Natural Features Inventory and Management Recommendations for Middleville State Game Area

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Cover Photo: Dry-mesic southern forest in Middleville State Game Area. Photo by Jesse M. Licnoln.

EXECUTIVE SUMMARY

Middleville State Game Area (SGA) is a large block of semi-continuous public land in southwest Lower Michigan, consisting of approximately 4,500 acres of Barry County. Middleville SGA is important ecologically because it provides critical habitat for a myriad of game and non-game species and supports over 3,900 acres of forest including over 750 acres of high-quality forest that contain numerous wetlands and vernal pools. Because the landscape surrounding Middleville SGA is dominated by agriculture and rural development, the large area of forest within the game area serves as an important island of biodiversity for the local region, especially for interior-forest obligates and species dependent on mature forest ecosystems and the wetlands and vernal pools nested within that forest matrix.

Michigan Natural Features Inventory (MNFI) conducted Integrated Forest Monitoring, Assessment, and Prescription System (IFMAP) Stage 1 inventory and surveys for high-quality natural communities and rare animal species in Middleville SGA as part of the Integrated Inventory Project for the Michigan Department of Natural Resources (DNR) Wildlife Division. Surveys resulted in 12 new element occurrences (EOs) and provided information for updating an additional three EOs. In all, 20 species of greatest conservation need (SGCN) and six rare animal species have been recorded in Middleville SGA with 18 SGCN and four rare animal species documented during the course of this project. In total, 22 EOs have been documented in Middleville SGA including seven animal EOs, eight plant EOs, and seven natural community EOs.

Surveys for exemplary natural communities relied on information collected during IFMAP Stage 1 inventories to help target the locations of potential new natural community EOs. Middleville SGA supports seven high-quality natural community EOs. During the summer of 2013, MNFI ecologists documented five new high-quality natural communities and also updated one known high-quality community EO. Two different natural community types were surveyed in 2013 including: dry-mesic southern forest (5 EOs) and mesic southern forest (2 EOs). We assessed the current ranking, classification, and delineation of these occurrences and detailed the vegetative structure and composition, ecological boundaries, landscape and abiotic context, threats, management needs, and restoration opportunities. The report provides detailed descriptions of each site as well as a comprehensive discussion of site-specific threats and stewardship needs and opportunities.

The site descriptions for natural community EOs include discussion of rare plant populations documented within the high-quality natural communities. During the course of this project, we documented five new rare plant EOs. Newly documented rare plant species included four records for ginseng (*Panax quinquefolius*, state threatened) and one record for beak grass (*Diarrhena obovata*, state threatened).

In 2014, 221 potential vernal pools were identified and mapped from aerial photo interpretation, and 14 vernal pools were surveyed and verified in the field. These survey and mapping results provide baseline information on vernal pool status, distribution, and ecology in the Middleville SGA, which will help natural resource planners and managers develop and implement appropriate management of these wetlands.

Surveys for rare avian species included point-counts for forest songbirds and red-shouldered hawks (*Buteo lineatus*, state threatened). We conducted morning surveys for rare songbirds at 57 point-count locations within forest. These surveys resulted in updated records for two rare songbird species that occur in Middleville SGA: hooded warbler (*Setophaga citrina*, state special concern) and cerulean warbler (*Setophaga cerulea*, state threatened), a focal species of the DNR's Wildlife Action Plan. Point-count surveys resulted in the documentation of 49 bird species including ten SGCN: yellow-billed cuckoo (*Coccyzus americanus*), northern flicker (*Colaptes auratus*), Acadian flycatcher (*Empidonax virescens*), purple martin (*Progne subis*), wood thrush (*Hylocichla mustelina*), blue-winged warbler (*Vermivora cyanoptera*), cerulean warbler, hooded warbler, eastern towhee (*Pipilo erythrophthalmus*), and field sparrow (*Spizella pusilla*). A total of four rare bird species have been documented in the game area with two being recorded during the 2014 breeding season.

We conducted visual encounter or meander surveys, basking surveys, dipnetting, aquatic funnel trapping, and breeding frog call surveys for rare amphibians and reptiles. Surveys and incidental observations by MNFI staff resulted in two new herptile EOs including a new EO for Blanding's turtle (*Emydoidea blandingii*, state special concern) and a new EO for eastern box turtle (*Terrapene carolina carolina*, state special concern), a focal species of the DNR's Wildlife Action Plan. Herptile surveys resulted in the documentation of four additional SGCN: blue-spotted salamander (*Ambystoma*

laterale), spotted salamander (*Ambystoma maculatum*), eastern tiger salamander (*Ambystoma tigrinum*), and western chorus frog (*Pseudacris triseriata*). A total of six amphibian and reptile SGCN have been documented in the Middleville SGA, with all six being recorded during this project. In addition, two rare herptile species have been documented in the game area with both species being recorded in 2014.

Primary management recommendations for the Middleville SGA include 1) invasive species control focused in high-quality forests, 2) the maintenance of the canopy closure of mature forest ecosystems, 3) the reduction of fragmentation and promotion of connectivity across the game area but focused in the vicinity of wetlands and high-quality natural communities, 4) the use of landscape-scale prescribed fire focused in high-quality natural communities and with rotating non-fire refugia where fire-sensitive rare species occur, 5) the opportunistic restoration of oak savanna ecosystems, and 6) the careful prioritization of management efforts in the most critical habitats. Monitoring of these management activities is recommended to facilitate adaptive management.

Mesic southern forest, Middleville State Game Area. Photo by Jesse M. Lincoln.

ACKNOWLEDGMENTS

Funding for this project was provided by the Michigan Department of Natural Resources (DNR) Wildlife Division (WD). We express our sincere gratitude to the numerous DNR staff that helped administer and guide this project including Michael Donovan, Patrick Lederle, Ann LeClaire-Mitchell, Steve Beyer, Christine Hanaburgh, Mark MacKay, Sara Schaefer, Mark Sargent, and Jesse Bramer. In addition to the authors, this report relies on data collected by many present and former Michigan Natural Features Inventory (MNFI) field scientists, especially: Mike Penskar, Aaron Kortenhoven, Mike Sanders, and Adrienne Bozic. For their support and assistance throughout this project, we thank our MNFI colleagues, especially Rebecca Rogers, Ed Schools, Kraig Korroch, Sue Ridge, Nancy Toben, Brian Klatt, and Dave Cuthrell. We gratefully acknowledge the editorial assistance provided by Aaron Kortenhoven.

Dry-mesic southern forest, Middleville State Game Area. Photo by Jesse M. Lincoln.

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INTRODUCTION

Middleville State Game Area (SGA) is a large block of semi-continuous public land in southwest Lower Michigan, consisting of approximately 4,500 acres of Barry County. Together with nearby Barry SGA and Yankee Springs State Recreation Area (SRA), these Michigan Department of Natural Resources' (DNR) properties total more than 26,500 acres. Middleville SGA is important ecologically because it provides critical habitat for a myriad of game and non-game species and supports over 3,900 acres of forest that contain numerous vernal pools and small wetlands. Because the landscape surrounding Middleville SGA is dominated by agriculture, the large area of forest within the game area serves as an important island of biodiversity for the local region (Figure 1). Middleville SGA's forested ecosystems and the wetlands nested within the forested matrix support a wide array of rare herptiles, avian, and plant species. Within Barry County, natural cover constitutes 48% of the county. In comparison, natural cover constitutes approximately 93% of Middleville SGA. Prior to this project, numerous rare species and high-quality natural communities had been documented in Middleville SGA (Tables 1-4). Before 2013, ten element occurrences (EOs) had been documented for Middleville SGA composed of eight rare species occurrences and two high-quality natural communities. Of those rare species occurrences, one was a rare herptile, three were rare plant EOs, and four were bird EOs. Seven species were represented by these occurrences and one natural community type (Tables 1-4).

From 2012 to 2014, Michigan Natural Features Inventory (MNFI) conducted Integrated Forest Monitoring, Assessment, and Prescription System (IFMAP) Stage 1 inventory and surveys for additional exemplary natural communities and rare animals in Middleville SGA as part of the Integrated Inventory Project. This project is part of a long-term effort by the Michigan DNR Wildlife Division to document and sustainably manage areas of high conservation significance on state lands. This report provides an overview of the landscape and historical context of Middleville SGA, summarizes the findings of MNFI's surveys of Middleville SGA for high-quality natural communities and rare animal species, and discusses stewardship needs, opportunities, and priorities within the game area. Specific management recommendations are provided for rare species and groups of rare species and also for each natural community EO found within the game area. In addition, to species-based and site-based stewardship discussion, general management recommendations for the game area as a whole are provided.

Ecoregions and Subsections

The regional landscape ecosystems of Michigan have been classified and mapped based on an integration of climate, physiography, soils, and natural vegetation (Albert 1995) (Figure 2). This classification system can be useful for conservation planning and integrated resource management because it provides a framework for understanding the distribution patterns of species, natural communities, anthropogenic activities, and natural disturbance regimes. The classification is hierarchically structured with three levels in a nested series, from broad landscape regions called **sections**, down to smaller **subsections** and **sub-subsections**. Middleville SGA lies within two subsections, the Kalamazoo Interlobate subsection (Subsection VI.2) and the Ionia subsection (Subsection VI.4). The southern margin of the game area falls within the Kalamazoo Interlobate subsection while the majority of the game area occurs within the Ionia subsection. The portion of the game area within the Ionia Subsection occurs entirely within the Lansing Till Plain (Sub-Subsection VI.4.1) and the portion of the game area within the Kalamazoo Interlobate falls entirely within the Battle Creek Outwash Plain (Sub-subsection VI.2.1) (Figure 2).

Kalamazoo Interlobate

The Kalamazoo Interlobate subsection is the southern portion of an interlobate area between three glacial lobes, which formed approximately 13,000 to 16,000 years ago. Glacial end moraines, ice-contact ridges, and outwash plains that characterize this area are the result of contact between these three glacial lobes. The entire interlobate is more than 240 kilometers (150 mi) long and the flat plain within the region was the northernmost extension of the "Prairie Peninsula", as described by Transeau (1935). Kettle lakes, kettle depressions, and streams are numerous throughout the subsection. The subsection is entirely underlain by Mississippian (Paleozoic) shale (Dorr and Eschman 1970, Milstein 1987) of variable depth with prevalent soils including sands and sandy loams. The Kalamazoo Interlobate is one of the warmest subsections in the state. The average growing season ranges from approximately 140 days at the north edge of the subsection to more than 160 days in the southwest (Eichenlaub et al. 1990). Average annual precipitation ranges from 81 cm (32 in) in the north to 97 cm (38 in) in the southwest. During the relatively long growing season, most precipitation is associated with passing cold fronts and showers caused by air mass instability. The winters are mild and average snowfall ranges from 127 cm (50 in) in the east to more than 152 cm (60 in) in the southwest near Lake Michigan. Extreme minimum temperature ranges from -30.3 °C (-22.5 °F) in the south to -34.7 °C (-30.5 °F) in the extreme north. Prevalent vegetation types within this region historically included oak savanna, oak-hickory forest, prairie (including

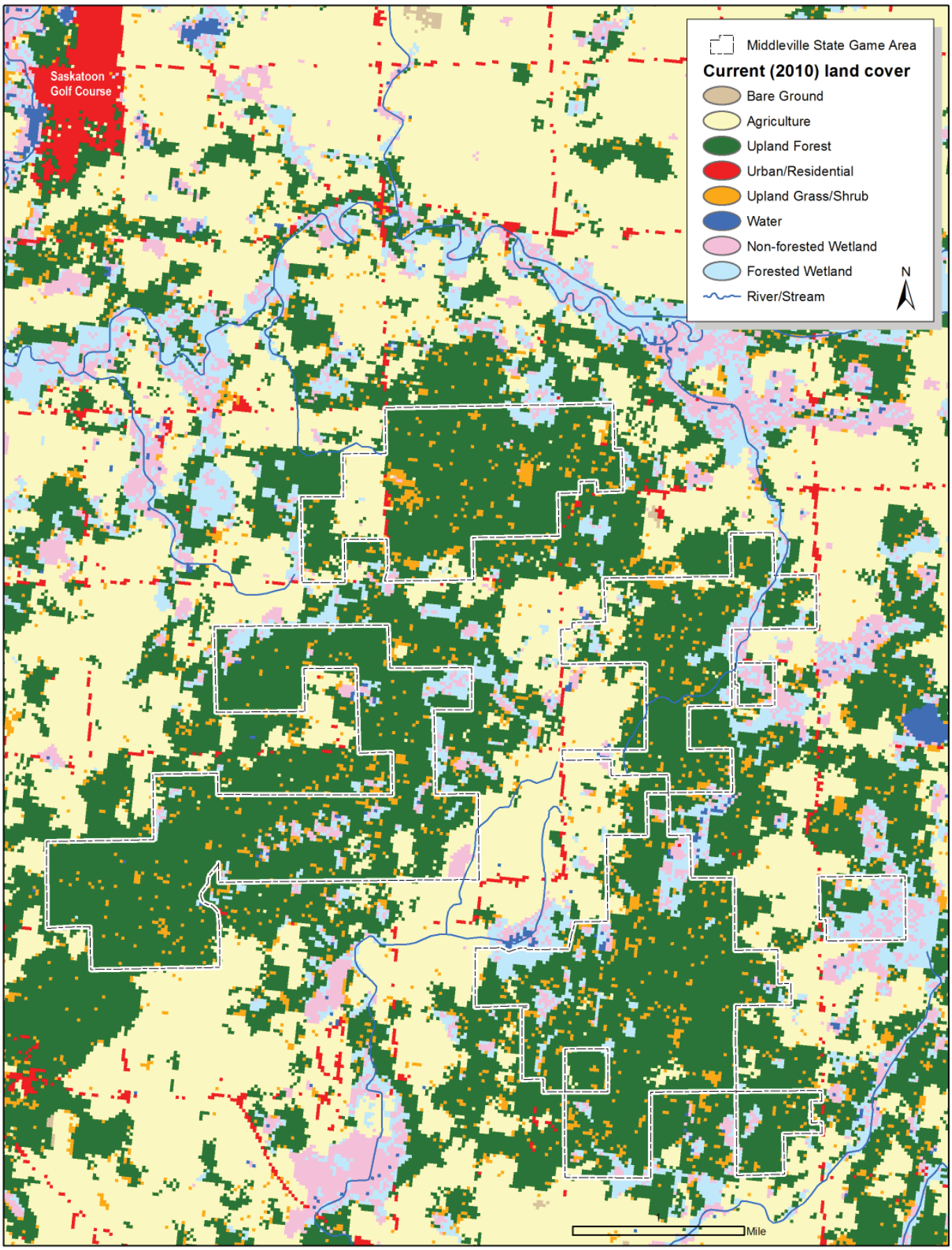


Figure 1. Current land cover of Middleville State Game Area.

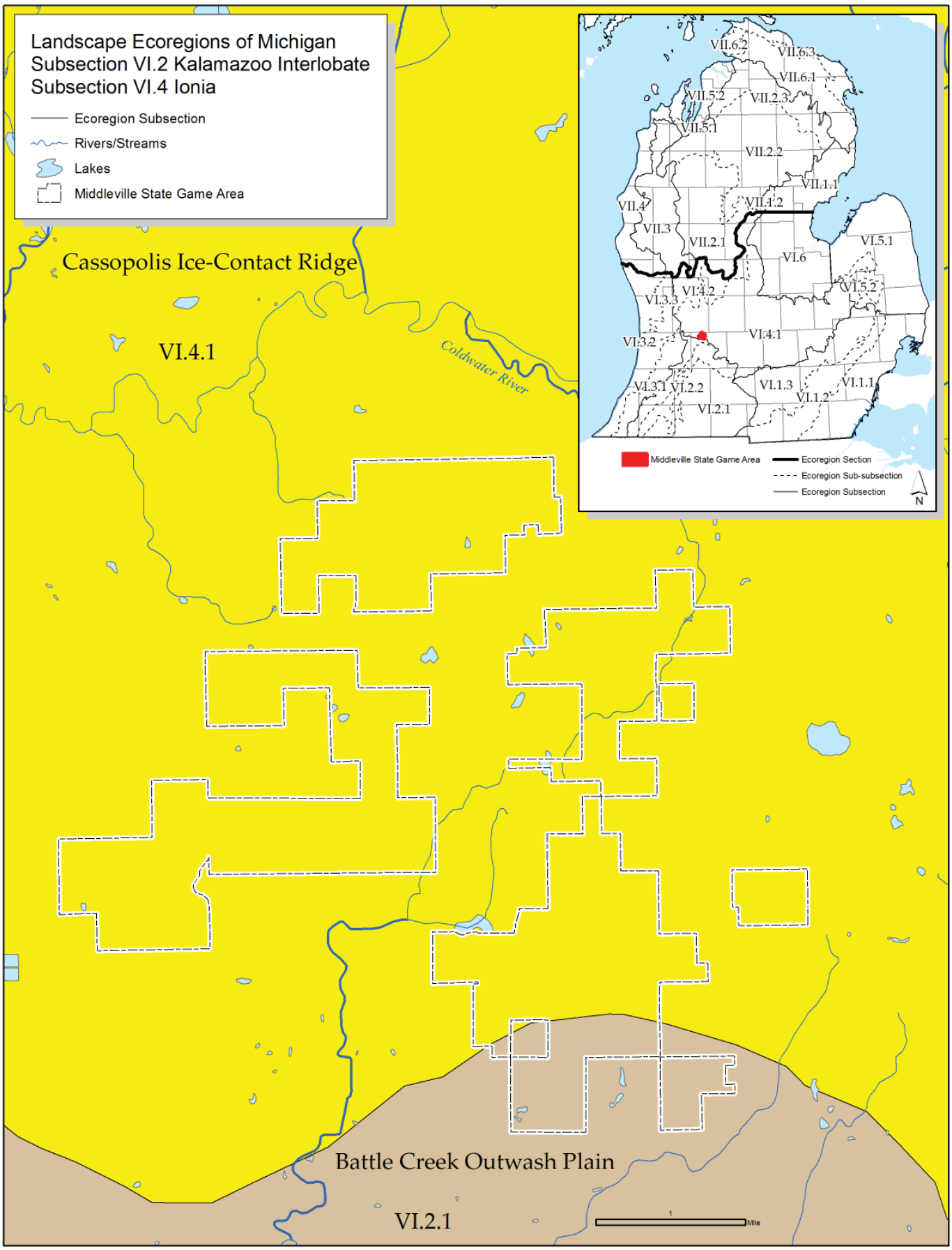


Figure 2. Ecoregions of Middleville State Game Area (Albert 1995)

upland and palustrine types), swamp forest, and prairie fen. Due to fire suppression, agriculture, and residential development, much of the prairie and savanna have been eliminated or degraded. Remaining natural cover within this subsection is primarily oak-dominated forest (Albert 1995).

