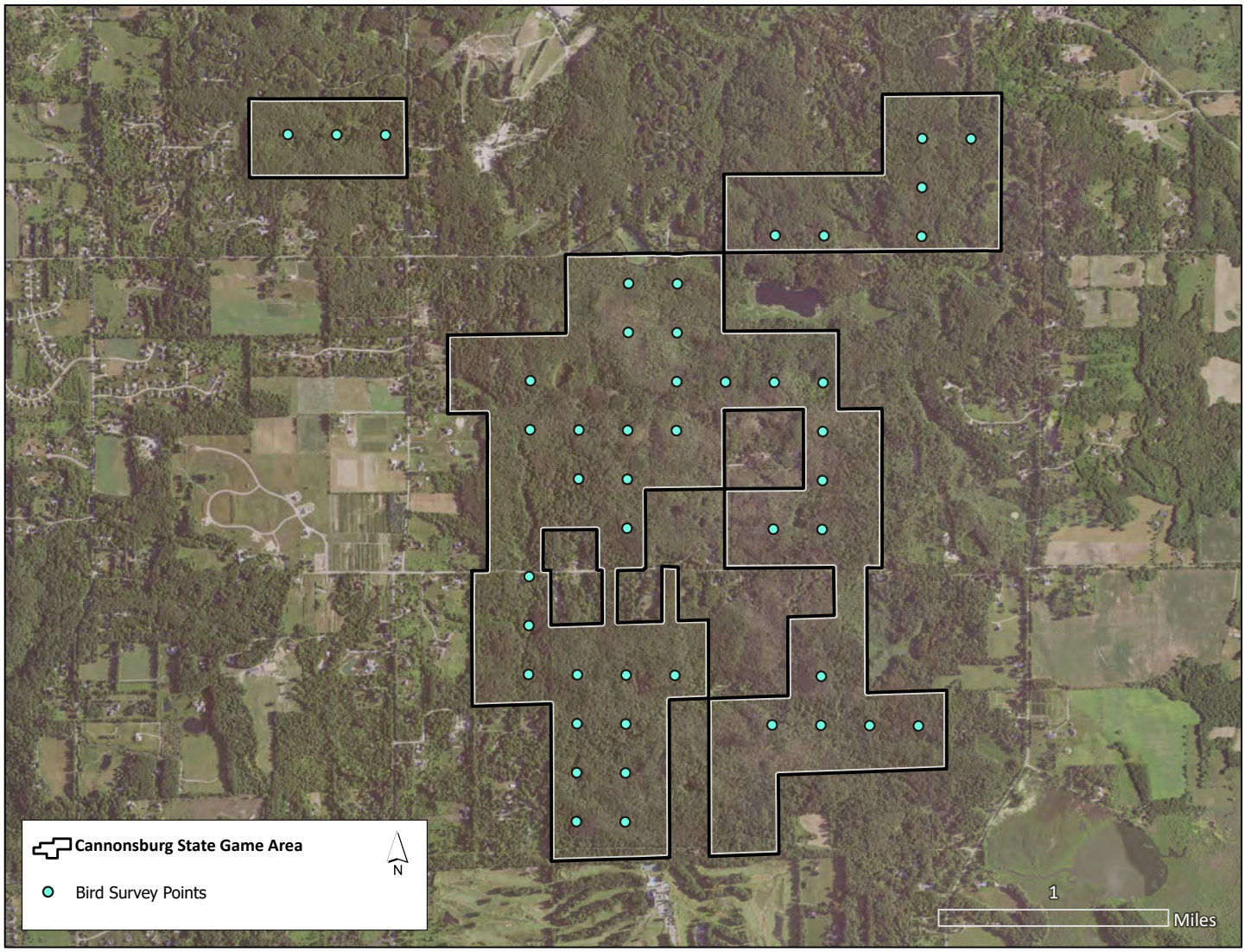


Figure 10. Location of songbird and raptor surveys.


Hooded warbler recorded at Cannonsburg SGA. Photo by Aaron Kortenhoven.

RESULTS

We recorded nine new elements occurrences: three natural community EOs, three snail EOs, two herptile EOs, and one bird EO. In addition, we updated one herptile EO and one bird EO. Data compiled on these EOs were entered into MNFI's Natural Heritage Database (MNFI 2024).

Natural Community Results

MNFI ecologists documented three new high-quality natural communities in the Cannonsburg SGA that included two dry southern forest EOs and one southern hardwood swamp EO (Table 2, Figure 11). These high-quality natural communities cover 113.1 acres of the game area. The following site summaries contain a detailed discussion for each of the three natural community EOs.

Table 2. Natural community element occurrences for Cannonsburg Game Area. All natural community EOs documented in Cannonsburg SGA were new and recorded during the Integrated Inventory surveys.

Site Name	EO ID	Rank	Size (Ac)	First Visit	Last Visit	Stands
Dry Southern Forest						
Cannonsburg Woods	27076	C	13.7	2023	2023	2
Dursum Woods	27077	CD	84.1	2023	2023	21
Southern Hardwood Swamp						
Egypt Creek Swamp	27079	C	15.3	2023	2023	88

Cannonsburg Woods Dry Southern Forest Element Ocurrence. Photo by Jesse Lincoln.

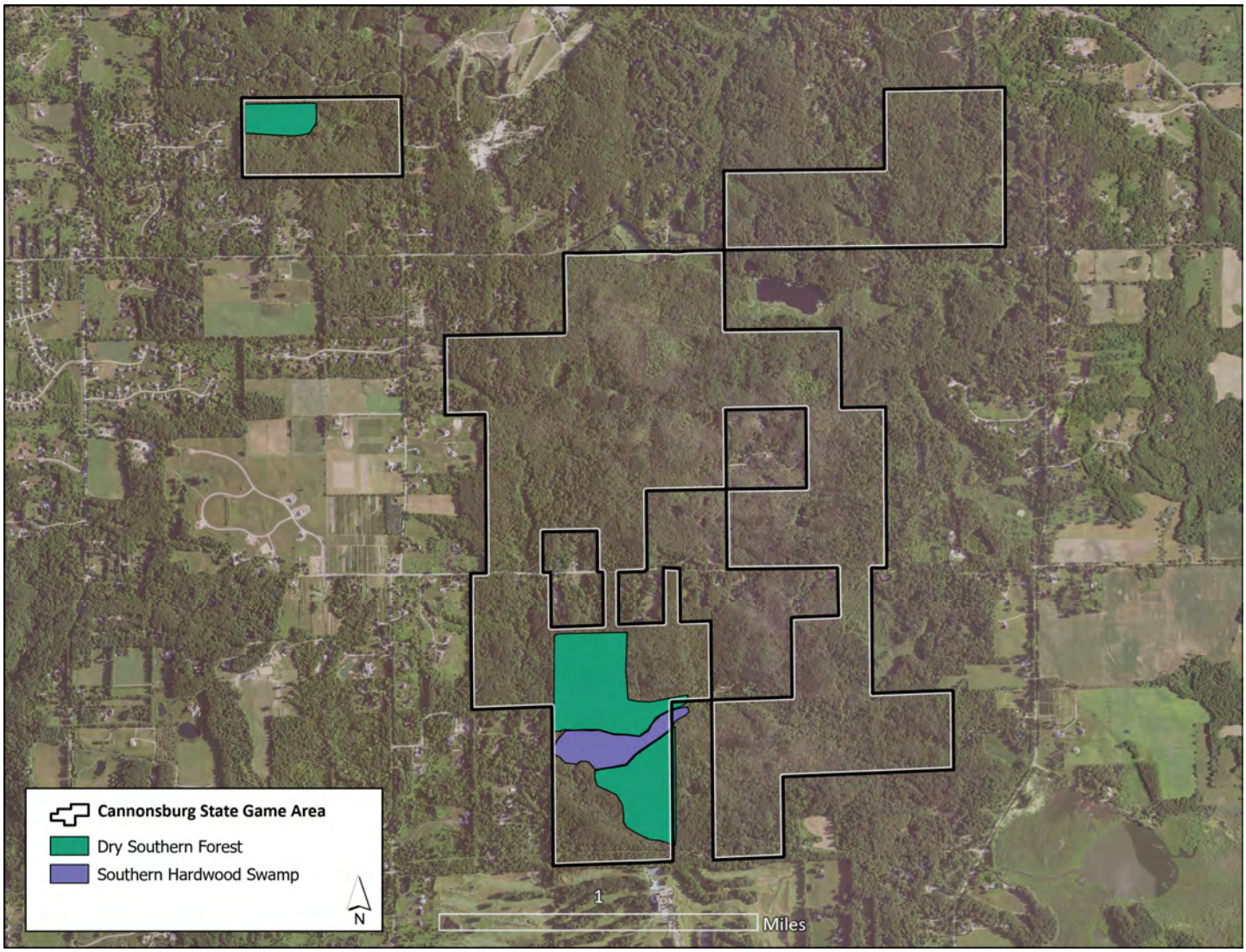


Figure 11. Natural Community Element Occurences in Cannonsburg State Game Area


Dursum Woods Dry Southern Forest Element Ocurrence. Photo by Jesse Lincoln.

1. Cannonsburg Woods
Natural Community Type: Dry Southern Forest
Rank: G4 S3, apparently secure globally and vulnerable within the state
Element Occurrence Rank: CD
Size: 13.7 acres
Location: Compartment 1; Stand 2
Element Occurrence Identification Number: 27076 (New)

Cannonsburg Woods is a maturing second-growth oak forest that occurs on steep moraine (Figure 12). Soils are generally covered with thick oak litter to approximately 2 cm depth. The top layer of soil consists of slightly acidic (pH 6.0) medium-textured sands with dark organics to a depth of 3 cm over fine sand with organics (pH 6.0-5.5) to a depth of about approximately 8 cm.

This is a mature black oak (*Quercus velutina*) and white oak (*Quercus able*) dominated, closed-canopy, second-growth forest (85-90% coverage). Many white oaks with branch scars indicate that they were open grown when they were established and have been fire suppressed for the past several decades. The forest was likely cleared historically, and a few trees remained which are now the oldest in the canopy. It appears to have been untilled and probably minimally grazed. Historically fire was a widespread disturbance on the landscape. Recently the stand has been strongly influenced by deer herbivory.

The canopy is approximately 56% black oak, 40% white oak, 2% red oak (*Quercus rubra*), and 2% pignut hickory (*Carya glabra*). Red oak distribution within the stand is limited to north-facing slopes. Red maple (*Acer rubrum*) is present but less than 2% of canopy. Tree diameters typically range from 50 to 80 cm and documented tree ages ranged between 110 and 200 years old. A 51.3 cm DBH white oak had 220 rings observed (in 2023). A 72.6 cm DBH white oak had 196 rings in 2023. We cored two black oaks in 2023; one was 74.7 cm DBH with 144 rings and the other was 50.3 cm DBH with 106 rings. Most trees are less than 200 years old and likely established after clearing in the 1840s when the municipality of Cannonsburg was founded.

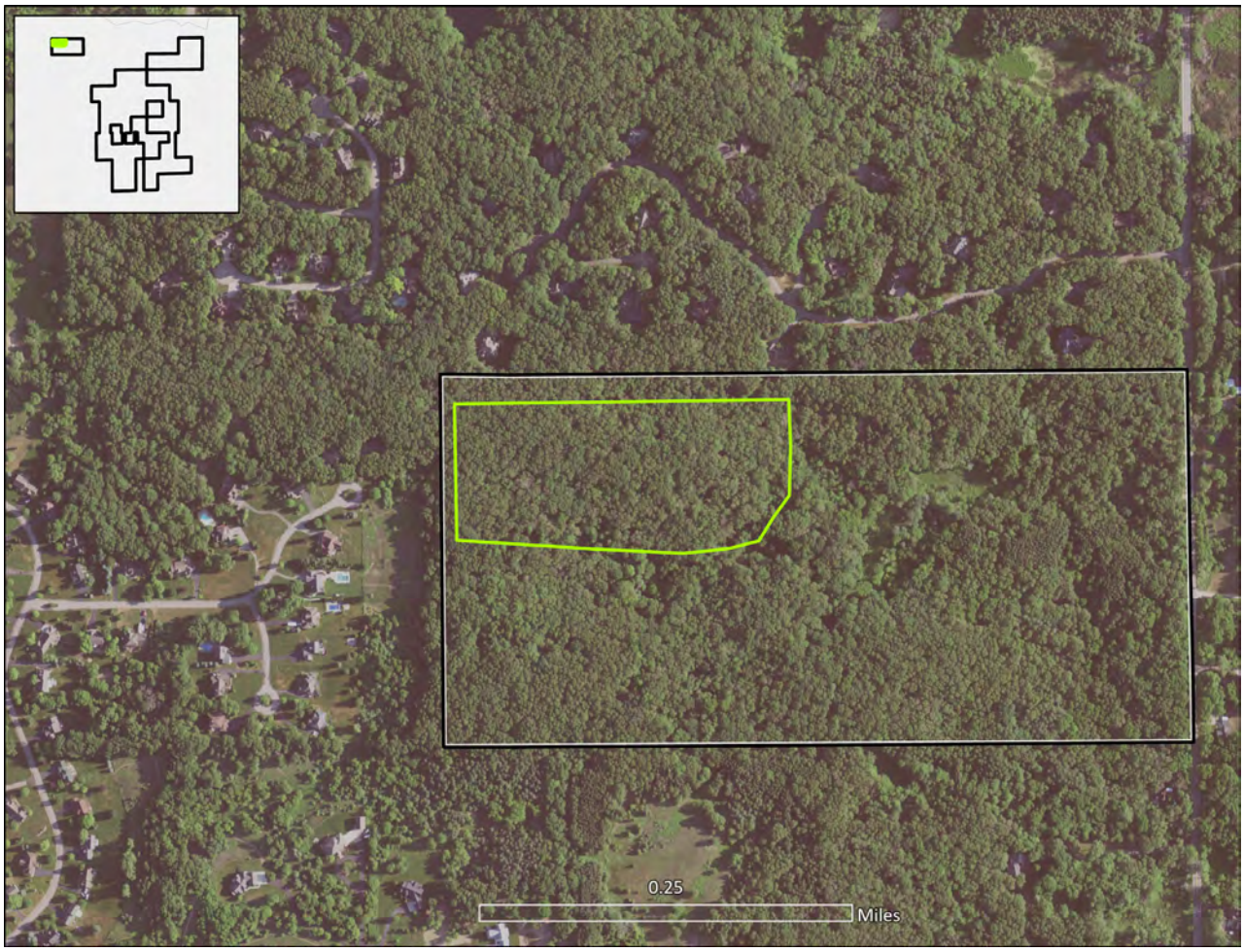
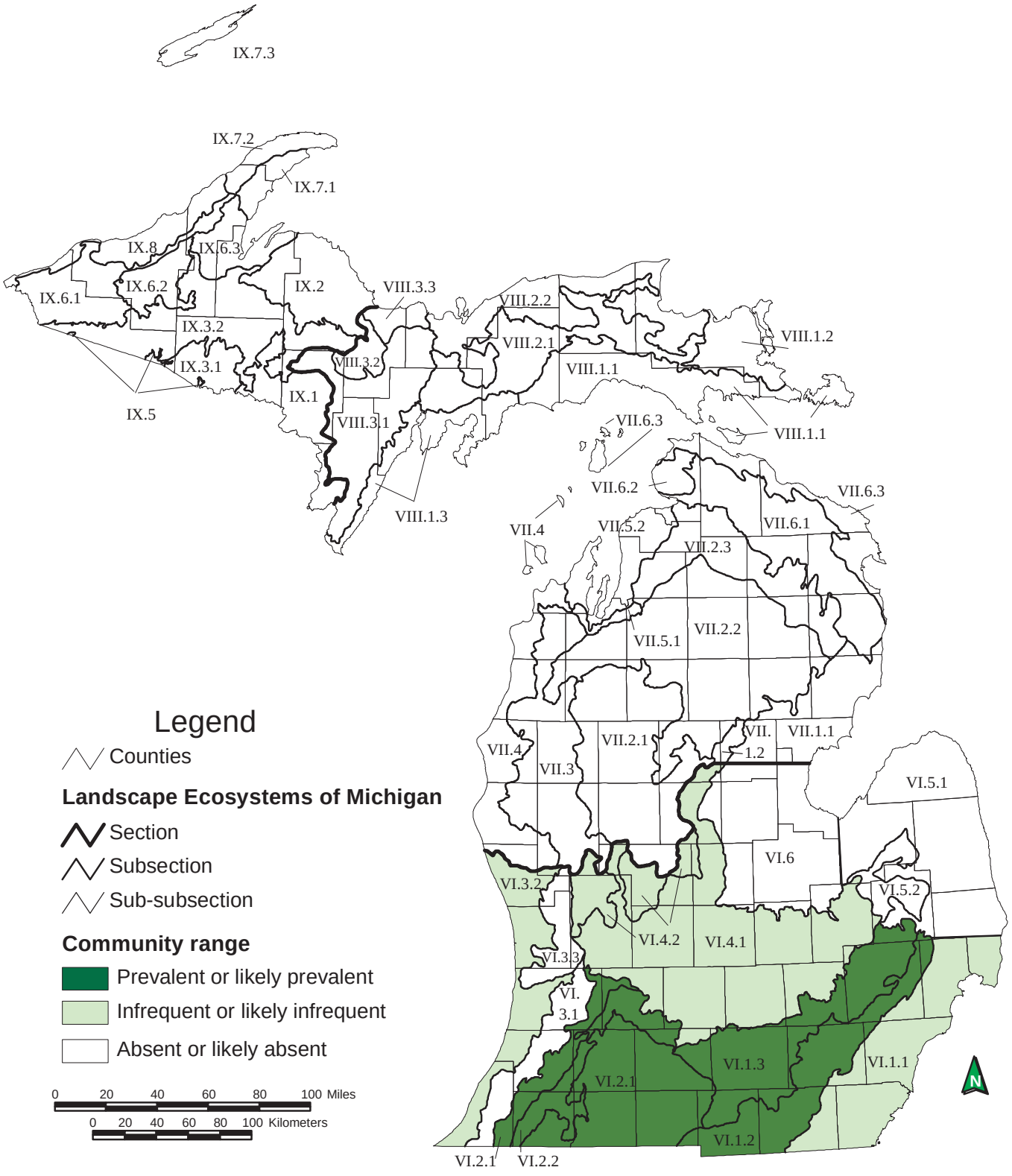


Figure 12. Location of Cannonsburg Woods Dry Southern Forest.