Battle Creek Outwash Plain

The Battle Creek Outwash Plain (VI.2.1) is a broad, flat outwash plain containing numerous small lakes and wetlands and small ridges of ground moraine (Figure 3). Portions of the outwash are excessively drained and fire prone, while other areas are poorly drained, with numerous kettle lakes and wetlands. Numerous streams and headwater streams occur within this region. Outwash deposits of sand and gravel cover more than half of the sub-subsection. Soils are primarily well drained sands and loamy sands and less frequently sandy loams. Poorly drained mineral and organic soils are concentrated in the narrow outwash channels and in the kettle depressions. More than 80% of the outwash plain is in the 0 to 6% slope class. Small areas of ground moraine and even end moraine are scattered throughout the outwash plain but are concentrated in the southeastern portion of the sub-subsection. Historically the areas of well-drained outwash plain supported fire-dependent tallgrass prairie and oak savanna. Islands of ground moraine supported savanna and oak woodland and steeper end moraines supported oak woodland and oak forest. Areas of poorly drained outwash plain, outwash channels, and kettle depressions supported swamp forest, wet prairie, prairie fen, and wet meadow. Today the majority of the prairie and savanna systems have been eliminated due to fire suppression and agricultural conversion and forests and wetlands persist locally, typically in areas with excessive or poor drainage (Albert 1995).

Ionia

The Ionia subsection (VI.4) is characterized by medium- to coarse-textured moraines. Morainal features within the subsection primarily include loamy till plain and narrow bands of loamy end moraine with localized areas of sandy ground moraine and sandy, steep end moraine in the northern portion of the subsection. Streams are numerous throughout the subsection and lakes are locally common in the north. The subsection is underlain by Paleozoic Era bedrock, primarily Pennsylvanian sandstone, shale, coal, and limestone, with Mississippian shale and gypsum occurring at the western edge (Dorr and Eschman 1970). Prevalent soils include loams, sandy loams, and loamy sands, with sands occurring locally. The average growing season ranges from approximately 130 days at the northern edge of the subsection to 160 days at the western edge (Eichenlaub et al. 1990). It is the least lake-moderated subsection in Section VI. Average annual precipitation ranges from to 76 cm to 81 cm (30 in to 32 in) and average annual snowfall ranges from 102 cm to 203 cm (40 to 80 in), with highest levels in the west, closer to Lake Michigan. Extreme minimum temperature ranges from -31 °C to -38 °C (-24 °F to -36 °F). In general, the extreme minimum temperature becomes lower farther north in the subsection. Prevalent vegetation types within this region historically included beech and sugar maple forest, oak-hickory forest, oak-pine forest, and conifer and deciduous swamp forest. Drainage for agriculture has impacted wetlands throughout the subsection. Much of the subsection has been converted to agriculture and much of the forest and swamp forest have been lost or now occur as small remnant fragments surrounded by agricultural lands (Albert 1995).

Lansing Till Plain

The Lansing Till Plain (VI.2.1), the largest sub-subsection in Lower Michigan, consists of rolling, loamy till plain or ground moraine and narrow bands of loamy end moraine (Figure 3). The gently sloping ground moraine is medium-textured and is broken by several outwash channels and also by numerous end moraine ridges, many of which are steeper than the surrounding ground moraine topography. Most of the gently rolling hills of ground moraine are only 12 to 18 meters (40 to 60 ft) high, but hills up to 30 meters (100 ft) are found on the eastern and western edges of the sub-subsection. Typical slopes along the moraines are within the 0 to 6% slope class. The greatest elevation changes in the sub-subsection, accompanied by steep slopes, are along the outwash channels, which are commonly 15 to 30 meters (50 to 100 ft) lower than the adjacent ground moraine. The end moraine ridges, which cross-cut the till plain, typically form narrow bands 2 to 5 kilometers (1 to 3 mi) wide. Usually the end moraines do not form single, welldefined ridges but rather occur as groups of low ridges (less than 15 m or 50 ft) and swampy depressions. Streams within the sub-subsection occupy glacial outwash channels and the few lakes within the sub-subsection occur in kettles on the end moraines and in linear depressions on the till plain. Soils are primarily rich, well drained loams with very poorly drained soils occurring in depressions and glacial drainageways. Historically both the upland ground moraines and end moraines were dominated by beech-sugar maple forest. Windthrow was most likely the most common form of natural disturbance within the sub-subsection. Areas of dry end moraine and sand ridges within outwash deposits supported oak-hickory forest. Depressions within the moraines were dominated by hardwood swamps, and very poorly drained outwash channels supported southern wet meadow, wet prairie, shrub swamp, and hardwood-conifer swamp. Many of the wetlands were drained for agriculture and drainage ditches are prevalent within the sub-subsection. Today most of the

uplands have been converted to crop land, while most of the swamp forest has been converted to pasture. Swamp forests, wet meadows, and small woodlots with mesic southern forest and dry-mesic southern forest persist locally on this heavily fragmented landscape, while wet prairie has been virtually eliminated (Albert 1995).

Circa 1800s Vegetation

Interpretations of the General Land Office (GLO) surveyor notes by MNFI ecologists indicated that the Middleville SGA and surrounding area contained several distinct vegetation assemblages (Comer et al. 1995, Figure 4). Surveyors recorded information on the tree species composition, tree size, and general condition of the lands within and surrounding the Middleville SGA. Areas of steep end moraine, rolling ground moraine, and ice-contact ridges within outwash supported oak-hickory forest and beech-sugar maple forest, the two most prevalent cover types within the game area (covering 78% and 13% of the game area at the time of the GLO survey, respectively). The oak-hickory forests were described by the surveyors as "timbered thinly with oaks, gently rolling", and "timbered thinly with oak and no undergrowth". Ground fires likely maintained the open understory conditions noted by the surveyors. These fires were likely both natural wildfires ignited by lightning strike and also intentionally set by Native Americans. Numerous "Indian Paths" were noted by the surveyors throughout the area. Abundant tree species recorded in this area by the GLO surveyors in the uplands classified as oak-hickory forest (White Oak, Black Oak, Hickory Forest) included white oak (*Quercus alba*) (overwhelmingly the most common tree noted), black oak (*Q. velutina*), red oak (*Q. rubra*), and chinquapin oak (*Q. muehlenbergii*). Less frequently recorded trees were hickories (*Carya* spp.), American beech (*Fagus grandifolia*), aspen (*Populus* sp.), and elm (*Ulmus* sp.). The majority of the game area was mapped as the oak-hickory cover type. Within the areas classified as oak-hickory forest, recorded diameters of trees ranged widely from 10 to 86 cm (4 to 34 in) with an average of 34 cm (13 in) (N = 285).

Within the central portion of the game area, there was a large block of beech-sugar maple forest (Figure 4). Within these mesic uplands, abundant tree species recorded by the GLO surveyors included white oak, beech, and sugar maple (*Acer saccharum*). Less frequently recorded trees were red oak, basswood (*Tilia americana*), ironwood (*Ostrya virginiana*), white ash (*Fraxinus americana*), and American elm (*Ulmus americana*). Within the areas classified as beech-sugar maple forest, recorded diameters of trees ranged widely from 13 to 81 cm (5 to 32 in) with an average of 37 cm (15 in) (N = 30).

Within southern Michigan, oak savanna was common on areas of well-drained outwash and gently sloping moraine and localized on slopes with southern and western aspects. At the time of the GLO survey, oak savanna (Oak Openings) occurred on approximately 3% of the game area. Within southwestern Michigan, oak savanna and oak-hickory forest occurred in a shifting forest-savanna mosaic that varied in time and space depending on the frequency and intensity of fire disturbance events. Although mapped as predominantly oak-hickory forest on the circa 1800 map, much of the game area likely transitioned to and from oak-hickory forest to oak savanna over long periods of time. In addition, within the areas of mapped forest, there were likely pockets of open oak savanna. Repeated low-intensity fires, working in concert with drought and windthrow, maintained open conditions in these oak savanna ecosystems. Within dry-mesic savanna systems, such as oak openings, it is likely that annual or nearly annual fire disturbance was the primary factor influencing the vegetative structure and floristic composition. These fires occurred during the late spring, late summer, and fall since flammability peaks in the spring before grass and forb growth resumes and then again in the late summer and autumn after the above-ground biomass dies back (Grimm 1984). As noted above, these fires were caused naturally by lightning strike and also set intentionally by indigenous peoples. Within southwestern Michigan, Native Americans probably played a significant role in maintaining savanna conditions through their use of fire as a land management tool (Cronon 1983, MacLeigh 1994). Throughout southern Michigan, Indian trails and encampments were often noted within areas identified by the GLO surveyors as oak savanna and oak barrens. As noted above, several "Indian Trails" were noted by the GLO surveyors in the area surrounding the Middleville SGA. Within the northern portion of the game area, there was a small area of oak savanna (Figure 4). The oak openings within and adjacent to the game area were characterized by scattered white oak as the overwhelming canopy dominant. Within these savanna areas, recorded diameters of canopy trees ranged from 25 to 61 cm (10 to 24 in) with an average of 42 cm (17 in) (N = 6). The larger average size of canopy trees within the savanna systems compared to the forested systems was perhaps due to the trees in the savannas being open grown and facing less competition from other trees.

Circa 1800, wetlands were infrequently scattered throughout the game area, concentrated along the margins of small streams, within kettle depressions, in poorly drained portions of outwash plain and outwash channels, and along lower slopes of moraines (Figure 4). Circa 1800 wetland cover types included Mixed Conifer Swamp (4% of the game area) and Shrub Swamp/Emergent Marsh (3%). The Mixed Conifer Swamp class likely included rich

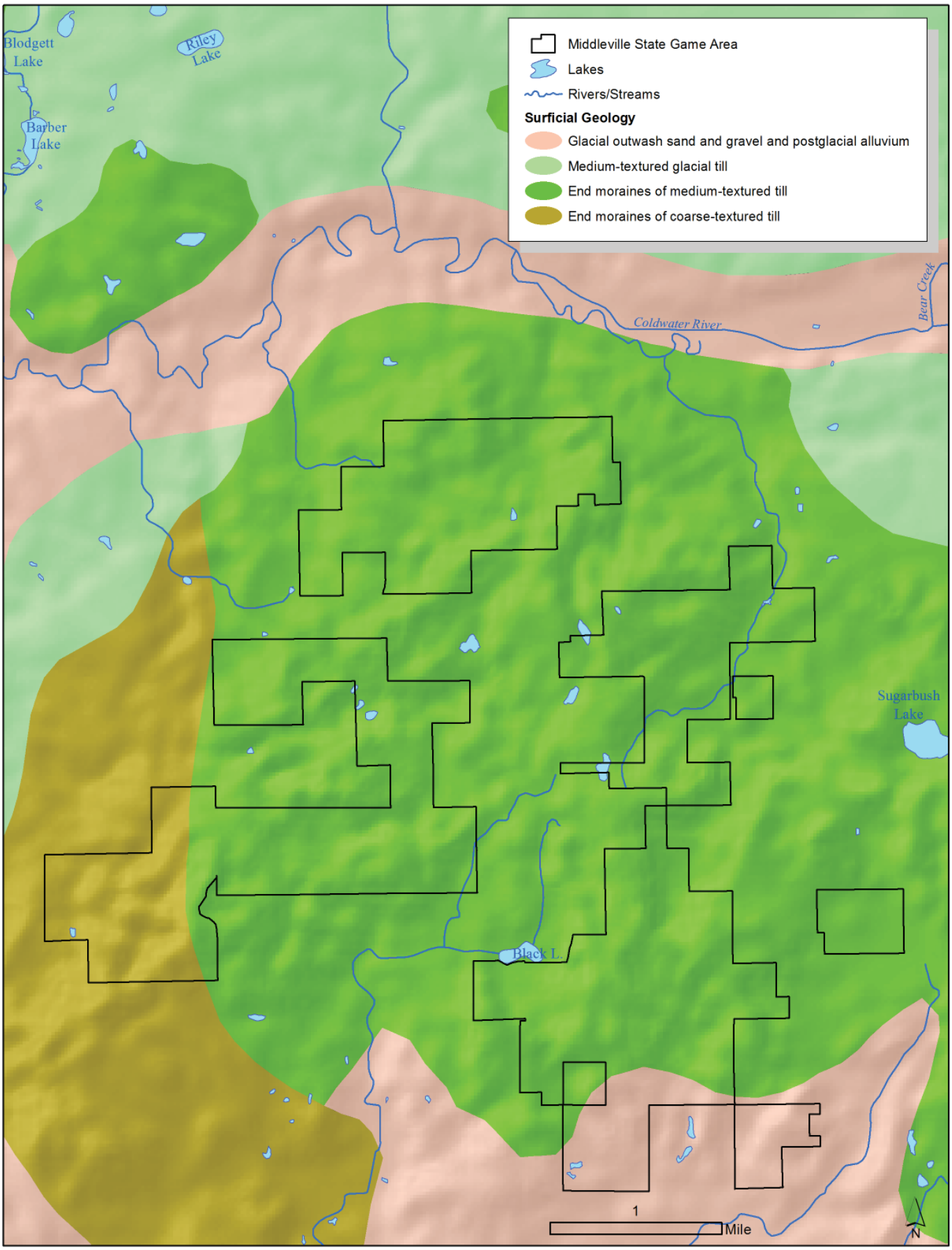


Figure 3. Surficial geology and relief of Middleville State Game Area (Farrand and Bell 1982, USGS 2009).

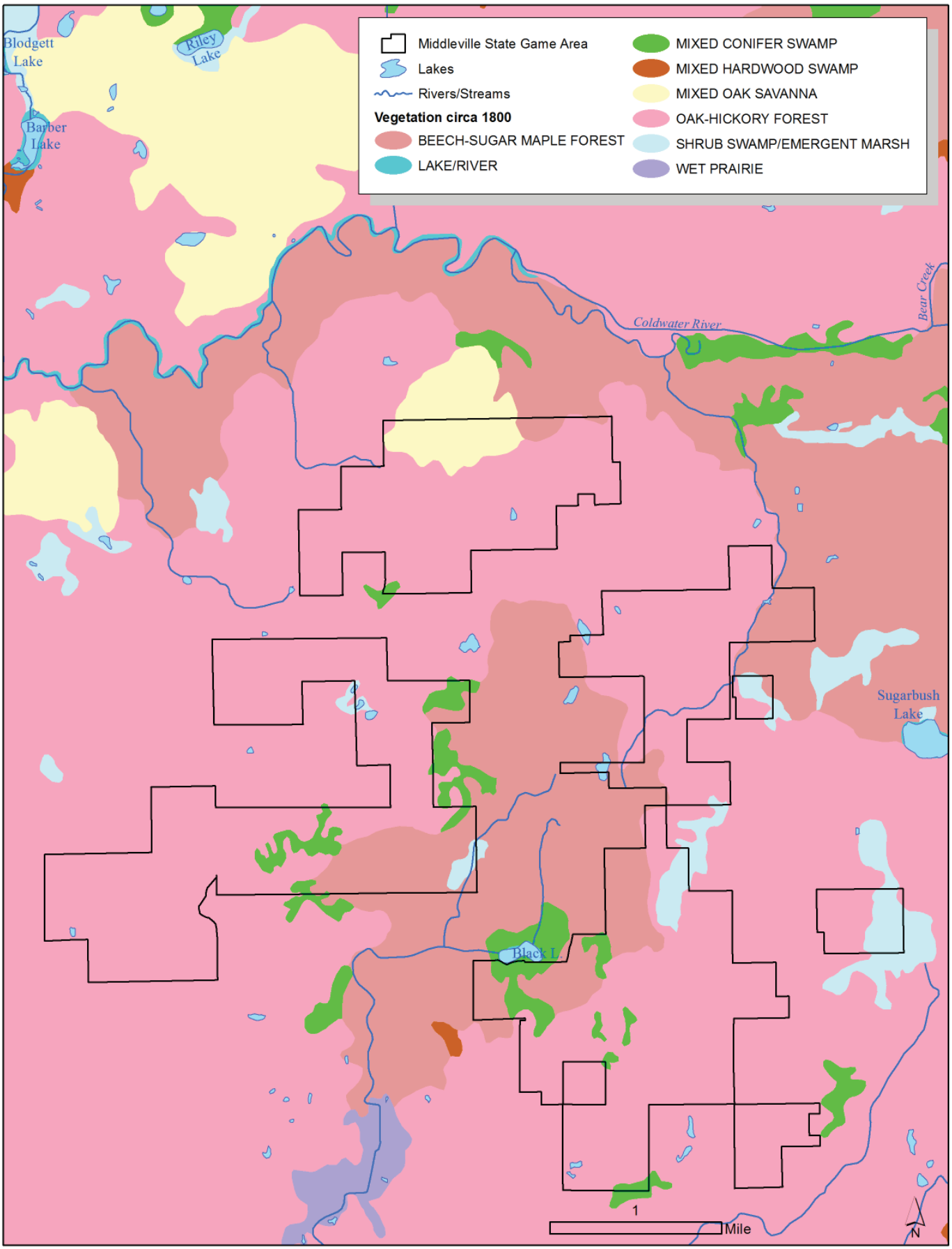


Figure 4. Circa 1800 vegetation of Middleville State Game Area (Comer et al. 1995).

tamarack swamp and to a lesser extent, hardwood-conifer swamp. Where the surveyors noted canopy composition of these conifer swamps, small-diameter tamarack (*Larix laricina*) was prevalent. MNFI's open wetland classification for the circa 1800 map is very broad because the surveyors gathered limited information that does not allow for current ecologists to more specifically classify the wetlands encountered. The very broad Shrub Swamp/ Emergent Marsh cover type for the circa 1800 map likely included southern shrub-carr, inundated shrub swamp, prairie fen, bog, southern wet meadow, emergent marsh, and intermittent wetland.