MICHIGAN STATE UNIVERSITY EXTENSION

Michigan Natural Features Inventory

Dry Southern Forest

Albert, D.A., J.G. Cohen, M.A. Kost, B.S. Slaughter, and H.D. Enander. 2008. Distribution Maps of Michigan's Natural Communities. Michigan Natural Features Inventory, Report No. 2008-01, Lansing, MI. 166 pp.

Figure 13. Statewide distribution of Dry Southern Forest.

The subcanopy is dense (65 to 75% coverage) and dominated by red maple with scattered sassafras (*Sassafras albidum*), white oak, ironwood (*Ostrya virginiana*), juneberry (*Amelanchier arborea*), and pignut hickory.

The understory is dominated by red maple with scattered sassafras, white oak, and ironwood. The tall shrub layer (5 to 10%) has black cherry (*Prunus serotina*), autumn olive (*Elaeagnus umbellata*), red maple, white oak, sassafras, juneberry, maple leaf viburnum (*Viburnum acerifolium*), and hazelnut (*Corylus americana*). Witch-hazel (*Hamamelis virginiana*) is more abundant along the north-facing slopes.

The low shrub layer is patchy with locally dense areas (5 to 50% coverage). Common shrubs in the low shrub layer include maple leaf viburnum, huckleberry (*Gaylussacia baccata*), autumn olive, and American hazelnut (*Corlyus americana*). Huckleberry is dense at the top of the slopes and on south-facing slopes.

Other native shrubs include wild gooseberry (*Ribes cynosbati*), pasture rose (*Rosa Carolina*), downy arrow-wood (*Viburnum rafinesquianum*), and low sweet blueberry (*Vaccinium angustifolium*). Oak, hickory, sassafras, and maple seedlings are also prevalent in the low shrub layer. Autumn olive is common, while multiflora rose (*Rosa multiflora*) and Japanese barberry (*Berberis thumbergii*) are infrequent. Witch hazel is more abundant along the north-facing slopes.

The ground layer is patchy to abundant (5 to 60%) and is dominated by *Carex pensylvanica*. Nodding fescue (*Festuca subverticillata; f. obtuse*) and Kentucky bluegrass (*Poa pratensis*) are infrequent. Forbs are infrequent, which is likely due to fire suppression, interception of light by red maple, and overabundance of deer. Additional ground cover species include bluestem golden rod (*Solidago caesia*), naked tick-trefoil (*Hylodesmum nudiflorum*), old-field cinquefoil (*Potentilla simplex*), white wild licorice (*Galium circaezans*), northern bedstraw (*Galium boreale*), round-lobed hepatica (*Hepatica americana*), bracken fern (*Pteridium aquilinum*), white avens (*Geum canadense*), big-leaved aster (*Eurybia macrophylla*), spotted wintergreen (*Chimaphila maculata*), Canada mayflower (*Maianthemum canadense*), Canada brome (*Bromus pubescens*), and pokeweed (*Phytolacca americana*).

Invasive species occur sporadically throughout the stand with a few dense pockets along the stand boundaries where invasive species occur at higher densities in adjacent stands. We recorded multiflora rose, autumn olive, garlic mustard marrow honeysuckle and invasive bittersweet, Kentucky bluegrass, garlic mustard (*Alliaria petiolata*) morrow honeysuckle (*Lonicera morrowii*) Japanese barberry, and common buckthorn (*Rhamnus cathartica*). Autumn olive was the most abundant invasive species in this stand.

Threats and Management Recommendations

Without recurrent fire on the landscape many oak-dominant forests will become dominated by less fire-tolerant tree species (Nowacki and Abrams 2008). Fire suppression in Cannonsburg Woods has led to a dominance of red maple in the understory and an overall decline in fire-tolerant native vegetation. Lee and Kost (2008) found a negative relationship between oak regeneration and overstory

Cannonsburg Woods Dry Southern Forest Element Ocurrence. Photo by Jesse Lincoln.

shading by red maples in Southern Michigan. This same research found an apparent negative relationship between deer abundance and oak regeneration. Our qualitative assessment of Cannonsburg Woods would indicate that abundance of red maple, invasive shrubs, and deer are impacting oak regeneration in this forest.

Repeated fires may express fire-dependent species and help oak regeneration. We suggest a fire return interval of 3 to 5 years, with initial burns being low intensity late season burns. Regular assessments of how burns promote oak regeneration and native species propagation should be conducted. Burn frequency should be informed by post burn assessments of native vegetation. If barrens species become prevalent, increasing burn frequency could be beneficial. Artificial fire lines should be avoided, and fires should be allowed to naturally extinguish along swamp margins of adjacent wetlands at the base of slopes.

Invasive species are locally abundant. Areas with invasive species should be treated before and after prescribed burns. We suggest focusing invasive species management on autumn olive, multiflora rose, and invasive bittersweet before burns take place.

Treating red maple ahead of burns will help make burns more effective in reducing oak leaf litter and help burns cover more area (Randy Heinze pers. comm.). Much of the red maple can be treated with basal bark applications of herbicide but larger trees will likely need “hack and squirt” treatment of herbicide. Treating red maple in the subcanopy will also help make canopy oak more resilient to drought conditions by reducing competitive pressures. A study examining the response of red maple to prescribed burning found that without additional treatment, red maple recruitment can increase after burns (Clark and Schweitzer 2009), thus highlighting the importance of pre-burn treatment.

There are bike trails throughout Canonsburg SGA. These bike trails are established in areas of the SGA with steep topography. The areas in the SGA with steep topography often harbor the highest quality forests because they were not as intensely farmed as flatter areas. Because these steeper areas had less anthropogenic disturbances, they have fewer invasive shrubs making them more appealing for bike trails. These trails are conduits for invasive species and cause erosion. Managers should prevent the establishment of bike trails within this and other quality forests in the SGA.

Heavily trafficked bike trail in Cannsonburg State Game Area. Throughout the SGA, bike trails are exposing tree roots and causing erosion. Photo by Aaron Kortenhoven.

2. Dursum Woods
Natural Community Type: Dry Southern Forest
Rank: G4 S3, apparently secure gobally vulnerable within the state
Element Occurrence Rank: CD
Size: 84.1 acres
Location: Compartment 1; Stand 21
Element Occurrence Identification Number: 27077 (New)

This maturing second-growth oak forest occurs on rolling moraines (Figure 14). Soils were generally covered with thick oak leaf litter to approximately 1 cm depth. The top layer of soil consists of slightly acidic (pH 6.0) coarse-textured sands with dark organics to a depth of 8 cm over coarse loamy sands (pH 5.5).

The canopy is approximately 62% black oak, 20% white oak, 6% red maple, 5% red oak, 4% pignut hickory, and 3% bigtooth aspen (*Populus grandidentata*). Black cherry is present but less than 2% of the canopy. Tree diameters range from 40 to 100 cm. Based on ring counts most trees were between 160 and 210 years old. A 70.1 cm DBH white oak had 208 rings observed (in 2023). A 73.7 cm DBH black oak had 168 rings. Based on these ring counts we extrapolated that most trees established after clearing in the 1840s when the municipality of Cannonsburg was founded.

Red maple, ironwood, and white oak make up 11 to 40% of the subcanopy with red maple being the most dominant at a density of approximately 40%. Species that comprise 2 to 10% of the understory include autumn olive, sassafras, flowering dogwood (*Cornus florida*), pignut hickory,

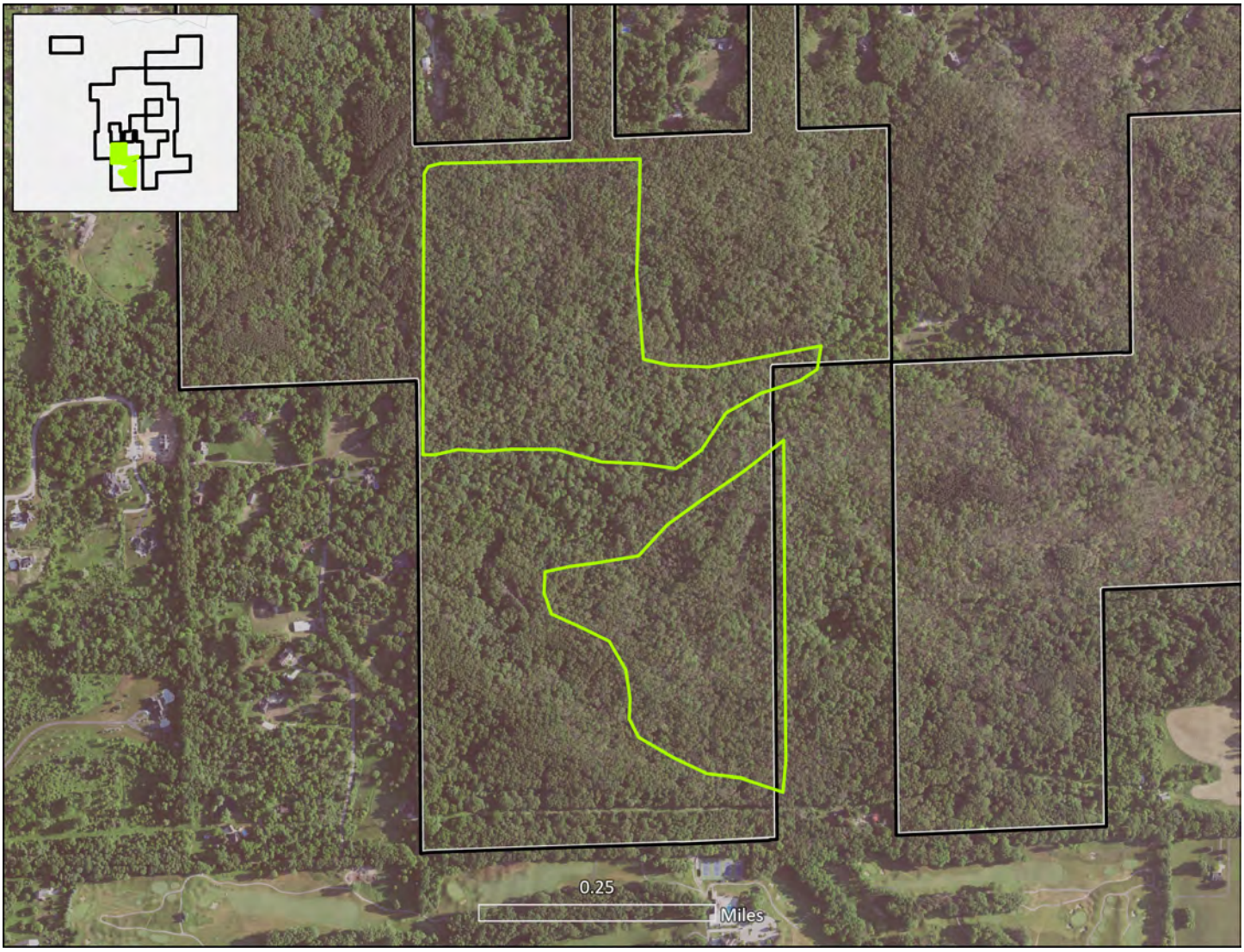


Figure 14. The location of Dursum Woods Dry Southern Forest.

black cherry, juneberry, witch hazel, autumn olive, and common blackberry (*Rubus allegheniensis*). Low ground cover is comprised of prickly gooseberry, huckleberry, low sweet blueberry, multiflora rose, black raspberry (*Rubus occidentalis*), Sassafrass, maple-leaf viburnum.

White pine (*Pinus strobus*), white ash (*Fraxinus americana*), dotted hawthorn (*Crataegus punctata*), choke cherry (*Prunus virginiana*), and Amur honeysuckle (*Lonicera maackii*) make up less than 2% of the shrub layer. Tall shrubs include witch hazel, autumn olive, and dotted hawthorn (*Crataegus punctata*). Low shrubs include common black berry (*Rubus allegheniensis*) prickly gooseberry, choke cherry (*Prunus virginiana*), huckleberry, low sweet blueberry, multiflora rose, black raspberry (*Rubus occidentalis*), sassafrass, and maple-leaf viburnum.

Common species in the herbaceous layer are Pennsylvania sedge (*Carex pensylvanica*), bracken fern, naked tick-trefoil (*Hylodesmum nudiflorum*), hog peanut (*Amphicarpaea bracteate*), downy Solomon seal (*Polygonatum pubescens*), wild sarsaparilla (*Aralia nudicaulis*), bluestem goldenrod (*Solidago caesia*), clustered-leaved tick-trefoil (*Hylodesmum glutinosum*), wild white licorice (*Galium circaezans*), yellow wild licorice (*Galium lanceolatum*), wild geranium (*Geranium maculatum*), big-leaved aster (*Eurybia macrophylla*), poverty grass (*Danthonia spicata*), American cancer-root (*Conopholis americana*), interrupted fern (*Osmunda claytoniana*), curly-styled wood sedge (*Carex rosea*), and broad-leaved panic grass (*Dichanthelium latifolium*).

Based on the presence of several barrens' species we recorded throughout this stand, it is likely that portions were historically barrens. We recorded the following barrens indicators: birdfoot violet (*Viola pedate*), sandcress (*Arabidopsis lyrate*), bastard-toadflax (*Comandra umbellate*), huckleberry (*Gaylussacia baccata*), pasture rose (*Rosa Carolina*), American vetch (*Vicia americana*), low sweet blueberry, and balsam ragwort (*Packera paupercula*).

Invasive species occur sporadically throughout the stand with a few dense pockets along the stand boundaries where invasive species occur at higher densities in adjacent stands. We recorded multiflora rose, autumn olive, garlic mustard, marrow honeysuckle, and invasive bittersweet.

Threats and Management Recommendations

Without recurrent fire on the landscape many oak-dominant forests will become dominated by less fire-tolerant tree species (Nowacki and Abrams 2008). Fire suppression in Cannonsburg Woods has led to a dominance of red maple in the understory and an overall decline in fire-tolerant native vegetation. Lee and Kost (2008) found a negative relationship between oak regeneration and overstory shading by red maples in Southern Michigan. This same research found an apparent negative relationship between deer abundance and oak regeneration. Our assessment of Dursum Woods would indicate that abundance of red maple and deer are impacting oak regeneration in this forest.

Repeated fires may express barrens species and help oak regeneration. We suggest a fire return interval of 3 to 5 years, with initial burns being low-intensity late-season burns (September/October). Regular assessments of how burns promote oak regeneration and native and barrens species propagation should be conducted. Burn frequency should be determined by post-burn assessments of native vegetation. If barrens species become prevalent, increasing burn frequency could be beneficial. Existing features such as trails and streams should be utilized as much as possible to avoid establishing new burn breaks in sensitive habitats. Fires should be allowed to naturally extinguish along swamp margins of adjacent wetlands at the base of slopes.

Invasive species are locally abundant. Areas with invasive species should be treated before and after prescribed burns. We suggest focusing invasive species management on autumn olive, multiflora rose, and invasive bittersweet before burns occur.

Treating red maple ahead of burns will help make burns more effective in reducing oak leaf litter and help burns cover more area (Randy Heinze pers. comm.). Much of the red maple can be treated with basal bark applications of herbicide but larger trees will likely need "hack and squirt" treatment of herbicide. Treating red maple in the understory will also help make canopy oak more resilient to drought conditions by reducing competitive pressures. A study examining the response of red maple to prescribed burning found that without additional treatment red maple recruitment can increase after burns (Clark and Schweitzer 2009), thus highlighting the importance of pre-burn treatment.

There are bike trails throughout Canonsburg SGA. These bike trails are established in areas of the SGA that have steep topography. The areas within the SGA with steep topography often harbor the highest quality forests because they were not as intensely logged or farmed as the flatter areas. Because these steeper areas had less anthropogenic disturbances, they have fewer invasive shrubs making them more appealing for bike trails. These trails are conduits for invasive species and cause erosion.

Bike trail with heavy erosion in a Dry Southern Forest. Photo by Aaron Kortenhoven.

3. Egypt Creek Swamp
Natural Community Type: Southern Hardwood Swamp
Rank: G3 S3, secure globally and vulnerable within the state
Element Occurrence Rank: CD
Size:15.3 acres
Location: Compartment 1, Stand 88.
Element Occurrence Identification Number: 27079 (New)

This second-growth southern hardwood swamp flanks Egypt Creek. Egypt Creek cuts through steep moraine with a sandy gravel substrate (Figure 15). The narrow channel features variability due to the stream and the degree of saturation from seeps at the base of surrounding slopes. The stream creates small areas of erosion and deposition leading to fine-scale variability in the stream bed. There are some subtle rises within the mapped swamp featuring upland species, but the majority of the stand is dominated by red maple growing on saturated soils. Zones of deep muck feature fewer canopy trees and extensive patches of skunk cabbage (*Symplocarpus foetidus*) and marsh marigold (*Caltha palustris*). Soils are detritus over muck to approximately 40 cm deep over wet sand (pH 7.0).

The canopy is approximately 63% red maple, 7% red oak, 5% basswood (*Tilia americana*), 5% black maple (*Acer nigrum*) 5% black walnut (*Juglans nigra*), 5% bur oak (*Quercus macrocarpa*), 3% white oak, 3% quaking aspen (*Populus tremuloides*), and 2% black oak with swamp white oak (*Quercus bicolor*) present but less than 1% of the canopy. There are canopy gaps throughout the swamp due to ash mortality from emerald ash borer, which has reduced coverage in some areas to an estimated 50 to 70%. Green ash (*Fraxinus pennsylvanica*) was historically about 30% of the canopy. Tree diameters range from 40 to 70 cm and ring-counts show that tree ages are between 90 and 130 years old.