Current Land Cover

The land cover within the Middleville SGA (Figure 1) has changed significantly since 1800 due to logging, agriculture, deer herbivory, fire suppression, and hydrologic alteration. The mosaic of aerial photographs from 1938 (Figure 5) shows how logging and the expansion of agriculture heavily impacted the Middleville SGA and the surrounding area. Lands that remained forested were typically areas of steep slope or poor drainage. Many of the forested patches that persisted were nevertheless selectively logged with many oaks and sugar maple being harvested. In addition, where forests and wetlands occurred adjacent to agricultural lands, grazing was prevalent. Much of the game area was formerly agricultural lands that have been since abandoned due to unfavorable slope, drainage, and/ or soil conditions. Many of these former agricultural areas have reverted to early-successional forest.

Current land cover in Middleville SGA is dominated by deciduous forest (80% of the game area) (Figure 1). This forest is primarily composed of oak-hickory forest (dry-mesic southern forest), beech-sugar maple forest (mesic southern forest), and early-successional forest. IFMAP stand types delineated in Middleville SGA that fall within the broad class of deciduous forest include Mixed Upland Deciduous (37%), Oak Types (21%), Northern Hardwoods (13%), Aspen Types (7%), and Other Upland Deciduous (< 1%). These forests occur throughout the game area and are especially prevalent on moderate to steep end moraine, rolling ground moraine, and ice-contact ridges. The majority of these forested systems within Middleville SGA are early-successional forest with over 75% of the total forested acreage being less than 100 years old and only 25% being over 100 years old or classified as uneven-aged. Early-successional forests have established on lands that were logged and/or farmed. In addition, areas that once supported oak savanna have now converted to early-successional forest. High levels of invasive shrub species occur within the understory of these early-successional forests. In addition, many of the oak and oak-hickory forest types are fire suppressed and have a significant component of mesophytic competition in the understory. As a result of competition and high levels of deer herbivory, oak regeneration is sparse throughout the understory of these forests.

A small portion of the game area (approximately 9%) is composed of open uplands that include managed agricultural crops (3%), and abandoned agricultural fields dominated by old-field herbaceous species (3%) or upland shrubs (3%).

Wetlands remain an important component of the game area with forested wetlands accounting for 4%, open wetlands accounting for 2%, shrub wetlands accounting for approximately 1.5%, and open water accounting for approximately 1% of the area. Open wetland types delineated in Middleville SGA by IFMAP stage 1 inventory include Emergent Wetland and Mixed Non-Forested Wetland. Shrub wetland and forested wetland types include Lowland Shrub and Lowland Deciduous Forest, respectively. Wetlands throughout Middleville SGA have been impacted by hydrologic alteration (e.g., ditching and dredging), grazing, marsh haying, invasive species encroachment, and fire suppression.

Despite the considerable loss of natural habitat due to conversion to agriculture and logging and degradation of remaining natural habitat due to deer herbivory, grazing, hydrologic alteration, invasive species encroachment, and fire suppression, a significant portion of Middleville SGA supports high-quality natural communities. In addition, compared to the surrounding fragmented landscape, Middleville SGA is characterized by a significant portion of natural cover. As noted above, 92% of the game area is natural cover. In comparison, 35% of the Battle Creek Outwash Plain (VI.2.1) and 29% of the Lansing Till Plain (VI.4.1) are natural cover. Prior to the 2013 survey effort, two natural community element occurrences (EO), both mesic southern forests, were documented within Middleville SGA (Table 1). Surveys in 2013 identified an additional five natural community EOs, four dry-mesic southern forests and one mesic southern forest. These natural community EOs will be described in detail within the **Natural Community Results** section. Documented high-quality natural communities constitute over 16% of Middleville SGA.

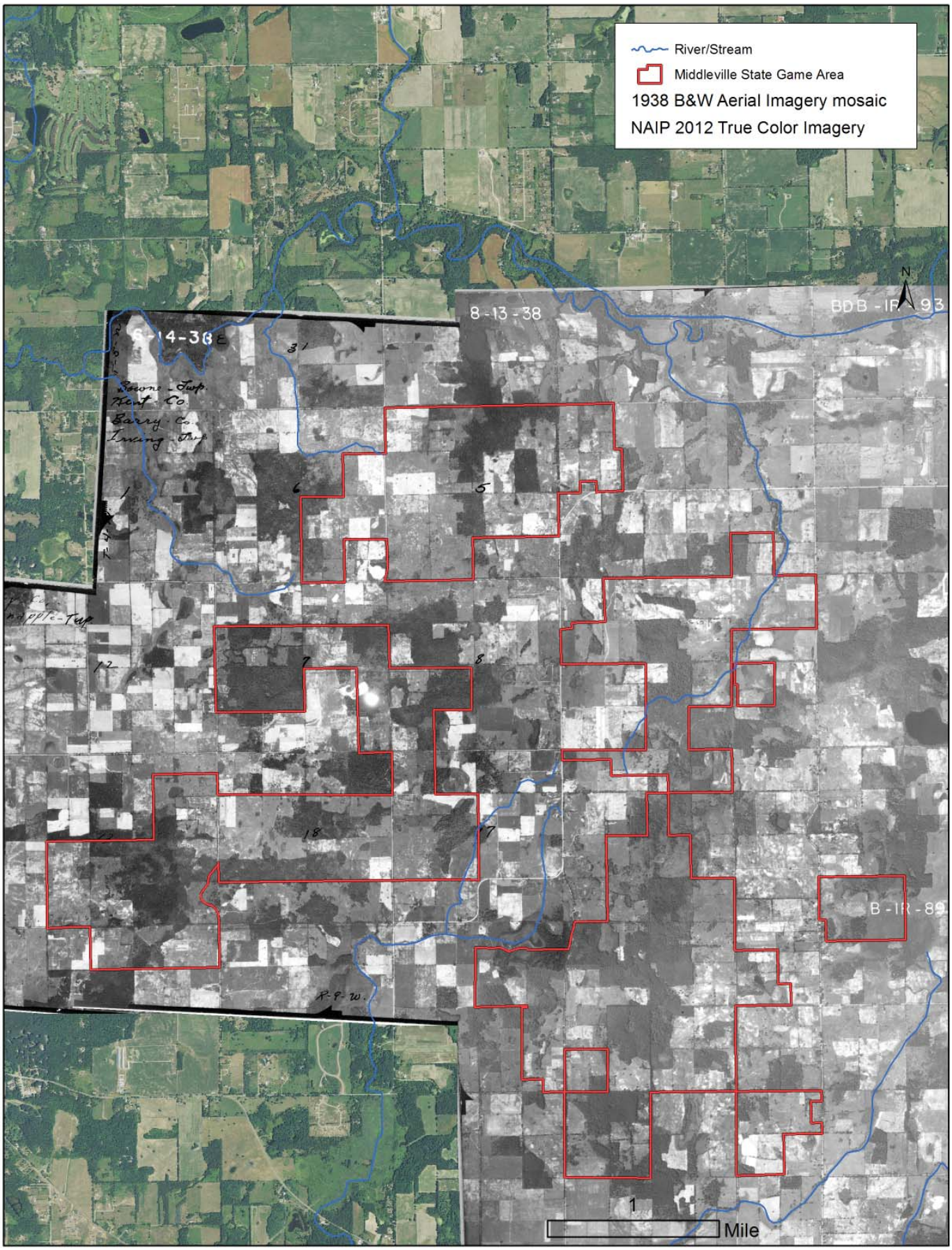


Figure 5. Mosaic of 1938 aerial photographs of Middleville State Game Area (MNFI 2014).

METHODS

Throughout this report, all high-quality natural communities and state and federally listed rare species are referred to as elements and their documented occurrence at a specific location is referred to as an element occurrence or "EO."

Natural Community Survey Methods

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 (Cohen et al. 2014). Protecting and managing representative natural communities is critical to biodiversity conservation, since native organisms are best adapted to environmental and biotic forces with which they have survived and evolved over the millennia (Kost et al. 2007). According to MNFI's natural community classification, there are 77 natural community types in Michigan (Kost et al. 2007, Cohen et al. 2014). Surveys assessed the current ranking, classification, and delineation of these occurrences and detailed the vegetative structure and composition, ecological boundaries, landscape and abiotic context, threats, management needs, and restoration opportunities. The primary goal of this survey effort is to provide resource managers and planners with standardized, baseline information on each natural community EO. This baseline information is critical for facilitating site-level decisions about biodiversity stewardship, prioritizing protection, management and restoration, monitoring the success of management and restoration, and informing landscape-level biodiversity planning efforts.

Field Surveys

Each natural community was evaluated employing Natural Heritage and MNFI methodology, which considers three factors to assess a natural community's ecological integrity or quality: size, landscape context, and condition (Faber-Langendoen et al. 2008). 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 element occurrence, and given a rank based on the consideration of its size, landscape context, and condition. Ecological field surveys were conducted during the growing season (from June to July of 2013) to evaluate the condition and classification of the sites. To assess natural community size and landscape context, a combination of field surveys, aerial photographic interpretation, and Geographic Information System (GIS) analysis was employed. Typically, a minimum of a half day to a day was dedicated to each site, depending on the size and complexity of the site. For sites that occur on multiple ownerships, surveys were restricted to SGA portions of the occurrences unless permission was granted to access other ownerships.

The ecological field surveys typically involved:

a) compiling comprehensive plant species lists and noting dominant and representative species

b) describing site-specific structural attributes and ecological processes

c) measuring tree diameter at breast height (DBH) of representative canopy trees and aging canopy dominants (where appropriate)

d) analyzing soils and hydrology

e) noting current and historical anthropogenic disturbances

f) evaluating potential threats

g) ground-truthing aerial photographic interpretation using GPS (Garmin units were utilized)

h) taking digital photos and GPS points at significant locations

i) surveying adjacent lands when possible to assess landscape context

j) evaluating the natural community classification and mapped ecological boundaries

k) assigning or updating element occurrence ranks

l) noting management needs and restoration opportunities or evaluating past and current restoration activities and noting additional management needs and restoration opportunities

Following completion of the field surveys, the collected data were analyzed and transcribed to update or create new EO records in MNFI's statewide biodiversity conservation database (MNFI 2015). Natural community boundaries were mapped or re-mapped. Information from these surveys and prior surveys, if available, was used to produce site descriptions, threat assessments, and management recommendations for each natural community occurrence, which appear within the following **Natural Community Surveys Results** section.

Vernal Pools Methods

Vernal pools are small, generally isolated, temporary pools of water that form in shallow depressions in forested areas throughout Michigan (Thomas et al. 2010). These wetlands fill with water from rainfall, snowmelt, and/or groundwater between late fall and spring, and usually dry up by mid to late summer. The periodic drying of vernal pools prevents fish from establishing populations in these wetlands. Because vernal pools lack predatory fish populations, these wetlands provide critical breeding habitats for a host of forest-dwelling amphibians and invertebrates, including some species that are specialized for life in vernal pools and depend on these unique habitats for their survival. These include the blue-spotted salamander (*Ambystoma laterale*), spotted salamander (*Ambystoma maculatum*), wood frog (*Rana sylvatica*), and fairy shrimp (*Eubranchipus* spp.) (Colburn 2004, Calhoun and deMaynadier 2008). Vernal pools provide habitat for a number of other animal and plant species including endangered, threatened, or rare species in Michigan, such as the state special concern Blanding's turtle (*Emydoidea blandingii*) and federally threatened and state endangered copperbelly water snake (*Nerodia erythrogaster neglecta*). Vernal pools also contribute other important ecosystem services including nutrient cycling, water storage and infiltration, groundwater recharge, and flood control (Colburn 2004, Calhoun and deMaynadier 2008). However, because vernal pools are small, isolated, and dry for part of the year, they can be difficult to identify in the field, and can be easily overlooked and unintentionally damaged or destroyed. They also are not well-protected under current federal and state wetland regulations, and limited information is available on their status, distribution, and ecology in the state.

Potential and verified vernal pools were identified and mapped in Middleville SGA in 2014 using remote sensing and field sampling. The primary goal of this mapping and survey effort is to provide resource managers and planners with baseline information on vernal pool status and distribution within the game area. This baseline information is critical for developing and implementing appropriate management and protection of these unique wetlands. Vernal pools also were identified and mapped to pinpoint potential sites for amphibian and reptile surveys in the game area since these wetlands provide habitat for several amphibian and reptile species targeted for surveys in 2014.

Potential vernal pools were identified and mapped based on aerial photograph interpretation. Aerial photo interpretation is currently still the most effective method available for identifying and mapping vernal pools remotely (Calhoun and deMaynadier 2008). Aerial photograph interpretation was conducted in the spring of 2014 prior to field surveys to identify and map potential vernal pools (PVPs) within portions of two subunits within the game area (i.e., subunits on the west side and southeast end of the game area). These two subunits were selected because amphibian and reptile surveys focused on these areas due to available habitat for targeted species. Aerial photograph interpretation to identify and map potential vernal pools in these and other subunits within the game area was completed in the winter of 2015.

Aerial photograph interpretation consisted of using ESRI ArcGIS software to visually examine available aerial imagery and other available imagery of the game area on a computer screen. Aerial imagery that were examined to identify and map PVPs included color infrared, leaf-off aerial imagery from the spring of 1998, and natural color aerial imagery from the summer of 2005, 2010, and 2012 (NAIP 2005, NAIP 2010, and NAIP 2012 True Color). Additional high-resolution, leaf-off, natural color imagery and topographic maps of the game area also were examined. The aerial imagery and other data layers were available through Michigan State University's Remote Sensing and GIS (RSGIS) Center and the State of Michigan. We used a map scale of 1:5000 as a compromise between a high level of visible detail and spatial extent of the imagery displayed on the computer screen to detect PVPs. PVPs were digitized and mapped as polygons using ESRI ArcGIS software. PVPs were added to a statewide vernal pool geodatabase developed by MNFI to record and track data on the locations and characteristics of potential and verified vernal pools in the state. Each PVP polygon was assigned a unique identification number for reference, and some preliminary information about these polygons were included in the geodatabase.

A subset of the PVPs mapped in the game area was surveyed on May 21st and July 24th through 25th, 2014 to verify, map, and collect data on vernal pools in the field. These surveys were conducted during surveys for rare amphibians and reptiles. Most potential pools were surveyed only once, but several pools were visited two or three times during the sampling period. Surveyors verified if PVPs represented actual vernal pools in the field, or if the PVPs were other types of wetlands or other habitats. The status of PVPs visited in the field was documented using one of the following five designations: 1) verified as a vernal pool and is active/present; 2) verified as a vernal pool and is no longer active/has been destroyed; 3) visited in the field but status still uncertain/insufficient information; 4) visited in the field and is not a vernal pool/some other wetland type; and 5) visited in the field and is not a vernal pool/no water present. Vernal pools verified in the field were mapped using a GPS unit. Additional vernal pools that were encountered during field sampling

and had not been remotely mapped as PVPs also were recorded and mapped. Basic information about the physical characteristics, general condition, surrounding habitat, vegetative structure, and presence of vernal pool indicator species (i.e., fairy shrimp, wood frog egg masses and tadpoles, and/or blue-spotted and spotted salamander egg masses and larvae) and other animals in the pools were recorded in the field using a standardized vernal pool monitoring data form (Appendix 1). Vernal pools verified in the field were classified into the following six general vernal pool types based on vegetation within the pools: open pools, sparsely vegetated pools, shrubby pools, forested pools, marsh pools, and other (e.g., half open and half shrubby). Definitions of vernal pool types are provided in Appendix 2. Vernal pools and other wetlands and habitats identified in the field were photographed for documentation and verification. Field sampling results and data were incorporated into a statewide vernal pool geodatabase.