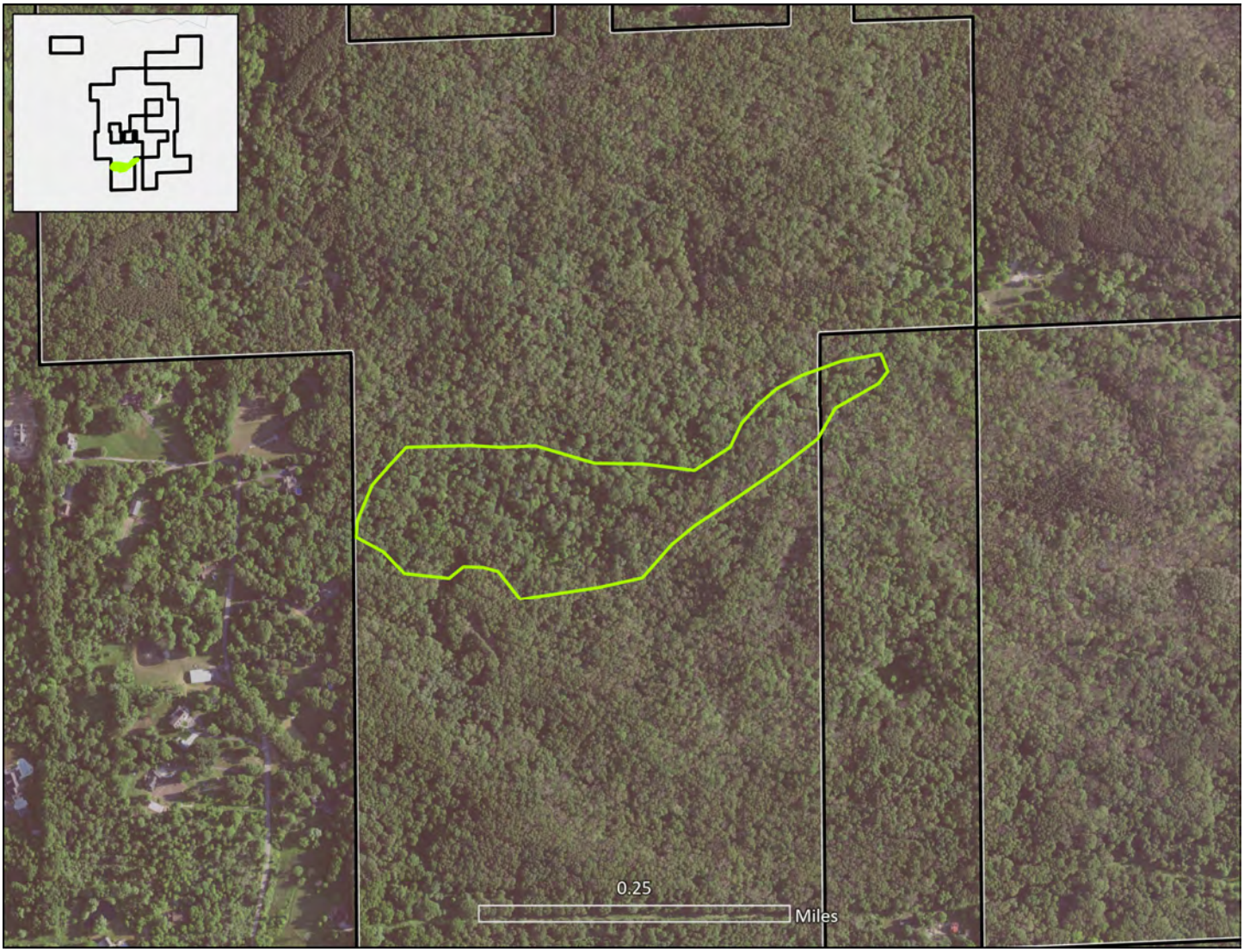
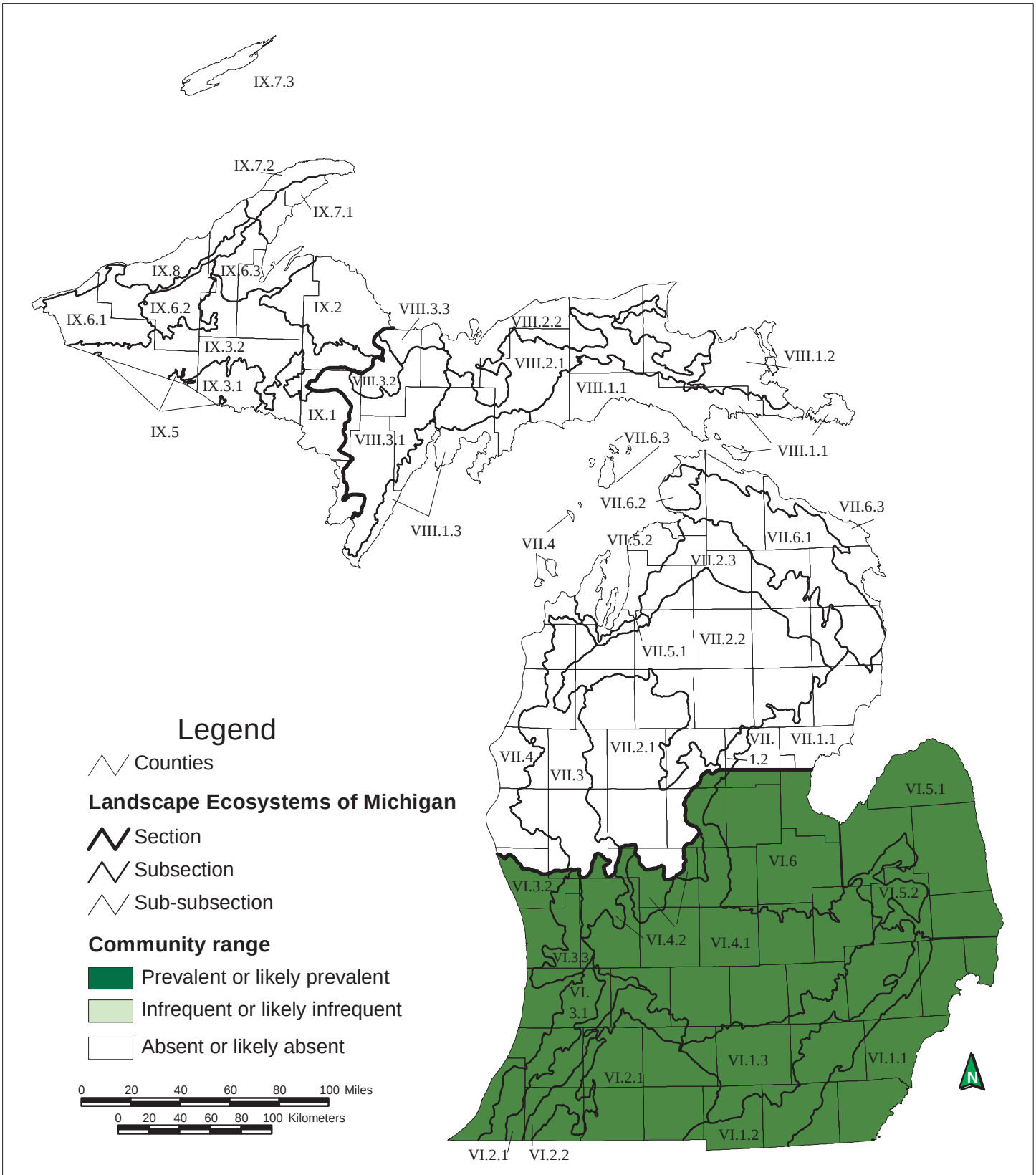


Figure 15. The location of Egypt Creek Swamp Southern Hardwood Swamp.



MICHIGAN STATE UNIVERSITY EXTENSION

Michigan Natural Features Inventory

Southern Hardwood Swamp

Albert, D.A., J.G. Cohen, M.A. Kost, B.S. Slaughter, and H.D. Enander. 2008. Distribution Maps of Michigan's Natural Communities. Michigan Natural Features Inventory, Report No. 2008-01, Lansing, MI. 166 pp.

Figure 16. Statewide distribution of Southern Hardwood Swamp.

Red maple and musclewood (*Carpinus caroliniana*), are codominant in the subcanopy with both reaching 40% coverage. The remaining species in the tall shrub layer include green ash, ironwood (*Ostrya virginiana*), black maple, American elm (*Ulmus americana*), alternate leaved dogwood (*Cornus alternifolia*), black cherry, privet (*Ligustrum vulgare),* prickly ash (*Zanthoxylum* americanum), spicebush (*Lindera benzoin*), multiflora rose, prickly gooseberry, pasture rose, downy arrowwood, low sweet blueberry, and dewberry (*Rubus flagellaris*). Multiflora rose occurs in concentrations along the stream and morrow honeysuckle and Japanese barberry are infrequent throughout the stand.

The ground layer is diverse and ranges from 60 to 90% coverage. The species composition in the ground layer is influenced by erosion along the stream and seepage areas. Forbs include skunk cabbage (*Symplocarpus foetidus*), marsh-marigold (*Caltha palustris*), wild geranium (*Geranium maculatum*), jumpseed (*Persicaria virginiana*), swamp buttercup (*Ranunculus hispidus*), black snakeroot (*Sanicula odorata*), marsh violet (*Viola cucullata*), mayapple (*Podophyllum peltatum*), wood nettle (*Laportea canadensis*), southern blue flag (*Iris virginica*), spotted touch-me-not (*Impatiens capensis*), and jack-in-the-pulpit (*Arisaema triphyllum*).

Graminoids include brome-sedge (*Carex bromoides*), wood reedgrass (*Cinna arundinacea*), and long-awned wood grass (*Brachyelytrum erectum*). Ferns are locally abundant and include spinulose woodfern (*Dryopteris carthusiana*), sensitive fern (*Onoclea sensibilis*), New York fern (*Thelypteris noveboracensis*), royal fern (*Osmunda regalis*), and maidenhair fern (*Adiantum pedatum*).

Threats and Management Recommendations

During the 2023 rare songbird surveys, two Louisiana waterthrush (*Parkesia motacilla,* State Threatened) were recorded within the southern hardwood swamp.

The primary threat to this southern hardwood swamp are invasive species and fragmentation. Our primary management recommendations are to 1) maintain a forested buffer adjacent the stand, 2) treat invasive species in the highest quality areas of the swamp, and 3) minimize the impact of bike trails near the stream. When including neighboring stands in prescribed fires, do not exclude this swamp from fires with burn lines. Allow fires to extinguish naturally in saturated soils and minimize equipment in sensitive areas.

Egypt Creek Swamp with skunk cabbage and marsh-marigold in the foreground. Photo by Jesse Lincoln.

Rare Amphibians and Reptiles Surveys

We documented two rare amphibian and one rare reptile species in the Cannonsburg SGA (Table 3 , Figure 17). These include an update of an existing EO for eastern box turtle (EO ID 14393); one new EOs for pickerel frog (EO ID 27094) and one new EO for Fowler's toad (EO ID 27095; Table 3, Figure 17). We also documented one northern ribbon snake which is a Species of Greatest Conservation Need in Michigan.

We have documented numerous Eastern Box turtle throughout and adjacent to Cannonsburg SGA. During MNFI's surveys in 2023 one eastern box turtle shell was documented in Stand 19 and an adult box turtle was documented in Stand 33. Seven box turtles were recorded during MIFI surveys in in 2016 (Figure 17).

Four box turtle observations from external sources were reported in 2023 and include a breeding pair in stand 80, one box turtle in stand 27, and one box turtle along Four Mile Road near the game area (MNFI 2023). Observations reported in the Michigan Herp Atlas (2019) include six turtles between 2015 and 2016 (Figure 17). All these observations fall withing a single EO (EO ID 14393; Table 3).

The new pickerel frog element occurrence (EO ID 27094) consisted of 10 to 20 pickerel frogs that were recorded on the southeast corner of Hyser Lake (Figure 17). One Fowler's toad (EO ID 27095) was observed along the southern edge Hyser Lake (Figure 17). Both these EOs were ranked as extant given limited information available (Table 3).

We were unable to confirm the presence of Blanchard's cricket frogs in Cannonsburg SGA. A Blanchard's cricket frog EO (EO ID 8204) was documented in the game area in 1985 along Egypt Creek (Figure 17). Blanchard's cricket frogs typically inhabit open edges of permanent ponds, lakes, floodings, bogs, seeps, slow-moving streams, and rivers. They prefer open to partially vegetated mud flats, muddy or sandy shorelines, and mats of emergent aquatic vegetation in shallow water (Harding and Mifsud 2017). The site of the 1985 observation along Egypt Creek is currently heavily vegetated and is no longer suitable habitat.

We did not document Blanding's turtles during the aquatic turtle trapping surveys in 2023. Blanding's turtles utilize

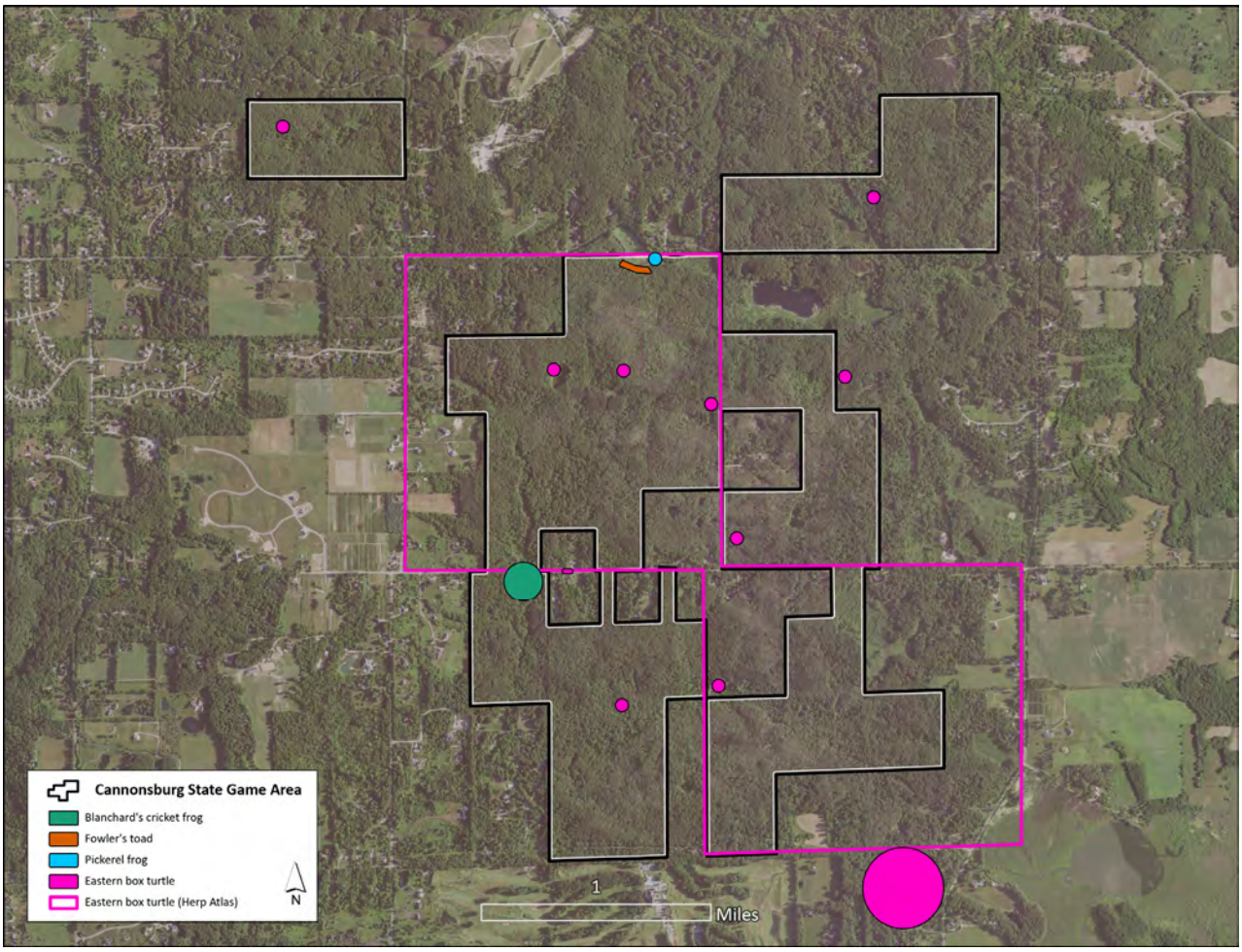


Figure 17. The location of Herpitile EOs in Cannonsburg SGA.

Blanchard's cricket frog. Photo by Courtney Ross.

Fowler's toad recorded during surveys at Cannonsburg. Photo by Courtney Ross.

several habitat types all of which occur within the state game area. Potential habitat for Blanding's turtle within the game area include emergent marsh and mixed lowland shrub/shrub-carr near Hyser Lake (Stands 14 and 15), southern hardwood swamp (Stands 56, 60, and 88), rich tamarack swamp (Stand 9), emergent marsh (Stand 11), and the wetlands around Austin Lake to the east of the game area.

Common amphibian and reptile species detected during herptile surveys in 2023 included the American bullfrog (*Lithobates catesbeianus*), green frog (*Lithobates clamitans*), wood frog (*Lithobates sylvaticus*), eastern gray treefrog (*Hyla versicolor*), eastern American toad *(Anaxyrus americanus americanus*), northern water snake (*Nerodia sipedon sipedon*), snapping turtle (*Chelydra serpentina*), and painted turtle (*Chrysemys picta*). A total of 15 individual painted turtles and 3 juvenile snapping turtles were captured during surveys.

Table 3. Amphibian and reptile element occurences documented in Cannonsburg SGA.

Common Name	Scientific Name	State Status	EO ID	EO Rank	Year First Observed	Year Last Observed
Blanchard's Cricket Frog	*Acris blanchardi*	T	8204	F	1985	1985
Fowler's Toad	*Anaxyrus fowleri*	SC	27095	E	2023	2023
Pickerel Frog	*Lithobates palustris*	SC	27094	E	2023	2023
Eastern Box Turtle	*Terrapene carolina*	T	14393	AC	2004	2023

Eastern box turtle at Cannonsburg. Photo by Jesse Lincoln.

Rare Snail and Mussel Surveys

Watercress Snails

Three new populations of watercress snails were documented, each representing a new EO (Table 4). One population was found in a small (1 m wide) tributary of Egypt Creek, one in the North Branch of Egypt Creek just north of 4 Mile Rd., and one in a small tributary of Bear Creek in the northwest section of the game area (Table 5; Figure 19). Just two live individuals were found in the small tributary of Egypt Creek within a small patch of watercress plants approximately 2m^2 in area. The population in the North Branch of Egypt Creek consisted of four patches of live individuals found among watercress plants with the following estimated densities: 120 indvs/m^2 in 2.5 m^2 area, 100 indvs/m^2 in 1 m^2, 20 indvs/m^2 in 1 m^2, and 100 indvs/m^2 in 10 m^2 (sites WCS2-5 respectively). The population in the tributary of Bear Creek occurred in two patches of watercress plants, one with an estimated density of 1 indv/m^2 in a 4m^2 area and the other with an estimated density of 15 indvs/m^2 in 3m^2 (Sites WCS6 and 7 respectively).

Mussel Surveys

No unionid mussels were found at the five survey sites in Egypt Creek (Table 6) and no unionid mussels were found in qualitative searches of longer reaches in Egypt Creek

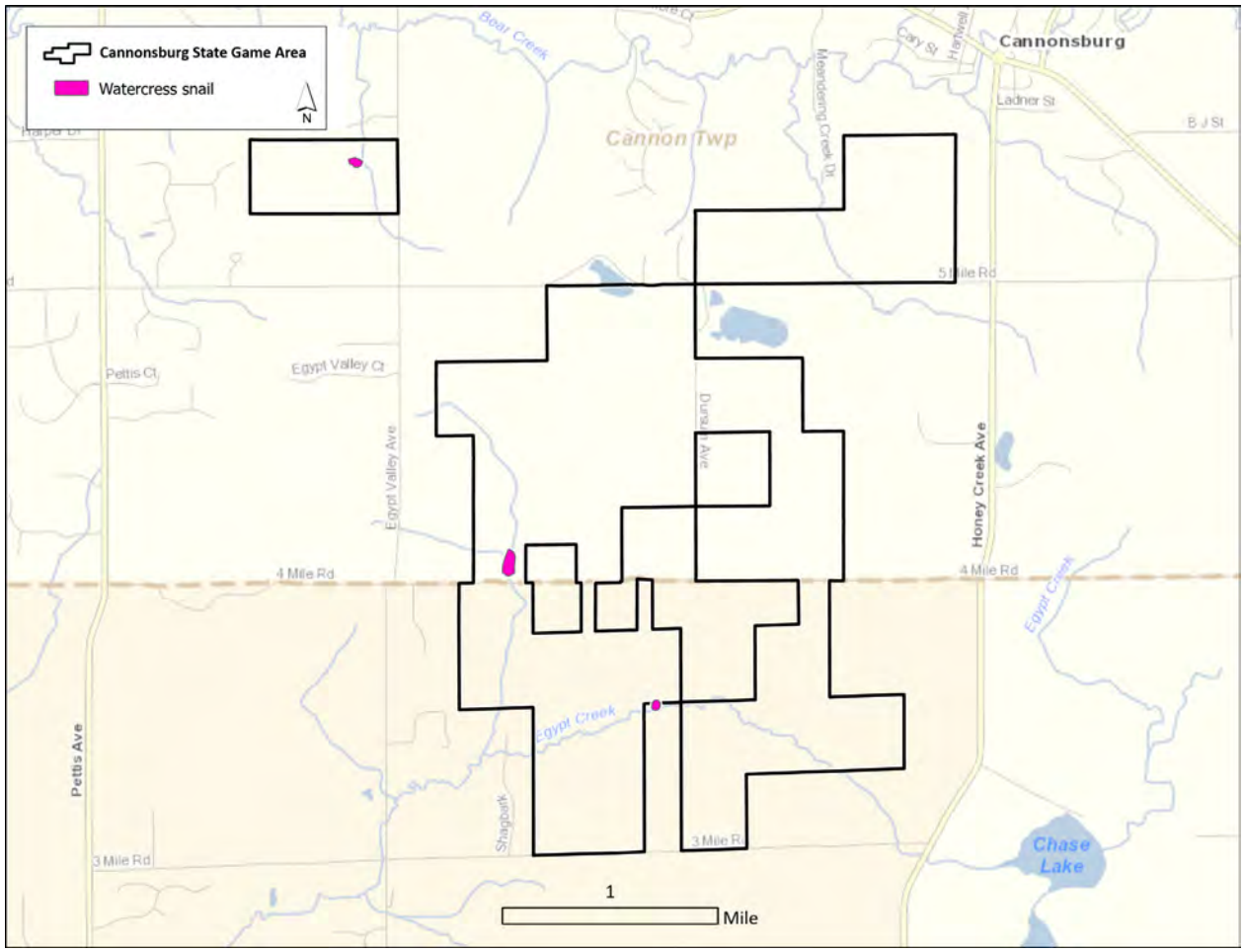


Figure 18. Location of Watercress snail in Cannonsburg SGA.

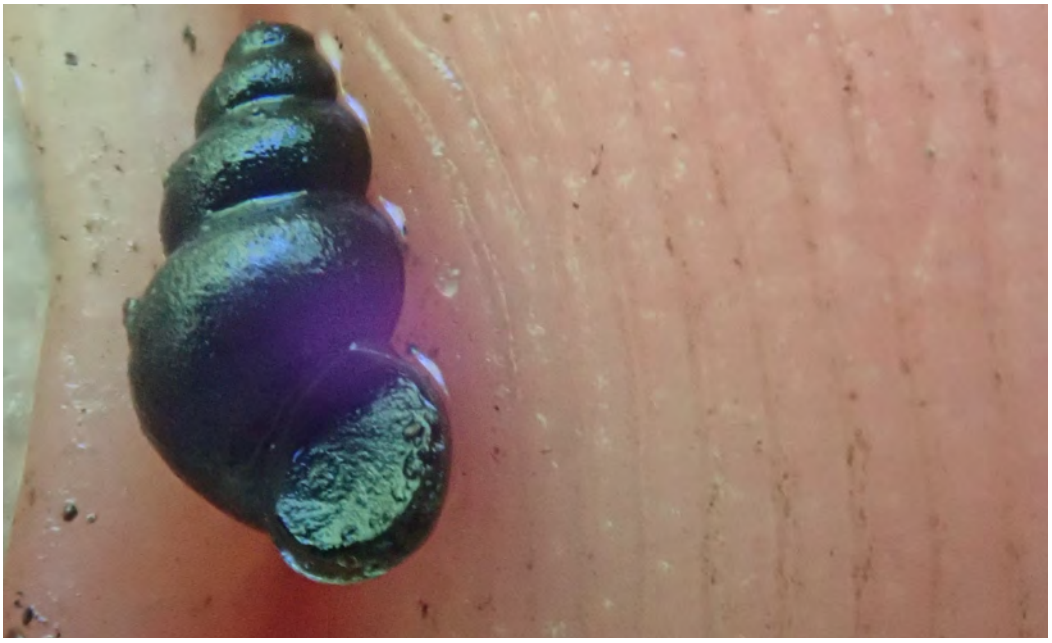
Table 4. Watercress snail EO table. Status abbreviations: SC = state special concern.

Common Name	Scientific Name	State Status	Federal Status	EOID	EO Num	EO Rank	Year First Observed	Year Last Observed	Survey Site #
Watercress snail	*Fontigens nickliniana*	SC		27186	44	CD	2023	2023	WCS1
Watercress snail	*Fontigens nickliniana*	SC		27191	45	AB	2023	2023	WCS2-5
Watercress snail	*Fontigens nickliniana*	SC		27082	43	E	2023	2023	WCS6-7

Table 5. Locations where watercress snail were documented during integrated Inventory Surveys in 2023.

Site	Waterbody	Access	Latitude (N)	Longitude (W)	EOID
WCS1	1 m wide tributary of Egypt Creek	Trailhead off 3 Mile Rd.	43.022250	-85.493008	27186
WCS2	North Branch of Egypt Creek	Trailhead off 4 Mile Rd.	43.028973	-85.502815	27191
WCS3	"	"	43.029282	-85.502830	27191
WCS4	"	"	43.029441	-85.502766	27191
WCS5	"	"	43.029474	-85.502755	27191
WCS6	Tributary of Bear Creek	Trailhead off Egypt Valley Ave. NE	43.0489509	-85.5131381	27082
WCS7	"	"	43.048790	-85.512982	27082

Watercress snail and habitat along the North Branch of Egypt Creek. Photo by Pete Badra.



Watercress snail documented along the North Branch of Egypt Creek. Photo by Pete Badra.

Table 6. Locations of mussel survey sites within Cannonsburg State Game Area, Summer 2023.

Site	Waterbody	Access	Latitude (N)	Longitude (W)	Search Area (m^2)
1	Egypt Creek	Trailhead off 3 Mile Rd.	43.019824	-85.500376	130
2	"	"	43.021086	-85.496235	175
3	"	"	43.022141	-85.491915	133
4	"	"	43.021068	-85.486140	77
5	"	"	43.019024	-85.480768	128

Table 7. Incidental finds at mussel survey sites, including snails/slugs, fingernail clams, crayfish, amphipods, and fish.

Common Name	Taxa/Species	Site				
		1	2	3	4	5
Snails/Slugs	Gastropoda					
Dusky Arion*	*Arion subfuscus*		X			
Disc gyro	*Gyraulus circumstriatus*				X	X
Spotted Garden slug*	*Limax maximus*					X
Physa	*Physa sp.*	X		X	X	
Marsh pondsnail	*Stagnicola elodes*				X	X
Marsh rams-horn	*Planorbella trivolvis*	X	X		X	X
Fingernail clams	Sphaeriidae				X	X
Side-swimmers	Amphipoda: Gammaridae					X
Crayfish	Decapoda		X			
Fish	Osteichthyes					
Bluegill	*Lepomis macrochirus*		X			
Rainbow trout	*Oncorhynchus mykiss*					X

* Non-native, invasive slug species

Table 8. 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), and silt/clay (<0.0625mm).

Site #	Boulder	Cobble	Pebble	Gravel	Sand	Silt
1		5	25	25	35	10
2		5	10	25	40	20
3		20	30	20	20	10
4	10	20	20	20	20	10
5	5	10	20	15	30	20

Table 9. Physical habitat characteristics recorded at mussel survey sites.

Site #	Current speed (m/second)	Aquatic vegetation?	Woody debris?	Eroded banks?	%Pool	%Riffle	%Run
1	0.20	Y	Y	N	10	10	80
2	0.25	N	Y	N	10	10	80
3	0.20	N	Y	N	10	10	80
4	0.33	N	Y	Y	33	34	33
5	0.33	N	Y	Y	33	34	33

and the North Branch of Egypt Creek. Juvenile rainbow trout (*Oncorhynchus mykiss*) were seen in Egypt Creek at Site 5 and bluegill (*Lepomis macrochirus*) at Site 2. Aquatic snail species (Gastropoda) were noted at all five mussel survey sites and fingernail clams (Sphaeriidae) were noted at two sites. Two non-native invasive gastropod species were observed in or on the banks of Egypt Creek; dusky arion (*Arion subfuscus*) and spotted garden slug (*Limax maximus*). Both are terrestrial slug species. No zebra mussels (*Dreissena polymorpha*) or Asian clams (*Corbicula fluminea*) were observed during surveys. Additional incidental finds are given in Table 7. Stream substrate at aquatic survey sites was favorable for native mussels and was comprised of a mix of particle size classes from boulder to silt, with sand and pebble being the most dominant (Table 8). Aquatic vegetation was mostly absent but the presence of large woody debris at all sites provides cover and habitat structure for potential host fish. Stream morphology at mussel survey sites included a mix of pool, riffle, and run (Table 9).

Rare Insects

We did not document tamarack tree cricket during sweep surveys at Cannonsburg State Game Area in 2023. The most frequently encountered cricket was Say's trig (*Anaxipha exigua*) which was documented on 15 tamarack trees and within each of the surveyed stands. This species is found throughout the eastern half of the United States from New Hampshire and Minnesota south to Florida and Texas. It is also found in Ontario, Canada.

We did not record Karner blue or frosted elfin butterflies during our 2023 butterfly surveys. We recorded 15 butterfliy species during 2023 surveys (Table 10). The most common species documented include cabbage white (*Pieris rapae*, n = 8), juvenile duskywing (*Erynnis juvenalis*, n = 4), and monarch butterfly (*Danaus plexippus*, n = 4). While the monarch butterfly is not currently listed under the Endangered Species Act (ESA), the United States Fish and Wildlife Service determined that this species warrants listing but is currently precluded by work on higher-priority listing actions. Therefore, this species remains a candidate for listing under the ESA and will be reassessed yearly until a final listing decision is made.

We did not record any state listed bumble bee species during our surveys at Cannonsburg SGA. We documented four bumble bees species. The most observed species were the common eastern bumble bee (*B. impatiens*, n = 8), and the brown belted bumble bee (*B. griseocollis*, n = 5). Bumble bee occurrences were documented on spotted knapweed (*Centaurea stoebe*; n = 10), and butterfly weed (*Asclepias tuberosa*; n = 6).

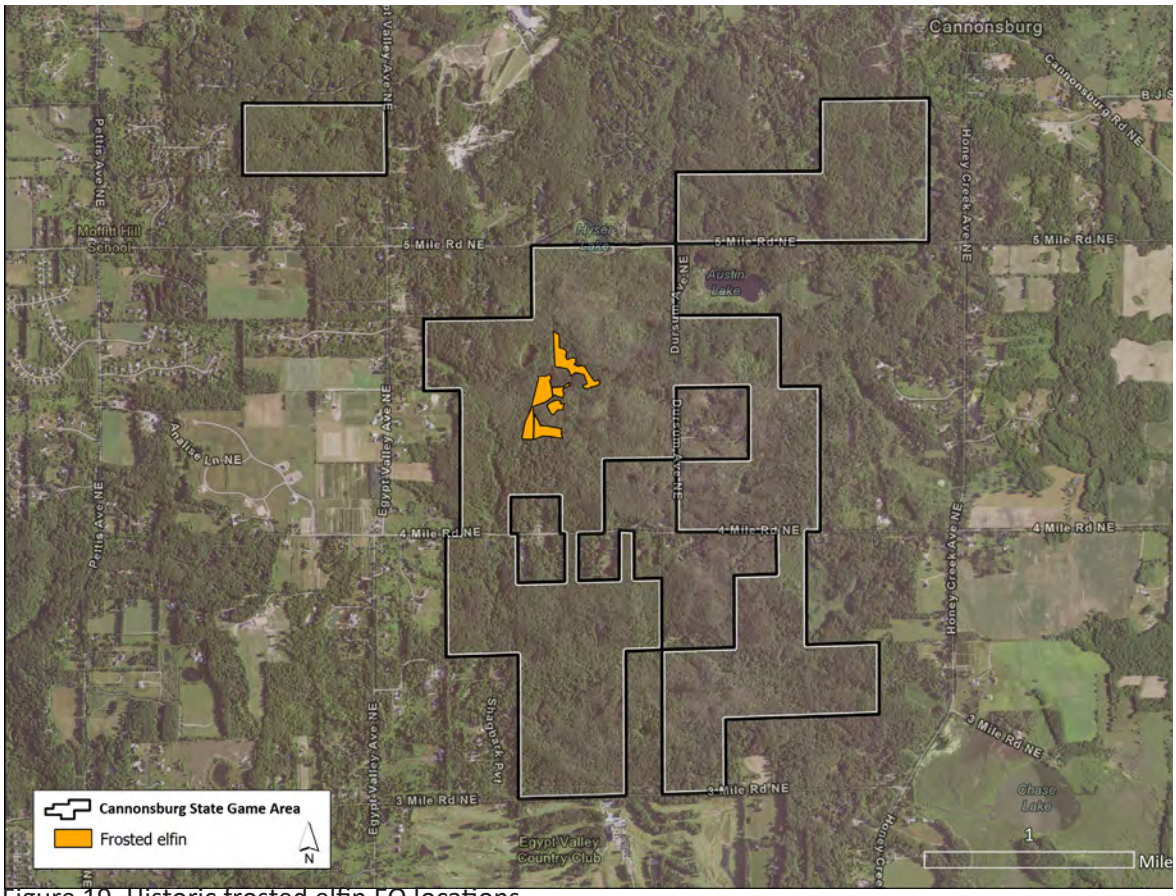


Figure 19. Historic frosted elfin EO locations.

Table 10. Unlisted butterflies observed during insect surveys.

Common Name	Scientific Name
Juvenals Duskywing	*Erynnis juvenalis*
Mourning Cloak	*Nymphalis antiopa*
Spring Azure	*Celastrina ladon*
Cabbage White	*Pieris rapae*
Clouded Sulphur	*Colias philodice*
American Copper	*Lycaena phlaeas*
Giant Swallowtail	*Papilio cresphontes*
Red Admiral	*Vanessa atalanta*
Painted Lady	*Vanessa cardui*
Black Swallowtail	*Papilio polyxenes*
Roadside Skipper	*Amblyscirtes vialis*
Eastern Tailed Blue	*Everes comyntas*
Little Wood Satyr	*Megisto cymela*
Monarch Butterfly	*Danaus plexippus*
Pearl Crescent	*Phyciodes tharos*

MNFI biologist searching for tamarack tree crickets. Photo by Ashley Cole-Wick.