Rare Animal Survey Methods

We identified rare animal target species for surveys using historical distribution within Michigan, past occurrences in or near Middleville SGA, and the presence of potential habitat within the game area. A variety of data sources were used to determine if potential habitat occurred within the game area, including natural community occurrences, IFMAP descriptions, aerial photography, and on-the-ground observations. We conducted surveys for target animal species in appropriate potential habitats during time periods when targeted elements were expected to be most active and detectable (e.g., breeding season). Surveys were done to identify new occurrences, update and/or expand existing occurrences, and revisit historical occurrences of select rare species. In addition to documenting rare species, we also recorded observations of species of greatest conservation need (SGCN) identified in Michigan's Wildlife Action Plan (Eagle et al. 2005; Amy Derosier, personal communication, March 2015).

Bird Surveys

Given the presence of tracts of mature forest and results of previous surveys, we focused our surveys in the game area on red-shouldered hawk (*Buteo lineatus*, state threatened, DNR featured species) and rare songbird species. Contiguous forest stands at least 4 ha (10 acres) in area were considered potential habitat for target forest-nesting species. We generated a 250 m X 250 m grid of possible survey points that was overlaid over the potential survey stands. Those points falling within the potential survey stands were used for conducting red-shouldered hawk and songbird surveys. Points were assigned unique identification numbers and uploaded to a GPS unit for field location. We identified 74 potential survey points within Middleville SGA stands (Figure 6). In addition to surveying for red-shouldered hawk and rare songbirds, point-count sampling was used to gather baseline information about the forest bird community, including relative abundance and species richness.

We conducted three minute red-shouldered hawk surveys at systematically located point count stations (Figure 6; Mosher et al. 1990, Anderson 2007, Bruggeman et al. 2011). Each three minute point count consisted of two minutes of broadcasts and one minute of silent listening. Surveys were conducted April 15th through April 17th, 2014. At each station the following data were recorded: whether or not 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 red-shouldered hawk was observed, the vicinity surrounding the point was searched for nests. While walking and driving between station locations, we also visually inspected trees for stick nests.

Forest bird surveys focused on detecting hooded warbler (*Setophaga citrina*, state special concern) and cerulean warbler (*Setophaga cerulea*, state threatened), a focal species of the DNR's Wildlife Action Plan (Amy Derosier, personal communication, March 2015). Forest songbird point counts were conducted using the same set of systematically located points used for red-shouldered hawk surveys (Figure 6). Ralph et al. (1995) noted that it is usually more desirable to increase the number of independent point-count stations than to conduct repeated surveys at a smaller number of locations, so we visited each point only once. Surveys were conducted from June 9th through June 13th and from July 14th through July 15th, 2014 between sunrise and four hours after sunrise. In addition to documenting observations of the three rare species, we gathered data on all birds seen or heard during each ten minute point count. We recorded the species and number of individuals observed during three independent periods (2 min, 3 min, and 5 min) for a total of ten 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) and commonly used 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 and hooded warbler and recorded any invasive plant species seen.

In addition to prior records within the game area for cerulean warbler and hooded warbler, two rare grassland birds were documented in Middleville SGA in 2007.

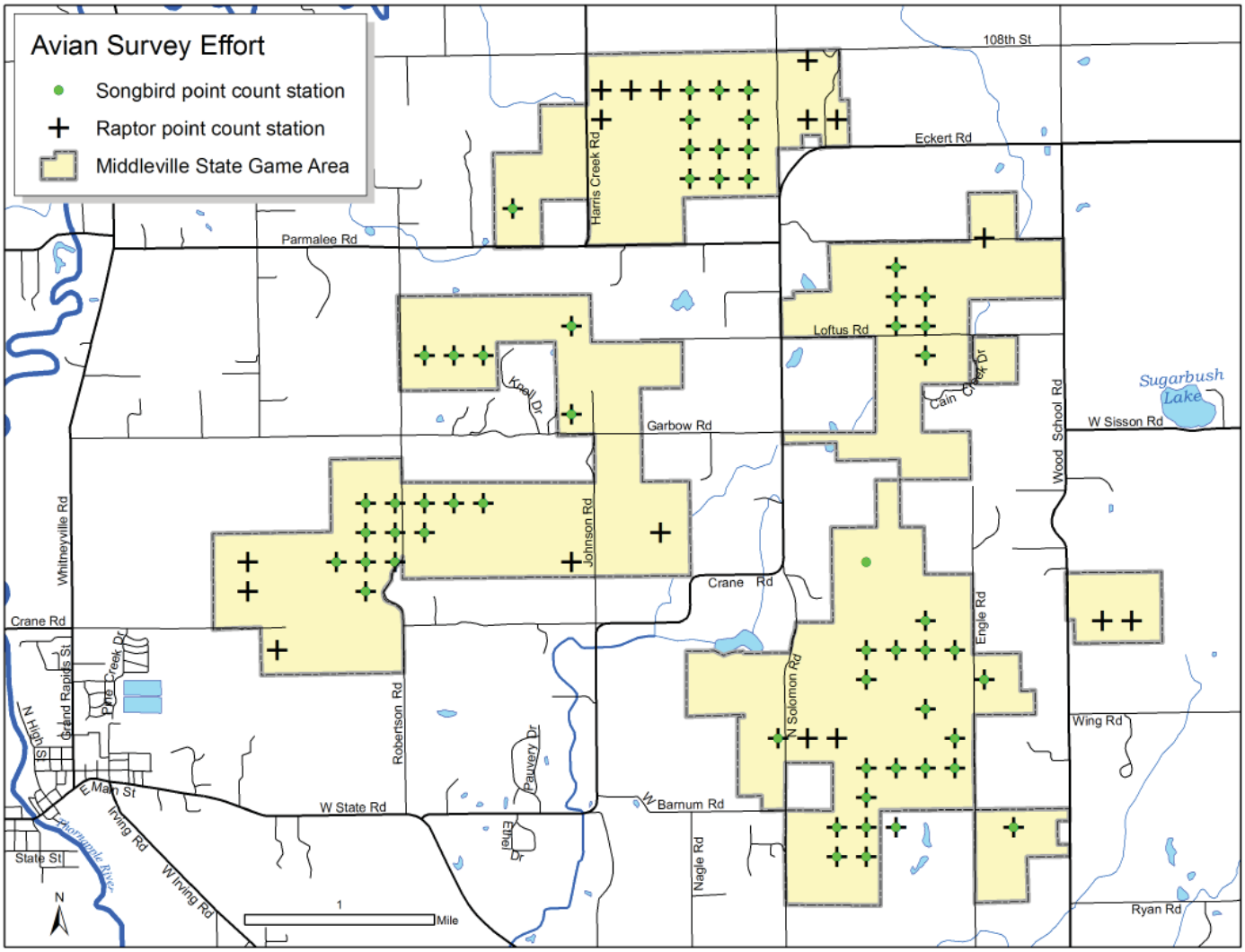


Figure 6. Locations of forest songbird and raptor point counts conducted in Middleville State Game Area in 2014.

Suitable habitat for hooded warbler (*Setophaga citrina*, state special concern), which nest in small trees or shrubs in the understory of mature deciduous forest.

Henslow's sparrow (*Ammodramus henslowii*, state endangered) and grasshopper sparrow (*A. savannarum*, state special concern) records were documented from a field just west of Harris Creek Road (Table 3). However, we did not conduct surveys for these two grassland birds because the field was planted to row crops at the time of surveys and no suitable habitat occurs within the game area.

Reptile and Amphibian Surveys

The following species of amphibians and reptiles (i.e., herptiles) were targeted for surveys in Middleville SGA in 2014: Blanchard's cricket frog (*Acris blanchardi*, state threatened), Blanding's turtle (*Emydoidea blandingii*, state special concern), eastern box turtle (*Terrapene carolina carolina*, state special concern), and copperbelly water snake (*Nerodia erythrogaster neglecta*, state endangered and federally threatened) (Appendix 3). Eastern box turtle is a focal species of the DNR's Wildlife Action Plan (Amy Derosier, personal communication, March 2015). Surveys in 2014 also targeted several amphibian species identified as SGCN in Michigan's Wildlife Action Plan (Eagle et al. 2005, Appendix 3). These SGCN included the blue-spotted salamander (*Ambystoma laterale*), spotted salamander (*Ambystoma maculatum*), and eastern tiger salamander (*Ambystoma tigrinum*) (although the blue-spotted salamander and eastern tiger salamander have been proposed by the MDNR to be removed from the revised list of SGCN) (Amy Derosier, personal communication, March 2015). Visual encounter surveys, basking surveys, auditory or breeding frog call surveys, dipnetting, and aquatic funnel trapping were conducted for the target species. Surveys focused on identifying new occurrences or additional locations for existing occurrences. Some previously documented sites also were surveyed to reconfirm the occurrence of target species, particularly those from which the species had not been reported within the last ten to twenty years. We also documented other rare or common amphibian and reptile species encountered incidentally during surveys in 2014.

Visual encounter surveys were conducted on May 21st and July 24th through July 25th, 2014 using a standard method for surveying amphibians and reptiles (Campbell and Christman 1982, Corn and Bury 1990, Crump and Scott 1994). Visual encounter surveys were conducted in or along the edge of open wetlands, waterbodies (e.g., vernal pools, permanent ponds, lakes, streams, and rivers), upland and lowland deciduous or mixed forest stands, and/or open uplands adjacent to wetlands or waterbodies. Visual encounter surveys were conducted at 13 different sites in Middleville SGA, focusing on areas with suitable habitats for targeted species (Figure 7). These surveys had potential for detecting all targeted rare turtles and snakes. Survey sites included three previously mapped wetlands (identified through stage 1 IFMAP inventory), 12 vernal pools/potential vernal pools, and surrounding forest stands. These twelve vernal pools had not been mapped in the game area prior to this project. The survey sites were visited one to two times during the field season. Visual encounter surveys were conducted during daylight hours and under appropriate weather conditions when targeted species were expected to be active and/or visible (i.e., between 15-27 °C or 60-80 °F, wind less than 15 mph, no or light precipitation). These surveys consisted of one or two surveyors walking slowly through areas with suitable habitat for survey targets, overturning cover (e.g., logs, rocks, etc.), inspecting retreats, and looking for basking, resting, and/or active individuals on the surface or under cover.

Basking surveys were conducted on May 21st, 2014, primarily to search for copperbelly water snakes and Blanding's turtles. We conducted basking surveys at three of the survey sites containing open and/or shrubby wetlands or waterbodies that provided suitable habitat for copperbelly water snakes and/or Blanding's turtles (Figure 7). Basking surveys consisted of slowly walking around the edge or shore of the wetlands or waterbodies and scanning the habitat with binoculars to look for turtles and snakes partially submerged in the water or basking on logs, woody debris, islands, or other structures.

Auditory surveys for breeding frog calls were conducted for the Blanchard's cricket frog on July 6th, 2014. These surveys were completed at 19 sites throughout Middleville SGA and on adjacent private lands. These sites were comprised of permanent lakes and ponds and surrounding open wetlands located near roads (Figure 7). We conducted frog call surveys along roads in the evening or at night (17:30 – 01:00 EDT) by listening for breeding calls of cricket frogs emanating from the nearby wetlands or bodies of water. Species, call index values, location, time, and weather conditions were recorded during 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) (Michigan DNR 2002).

Dipnetting surveys for blue-spotted salamander, spotted salamander, and eastern tiger salamander larvae were conducted in 12 vernal pools (Figure 7). These surveys took place May 21st and July 24th through July 25th, 2014. These species primarily breed in vernal pools (Harding 1997). Dipnetting consisted of using a small aquarium net to take multiple sweeps through the water column and along the

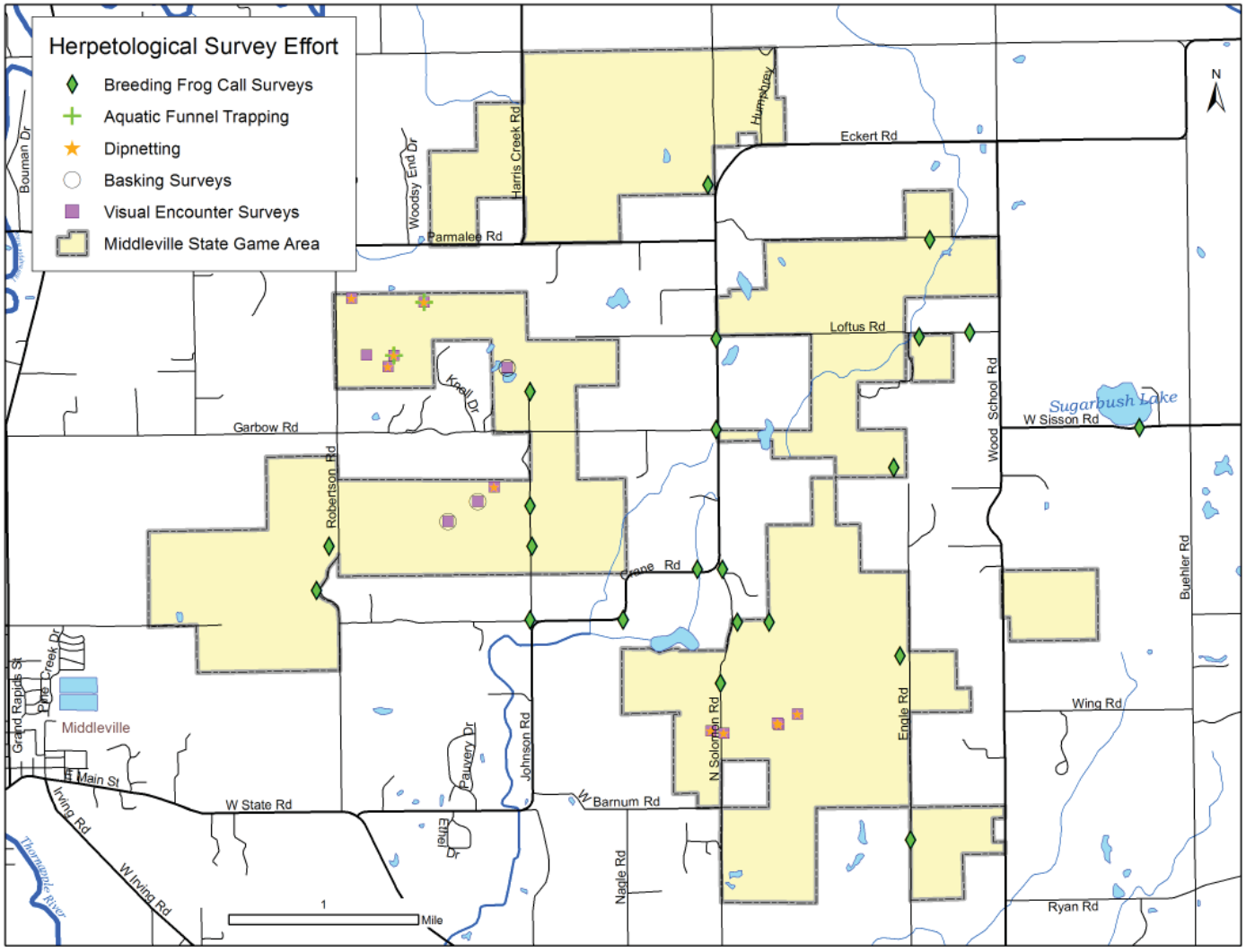


Figure 7. Locations of reptile and amphibian surveys conducted in and nearby Middleville State Game Area in 2014.

Dipnetting surveys within a vernal pool in Middleville State Game Area. Photo by Yu Man Lee.

substrate and cover objects (e.g., woody debris, emergent or submergent vegetation) in the pools to try to capture larvae of target species and other amphibians. Amphibian larvae were identified to the lowest taxonomic level possible. Specimens were, recorded, photographed, and released at the capture site. Photographs of the amphibian larvae were used for species verification and documentation.

Aquatic funnel trapping was conducted July 24th through July 25th, 2014 to survey for larvae of spotted salamanders, blue-spotted salamanders, and eastern tiger salamanders. Aquatic funnel trapping was conducted at two small, open vernal pools in the Garbow Woods dry-mesic southern forest (EO ID 19802, Compartment 1, stand 16) (Figure 7). Commercially available modified minnow traps were used for aquatic funnel traps. These traps were about 46 cm long x 25 cm wide (18 in long x 12 in wide) and consisted of a collapsible, spring loaded, metal or wire frame covered with 3 mm mesh nylon webbing with funnels with 5 cm (2 in) openings extending inward at both ends. Traps were placed in the water so that the funnel openings at the ends of each trap were completely submerged in the water but the top of the trap was above the surface of the water to provide an air pocket for animals captured in the trap. A total of twelve traps, ten in one vernal pool and two in the other pool, were set during the day. The traps were left overnight in the pools, and checked and removed the following day. This resulted in a total of twelve trap nights. Amphibian adults and larvae captured in the traps were identified to the extent possible, photographed, recorded, and released. Photographs were taken of the amphibian adults and/or larvae captured in the traps for species verification and documentation.