We did not record royal fern borer during the survey at Cannonsburg SGA. We documented a total of 13 Papaipema borer moths. Ten of these were the sensitive fern borer (*P. inquaesita*) and 3 were the joe pye weed borer (*P. eupatorii*). While not listed in Michigan, the joe pye weed borer is considered vulnerable in the lower regions of its range. Surveys in Michigan generally do not pick up this species so documenting it at Cannonsburg SGA is valuable information.

Rare Birds

We completed rare raptor surveys at 28 points within the game area (Figure 10). Red-shouldered hawks (RSHA) responded to playbacks at two survey points (Figure 20). We did not record any active RSHA nests.

We conducted forest songbird surveys at 28 points (Figure 10). We recorded 12 singing male hooded warblers at nine survey points spread across the SGA (Figure 20). These observations fall within an existing element occurrence (EO ID 15501). This EO has been updated. We recorded two singing Louisiana waterthrush at two points within the SGA (Figure 20). These Louisiana water thrush observations are a new element occurrence and have been entered into our Natural Heritage Database (EO ID 27114).

We recorded a total of 48 bird species during point counts at the Caonnonsburg State Game Area (Table 11). The 10 most detected species were: ovenbird (*Seiurus aurocapilla;* 91%) eastern wood-pewee (*Contopus virens;* 79%), red-eyed vireo (*Vireo olivaceus;* 71%), tufted titmouse (*Baeolophus bicolor;* 71%), wood thrush (*Hylocichla mustelina;* 54%), hooded warbler (*Setophaga citrina,* 50%), Acadian flycatcher (*Empidonax virescens;* 46%), northern cardinal *(Cardinalis cardinalis;* 46%), red-bellied woodpecker (*Melanerpes carolinus;* 43%), and scarlet tanager (*Piranga olivacea*; 43%).

The following nine species were regularly observed (20-39% of points surveyed): brown-headed cowbird (*Molothrus ater;* 39%), black-capped chickadee (*Poecile atricapillus*; 36%), blue-jay (*Cyanocitta cristata;* 36%), American robin (*Turdus migratorius;* 32%) great-crested flycatcher (*Myiarchus crinitus*; 27%), white-breasted nuthatch (*Sitta carolinensis*; 29%), American crow (*Corvus brachyrhynchos*; 21%), brown creeper (*Certhia americana*; 21%), and yellow warbler (*Setophaga petechia*; 21%).

Several bird species detected have special conservation status (Table 11). Wood thrush and plieated woodpecker are MDNR featured species. Hooded warbler and wood thrush are Species of Greatest Conservation Need (Derosier et al. 2015). Wood thrush is a focal species of the Landbird Habitat Conservation Strategy (Potter et al. 2007).

Hooded warbler seen at Cannonsburg State Game area in Stand 35. Photo by Aaron Kortenhoven.

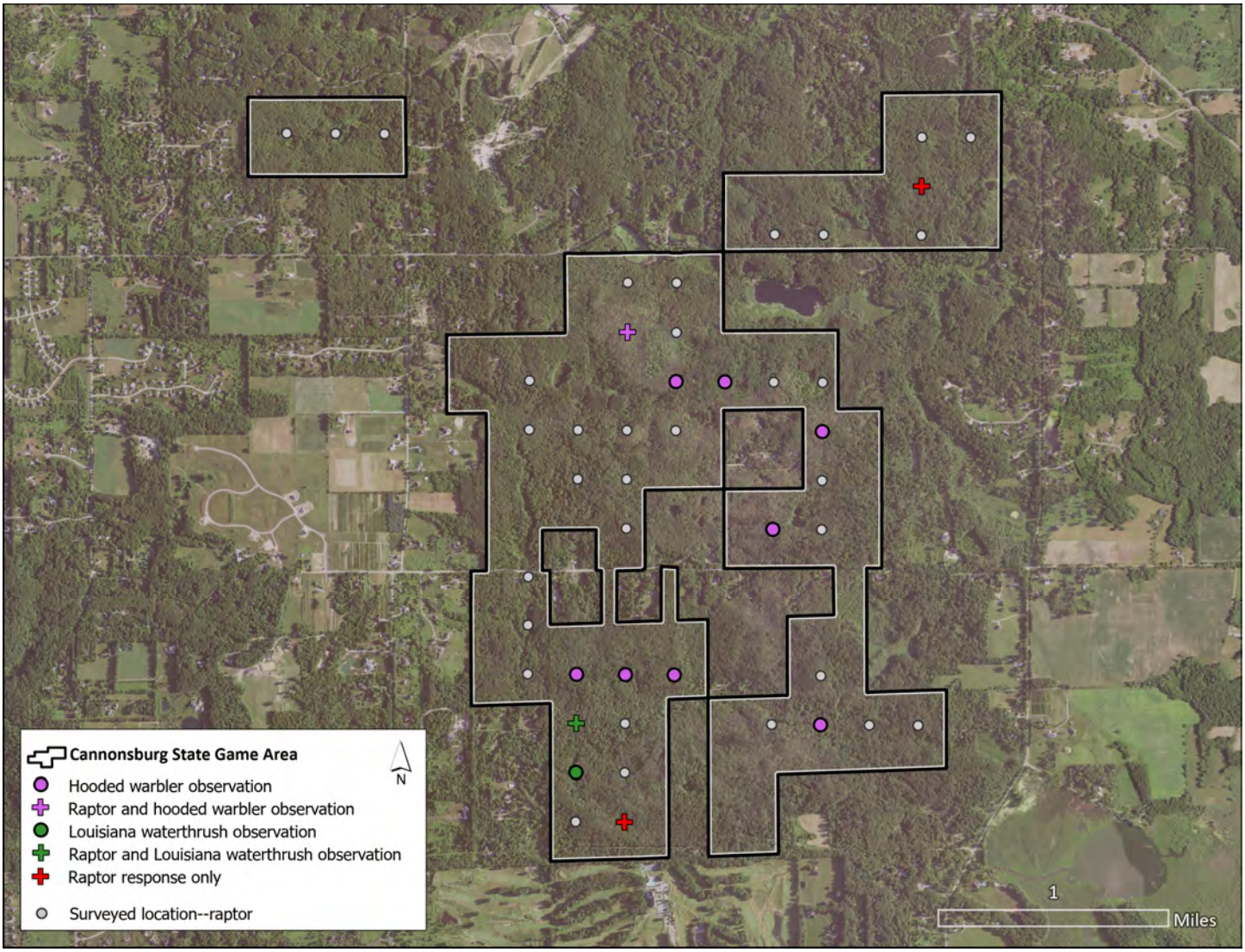


Figure 20. Survey points where bird target bird species were documented during 2023 surveys.


The banks along Egypt Creek provide ideal nesting habitat for Louisiana waterthrush. Photo by Aaron Kortenhoven.

Table 11. Bird species documented during surveys of Cannonsburg State Game Area. Status abbreviations are: T, State Threatened and SC, State Special Concern.

Common Name	Scientific Name	State Status	Featured Species	SGCN	JV Focal Species	Prop. of Points
Acadian Flycatcher	*Empidonax virescens*					0.46
American Crow	*Corvus brachyrhynchos*					0.21
American Goldfinch	*Spinus tristis*					0.07
American Redstart	*Setophaga ruticilla*					0.14
American Robin	*Turdus migratorius*					0.32
Black-billed Cuckoo	*Coccyzus erythropthalmus*		X			0.11
Black-capped Chickadee	*Poecile atricapillus*					0.36
Blue Jay	*Cyanocitta cristata*					0.36
Blue-gray Gnatcatcher	*Polioptila caerulea*					0.04
Blue-headed Vireo	*Vireo solitarius*					0.04
Blue-winged Warbler	*Coccyzus erythropthalmus*					0.11
Brown Creeper	*Poecile atricapillus*					0.21
Brown Thrasher	*Cyanocitta cristata*					0.04
Brown-headed Cowbird	*Molothrus ater*					0.39
Cedar Waxwing	*Bombycilla cedrorum*					0.04
Chipping Sparrow	*Spizella passerina*					0.07
Common grackle	*Quiscalus quiscula*					0.07
Common Yellowthroat	*Geothlypis trichas*					0.14
Downy Woodpecker	*Picoides pubescens*					0.18
Eastern Bluebird	*Sialia sialis*					0.07
Eastern Wood-Pewee	*Contopus virens*					0.79
Gray Catbird	*Dumetella carolinensis*					0.11
Great-crested Flycatcher	*Myiarchus crinitus*					0.29
Hairy Woodpecker	*Picoides villosus*					0.14
Hooded Warbler	*Setophaga citrina*	SC		X		0.50
House Wren	*Troglodytes aedon*					0.11
Indigo Bunting	*Passerina cyanea*					0.18
Lousiana waterthrush	*Parkesia motacilla*	T				0.07
Mourning Dove	*Zenaida macroura*					0.04
Northern Cardinal	*Cardinalis cardinalis*					0.46
Northern Flicker	*Colaptes auratus*					0.04
Ovenbird	*Seiurus aurocapilla*					0.93
Pileated Woodpecker	*Dryocopus pileatus*		X			0.11
Red-bellied Woodpecker	*Melanerpes erythrocephalus*					0.43
Red-eyed Vireo	*Vireo olivaceus*					0.71
Red-winged Blackbird	*Agelaius phoeniceus*					0.04
Rose-breasted Grosbeak	*Pheucticus ludovicianus*					0.18
Sandhill Crane	*Antigone canadensis*					0.07
Scarlet Tanager	*Piranga olivacea*					0.43
Tufted Titmouse	*Baeolophus bicolor*					0.71
Veery	*Catharus fuscescens*					0.04
White-breasted Nuthatch	*Sitta carolinensis*					0.29
Wood Thrush	*Hylocichla mustelina*		X	X	X	0.54
Yellow Warbler	*Setophaga petechia*					0.21
Yellow-billed Cuckoo	*Coccyzus americanus*					0.18
Yellow-throated Vireo	*Vireo flavifrons*					0.07

DISCUSSION

As stated within the DNR's Master Plan for Cannonsburg SGA, this public land was acquired by the State of Michigan to preserve and improve natural habitat for wildlife. Our report summarizing the natural features of Cannonsburg SGA is intended to aide land managers in their decision making while developing management plans to meet these land stewardship goals.

Natural Community Discussion and Recommendations
Descriptions of each natural community EO and associated management recommendations are provided in the Results section above. In addition to the specific management recommendations, we provide the following general management recommendations for your consideration. We encourage invasive species control focused in high-quality natural communities, the maintenance of the canopy closure of high-quality forest, the reduction of fragmentation and promotion of connectivity across the game area, the use of landscape-scale prescribed fire, and the careful prioritization of stewardship efforts in the most critical habitats. Finally, monitoring of these management activities is recommended to facilitate adaptive management.

Effectively protecting and managing natural communities for native species is best accomplished by emulating the ecosystems in which native species evolved. It is much easier to protect high-quality sites from degradation than it is to restore degraded areas. Stewardship actions within the game area should focus on the highest quality natural communities in the game area. To that end, we provide the following specific management recommendations in order of importance: 1) minimize forest fragmentation adjacent to high-quality natural communities identified in this report; 2) implement prescribed fire in oak-dominated forests; 3) control invasive species within high-quality natural communities and 4) prevent the establishment of new bike trails and minimize erosion of current bike trails.

Forest Fragmentation
Cannonsburg SGA supports 1,278 acres of upland and lowland forest with only 113.1 acres of this acreage being high-quality forest. Of this high-quality forest, 97.8 acres is upland forest, and 15.3 acres is lowland forest. Given that only 8.84% of the game area is high-quality forest the conservation significance of these areas to the rare species that use them is critical.

Many of the forests within the game area were logged and cleared for agriculture. Based on the current age of trees and the pattern of European colonization we estimate that most forests in Cannonsburg SGA were logged in the late 1800s. The forests with the highest level of ecological integrity that remain in the game area correspond to areas that were not converted to agriculture. The forests identified in this report as exemplary natural communities escaped intensive agriculture. As a result, these forests better reflect historic conditions. In comparison to areas that were grazed and tilled, they have lower density of invasive species, a higher frequncy of older trees, and a greater concentration of native flora. The effects of forest fragmentation on native plants and animals and ecosystem processes are detrimental (Heilman et al. 2002). Local population extinctions are accelerated by reduced habitat. Native plant diversity within forested fragments decreases due to low seedling survivorship, diminished seed dispersal, increased herbivory, and increased invasive species, which thrive after forest clearing (Brosofske et al. 2001, Heilman et al. 2002, Hewitt and Kellman 2004). The rare species we recorded in Cannonsburg SGA are sensitive to fragmentation and if further fragmentation occurs within the game area it is likely that local species extirpation will occur soon.

Fire as an Ecological Process
Fire was an important disturbance factor within Cannonsburg SGA based on the historic descriptions of the natural communities and fire-adapted plant communities present, but today the landscape is fire suppressed. Application of prescribed fire across the game area will reduce mesophytic species in oak forests and promote fire-adapted herbaceous species. We ran MNFI's fire needs assessment model (Cohen et al. 2021) for Cannonsburg SGA. While the model indicated that most of the uplands within Cannonsburg SGA support fire-dependent ecosystems Stands 2 (Cannonsburg Woods) and 21 (Dursum Woods), had the highest fire needs score in the SGA (Figure 22). We recommend focusing fire on these communities.

Resources for burning are limited and should be prioritized for high-quality fire-dependent oak forests and adjacent areas. Land managers could consider developing permanent project areas and applying prescribed fire with the goals of reducing red maple and invasive shrubs in the understory while increasing herbaceous vegetation and promoting oak recruitment. To achieve these permanent burn areas, existing roads, trails, and streams can be utilized as burn breaks. These existing features will allow fire to cross ecotones and avoid the need to create burn breaks in ecologically sensitive areas. Developing permanent burn units that include young forests adjacent

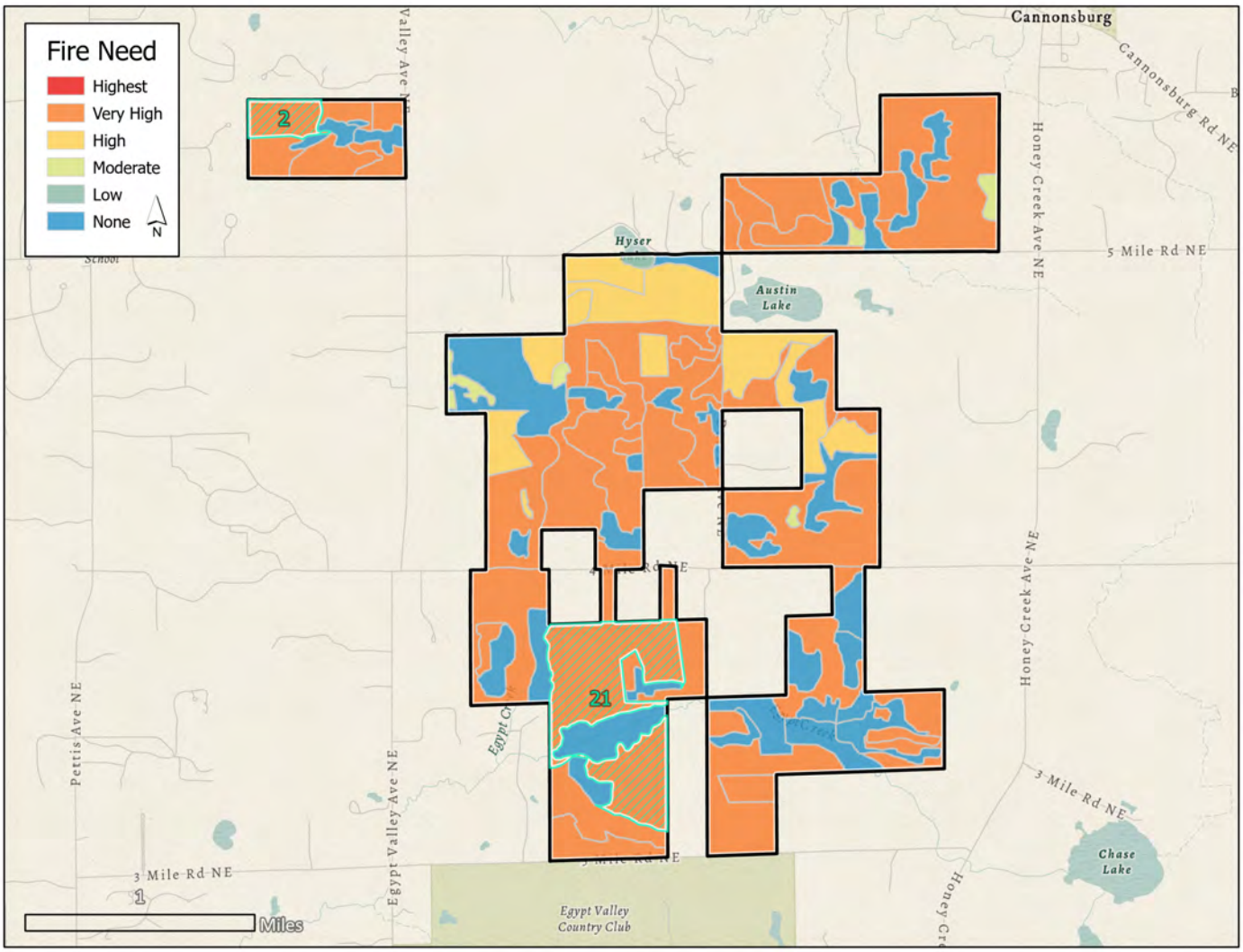


Figure 21. Most of the uplands within the game area have a “high” need for prescribed fire. Some areas that have a fire need of “none” are areas of planted pine, or are generally degraded. Stands 2 and 21, where we suggest priscribed fire, are marked by slanting green lines and have the highest fire needs score within the state game area.

to exemplary natural communities will establish multi-age forests without needing to harvest timber in sensitive areas. Multi-age forests will be beneficial to turkey, fox squirrels, white-tailed deer, and pileated woodpeckers, all of which are target species for Cannonsburg SGA.

Although prescribed fire can improve the overall quality of habitat for many animal species, the impact fire has on rare animals should be considered during the planning process. Amphibians and reptiles are at a particularly high risk during prescribed burns. To protect the box turtle population at Cannonsburg, we recommended that managers avoid applying prescribed fires during the early spring emergence period (April to mid-May) when turtles may be lethargic after emerging from hibernacula. Instead, fires should be conducted later in the growing season when turtles are fully active and may be able to evade slow-moving flames or find suitable refugia during prescribed fires (Melvin 2017).

For turtles, if prescribed burning needs to occur during the active season, conducting these activities in early July through mid-August would minimize the potential for harming turtles (Laarman et al. 2018). This period avoids turtle emergence, nesting season (mid-May to late June), and hatchling emergence (mid-August through October) (Melvin 2017, Laarman et al. 2018). If 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 turtles during fires.

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,

Invasive species are common throughout Cannonsburg. Pictured here are invasive bittersweet, garlic mustard, multiflora rose, and autumn olive in Stand 93. Photo by Aaron Kortenhoven.

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.

Controlling Invasive Species

Biological invasions are critical drivers 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, Cohen et al. 2024). This model identifies stands within the Cannonsburg SGA that have the highest ecological need for invasive species management (Figure 21). Invasive species in Cannonsburg SGA degrade the composition of the most important natural communities. The treatment of invasive species in Cannonsburg 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 on the highest quality upland forests.

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.

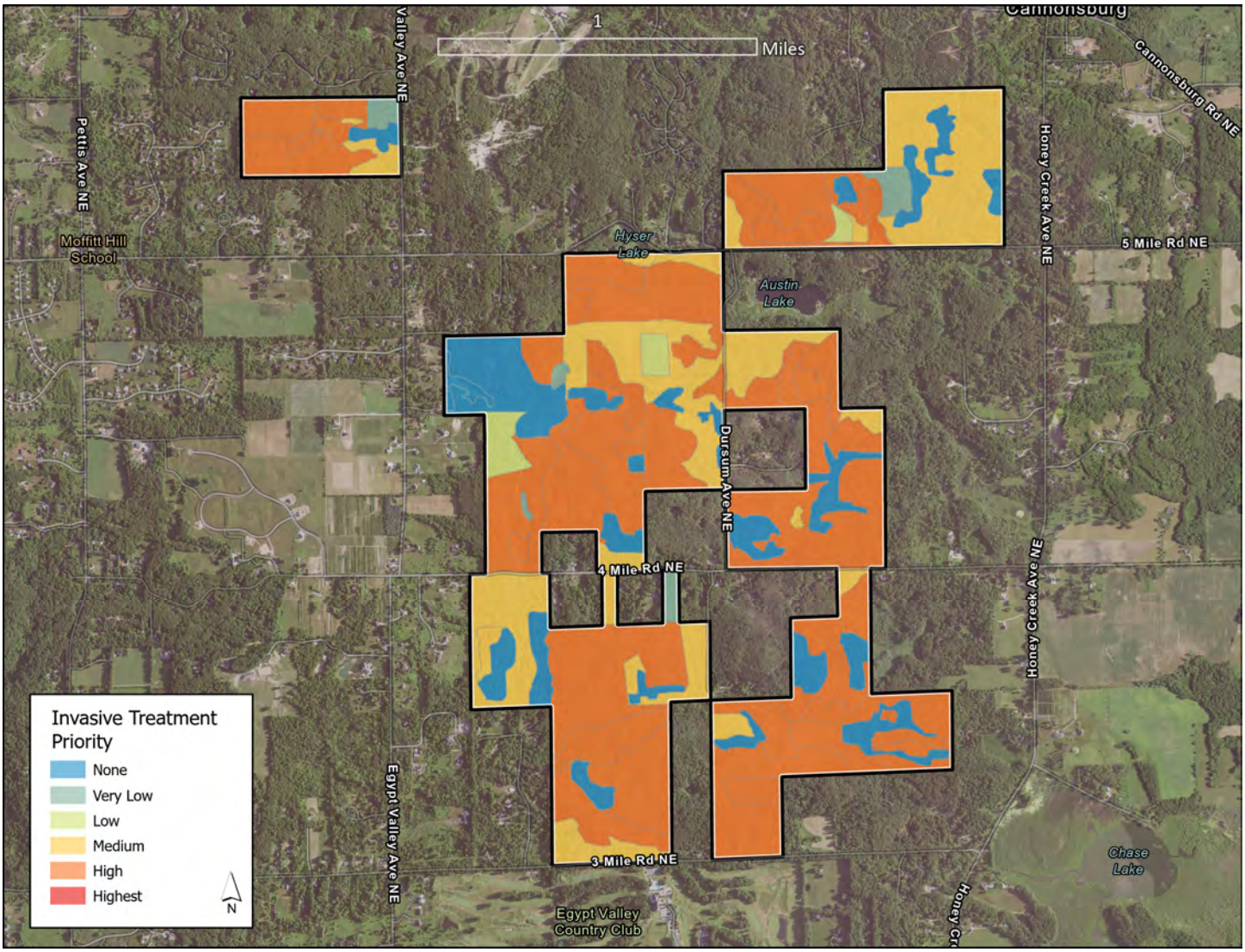


Figure 22. MNFI's Invasive species treament prioritization model identified the forest blocks where each natural community EO is located as high priority for invasive species control efforts.

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 in the identification of rare species and familiar with applying herbicides in sensitive areas and wetlands. The location of the populations of rare species should be clearly communicated prior to implementation of control. Partnerships with local 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. Autumn olive and multiflora rose 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.

Ecological Impact of Recreational Use

Many of the bike trails at Cannonsburg SGA travel through areas of high ecological integrity. The propensity for bikers to create trails is leading to the establishment of new trails and bypasses on existing trails. Trails create soil disturbances that provide ideal conditions for invasive species; as a result trails become invasive species corridors in addition to promoting erosion in ecologically sensitive areas. Restricting access to existing trials would be difficult.

Monitoring trails and posting signs that inform the public of the impact that bike trails have on the ecology of the area would help mitigate negative impacts. Most bikers don't want to lose access to Cannonsburg SGA as a biking area and will comply with signage. The West Michigan Mountain Biking Association is an active group and having regular communications with this association when new trails are seen or signage in being ignored, would both build a relationship with them, and provide information to mountain bikers in the area.

Rare Amphibians and Reptiles

Our 2023 survey results indicate that eastern box turtles occur throughout the Cannonsburg SGA. Given the distribution of observations across space and time this population may be large.

The number of observations and suitable habitat in the game area suggest the box turtle population in the Cannonsburg SGA has excellent to good viability. We did not record juvenile box turtles however we did record a breading pair of box turtles. Given this species low fecundity and length it takes to reach sexual maturity a high adult survival rate is required to sustain viable populations of eastern box turtles (Congdon et al. 1994, Hall et al. 1999, Ernst and Lovich 2009, Willey 2010, Willey and Sievert 2012). More intensive multi-year studies would be required to obtain the demography of the Canonsburg population. Such information is critical for effective management.

Additional surveys and monitoring are needed to assess the status and distribution of Fowler's toads and pickerel frogs within the Cannonsburg SGA to inform management of these species. Fowler's toads are closely associated with habitats that have deep, loose, sandy or gravelly soil in which they can easily burrow (Harding and Mifsud 2017). These habitats include open woodlands, meadows, sand prairies, beaches, dunes, sandy lakeshores, river valleys, and floodplains as well as agricultural and residential areas including gardens, yards, fields, pastures, and roadsides (Harding and Mifsud 2017, AmphibiaWeb 2024a, NatureServe 2024).

Pickerel frogs occur in a variety of aquatic and wetland habitats, including fens, bogs, marshes, wet meadows, forested wetlands, ponds, slow-moving streams, springs, and backwater sloughs. Pickerel frogs prefer habitats with cool, clear water and avoid polluted or stagnant water (Harding and Mifsud 2017, AmphibiaWeb 2024b). Pickerel frogs and Fowler's toads breed in warm, shallow waters that are open, including vernal pools, permanent ponds, marshes, bog ponds, flooded ditches, river floodplains, or backwaters (Harding and Mifsud 2017, AmphibiaWeb 2024a and 2024b, NatureServe 2024). Fowler's toads and pickerel frogs have potential to occur in other open wetlands and adjacent open uplands or forests in the game area (e.g., lowland shrub/shrub carr in Stand 14, bog/intermittent wetland in Stand 19, and the herbaceous opening nearby in Stand 18). Surveys to identify critical habitats for these species (e.g., breeding and overwintering sites) and assess threats to their populations would inform and guide management efforts.

Maintaining high-quality wetland and upland habitats that meet the needs of all the life history stages of the

Mating box turtles recorded during natural community surveys. Photo by Jesse Lincoln.

amphibian and reptile species occurring within the Cannonsburg SGA is critical for conserving the game area's herptile diversity. The rare amphibian and reptile species that have been documented in the game area utilize a variety of wetland habitats (Harding and Mifsud 2017). Controlling woody encroachment and invasive species, and maintaining open or emergent wetlands would provide suitable habitat for these rare species. Promoting structural diversity (e.g., grasses and sedges, thatch on the ground, sedge/sphagnum hummocks, occasional shrubs/trees, downed logs/woody debris) within these wetlands would benefit these species. Alterations to the vegetative structure and hydrology of wetlands can significantly impact habitat quality and suitability for amphibians and reptiles. Lowering the water table during late fall and winter could lead to mortality of amphibians and reptiles overwintering in aquatic and wetland habitats. Flooding for long periods of time during the active season or the wintering period can result in habitat loss, temporary or permanent displacement of individuals, and mortality.

Protecting vernal pools (Stand 21) will help maintain important habitats for amphibians and reptiles in the game area. Vernal pools are small, shallow, seasonally flooded wetlands that are typically wet in the spring and dry up or draw down significantly by late summer/early fall (Colburn 2004, Calhoun and deMaynadier 2008). Since vernal pools dry up and are not connected to permanent waterbodies they lack fish predators and provide critical breeding habitat for a number of invertebrate and amphibian species. These conditions allow certain invertebrate and amphibian species to have higher survival and reproductive rates in vernal pools than in wetlands and waterbodies with fish. The result of this changing hydrology is a unique and diverse assemblage of animal species (Colburn 2004, Calhoun and deMaynadier 2008). Species in Michigan that rely on vernal pools for their survival include fairy shrimp (*Eubranchipus* spp.), wood frogs (*Lithobates sylvaticus*), spotted salamanders (*Ambystoma maculatum*), and blue-spotted salamanders (*Ambystoma laterale*). In addition to providing important habitat for wildlife, vernal pools provide ecosystem services in the form energy and nutrient cycling, water storage and infiltration, and groundwater recharge. The ecosystem services maintain healthy forests (Colburn 2004, Calhoun and deMaynadier 2008). Eastern box turtles use vernal pools for foraging, access to water, resting, and cooling during hot, dry periods (Donaldson and Echternacht 2005). Fowler's toads and pickerel frogs use vernal pools for breeding (Harding and Mifsud 2017, AmphibiaWeb 2024a and 2024b, NatureServe 2024).

Best management practices for protecting vernal pools include:

1) Identify and map vernal pools in the spring when they are full.
2) Avoid disturbance to the vernal pool depressions year-round.
3) Maintain a forested buffer of 70 and 75% canopy cover within 30 meters of the high-water mark.
4) Maintain at least a partially forested buffer (at least 50% canopy cover) within 30 to 122 meters surrounding the vernal pool.
5) Protect the forest floor by conducting timber harvests when the soil is completely frozen or dry.
6) Maintain coarse woody debris.
7) Avoid use of chemicals within 130 meters of the high water mark.

Maintaining a diversity of early-successional upland and forested natural communities containing canopy gaps will provide habitat for a range of amphibian and reptile species in the Cannonsburg SGA. Eastern box turtles are strongly associated with ecotones obtained through natural gap-phase dynamics and periodic fire (Dodd 2001, Ernst and Lovich 2009). Eastern box turtles and other turtle species utilize open canopy, sunny, unvegetated or sparsely vegetated upland areas with moist but well-drained, substrates for nesting (Harding and Mifsud 2017). Eastern box turtles overwinter underground in deciduous or mixed forested habitats with deep leaf litter (Savva et al. 2010).

Fowler's toads and pickerel frogs occur in open upland forests, grassy meadows, and fields adjacent to suitable wetland habitats (Harding and Mifsud 2017, NatureServe 2023). Canopy heterogeneity achieved through natural gap-phase dynamics and periodic fire leads to canopy openings in upland forests that provide thermoregulatory opportunities and habitat for herptile species (Felix et al. 2008, Currylow et al. 2012). Leaving downed woody debris, brush piles, and leaf litter provides refugia for overwintering, thermoregulation, protection from predators, and nesting (Ernst and Ernst 2003, Harding and Mifsud 2017, Erb and Roberts 2023b, Mifsud 2023). Maintaining and restoring open natural black oak barrens will provide suitable nesting habitat for eastern box turtles and other turtles in the SGA (Erb and Roberts 2023b, Mifsud 2023).

Road mortality poses a substantial threat to amphibian and reptile populations (Steen and Gibbs 2004,). Road mortality can be mediated by closing roads, reducing speed limits, installing appropriate signage, and installing barrier fencing along high-use areas (Ontario Ministry of Natural Resources and Forestry 2016). Turtle nest predation rates can be very high (over 80-100%) in

fragmented landscapes (Willey and Sievert 2012). Installing nest cages and enclosures around nesting areas during nesting season will reduce egg mortality.

Management activities, such as prescribed burning (see fire section above), timber harvesting, mechanical vegetation control or removal, and water level manipulation, are important tools for maintaining and restoring suitable habitat for rare and common herptile species, but they also can have adverse impacts on these species as well. Adjusting the timing and way these management practices are conducted can mitigate these adverse impacts. Conducting management in late fall, winter, or early spring when species are in their hibernacula should be considered.

Rare Snails and Mussels

Watercress Snail Surveys

Recent surveys for watercress snail in Michigan, including this effort and surveys in and around Fort Custer Training Center (Badra 2023), are building evidence that southwest Michigan is the global stronghold for the species. Although the global range of watercress snail includes the eastern half of North America, most occurrences are concentrated in Michigan and the Appalachian states of Virginia, West Virginia, Kentucky, and Tennessee. Only a scattering of records for the species exist to the north in Pennsylvania, New York, and Ontario; to the south in Alabama; and in the Midwest states of Ohio, Indiana, and Illinois (NatureServe 2024, GBIF 2024, Evans and Ray 2010).

The population found in the North Branch of Egypt Creek is particularly significant because of its size and the intact riparian corridor that supports habitat conditions required by the species. Its EO rank of AB reflects a high expected long term (50+ years) population viability due to the population size, habitat quality and quantity, and the relatively high protection it has residing in Cannnonsburg SGA. It is one of two EO records for the species with an EO rank of AB in Michigan. There are currently 44 occurrence records for watercress snail for Michigan in the Natural Heritage Database. The only ones with an EO rank equal or higher than C (fair estimated population viability) are those at Fort Custer Training Center (BC and C), Victory Park in southwest Michigan (BC), and Camp Grayling (AB). The rest are either historical, most of which were last observed in 1947 or earlier, or have EO ranks lower than C. An EO rank of BC is defined as good to fair population viability and AB is excellent or good viability.

Avoiding impacts to the unique conditions watercress snails rely on in groundwater seeps, springs, streams, and wetlands is key to maintaining populations. We recommend that trail crossings over streams within Cannonsburg SGA minimize erosion and that removal of riparian vegetation is avoided. Watercress snails depend on the specific 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 streams, springs, and seeps can help maintain groundwater flow that creates these microhabitats. Retaining naturally vegetated riparian zones and landcover around streams, springs, and seeps with watercress snails 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 for de-icing and/or dust control on dirt roads, metals (e.g. copper, mercury, and zinc), and excess nutrients from agricultural runoff (Johnson et al. 2013, Lydeard et al. 2004). Avoiding impacts to populations once they are documented is the next step in securing and improving this species' conservation status in Michigan and globally.

Mussel Surveys

Despite the proximity, of Cannonsburg SGA to the species rich mussel community of the lower Grand River, no unionid mussels were found in Egypt Creek. The lower Grand River watershed, which Egypt Creek is part of, has records for nine mussel species of Special concern, two State Threatened, four State Endangered, and two Federally Endangered mussel species. Historically (pre-1960), the lower Grand River ranks second in Michigan behind the Detroit River in mussel species richness with 31 of Michigan's 43 native mussel species. In more recent surveys (1989-2009) the lower Grand River is tied for third most (23) with the Kalamazoo River and St. Joseph River (Lake MI drainage) behind the St. Clair River tributaries (Belle, Pine, and Black Rivers) and the Huron River (Badra 2010).

There are several potential reasons for the lack of unionid mussels from the reach of Egypt Creek within Cannonsburg SGA including river size, availability of fish hosts, and barriers to fish movement. There is a positive correlation to river drainage size and both mussel species richness and fish species richness (Watters 1992). Egypt Creek is a small headwater stream and so, is expected to have lower

mussel and fish species richness. Unionid mussels' reliance on fish hosts to transform from the larval (glochidial) stage to adult means that a shortage of fish hosts could reduce or exclude their populations. Unionid mussels also rely on fish hosts to carry glochidia to upstream habitats. Barriers to fish movement in Egypt Creek between the Grand River and Cannonburg SGA would interfere with the immigration of unionid mussels to the game area (Watters 1996).

Erosion of the stream bank at Sites 4 and 5 was not caused by any apparent local impact but looked to be natural erosion or possibly erosion exacerbated by increased flashy hydrological pattern by more extreme precipitation events. High-quality headwater streams such as Egypt Creek support the habitat quality and ecosystem function of larger rivers downstream and the species that are part of these systems. The relatively intact and natural landcover of Cannonsburg SGA not only benefits Egypt Creek, but the lower Grand River and listed mussel species it supports as well.