Survey data forms (Appendix 4) were completed for all herptile surveys, and survey locations were recorded with a Garmin GPS or Ashtech unit. We noted all rare and common reptiles and amphibians and other animals encountered during surveys. The species, number of individuals, age class, location, general habitat, behavior, and time of observation were noted. Weather conditions and start and end times of surveys also were recorded. We completed MNFI special animal survey forms when rare reptile or amphibian species were encountered and recorded spatial locations with a Garmin GPS or Ashtech unit. Whenever possible, photos of rare species were taken for supporting documentation.

Aquatic funnel traps set within a vernal pool in Middleville State Game Area. Photo by Yu Man Lee.

RESULTS

During the Integrated Inventory Project at Middleville SGA, MNFI documented 12 new EOs and provided information for updating an additional three EOs (Tables 1-4). Data compiled on these EOs was entered into MNFI's Biotics database (MNFI 2015). In total, 29 SGCN were documented during the project including 14 different rare animal species (Table 5). The locations in Middleville SGA of all natural community and rare species occurrences (both new and prior occurrences) are illustrated in Figures 8 through 10. In addition, MNFI scientists mapped the location of 14 vernal pools within the game area (Figure 11). The Results section is divided into three sections, a Natural Community Survey Results section, a Vernal Pools Results section, and a Rare Animal Survey Results section. The Natural Community Survey Results section provides in depth description of each natural community EO as well as site-specific threat assessments and management recommendations. The Vernal Pools Results section describes survey results for the vernal pools surveys. The Rare Animal Survey Results section describes survey results for each grouping of rare animals: birds, and reptiles and amphibians.

Natural Community Survey Results

During the summer of 2013, MNFI ecologists documented five new high-quality natural communities in the Middleville SGA and also updated one known high-quality community EO. One existing natural community EO was not visited in 2013 because it had been surveyed recently (2006). Middleville SGA supports seven high-quality natural community EOs (Table 1 and Figure 8). Table 1 lists the visited sites, their element occurrence ranks, their unique element occurrence identification number (EO ID), and the year first and last observed. Two different natural community types are represented in the six element occurrences surveyed including: dry-mesic southern forest (4 EOs) and mesic southern forest (2 EOs). As noted above, one additional natural community EO within Middleville was surveyed prior to this project and was not revisited in 2013 (mesic southern forest EO 16110). Over the course of the project, five new rare plant EOs were opportunistically documented (Table 2). Newly documented rare plant species include four records for ginseng (*Panax quinquefolius*, state threatened) and one record for beak grass (*Diarrhena obovata*, state threatened). The general location of these plant EOs is illustrated along with the natural community EOs in Figure 8. The site descriptions for natural community EOs include discussion of rare plant populations when they occur within the high-quality natural communities.

The following site summaries contain a detailed discussion for each of these seven natural communities organized alphabetically by community type and then by element occurrence. A summary of priority management recommendations is provided for each natural community EO in Table 7. The beginning of each grouping of communities contains an overview of the natural community type, which was adapted from MNFI's natural community classification (Kost et al. 2007, Cohen et al. 2014). In addition, an ecoregional distribution map is provided for each natural community type (Albert et al. 2008). For each site summary, the following information is provided:

a) site name
b) natural community type
c) state and global rank (see Appendix 5 for ranking criteria)
d) current element occurrence rank
e) size
f) locational information
g) digital photograph(s)
h) detailed description
i) threat assessment
j) management recommendations

Hills of Parmalee mesic southern forest. Photo by Jesse M. Lincoln.

Table 1. Newly documented and previously known natural community element occurrences for the Middleville State Game Area. EO rank abbreviations are as follows: BC, good or fair estimated viability; C, fair estimated viability; CD, fair or poor estimated viability; and D, poor estimated viability. * indicates that the EO was newly documented in 2013 and ** indicates that the EO was updated with information collected during inventory.

Site Name	Community Type	EO ID	EO Rank	Year First Observed	Year Last Observed	Global Rank	State Rank
County Line Woods*	Dry-mesic Southern Forest	19807	C	2013	2013	G4	S3
Garbow Woods*	Dry-mesic Southern Forest	19802	CD	2013	2013	G4	S3
North Country Woods*	Dry-mesic Southern Forest	19733	BC	2013	2013	G4	S3
Soloman Woods*	Dry-mesic Southern Forest	19803	C	2013	2013	G4	S3
Hills of Parmalee**	Mesic Southern Forest	19734	C	1987	2013	G4	S3
Johnson Woods	Mesic Southern Forest	16110	C	2006	2006	G4	S3
Middle Hills*	Mesic Southern Forest	19811	D	2013	2103	G4	S3

Table 2. Newly documented and previosuly known rare plant element occurrences at Middleville State Game Area. State status abbreviation of T signifies state threatened. EO rank abbreviations are as follows: B, good estimated viability; BC, good or fair estimated viability; C, fair estimated viability; CD, fair or poor estimated viability; and D, poor estimated viability. * indicates the EO was newly documented in 2013 or 2014.

Common Name	Scientific Name	State Status	EO ID	EO Rank	Year First Observed	Year Last Observed
Beak grass*	*Diarrhena obovata*	T	20107	B	2014	2014
Showy orchis	*Galearis spectabilis*	T	16135	D	2006	2006
Goldenseal	*Hydrastis canadensis*	T	16004	C	2005	2005
Goldenseal	*Hydrastis canadensis*	T	16134	C	2006	2006
Ginseng*	*Panax quinquefolius*	T	19814	CD	2013	2013
Ginseng*	*Panax quinquefolius*	T	20102	CD	2013	2013
Ginseng*	*Panax quinquefolius*	T	20109	D	2013	2013
Ginseng*	*Panax quinquefolius*	T	20113	BC	2014	2014

Ginseng (*Panax quinquefolius*) was recorded within the Hills of Parmalee mesic southern forest and the North CountryWoods dry-mesic southern forest. Photo by Joshua G. Cohen.

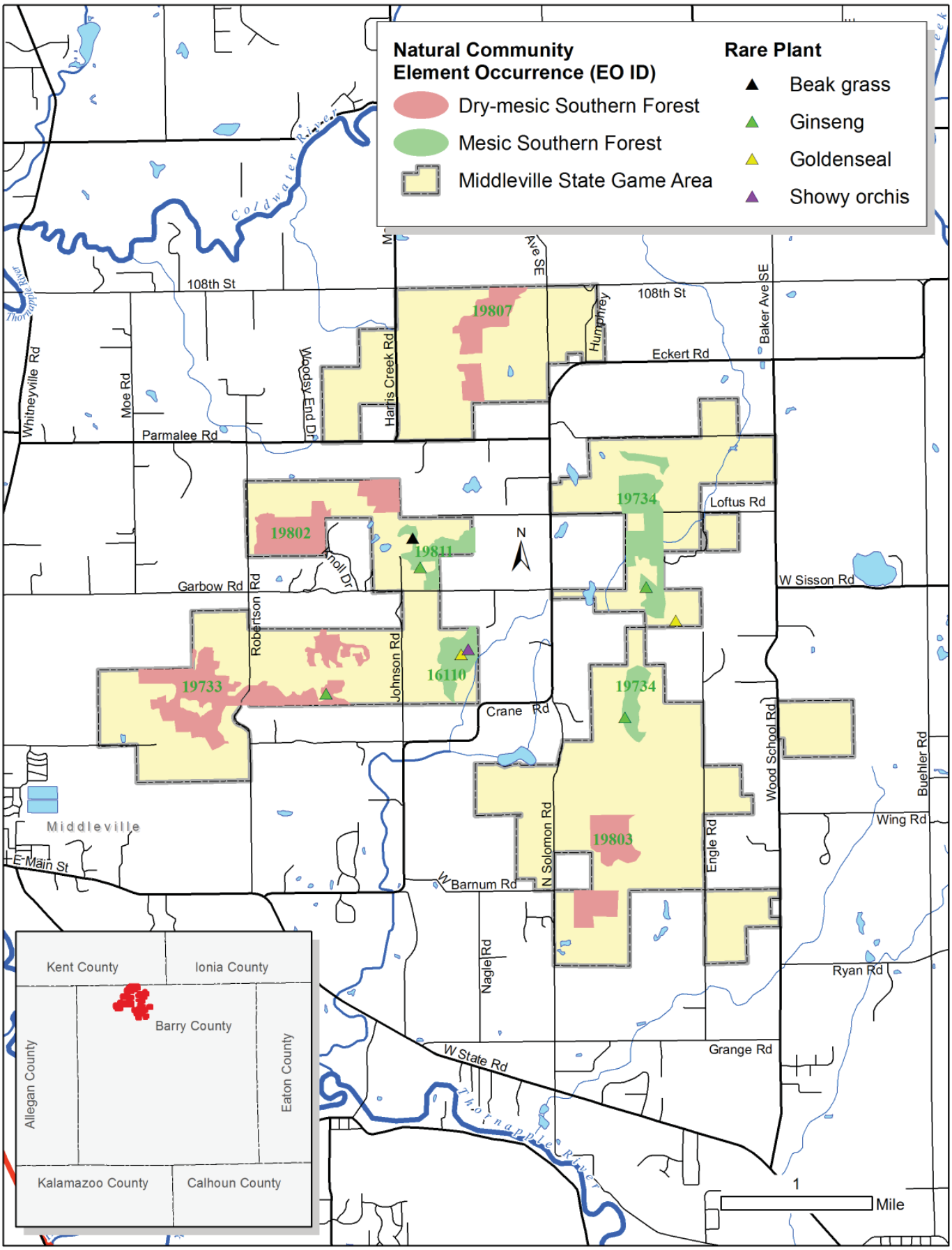
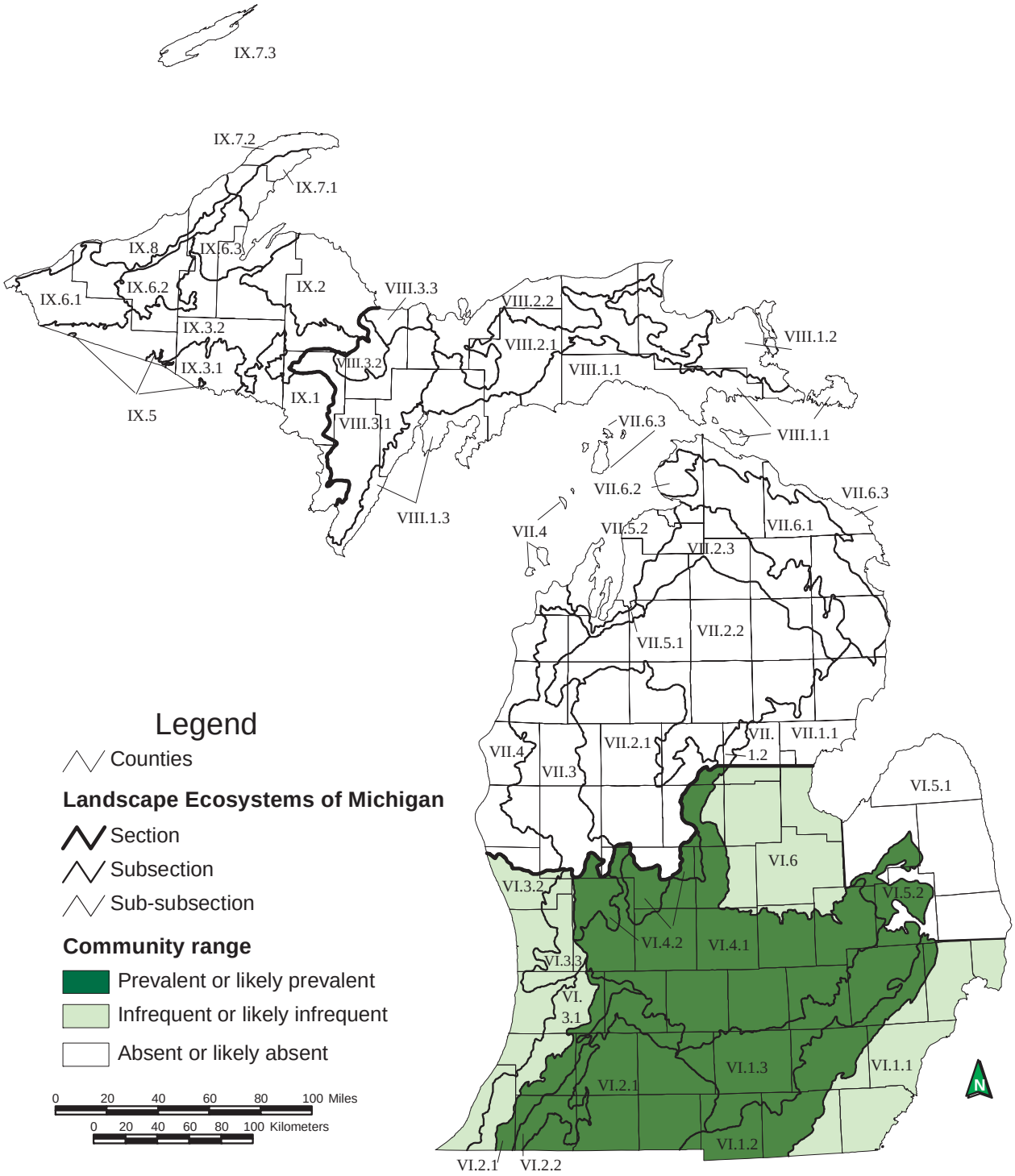


Figure 8. Natural community and rare plant element occurrences in Middleville State Game Area.

DRY-MESIC SOUTHERN FOREST

Overview: Dry-mesic southern forest is an oak-dominated, fire-dependent forest that occurs in the southern Lower Peninsula on glacial outwash plains, coarse-textured moraines, sandy lakeplains, kettle-kame topography, and sand dunes. The community is found on slightly acidic to circumneutral sandy loams or loams. Historically, frequent fires maintained semi-open conditions and promoted oak regeneration and plant diversity. Windthrow and insect outbreaks and pathogens associated with oak decline also influence species composition and community structure. Dry-mesic southern forest is dominated by oaks or oaks and hickories, particularly white oak (*Quercus alba*), black oak (*Q. velutina*), red oak (*Q. rubra*), pignut hickory (*Carya glabra*), and shagbark hickory (*C. ovata*) (Kost et al. 2007, Cohen et al. 2014).



Map 1. Distribution of dry-mesic southern forest in Michigan (Albert et al. 2008).

1. County Line Woods
Natural Community Type: Dry-Mesic Southern Forest
Rank: G4 S3, apparently secure globally and vulnerable within the state
Element Occurrence Rank: C
Size: 85 acres
Location: Compartment 1, Stands 49, 52, and 54
Element Occurrence Identification Number: 19807

Site Description: This dry-mesic southern forest occurs on rolling topography of end moraine with variable aspect. Soils of the dry-mesic southern forest are medium- to fine-textured, acidic loamy sand (pH 5.5). Some areas of slightly acidic (pH 6.0-6.5), sandy clay occur locally and correspond to a greater proportion of mesic species. Wet depressions and vernal pools occur throughout the forest and wet shrub thickets are relatively common with winterberry (*Ilex verticillata*), highbush blueberry (*Vaccinium corymbosum*), and buttonbush (*Cephalanthus occidentalis*) common to dominant in these inundated areas. This forest is comprised of two portions. The northern section is the largest and most intact, and the southern section is smaller and more influenced by fragmentation. The forest is characterized by mature and maturing, large trees, scattered windthrow gaps, moderate coarse woody debris, and localized patches of invasive species. A 57 cm (22 in) pignut hickory (*Carya glabra*) was cored and estimated to be 149 years old.

The closed canopy is dominated by mixed oaks and red maple (*Acer rubrum*). Canopy dominants include red oak (*Quercus rubra*), white oak (*Q. alba*), black oak (*Q. velutina*), and red maple. White oak and black oak are most prevalent on south and southwest facing slopes and sandy hill tops. Canopy associates include pignut hickory and tulip poplar (*Lireodendron tulipifera*). Hickories are also common, primarily in the southern portion of the forest. Diameters of the canopy cohort typically range from 40 to 70 cm (16 to 28 in) with some larger trees reaching 100 cm (39 in). The subcanopy and tall shrub layer are characterized by ironwood (*Ostrya virginiana*), red maple, pignut hickory, witch-hazel (*Hamamelis virginiana*), white ash (*Fraxinus americana*), American elm (*Ulmus americana*), beech (*Fagus grandifolia*), flowering dogwood (*Cornus florida*), sassafras (*Sassafras albidum*), and black cherry (*Prunus serotina*). Fire suppression is leading to the understory dominance of red maple, white ash, American elm, and black cherry. Very little oak recruitment was observed. Invasives are sparse to locally abundant in the understory and ground cover and include multiflora rose (*Rosa multiflora*), autumn olive (*Elaeagnus umbellata*), and garlic mustard (*Alliara petiolata*). The low shrub layer is primarily occupied by maple-leaved (*Viburnum acerifolium*) and prickly gooseberry (*Ribes cynosbati*) with multiflora rose and tree seedlings throughout. Vines are prevalent throughout the forest and include Virginia creeper (*Parthenocissus quinquefolia*), grapes (*Vitis* spp), poison-ivy (*Toxicodendron radicans*), and greenbriars (*Smilax* spp.). The ground cover is characterized by sedges (*Carex* spp.), wild geranium (*Geranium maculatum*), naked-flower tick-trefoil (*Hylodesmum nudiflorum*), long-awned wood grass (*Brachyelytrum erectum*), lopseed (*Phryma leptostachya*), bluestem goldenrod (*Solidago caesia*), white avens (*Geum canadense*), common trillium (*Trillium grandiflorum*), and downy Solomon seal (*Polygonatum pubescens*).