Rare Insects Surveys

Karner blue and frosted elfin

Karner blue and frosted elfin butterflies rely on stable lupine populations. Maintaining a prevalence of the host plants within a landscape will supprt populations of these rare butterflies. Wild lupine is an early-successional species adapted to dry infertile soils. Shade from tree canopy and competition from sod-forming grasses and sedges have excluded lupine from many former barrens. Gap-phase dynamics and fire disturbance that reduce canopy cover and leaf litter are necessary for wild lupine to persist. Well-planned fire management is critical for habitat restoration and maintenance. The frequency of fire management should be tailored to each management unit, taking into consideration the desired final community matrix, current community conditions, site characteristics, and the life histories of all fire-sensitive species present. The end goal being a mosaic of barrens, prairies, and woodlands at different successional stages. Semi-isolated butterfly populations in this landscape will fluctuate with the fluctuation of lupine populations. Having a landscape mosaic of differing successional stages would provide colonizers to sites recently opened by fire or to sites where butterflies have been lost to localized extinction events.

Poorly timed or poorly located use of herbicides can have a negative effect on Karner blue and frosted elfin butterflies by killing or suppressing lupine or important nectar plants. Mowing between late spring and midsummer is anticipated to have detrimental effects on Karner blue and frosted elfin populations.

The documented frosted elfin population is suppressed by a lack of connectivity between lupine patches. While the core (located within Stand 18) has abundant wild lupine, the rest of the EO does not. The lack of lupine is a result increased canopy cover.

Bumble bees

Bumble bees are foraging generalist and require access to abundant and diverse floral resources. Managing landscapes to maximize season-long availability of floral resources is necessary for colony health and reproduction. Management that will help bumblebee populations include protecting associated natural communities, planting wildflowers, and incorporating prairie species into habitat management programs. We recommend minimizing ground disturbance in occupied habitats to help provide adequate nesting locations. Bumblebees are particularly sensitive to ground management actions, such as disking,

Lupine growing Cannonsburg State Game area. Photo by Logan Rowe.

tilling, and herbicide applications. Spotted knapweed is a common a pernicious invasive species that is crowding out native species in Stand 18. The targeted application of herbicide to irradicate this species in Stand 18 will promote native flower diversity. Prescribed fire in the spring will also help reduce invasive species that are limiting native species growth in the area.

Bird Surveys

Hooded warblers occur in landscapes with mature deciduous forest where breeding populations require large blocks of mature forest to remain viable. Louisiana waterthrush occur along the banks of streams flowing through closed-canopy forest. The maintenance and expansion of mature forest blocks within the game area would likely benefit rare bird species and other forest-interior species including Acadian flycatcher and wood thrush. Activities that reduce mature forest reduce the value of Cannonsburg SGA to forest songbirds. In fragmented landscapes these species are more susceptible to nest parasitism by brown-headed cowbirds (*Molothrus ater*). Cowbirds thrive in fragmented landscapes (Robinson et al. 1995). Cowbirds were observed at 39% of the point-count stations. We recommend protecting existing stands of upland forests in the game area that are over 100 years old.

Red-shouldered hawks were heard during fieldwork at Cannonsburg SGA but they did not respond to playbacks. This species requires extensive forested cover interspersed with wetlands. This habitat is present at Cannonsburg but does not cover large areas and occurs around developments. Red-shouldered hawk utilize the area during migration and protection measures that help songbirds will also benefit this species. It is possible that management activities promoting natural cover will attract red-shouldered hawks and future survey will find nesting hawks.

Red-shouldered hawk seen during playback surveys in northern Michigan. Photo by Aaron Kortenhoven.

CONCLUSION

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 Cannonsburg SGA. To maintain the game area's critical contribution to biodiversity protection, resilience, ecological integrity, and ecosystems services, we recommend that managers prioritize actions around sustaining the unique natural communities and populations of rare species by preventing forest fragmentation adjacent to high-quality natural communities identified in this report; implementing prescribed fire in oak-dominated forests; controling invasive species within high-quality natural communities and preventing the establishment of new bike trails and minimizing erosion of current bike trails.

The Greater Grand Rapids Metropolitan Area is one of the most rapidly developing economic regions of the country. Cannonsburg SGA substantially contributes to the native biodiversity of the region. Extensive networks of green infrastructure like the Cannonsburg SGA protect native biodiversity and provide substantial return of ecosystem service, including maintenance of water quality and recharging groundwater aquifers that are the source of residential drinking water.

This game area was acquired by the State of Michigan to preserve and improve natural habitat for wildlife as urbanization, industrialization, and intensive farming are contributing to the destruction of such habitats. The game area is intended to offer a large variety of recreational opportunities including hunting and non-consumptive uses. Currently this area is used by mountain bikers throughout the non-hunting times of the year and if this area is to remain a natural area these trails should be limited to their current footprint.

As the extent of natural cover continues to decrease, public lands such as Cannonsburg State Game Area will have an ever-expanding role in the protection of Michigan's natural heritage and quality of life for its residents. Its unique position in a developing landscape and its accessible beauty offers an opportunity to introduce significant segments of the population to the phenomenon of public land. It is big enough to protect native biodiversity, offer myriad recreational opportunities, and maintain the critical access to hunting for which it was purchased. The importance of Cannonsburg SGA as both a reservoir of biodiversity and an entry point for citizens to experience that nature will only grow with the passage of time.

This was one of six vehicles with bike racks parked at Cannonsburg SGA during a posted "trail closed" period. Photo by Aaron Kortenhoven

LITERATURE CITED

American Turtle Observatory. 2017. Coordinated monitoring strategy for Blanding's turtle in the northeastern United States project overview and implementation protocols. Massachusetts, USA.

AmphibiaWeb. 2024a. *Anaxyrus fowleri*: Fowler's Toad <https://amphibiaweb.org/species/173> University of California, Berkeley, CA, USA. Accessed 31 January 2024.

AmphibiaWeb. 2024b. *Rana palustris*: Pickerel Frog <https://amphibiaweb.org/species/5121> University of California, Berkeley, CA, USA. Accessed 31 January 2024.

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, 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.

Aresco, M.J. 2005. The effect of sex-specific terrestrial movements and roads on the sex ratio of freshwater turtles. Biological Conservation 123:37–44.

Augustine, D.J., and L.E. Frelich. 1998. Effects of white-tailed deer on populations of an understory forb in fragmented deciduous forests. Conservation Biology 12(5): 995-1004.

Badra, P.J. 2023. Surveys for Watercress Snail (*Fontigens nickliniana*) in and around Fort Custer Training Center. Michigan Natural Features Inventory Report Number 2023-03, Lansing, MI.

Badra, P.J. 2010. Assessment of the Status and Distribution of Native Mussels (Unionidae) in Michigan, and Results of Unionid Surveys in the Eastern Upper Peninsula and Huron-Clinton Metroparks. Michigan Natural Features Inventory Report No. MNFI 2010-11. Report to Michigan Department of Natural Resources and Environment, Water Bureau, Lansing, MI. 71 pp.

Brosofske, K.D.; Chen, J.; Crow, Thomas R. 2001. Understory vegetation and site factors : implications for a managed Wisconsin landscape. Forest ecology and management. Vol. 146: p75-87

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.

Calhoun, A.J.K., and P.G. deMaynadier. 2008. Science and Conservation of Vernal Pools in Northeastern North America. CRC Press, New York, NY. 363 pp.

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).

Cohen, JG., H.D. Enander, T.J. Bassett, C.M. Wilton, and A. Cole-Wick. 2024. Using GIS-based multicriteria decision analysis to prioritize invasive plant treatment: A creative solution for a pernicious problem. Ecological Modelling Vol.495 110807

Colburn, E.A. 2004. Vernal Pools: Natural History and Conservation. The McDonald and Woodward Publishing Company, Granville, OH. 426 pp.

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.
Congdon, J.D., A.E. Dunham, and R.C. van Lobensels. 1994. Demographics of common snapping turtles (*Chelydra serpentina*): Implications for conservation and management of long-lived organisms. American Zoologist 34:397–408.
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.
Currylow, A.F., B.J. MacGowan, and R.N. Williams. 2012. Short-term forest management effects on a long-lived ectotherm. PLoS ONE 7:1-12.
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
Dodd, C.K., Jr. 2001. North American Box turtles: A Natural History. Norman, OK: University of Oklahoma Press.
Donaldson, B.M. and A.C. Echternacht. 2005. Aquatic habitat use relative to home range and seasonal movement of eastern box turtles (*Terrapene carolina carolina*: Emydidae) in eastern Tennessee. Journal of Herpetology 39:278–284.
Erb, L.A. and H.P. Roberts. 2023a. Status assessment for the eastern box turtle in the northeastern United States. Final report to the Northeast Association of Fish and Wildlife Agencies (NEAFWA) for a Regional Conservation Needs (RCN) award.
Erb, L.A. and H.P. Roberts. 2023b. A guide to habitat management for eastern box turtle (*Terrepene carolina carolina*). Final report to the Northeast Association of Fish and Wildlife Agencies (NEAFWA) for a Regional Conservation Needs (RCN) award.
Ernst, C.H. and E.M. Ernst. 2003. Snakes of the United States and Canada. Smithsonian Institution, Washington, D.C.
Ernst, C.H. and J.E. Lovich. 2009. Turtles of the United States and Canada. 2nd Edition. The Johns Hopkins University Press, Baltimore, MD.
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.
Felix, Z., Y. Wang, J. Czech, and C.J. Schweitzer. 2008. Abundance of juvenile eastern box turtles relative to canopy cover in managed forest stands in Alabama. Chelonian Conservation and Biology 7:128–130.
Flitz, B.A. and S.J. Mullin. 2006. Nest site selection in the eastern box turtle, *Terrapene carolina carolina*, in Illinois. Chelonian Conservation and Biology 5(2):309–312.
Forman, R.T.T., D. Sperling, J. A. Bissonette, A. P. Clevenger, C.D. Cutshall, V.H. Dale, L. Fahrig, R. France, C.R. Goldman, K. Heanue, J. A. Jones, F. J. Swanson, T. Turrentine, and T.C. Winter. 2003. Road Ecology. Island Press, Washington, D.C.
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
Gibbs, J.P. and D.A. Steen. 2005. Trends in sex ratios of turtles in the United States: implications of road mortality. Conservation Biology 19:552–556.
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.
Hall, R.J., P.F.P. Henry, and C.M. Bunck. 1999. Fifty-year trends in a box turtle population in Maryland. Biological Conservation 88(2):165–172.
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.
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.

Hewitt, N., and M. Kellman. 2004. Factors influencing tree colonization in fragmented forests: An experimental study of introduced seeds and seedlings. Forest Ecology and Management 191: 39-59.

Johnson, P.T.J., J.D. Olden, C.T. Solomon, and M.J. Vander Zanden. 2009. Interactions among invaders: community and ecosystem effects of multiple invasive species in an experimental aquatic system. Oecologia 159: 161-170.

Kjoss, V.A. and J.A. Litvaitis. 2001. Community structure of snakes in a human-dominated landscape. Biological Conservation 98:285–292.

Koester, B.O. 2016. Hibernacula site selection of the eastern box turtle, *Terrapene c. carolina*, in a West Virginia population. M.S. Thesis, Huntington, WV.

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.

Laarman, P.B., P. W. Keenlance, J. T. Altobelli, C. M. Schumacher, P. Huber, J. J. Jacquot, and J. A. Moore. 2018. Ecology of neonate eastern box turtles with prescribed fire implications. The Journal of Wildlife Management 82(7):1385-1395. 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 Herp Atlas. 2019. Michigan Herp Atlas - A Statewide Herpetological Atlas and Data Hub. Michigan, U.S.A. [Available at https://miherpatlas.org]

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

Michigan Natural Features Inventory. 2024. Michigan Natural Heritage Database, Lansing, 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.

Nicholson, B.J., D. P. Quinn, and M.A. Rivadeneyra. 2020. Post-natal movement, habitat use and hibernacula selection of eastern box turtles (*Terrapene carolina carolina*) in southern New England. Northeastern Naturalist 27(2):358–380.

Ontario Ministry of Natural Resources and Forestry. 2016. Best management practices for mitigating the effects of roads on amphibian and reptile species at risk in Ontario. Queen's Printer for Ontario.

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.

Potter, B.A., G.J. Soulliere, D.N. Ewert, M.G. Knutson, W.E. Thogmartin, J.S. Castrale, and M.J. Roell. 2007. Upper Mississippi River and Great Lakes Region Joint Venture Landbird Habitat Conservation Strategy. U.S. Fish and Wildlife Service, Fort Snelling, Minnesota. 124 pp.

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 ofMichigan, AnnArbor, 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

Rudolph, D.C., S. J. Burgdorf, R. N. Conner, and R. R. Schaefer. 1999. Preliminary evaluation of

the impact of roads and associated vehicular traffic on snake populations in eastern Texas. In: Proceedings of the Third International Conference on Wildlife Ecology and Transportation: 128–135. Evink, G., P. Garrett, and D. Zeigler. (Eds). Tallahassee: Florida Department of Transportation.

Sargent, L.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]

Savva, Y., C.W. Swarth, J. Gupchup, and K. Szlavecz. 2010. Thermal environments of overwintering eastern box turtles (*Terrapene carolina carolina*). Canadian Journal of Zoology 88:1086–1094.

Shepard, D.B., A.R. Kuhns, M.J. Dreslik, and C.A. Phillips. 2008. Roads as barriers to animal movement in fragmented landscapes. Animal Conservation 11:288-296.

Steen, D.A., and J.P. Gibbs. 2004. Effects of roads on the structure of freshwater turtle populations. Conservation Biology 18(4): 1143–1148.

Steen, D.A., M.J. Aresco, S. G. Beilke, B. W. Compton, E.P. Condon, C.K. Dodd Jr., H. Forrester, J.W. Gibbons, J.L. Greene, G. Johnson, T.A. Langen, M. Oldham, D.N. Oxier, R.A. Saumure, F.W. Schueler, J.M. Sleeman, L.L. Smith, J.K. Tucker, and J.P. Gibbs. 2006. Relative vulnerability of female turtles to road mortality. Animal Conservation 9:269–273.

Stickel, L.F. 1978. Changes in a box turtle population during three decades. Copeia 1978:221–225.

Willey, L.L. 2010. Ecology of eastern box turtles in central Massachusetts. Ph.D. Dissertation. University of Massachusetts, Amherst, MA.

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.

Willey, L.L. and P. R. Sievert. 2012. Notes on the nesting ecology of eastern box turtles near the northern limit of their range. Northeastern Naturalist 19(3):361–372.

APPENDICES

Appendix Ia. Floristic Quality Assessment for Cannonsburg Woods (EO ID 27076 pg 22).

Cannonsburg Woods Dry Southern Forest

Cannonsburg SGA

Practitioner: Jesse Lincoln

Conservatism-Based Metrics:

Total Mean C:	3.6
Native Mean C:	4
Total FQI:	28.6
Native FQI:	29.9
Adjusted FQI:	37.7
% C value 0:	14.3
% C value 1-3:	28.6
% C value 4-6:	49.2
% C value 7-10:	7.9
Native Tree Mean C:	4.2
Native Shrub Mean C:	4.3
Native Herbaceous Mean C:	3.8

Species Richness:

Total Species:	63	
Native Species:	56	88.90%
Non-native Species:	7	11.10%

Species Wetness:	
Mean Wetness:	3
Native Mean Wetness:	3.1

Physiognomy Metrics:

Tree:	16	25.40%
Shrub:	16	25.40%
Vine:	3	4.80%
Forb:	21	33.30%
Grass:	4	6.30%
Sedge:	2	3.20%
Rush:	0	0%
Fern:	1	1.60%
Bryophyte:	0	0%

Duration Metrics:

Annual:	1	1.60%
Perennial:	61	96.80%
Biennial:	1	1.60%
Native Annual:	1	1.60%
Native Perennial:	55	87.30%
Native Biennial:	0	0%

Appendix Ia. Floristic Quality Assessment for Cannonsburg Woods (EO ID 27076 pg 22).

Scientific Name	Common Name	Native?	C	W	Physiognomy
Acer rubrum	red maple	native	1	0	tree
Acer saccharum	sugar maple	native	5	3	tree
Alliaria petiolata	**garlic mustard**	**non-native**	**0**	**3**	**forb**
Amelanchier arborea	juneberry	native	4	3	tree
Apocynum androsaemifolium	spreading dogbane	native	3	5	forb
Berberis thunbergii	**japanese barberry**	**non-native**	**0**	**3**	**shrub**
Bromus pubescens	canada brome	native	5	3	grass
Carex pensylvanica	sedge	native	4	5	sedge
Carex rosea; c. convoluta	curly-styled wood sedge	native	2	5	sedge
Carya glabra	pignut hickory	native	5	3	tree
Chimaphila maculata	spotted wintergreen	native	8	5	shrub
Circaea canadensis; c. lutetiana	enchanters-nightshade	native	2	3	forb
Cornus florida	flowering dogwood	native	8	3	tree
Corylus americana	hazelnut	native	5	3	shrub
Elaeagnus umbellata	**autumn-olive**	**non-native**	**0**	**3**	**shrub**
Eurybia macrophylla; aster m.	big-leaved aster	native	4	5	forb
Festuca subverticillata; f. obtusa	nodding fescue	native	5	3	grass
Fraxinus americana	white ash	native	5	3	tree
Galium aparine	annual bedstraw	native	0	3	forb
Galium boreale	northern bedstraw	native	3	0	forb
Galium circaezans	white wild licorice	native	4	3	forb
Gaylussacia baccata	huckleberry	native	7	3	shrub
Geum canadense	white avens	native	1	0	forb
Hamamelis virginiana	witch-hazel	native	5	3	shrub
Helianthus divaricatus	woodland sunflower	native	5	5	forb
Hepatica americana	round-lobed hepatica	native	6	5	forb
Hylodesmum nudiflorum; desmodium n.	naked tick-trefoil	native	7	5	forb
Juniperus virginiana	red-cedar	native	3	3	tree
Lonicera morrowii	**morrow honeysuckle**	**non-native**	**0**	**3**	**shrub**
Maianthemum canadense	canada mayflower	native	4	3	forb
Ostrya virginiana	ironwood; hop-hornbeam	native	5	3	tree
Parthenocissus quinquefolia	virginia creeper	native	5	3	vine
Phryma leptostachya	lopseed	native	4	3	forb
Phytolacca americana	pokeweed	native	2	3	forb
Pinus strobus	white pine	native	3	3	tree
Poa alsodes	bluegrass	native	9	0	grass
Poa pratensis	**kentucky bluegrass**	**non-native**	**0**	**3**	**grass**
Podophyllum peltatum	may-apple	native	3	3	forb
Polygonatum pubescens	downy solomon seal	native	5	5	forb
Potentilla simplex	old-field cinquefoil	native	2	3	forb
Prunus serotina	wild black cherry	native	2	3	tree
Prunus virginiana	choke cherry	native	2	3	shrub
Pteridium aquilinum	bracken fern	native	0	3	fern

Appendix Ia. Floristic Quality Assessment for Cannonsburg Woods (EO ID 27076 pg 22).