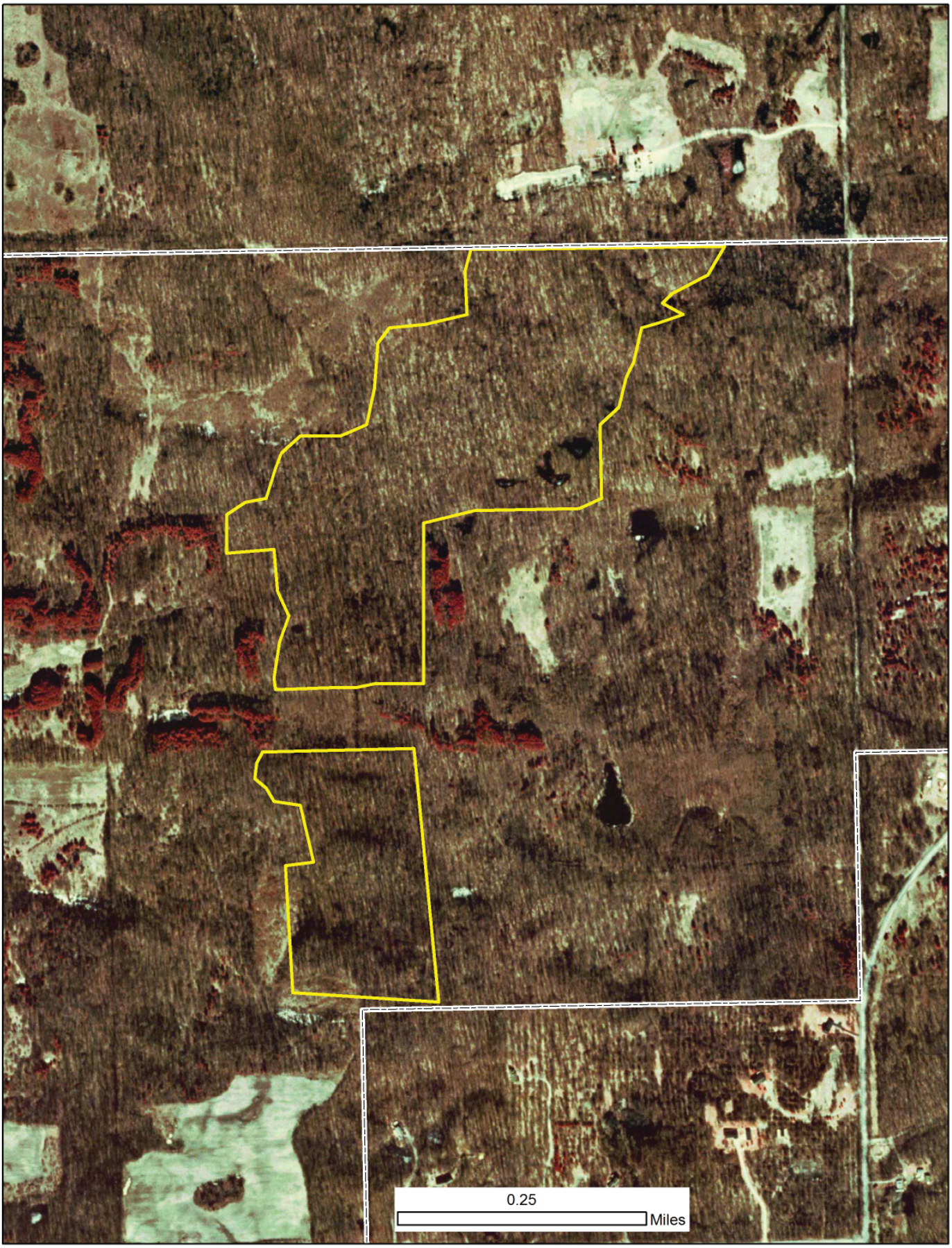
Hooded warbler (*Setophaga citrina*, state special concern) (EO ID 13382) and eastern box turtle (*Terrapene carolina carolina*, state special concern) (EO ID 20106) have been documented using this forest complex.

Threats: Species composition, vegetative structure, and successional trajectory are strongly influenced by gap dynamics, past logging, fire suppression, invasive species, and deer herbivory. Oak regeneration is sparse to absent, likely due to fire suppression and mesophytic invasion, competition from invasives and mesophytic species, and deer browse pressure. As noted above, invasive species are sparse to locally abundant in the understory and ground cover and include multiflora rose, autumn olive, and garlic mustard. Slightly higher densities of multiflora rose and autumn olive also seem to be associated with canopy gaps. In addition, high levels of invasive species occur in the adjacent degraded forests and provide a seed source for continued invasive species incursions. Finally, the landowner adjacent to the southern portion of the site appears to have been creating walking/hunting trails throughout the southern portion of the forest.

Management Recommendations: The primary management need is the reintroduction of fire as a prevalent disturbance factor. Implementation of prescribed fire is best done in the context of landscape-scale fire. Because eastern box turtle has been documented at this site, if prescribed fire is implemented, rotating non-fire refugia should be established within the forest. Subcanopy and understory red maple, sassafras, and black cherry could be girdled or mechanically felled if repeated fires do not control these mesophytic species. In addition, cutting and herbiciding concentrations of invasive

shrubs in the site and also in adjacent forested stands will also complement the use of fire to control invasive shrubs. Concentrations of garlic mustard can be pulled by hand. Control of invasive plant populations within the surrounding landscape will require a major, long-term effort. Reducing local deer browse pressure is recommended in order to dampen deer browse pressure on the understory and ground cover. Monitoring should be implemented to assess efforts to control non-native plant populations, to gauge the impact of deer herbivory, and evaluate oak regeneration and response of the forest to fire management. In addition, maintaining this forest as a closed-canopy system will benefit the breeding population of hooded warbler within this forest and the diverse array of species that depend on the vernal pools nested within the forest. Finally, the landowner that is creating trails within the southern portion of the site could be contacted and instructed to refrain from such activity.

County Line Woods dry-mesic southern forest. Photo by Jesse M. Lincoln.



1998 aerial photograph of County Line Woods dry-mesic southern forest.

2. Garbow Woods
Natural Community Type: Dry-Mesic Southern Forest
Rank: G4 S3, apparently secure globally and vulnerable within the state
Element Occurrence Rank: CD
Size: 113 acres
Location: Compartment 1, Stands 16 and 34
Element Occurrence Identification Number: 19802

Site Description: This dry-mesic southern forest occurs on moderately steep ground moraine with variable aspect and glacial erratics throughout. Soils of the dry-mesic southern forest are slightly acidic (pH 6.5), sandy clay loam. Wet depressions and vernal pools occur throughout the forest and wet shrub thickets are relatively common with winterberry (*Ilex verticillata*), highbush blueberry (*Vaccinium corymbosum*), and buttonbush (*Cephalanthus occidentalis*) common to dominant in these inundated areas. This forest is comprised of two portions. The western section is the largest but more impacted by invasive species. The eastern portion has inclusions that trend more towards dry southern forest with some savanna species throughout. Overall, the forest is characterized by mature and maturing, large trees, abundant coarse woody debris, and areas with local dominance by invasive species. A 61.3 cm (24 in) pignut hickory (*Carya glabra*) was cored and estimated to be 137 years old and an 80.5 cm (32 in) red oak (*Quercus rubra*) was cored and estimated to be 114 years old.

The canopy is dominated by oaks and hickories, particularly red oak and pignut hickory, with white oak (*Q. alba*), black oak (*Q. velutina*), and red maple (*Acer rubrum*) as significant canopy associates. Diameters of the canopy cohort typically range from 40 to 80 cm (16 to 31 in) with some larger trees reaching 100 cm (39 in). The subcanopy and tall shrub layer are characterized by ironwood (*Ostrya virginiana*), red maple, hickories, witch-hazel (*Hamamelis virginiana*), white ash (*Fraxinus americana*), American elm (*Ulmus americana*), beech (*Fagus grandifolia*), flowering dogwood (*Cornus florida*), sassafras (*Sassafras albidum*), and black cherry (*Prunus serotina*). Fire suppression and deer herbivory are leading to the understory dominance of red maple, white ash, American elm, and black cherry. Very little oak recruitment was observed. Invasives are locally dominant in the understory and ground cover and include multiflora rose (*Rosa multiflora*), autumn olive (*Elaeagnus umbellata*), Japanese barberry (*Berberis thunbergii*), and garlic mustard (*Alliara petiolata*). The low shrub layer is primarily occupied by maple-leaved (*Viburnum acerifolium*) and prickly gooseberry (*Ribes cynosbati*) with multiflora rose and tree seedlings throughout. Vines are prevalent throughout the forest and include Virginia creeper (*Parthenocissus quinquefolia*), grapes (*Vitis* spp), and poison-ivy (*Toxicodendron radicans*). The ground cover is characterized by sedges (*Carex* spp.), wild geranium (*Geranium maculatum*), tick-trefoils (*Hylodesmum* spp. and *Desmodium* spp.), long-awned wood grass (*Brachyelytrum erectum*), lopseed (*Phryma leptostachya*), bluestem goldenrod (*Solidago caesia*), white avens (*Geum canadense*), common trillium (*Trillium grandiflorum*), and downy Solomon seal (*Polygonatum pubescens*).

This element occurrence includes a dry southern forest inclusion within the eastern portion. This drier area appears to be a fire suppressed oak barrens that has transition to dry southern forest. Numerous species in the herbaceous layer of this area are barrens indicators including black oatgrass (*Piptochaetium avenaceum*), New Jersey tea (*Ceanothus americanus*), hairy hawkweed (*Hieracium gronovii*), bastard-toadflax (*Comandra umbellata*), and panic grasses (*Dichanthelium* spp.).

Hooded warblers (*Setophaga citrina*, state special concern) (EO ID 13382) have been documented using this forest complex.

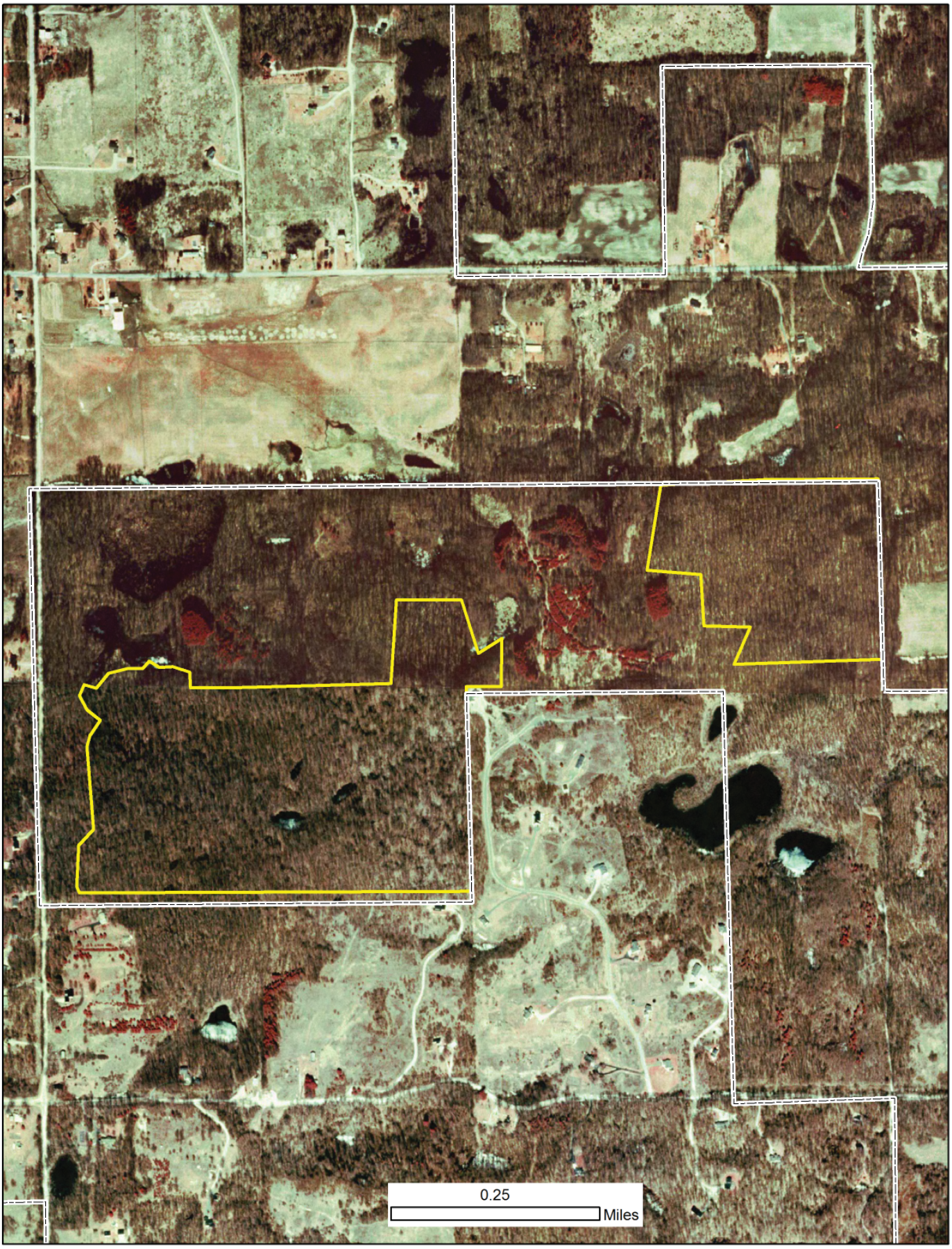
Threats: Species composition, vegetative structure, and successional trajectory are strongly influenced by gap dynamics, past logging, fire suppression, invasive species, and deer herbivory. Oak regeneration is sparse to absent, likely due to fire suppression and mesophytic invasion, competition from invasives and mesophytic species, and deer browse pressure. As noted above, invasive species are locally dominant in the understory and ground cover and include multiflora rose, Japanese barberry, autumn olive, and garlic mustard. Slightly higher densities of invasive species, especially multiflora rose, were noted in the western section. In addition, high levels of invasive species occur in the adjacent degraded forests and provide a seed source for continued invasive species incursions.

Management Recommendations: The primary management need is the reintroduction of fire as a prevalent disturbance factor. Implementation of prescribed fire is best done in the context of landscape-scale fire. Subcanopy and understory red maple and black cherry could be girdled or mechanically felled if repeated fires do not control these mesophytic species.

In addition, cutting and herbiciding concentrations of invasive shrubs in the site and also in adjacent forested stands will complement the use of fire to control invasive shrubs. A concerted effort will be needed to reduce the high levels of multiflora rose. Concentrations of garlic mustard can be pulled by hand. Control of invasive plant populations within the surrounding landscape will require a major, long-term effort. Reducing local deer densities is recommended in order to dampen deer browse pressure on the understory and ground cover. Monitoring should be implemented to assess efforts to control non-native plant populations, to gauge the impact of deer herbivory, and evaluate oak regeneration and response of the forest to fire management. In addition, maintaining this forest as a closed-canopy system will benefit the breeding population of hooded warbler within this forest and the diverse array of species that depend on the vernal pools nested within the forest.

The inclusion of dry southern forest in the eastern portion of the site could be burned more intensively and frequently in order to restore oak barrens. Specific recommendations for restoring oak barrens here include: conducting three prescribed burns every three years, removing remaining red maple and autumn olive, and thinning 40% of the canopy where burns have been conducted. In addition, we recommend, conducting follow up burns every three years after thinning and varying the seasonality of these burns.

Garbow Woods dry-mesic southern forest. Photo by Jesse M. Lincoln.



1998 aerial photograph of Garbow Woods dry-mesic southern forest.

3. North Country Woods
Natural Community Type: Dry-Mesic Southern Forest
Rank: G4 S3, apparently secure globally and vulnerable within the state
Element Occurrence Rank: BC
Size: 215 acres
Location: Compartment 1, Stands 73, 85, 100, 101, and 107
Element Occurrence Identification Number: 19733

Site Description: This dry-mesic southern forest occurs on steep to very steep ground moraine with variable aspect and glacial erratics throughout. Soils of the dry-mesic southern forest are medium- to fine-textured, acidic (pH 5.0-5.5), sandy loams and sands. Wet depressions and vernal pools occur throughout the forest and wet shrub thickets are relatively common with winterberry (*Ilex verticillata*), highbush blueberry (*Vaccinium corymbosum*), and buttonbush (*Cephalanthus occidentalis*) common to dominant in these inundated areas. This forest is comprised of three separate polygons. The eastern portions tends to have more wetlands throughout and adjacent to the forest. A small bog was noted at the northern edge of this forest, west of Robertson Road. The forest is characterized by mature and maturing, large trees, moderate coarse woody debris, and localized patches of invasive species. An 82.7 cm (32.6 in) pignut hickory (*Carya glabra*) was cored and estimated to be 184 years old and a 49.6 cm (19.5 in) red oak (*Quercus rubra*) was cored and estimated to be 80 years old.

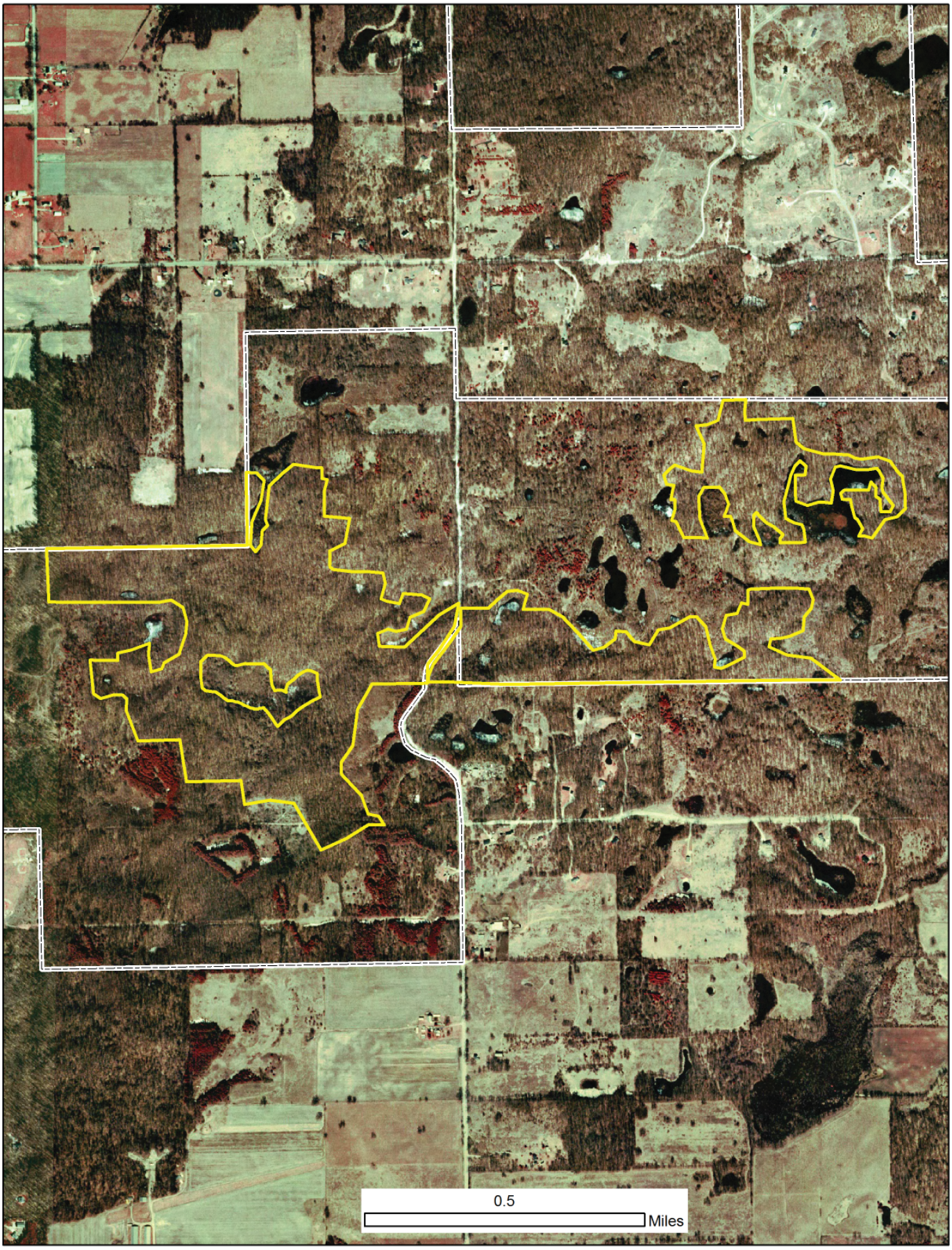
The closed canopy is dominated by oaks and hickories: primarily red oak, white oak (*Q. alba*), black oak (*Q. velutina*), and pignut hickory with canopy associates including shagbark hickory (*C. ovata*), red maple (*Acer rubrum*), tulip tree (*Lireodendron tulipifera*), and black cherry (*Prunus serotina*). Diameters of the canopy cohort typically range from 40 to 60 cm (16 to 24 in) with some larger oaks reaching 70 to 100 cm (28 to 39 in). Inclusions of younger forest, especially in the center of the largest stand, are characterized by canopy dominance of red oak along with red maple and black cherry. The subcanopy and tall shrub layer are characterized by ironwood (*Ostrya virginiana*), red maple, pignut hickory, witch-hazel (*Hamamelis virginiana*), flowering dogwood (*Cornus florida*), sassafras (*Sassafras albidum*), and black cherry. Invasives are sparse to locally abundant in the understory and ground cover and include multiflora rose (*Rosa multiflora*), autumn olive (*Elaeagnus umbellata*), morrow honeysuckle (*Lonicera morrowii*), and garlic mustard (*Alliara petiolata*). The low shrub layer is primarily occupied by maple-leaved (*Viburnum acerifolium*) and prickly gooseberry (*Ribes cynosbati*). Vines are prevalent throughout the forest and include Virginia creeper (*Parthenocissus quinquefolia*), riverbank grape (*Vitis riparia*), poison-ivy (*Toxicodendron radicans*), and greenbriars (*Smilax* spp.). The ground cover is characterized by sedges (*Carex* spp.), wild geranium (*Geranium maculatum*), pointed-leaf tick-trefoil (*Hylodesmum glutinosum*), bluestem goldenrod (*Solidago caesia*), bottlebrush grass (*Elymus hystrix*), Canada brome (*Bromus pubescens*), white wild licorice (*Galium circaezans*), elm-leaved goldenrod (*Solidago ulmifolia*), and woodland sunflower (*Helianthus divaricatus*). In addition, ginseng (*Panax quinquefolius*, state threatened) (EO ID 20113) was documented within the eastern portion of the southeastern polygon in an area with slightly more mesic soils characterized by a more diverse herbaceous layer and more mesic canopy composition including white oak, sugar maple (*Acer saccharum*), and beech (*Fagus grandifolia*).

In addition to ginseng, this dry-mesic southern forest also supports populations of hooded warbler (*Setophaga citrina*, state special concern) (EO ID 13382) and cerulean warbler (*Setophaga cerulea*, state threatened) (13383). Wetlands adjacent to the eastern portion of the site also support Blanding's turtle (*Emydoidea blandingii*, state special concern) (EO ID 20100).

Threats: Species composition, vegetative structure, and successional trajectory are strongly influenced by gap dynamics, past logging, fire suppression, invasive species, and deer herbivory. Signs of old anthropogenic disturbance were noted throughout the forest including scattered cut stumps, an old fence, and rock piles. Oak regeneration is sparse to absent, likely due to fire suppression and mesophytic invasion, competition from invasives and mesophytic species, and deer browse pressure. As noted above, invasive species occur locally in the understory and ground cover and include multiflora rose, morrow honeysuckle, autumn olive, and garlic mustard. Higher densities of invasive species occur in the central portion of the western section, which was likely logged more recently. In addition, high levels of invasive species occur in the adjacent degraded forests and provide a seed source for continued invasive species incursions.

Management Recommendations: The primary management need is the reintroduction of fire as a prevalent disturbance factor, particularly in the western portions of this forest. Implementation of prescribed fire is best done in the context of landscape-scale fire. Subcanopy and understory red maple and black cherry could be girdled or mechanically felled if repeated fires do not control these mesophytic species. In addition, cutting and herbiciding concentrations of invasive shrubs in the site and also in adjacent forested stands will complement the use of fire to control invasive shrubs. Concentrations of garlic mustard can be pulled by hand. Control of invasive plant populations within the surrounding landscape will require a major, long-term effort. Reducing local deer densities is recommended in order to dampen deer browse pressure on the understory and ground cover. Monitoring should be implemented to assess efforts to control non-native plant populations, to gauge the impact of deer herbivory, and evaluate oak regeneration and response of the forest to fire management. Within this site, care should be taken to protect the population of ginseng. Ginseng is a rare plant species that is sensitive to soil and canopy disturbance and competition from invasive species. In addition, maintaining this forest as a closed-canopy system will also benefit the breeding populations of hooded warbler and cerulean warbler documented within this forest and the diverse array of species that depend on the vernal pools nested within the forest.

North Country Woods dry-mesic southern forest. Photo by Jesse M. Lincoln.



1998 aerial photograph of North Country Woods dry-mesic southern forest.

4. Soloman Woods
Natural Community Type: Dry-Mesic Southern Forest
Rank: G4 S3, apparently secure globally and vulnerable within the state
Element Occurrence Rank: C
Size: 93 acres
Location: Compartment 1, Stands 255, 266, and 278
Element Occurrence Identification Number: 19803

Site Description: This dry-mesic southern forest occurs on rolling end moraine (northern polygon) and ice contact ridges within outwash (southern polygon) and is characterized by coarse-textured, acidic (pH 5.5-6.0) loamy sands with occasional glacial erratics. This site is composed of a northern and a southern block. Vernal pools occur throughout and a large wet depression occurs in the center of the northern block and is ringed by swamp hardwoods with wetland shrubs. The forest is characterized by mature and maturing trees, abundant coarse woody debris, dense herbaceous cover, and localized patches of invasive species. A 75 cm (30 in) black oak (*Quercus velutina*) was cored and estimated to be 149 years old and a 61 cm (24 in) white oak (*Q. alba*) was cored and estimated to be 145 years old. The northern block is less fragmented, has more level terrain, is more acidic, and is less impacted by invasive species compared to the southern block.

The closed canopy is dominated by oaks and hickories, primarily black oak, white oak, red oak (*Q. rubra*) and pignut hickory (*Carya glabra*) with red maple (*Acer rubrum*) as a prevalent canopy associate. Diameters of the canopy cohort typically range from 40 to 70 cm (16 to 28 in) with some larger oaks and hickories reaching 70 to 100 cm (28 to 39 in). A 101 cm (40 in) pignut hickory was documented in the northern block. Scattered canopy and supercanopy white pine (*Pinus strobus*) occur in the southern block. This is the only location in the game area where white pine was observed growing naturally in the uplands. The subcanopy and tall shrub layer are characterized by ironwood (*Ostrya virginiana*), red maple, witch-hazel (*Hamamelis virginiana*), flowering dogwood (*Cornus florida*), sassafras (*Sassafras albidum*), and black cherry (*Prunus serotina*). The subcanopy and shrub layers range from dense to patchy as does the herbaceous layer which can also be sparse in places. The prevalence of understory red maple, black cherry, and sassafras indicates that this forest is fire suppressed. Invasive species are sparse to locally abundant in the understory and ground cover and include multiflora rose (*Rosa multiflora*), tree-of-heaven (*Ailanthus altissima*), autumn olive (*Elaeagnus umbellata*), morrow honeysuckle (*Lonicera morrowii*), hedge-parsley (*Torilis japonica*), and garlic mustard (*Alliara petiolata*). The low shrub layer is primarily occupied by maple-leaved (*Viburnum acerifolium*) and prickly gooseberry (*Ribes cynosbati*). Vines range from dominant to sparse and include Virginia creeper (*Parthenocissus quinquefolia*), grapes (*Vitis* spp.), poison-ivy (*Toxicodendron radicans*), and greenbriars (*Smilax* spp.). The ground cover is characterized by Pennsylvania sedge (*Carex pensylvanica*), wild geranium (*Geranium maculatum*), naked-flower tick-trefoil (*Hylodesmum nudiflorum*), lopseed (*Phryma leptostachya*), bluestem goldenrod (*Solidago caesia*), bottlebrush grass (*Elymus hystrix*), Canada brome (*Bromus pubescens*), elm-leaved goldenrod (*Solidago ulmifolia*), hairy sweet cicely (*Osmorhiza claytonii*), enchanter's-nightshade (*Circaea canadensis*), yellow wild licorice (*Galium lanceolatum*), and jumpseed (*Persicaria virginiana*).

Hooded warblers (*Setophaga citrina*, state special concern) (EO ID 13382) have been documented using this forest complex.

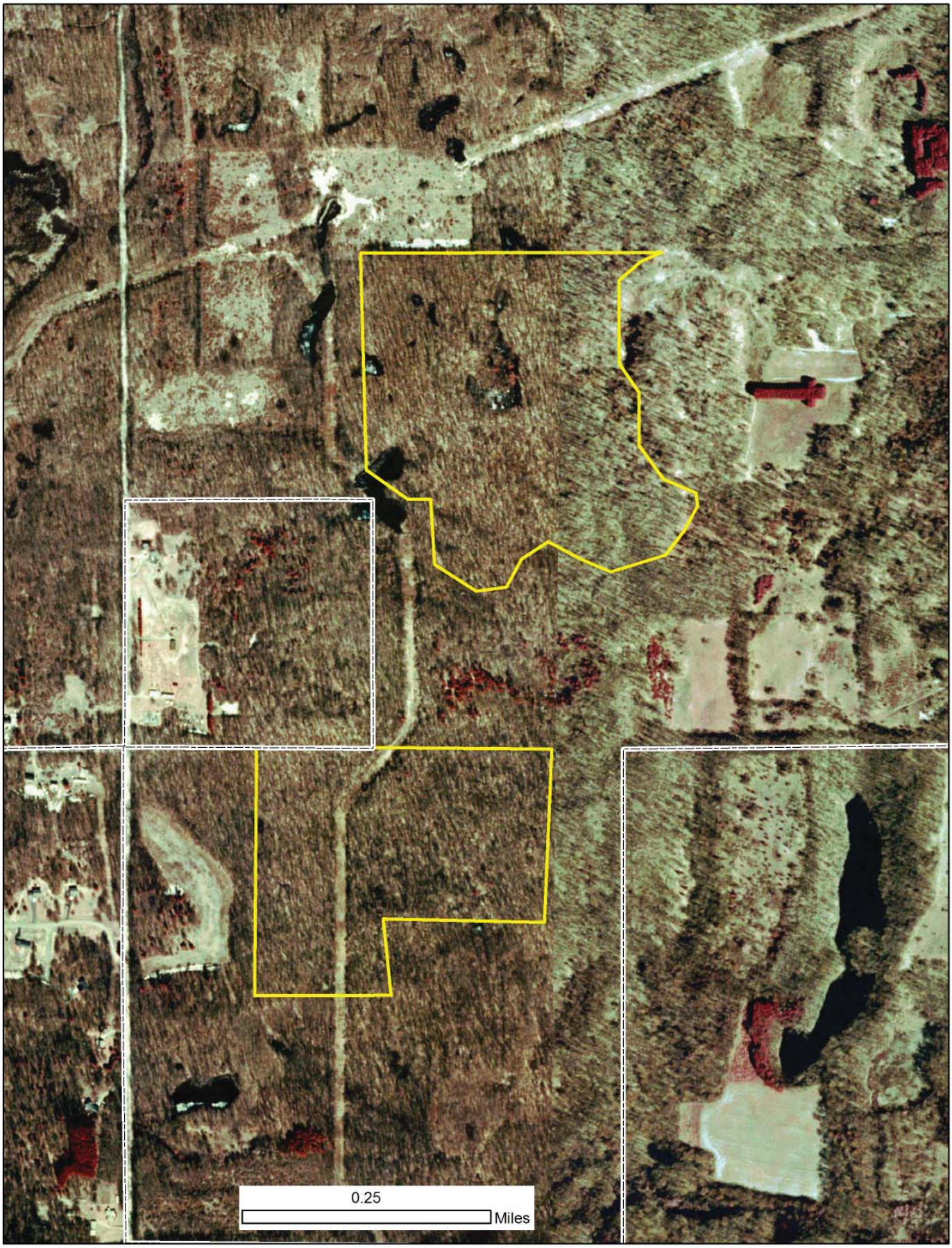
Threats: Species composition, vegetative structure, and successional trajectory are influenced by gap dynamics, logging history, deer herbivory, fire suppression, and invasive species. Signs of old anthropogenic disturbance were noted at the margins of the forest including scattered cut stumps, an old fence, and rock piles. Oak regeneration is sparse to absent, likely due to fire suppression and mesophytic invasion, competition from invasives and mesophytic species, and deer browse pressure (deer browse was observed). As noted above, invasive species are scattered in the understory and ground cover. Higher densities of invasive species occur in the southern polygon, which is fragmented by a powerline. Tree-of-heaven is concentrated along the powerline. In addition, high levels of invasive species occur in the adjacent degraded forests and provide a seed source for continued invasive species incursions. Multiflora rose, morrow honeysuckle, and autumn olive are especially prevalent in adjacent early-successional forests.

Management Recommendations: The primary management need is the reintroduction of fire as a prevalent disturbance factor. Implementation of prescribed fire is best done in the context of landscape-scale fire. Subcanopy and understory red maple, sassafras, and black cherry could be girdled or mechanically felled if repeated fires do not control these mesophytic

invaders. In addition, cutting and herbiciding concentrations of invasive shrubs within the site and also in adjacent forested stands will complement the use of fire to control invasive shrubs and trees. Concentrations of garlic mustard can be pulled by hand. Control of invasive plant populations within the surrounding landscape will require a major, long-term effort. Reducing local deer densities is recommended in order to dampen deer browse pressure on the understory and ground cover. Monitoring should be implemented to assess efforts to control non-native plant populations, to gauge the impact of deer herbivory, and evaluate oak regeneration and response of the forest to fire management. Maintaining this forest as a closed-canopy system will benefit the breeding population of hooded warbler documented within this forest and the diverse array of species that depend on the vernal pools nested within the forest.