Scientific Name	Common Name	Native?	C	W	Physiognomy
Quercus alba	white oak	native	5	3	tree
Quercus rubra	red oak	native	5	3	tree
Quercus velutina	black oak	native	6	5	tree
Rhamnus cathartica	**common buckthorn**	**non-native**	**0**	**0**	**tree**
Ribes cynosbati	prickly or wild gooseberry	native	4	3	shrub
Rosa carolina	pasture rose	native	4	3	shrub
Rosa multiflora	**multiflora rose**	**non-native**	**0**	**3**	**shrub**
Rubus allegheniensis	common blackberry	native	1	3	shrub
Rubus flagellaris	northern dewberry	native	1	3	shrub
Sassafras albidum	sassafras	native	5	3	tree
Smilax ecirrata	upright carrion-flower	native	6	5	forb
Solidago caesia	bluestem goldenrod	native	6	3	forb
Symphyotrichum cordifolium; aster c.	heart-leaved aster	native	4	5	forb
Toxicodendron radicans	poison-ivy	native	2	0	vine
Ulmus americana	american elm	native	1	-3	tree
Vaccinium angustifolium	low sweet blueberry	native	4	3	shrub
Viburnum acerifolium	maple-leaved viburnum	native	6	5	shrub
Viburnum rafinesquianum	downy arrow-wood	native	5	5	shrub
Viola sororia	common blue violet	native	1	0	forb
Vitis aestivalis	summer grape	native	6	3	vine

Appendix Ib. Floristic Quality Assessment for Dursum Woods (EO ID 27077 pg 26).

Dursum Woods Dry Souterhn Forest

Cannonsburg SGA

Practitioner: Jesse Lincoln

Conservatism-Based Metrics:

Total Mean C:	4.2
Native Mean C:	4.6
Total FQI:	39.2
Native FQI:	41.1
Adjusted FQI:	44.1
% C value 0:	9.2
% C value 1-3:	20.7
% C value 4-6:	56.3
% C value 7-10:	13.8
Native Tree Mean C:	4.3
Native Shrub Mean C:	4.3
Native Herbaceous Mean C:	4.7

Physiognomy Metrics:

Tree:	18	20.70%
Shrub:	16	18.40%
Vine:	7	8%
Forb:	32	36.80%
Grass:	6	6.90%
Sedge:	3	3.40%
Rush:	0	0%
Fern:	5	5.70%
Bryophyte:	0	0%

Species Richness:

Total Species:	87	
Native Species:	80	92%
Non-native Species:	7	8%

Duration Metrics:

Annual:	1	1.10%
Perennial:	83	95.40%
Biennial:	3	3.40%
Native Annual:	1	1.10%
Native Perennial:	77	88.50%
Native Biennial:	2	2.30%

Species Wetness:

Mean Wetness:	2.9
Native Mean Wetness:	2.9

Appendix Ib. Floristic Quality Assessment for Dursum Woods (EO ID 27077 pg 26).

Scientific Name	Common Name	Acronym	Native?	C	W	Physiognomy
Acer rubrum	red maple	ACERUB	native	1	0	tree
Acer saccharum	sugar maple	ACESAU	native	5	3	tree
Adiantum pedatum	maidenhair fern	ADIPED	native	6	3	fern
Agrostis perennans	autumn bent	AGRPER	native	5	3	grass
Amelanchier arborea	juneberry	AMEARB	native	4	3	tree
Amphicarpaea bracteata	hog-peanut	AMPBRA	native	5	0	vine
Anemone canadensis	canada anemone	ANECAN	native	4	-3	forb
Anemone quinquefolia	wood anemone	ANEQUI	native	5	3	forb
Arabidopsis lyrata; arabis l.	sand cress	ARALYR	native	7	3	forb
Aralia nudicaulis	wild sarsaparilla	ARANUD	native	5	3	forb
Asplenium platyneuron	ebony spleenwort	ASPPLA	native	2	3	fern
Brachyelytrum erectum	long-awned wood grass	BRAERE	native	7	5	grass
Carex blanda	sedge	CXBLAN	native	1	0	sedge
Carex pensylvanica	sedge	CXPENS	native	4	5	sedge
Carex rosea; c. convoluta	curly-styled wood sedge	CXROSE	native	2	5	sedge
Carya glabra	pignut hickory	CARGLA	native	5	3	tree
Chimaphila umbellata	pipsissewa	CHIUMB	native	8	5	shrub
Comandra umbellata	bastard-toadflax	COMUMB	native	5	3	forb
Conopholis americana	squaw-root	CONAME	native	10	5	forb
Cornus florida	flowering dogwood	CORFLO	native	8	3	tree
Crataegus punctata; c. nitidula	dotted hawthorn	CRAPUN	native	1	3	tree
Danthonia spicata	poverty grass; oatgrass	DANSPI	native	4	5	grass
Dichanthelium latifolium; panicum l.	broad-leaved panic grass	DICLAT	native	5	3	grass
Dryopteris intermedia	evergreen woodfern	DRYINT	native	5	0	fern
Erigeron pulchellus	robins-plantain	ERIPUL	native	5	3	forb
Eurybia macrophylla; aster m.	big-leaved aster	EURMAC	native	4	5	forb
Fagus grandifolia	american beech	FAGGRA	native	6	3	tree
Fraxinus americana	white ash	FRAAME	native	5	3	tree
Galium circaezans	white wild licorice	GALCIR	native	4	3	forb
Galium lanceolatum	yellow wild licorice	GALLAN	native	4	5	forb
Gaylussacia baccata	huckleberry	GAYBAC	native	7	3	shrub
Geranium maculatum	wild geranium	GERMAC	native	4	3	forb
Geum canadense	white avens	GEUCAN	native	1	0	forb
Hackelia virginiana	beggars lice	HACVIR	native	1	3	forb
Hamamelis virginiana	witch-hazel	HAMVIR	native	5	3	shrub
Hepatica americana	round-lobed hepatica	HEPAME	native	6	5	forb
Hylodesmum glutinosum; desmodium g.	clustered-leaved tick-trefoil	HYLGLU	native	5	5	forb
Hylodesmum nudiflorum; desmodium n.	naked tick-trefoil	HYLNUD	native	7	5	forb
Juniperus virginiana	red-cedar	JUNVIR	native	3	3	tree
Lindera benzoin	spicebush	LINBEN	native	7	-3	shrub
Maianthemum racemosum; smilacina r.	false spikenard	MAIRAC	native	5	3	forb
Mitchella repens	partridge-berry	MITREP	native	5	3	forb
Monotropa uniflora	indian-pipe	MONOUN	native	5	3	forb

Appendix Ib. Floristic Quality Assessment for Dursum Woods (EO ID 27077 pg 26).

Scientific Name	Common Name	Acronym	Native?	C	W	Physiognomy
Muhlenbergia tenuiflora	slender satin grass	MUHTEN	native	8	5	grass
Osmorhiza claytonii	hairy sweet-cicely	OSMCLI	native	4	3	forb
Osmunda claytoniana	interrupted fern	OSMCLN	native	6	0	fern
Ostrya virginiana	ironwood; hop-hornbeam	OSTVIR	native	5	3	tree
Packera paupercula; senecio p.; senecio plattensis	balsam ragwort	PACPAU	native	3	0	forb
Parthenocissus quinquefolia	virginia creeper	PARQUI	native	5	3	vine
Persicaria virginiana; polygonum v.	jumpseed	PERVIR	native	4	0	forb
Phryma leptostachya	lopseed	PHRLEP	native	4	3	forb
Pinus strobus	white pine	PINSTR	native	3	3	tree
Polygonatum pubescens	downy solomon seal	POLPUB	native	5	5	forb
Populus grandidentata	big-tooth aspen	POPGRA	native	4	3	tree
Potentilla simplex	old-field cinquefoil	POTSIM	native	2	3	forb
Prunus serotina	wild black cherry	PRUSER	native	2	3	tree
Prunus virginiana	choke cherry	PRUVIR	native	2	3	shrub
Pteridium aquilinum	bracken fern	PTEAQU	native	0	3	fern
Pyrola americana; p. rotundifolia	round-leaved pyrola	PYRAME	native	7	0	forb
Quercus alba	white oak	QUEALB	native	5	3	tree
Quercus rubra	red oak	QUERUB	native	5	3	tree
Quercus velutina	black oak	QUEVEL	native	6	5	tree
Ribes cynosbati	prickly or wild gooseberry	RIBCYN	native	4	3	shrub
Rosa carolina	pasture rose	ROSCAR	native	4	3	shrub
Rubus allegheniensis	common blackberry	RUBALL	native	1	3	shrub
Rubus flagellaris	northern dewberry	RUBFLA	native	1	3	shrub
Rubus occidentalis	black raspberry	RUBOCC	native	1	5	shrub
Sassafras albidum	sassafras	SASALB	native	5	3	tree
Smilax ecirrata	upright carrion-flower	SMIECI	native	6	5	forb
Smilax hispida; s. tamnoides	bristly greenbrier	SMIHIS	native	5	0	vine
Solidago caesia	bluestem goldenrod	SOLCAE	native	6	3	forb
Symphyotrichum urophyllum; aster sagittifolius	arrow-leaved aster	SYMURO	native	2	5	forb
Thalictrum thalictroides; anemonella t.	rue-anemone	THATHA	native	8	3	forb
Toxicodendron radicans	poison-ivy	TOXRAD	native	2	0	vine
Vaccinium angustifolium	low sweet blueberry	VACANG	native	4	3	shrub
Viburnum acerifolium	maple-leaved viburnum	VIBACE	native	6	5	shrub
Viburnum dentatum	arrow-wood	VIBDEN	native	6	0	shrub
Vicia americana	american vetch	VICAME	native	5	3	vine
Viola pedata	birdfoot violet	VIOPET	native	9	5	forb
Vitis aestivalis	summer grape	VITAES	native	6	3	vine
Alliaria petiolata	garlic mustard	ALLPET	non-native	0	3	forb
Celastrus orbiculatus	oriental bittersweet	CELORB	non-native	0	5	vine
Elaeagnus umbellata	autumn-olive	ELAUMB	non-native	0	3	shrub
Lonicera morrowii	morrow honeysuckle	LONMOR	non-native	0	3	shrub
Poa compressa	canada bluegrass	POACOM	non-native	0	3	grass
Prunus avium	sweet cherry	PRUAVI	non-native	0	5	tree
Rosa multiflora	multiflora rose	ROSMUL	non-native	0	3	shrub

Appendix Ic. Floristic Quality Assessment for Egypt Creek Swamp (EO ID 27079 pg 29).

Conservatism-Based Metrics:

Total Mean C:	4.5
Native Mean C:	4.8
Total FQI:	40.5
Native FQI:	41.8
Adjusted FQI:	46.5
% C value 0:	6.2
% C value 1-3:	21
% C value 4-6:	55.6
% C value 7-10:	17.3
Native Tree Mean C:	4
Native Shrub Mean C:	4.8
Native Herbaceous Mean C:	5.1

Species Richness:

Total Species:	81	
Native Species:	76	93.80%
Non-native Species:	5	6.20%

Species Wetness:

Mean Wetness:	0.2
Native Mean Wetness:	0

Physiognomy Metrics:

Tree:	15	18.50%
Shrub:	10	12.30%
Vine:	3	3.70%
Forb:	34	42%
Grass:	7	8.60%
Sedge:	4	4.90%
Rush:	0	0%
Fern:	8	9.90%
Bryophyte:	0	0%

Duration Metrics:

Annual:	3	3.70%
Perennial:	78	96.30%
Biennial:	0	0%
Native Annual:	3	3.70%
Native Perennial:	73	90.10%
Native Biennial:	0	0%

Appendix Ic. Floristic Quality Assessment for Egypt Creek Swamp (EO ID 27079 pg 29).

Scientific Name	Common Name	Native?	C	W	Physiognomy
Adiantum pedatum	maidenhair fern	native	6	3	fern
Athyrium filix-femina	lady fern	native	4	0	fern
Dryopteris carthusiana	spinulose woodfern	native	5	-3	fern
Dryopteris cristata	crested shield fern	native	6	-5	fern
Onoclea sensibilis	sensitive fern	native	2	-3	fern
Osmunda claytoniana	interrupted fern	native	6	0	fern
Osmunda regalis	royal fern	native	5	-5	fern
Thelypteris noveboracensis	new york fern	native	5	0	fern
Arisaema triphyllum	jack-in-the-pulpit	native	5	0	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
Caulophyllum thalictroides	blue cohosh	native	5	5	forb
Conopholis americana	squaw-root	native	10	5	forb
Cryptotaenia canadensis	honewort	native	2	0	forb
Geranium maculatum	wild geranium	native	4	3	forb
Hepatica acutiloba	sharp-lobed hepatica	native	8	5	forb
Hydrophyllum virginianum	virginia waterleaf	native	4	0	forb
Impatiens capensis	spotted touch-me-not	native	2	-3	forb
Iris virginica	southern blue flag	native	5	-5	forb
Laportea canadensis	wood nettle	native	4	-3	forb
Lobelia cardinalis	cardinal-flower	native	7	-5	forb
Maianthemum canadense	canada mayflower	native	4	3	forb
Mitchella repens	partridge-berry	native	5	3	forb
Mitella nuda	naked miterwort	native	8	-3	forb
Persicaria arifolia; polygonum a.	tear-thumb	native	7	-5	forb
Persicaria virginiana; polygonum v.	jumpseed	native	4	0	forb
Podophyllum peltatum	may-apple	native	3	3	forb
Polygonatum biflorum	solomon-seal	native	4	3	forb
Polygonatum pubescens	downy solomon seal	native	5	5	forb
Prenanthes altissima	tall white lettuce	native	5	3	forb
Pyrola americana; p. rotundifolia	round-leaved pyrola	native	7	0	forb
Ranunculus hispidus	swamp buttercup	native	5	0	forb
Rudbeckia laciniata	cut-leaf coneflower	native	6	-3	forb
Sanguinaria canadensis	bloodroot	native	5	3	forb
Sanicula odorata; s. gregaria	black snakeroot	native	2	0	forb
Symphyotrichum lateriflorum; aster l.	calico aster	native	2	0	forb
Symplocarpus foetidus	skunk-cabbage	native	6	-5	forb
Thalictrum dasycarpum	purple meadow-rue	native	3	-3	forb
Viola cucullata	marsh violet	native	5	-5	forb
Viola sororia	common blue violet	native	1	0	forb
Zizia aurea	golden alexanders	native	6	0	forb

Appendix Ic. Floristic Quality Assessment for Egypt Creek Swamp (EO ID 27079 pg 29).

Scientific Name	Common Name	Native?	C	W	Physiognomy
Brachyelytrum erectum	long-awned wood grass	native	7	5	grass
Bromus latiglumis	ear-leaved brome	native	6	-3	grass
Cinna arundinacea	wood reedgrass	native	7	-3	grass
Elymus hystrix; hystrix patula	bottlebrush grass	native	5	3	grass
Elymus riparius	riverbank wild-rye	native	8	-3	grass
Milium effusum	wood millet	native	8	3	grass
Poa alsodes	bluegrass	native	9	0	grass
Carex bromoides	sedge	native	6	-3	sedge
Carex cristatella	sedge	native	3	-3	sedge
Carex pedunculata	sedge	native	5	3	sedge
Carex pensylvanica	sedge	native	4	5	sedge
Berberis thunbergii	japanese barberry	non-native	0	3	shrub
Elaeagnus umbellata	autumn-olive	non-native	0	3	shrub
Ligustrum vulgare	common privet	non-native	0	3	shrub
Lindera benzoin	spicebush	native	7	-3	shrub
Lonicera morrowii	morrow honeysuckle	non-native	0	3	shrub
Rosa multiflora	multiflora rose	non-native	0	3	shrub
Rubus allegheniensis	common blackberry	native	1	3	shrub
Spiraea alba	meadowsweet	native	4	-3	shrub
Staphylea trifolia	bladdernut	native	9	0	shrub
Zanthoxylum americanum	prickly-ash	native	3	3	shrub
Acer nigrum; a. saccharum	black maple	native	4	3	tree
Acer rubrum	red maple	native	1	0	tree
Carpinus caroliniana	blue-beech	native	6	0	tree
Cornus alternifolia	alternate-leaved dogwood	native	5	3	tree
Fraxinus pennsylvanica	red ash	native	2	-3	tree
Juglans nigra	black walnut	native	5	3	tree
Ostrya virginiana	ironwood; hop-hornbeam	native	5	3	tree
Populus tremuloides	quaking aspen	native	1	0	tree
Prunus serotina	wild black cherry	native	2	3	tree
Quercus alba	white oak	native	5	3	tree
Quercus bicolor	swamp white oak	native	8	-3	tree
Quercus macrocarpa	bur oak	native	5	3	tree
Quercus rubra	red oak	native	5	3	tree
Tilia americana	basswood	native	5	3	tree
Ulmus americana	american elm	native	1	-3	tree
Amphicarpaea bracteata	hog-peanut	native	5	0	vine
Parthenocissus quinquefolia	virginia creeper	native	5	3	vine
Toxicodendron radicans	poison-ivy	native	2	0	vine