There are opportunities for oak barrens restoration in the areas between the two blocks of dry-mesic southern forest that constitute this EO. Within Compartment 1, sandy areas at the margins of Stand 272 harbor several barrens species, including lupine (*Lupinus perennis*), prairie phlox (*Phlox pilosa*), clasping milkweed (*Asclepias amplexicaluis*), butterfly milkweed (*A. tuberosa*), dwarf dandelion (*Krigia virginica*), pale Indian plantain (*Arnoglossum atriplicifolium*), and a variety of native grasses and sedges. Implementing prescribed fire throughout Stands 261, 272, and the northeast portion of Stand 278 along with removal of planted pines and thinning of the canopy would facilitate barrens restoration in this area and would help buffer the Soloman Woods dry-mesic southern forest EO.

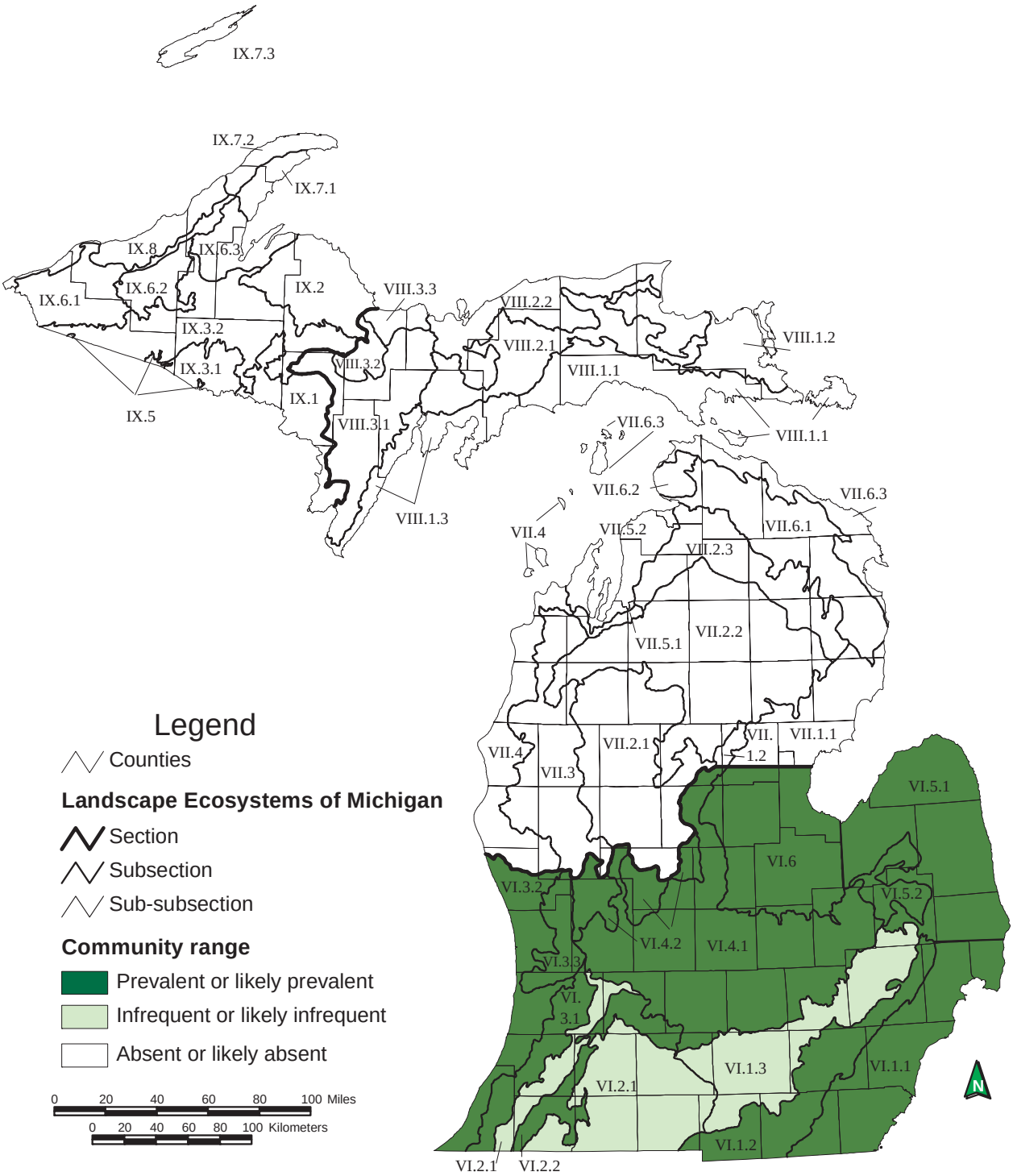
Soloman Woods dry-mesic southern forest. Photo by Jesse M. Lincoln.



1998 aerial photograph of Soloman Woods dry-mesic southern forest.

MESIC SOUTHERN FOREST

Overview: Mesic southern forest is a hardwood forest found throughout the southern Lower Peninsula on a wide variety of landforms. The community is most prevalent on gently rolling ground moraine but also occurs on flat glacial outwash plains and lakeplains, kettle-kame topography, and sand dunes. Soils vary widely but are typically well-drained loams with high water-holding capacity and high nutrient content. Frequent, small-scale windthrow events (i.e., gap-phase dynamics) promote species diversity and allow for the regeneration of shade-tolerant canopy species. Historically, mesic southern forest occurred as a matrix system, dominating vast areas of level to rolling, loamy uplands of southern Lower Michigan. These forests were multi-generational, with old-growth conditions lasting many centuries. Mesic southern forest is dominated by American beech (*Fagus grandifolia*) and sugar maple (*Acer saccharum*) (Kost et al. 2007, Cohen et al. 2014).



Map 2. Distribution of mesic southern forest in Michigan (Albert et al. 2008).

5. Hills of Parmalee
Natural Community Type: Mesic Southern Forest
Rank: G2G3 S3, imperiled to vulnerable globally and vulnerable within the state
Element Occurrence Rank: C
Size: 150 acres
Location: Compartment 1, Stands 160, 164, 168, 173, 206, 209, and 233
Element Occurrence Identification Number: 19734

Site Description: This mesic southern forest occurs on steep end moraine with variable aspect. This forest is comprised of three polygons: one large polygon occurs north and south of Loftus Road, one medium polygon further south, and one small polygon north of the road. The northern most section is very small and narrow and occurs primarily on a very steep, north-facing slope. Soils of the mesic southern forest are slightly acidic (pH 6.5-6.8), medium- to fine-textured sandy clay loam. Inundated shrub swamps and vernal pools occur throughout and correspond to depressions with clay deposits. Species composition and structure of the forest are influenced by gap-phase dynamics. Scattered windthrow has generated small canopy gaps leading to an uneven-aged forest and a moderate volume of coarse woody debris. A 62.8 cm (25 in) beech (*Fagus grandifolia*) was cored and estimated to be 164 years old.

The closed canopy is dominated by sugar maple (*Acer saccharum*), beech, and red oak (*Quercus rubra*) with canopy associates including basswood (*Tilia americana*) and bitternut hickory (*Carya cordiformis*). White ash (*Fraxinus americana*) and American elm (*Ulmus americana*) were recently important canopy components but have recently died due to emerald ash borer and Dutch elm's disease, respectively. Canopy composition is variable depending on slope, aspect, and local soil conditions. Diameters of the canopy cohort typically range from 40 to 60 cm (16 to 24 in) with some scattered 70 to 100 cm (28 to 39 in) trees. The subcanopy and tall shrub layer are characterized by sugar maple, white ash, beech, ironwood (*Ostrya virginiana*), musclewood (*Carpinus caroliniana*), and American elm. Invasive species are sparse to locally abundant in the understory and ground cover and include multiflora rose (*Rosa multiflora*), tree-of-heaven (*Ailanthus altissima*), autumn olive (*Elaeagnus umbellata*), morrow honeysuckle (*Lonicera morrowii*), and garlic mustard (*Alliara petiolata*). The low shrub layer is primarily occupied by maple-leaved (*Viburnum acerifolium*) and prickly gooseberry (*Ribes cynosbati*). Vines occur throughout the forest and include Virginia creeper (*Parthenocissus quinquefolia*), river grape (*Vitis riparia*), and poison-ivy (*Toxicodendron radicans*). The ground cover is characterized by sedges (*Carex* spp.), May apple (*Podophyllum peltatum*), long-awned wood grass (*Brachyelytrum erectum*), wood nettle (*Laportea canadensis*), lopseed (*Phryma leptostachya*), and violets (*Viola* spp.). In addition, ginseng (*Panax quinquefolius*, state threatened) occurs in the southern portion of the central polygon (EO ID 20102) and in the northern portion of the southern polygon (EO ID 19814).

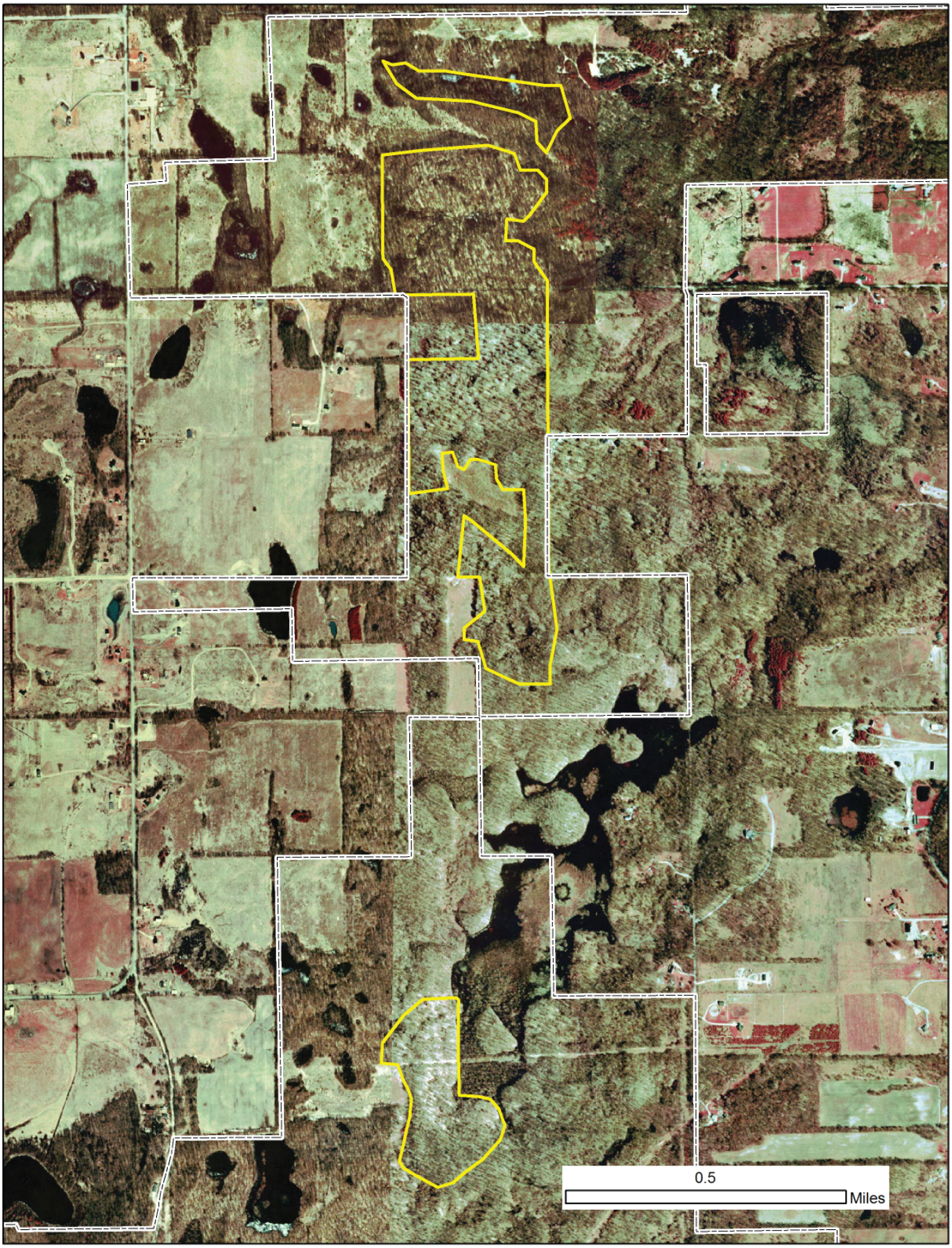
In addition to ginseng, a breeding population of cerulean warbler (*Setophaga cerulea*, state threatened) (EO ID 13383) has been documented just east of this mesic southern forest.

Threats: Species composition, vegetative structure, and successional trajectory are strongly influenced by gap dynamics, past logging and grazing history, invasive species, and deer herbivory. Emerald ash borer has killed the canopy ash within this forest. Areas of the forest that were selectively logged correspond strongly to areas where invasive species are locally prevalent. As noted above, invasive species are sparse to locally abundant in the understory and ground cover and include multiflora rose, tree-of-heaven, autumn olive, morrow honeysuckle, and garlic mustard. Deer browse was noted throughout and deer herbivory has likely impacted species composition and structure. Intense and persistent deer browse is leading to a sparse herbaceous layer and a lack of recruitment for many species. Non-native earthworms also appear to be having an impact on reduced leaf litter, which may be contributing to erosion, changes in nutrient cycling, and altered species composition. Areas of severe erosion occur along a vernal stream north of Loftus Road and may be the result of reduced leaf litter (likely due to earthworms), reduced herbaceous vegetation, and off-road vehicle use. The ginseng population in the central polygon appears to have declined in extent, possibly due to poaching.

Management Recommendations: The primary management needs are to maintain the closed canopy conditions, allow the forest to continue to mature, and control the invasive species. Cutting and herbiciding concentrations of invasive shrubs within the site and also in adjacent forested stands is recommended. Concentrations of garlic mustard can also be pulled by hand. Control of invasive plant populations within the surrounding landscape will require a major, long-term effort. Reducing local deer densities is recommended in order to dampen deer browse pressure on the understory and

ground cover. Monitoring should be implemented to assess efforts to control non-native plant populations, to gauge the impact of deer herbivory, and evaluate understory and herbaceous composition. Within this site, care should be taken to protect the populations of ginseng. Ginseng is a rare plant species that is sensitive to soil and canopy disturbance and competition from invasive species. Maintaining this forest as a closed-canopy system will also benefit the breeding population of cerulean warbler nearby this forest and the diverse array of species that depend on the vernal pools nested within the forest. Closing Loftus Road would help limit off-road vehicle activity and associated erosion within the forest.

Hills of Parmalee mesic southern forest. Photo by Jesse M. Lincoln.



1998 aerial photograph of Hills of Parmalee mesic southern forest.

6. Johnson Woods
Natural Community Type: Mesic Southern Forest
Rank: G2G3 S3, imperiled to vulnerable globally and vulnerable within the state
Element Occurrence Rank: C
Size: 50 acres
Location: Compartment 1, Stand 146
Element Occurrence Identification Number: 16110

Site Description: This mesic southern forest occurs on coarse-textured end moraine with rolling to steep terrain and variable aspect. The soils are acidic (pH 5.5-6.0) sandy loams and scattered glacial erratics and vernal pools occur throughout. The mature forest is characterized by large trees and high species diversity. The site is bordered by cultivated agricultural land to the east and south and early-successional upland forest to the north and west. Species composition, vegetative structure, and successional trajectory are driven by gap-phase dynamics and are also influenced by past selective logging and invasive species. The forest is characterized by abundant coarse woody debris both standing and downed. A 41 cm (16 in) sugar maple (*Acer saccharum*) was cored and estimated to be over 137 years old.

The closed canopy is dominated by sugar maple, beech (*Fagus grandifolia*), and red oak (*Quercus rubra*) with white ash (*Fraxinus americana*) and hickories (*Carya* spp.) as canopy associates. Canopy composition is variable depending on slope, aspect, and local soil conditions. Diameters of the canopy cohort typically range from 40 to 60 cm (16 to 24 in) with some scattered 60 to 90 cm (24 to 35 in) oaks. The subcanopy and tall shrub layer are characterized by sugar maple, ironwood (*Ostrya virginiana*), musclewood (*Carpinus caroliniana*), bitternut hickory (*Carya cordiformis*), and witch-hazel (*Hamamelis virginiana*). The herbaceous layer is sparse to absent (likely due to deer herbivory). In 2006, 70 native species were noted during the survey including goldenseal (*Hydrastis canadensis*, state threatened) (EO ID 16134) and showy orchis (*Galearis spectabilis*, state threatened) (EO ID 16135). Invasive species, including garlic mustard (*Alliara petiolata*) and multiflora rose (*Rosa multiflora*), are locally concentrated along trails, old logging logs, and under canopy gaps.

Threats: Species composition, vegetative structure, and successional trajectory are strongly influenced by gap dynamics, past logging, invasive species, and deer herbivory. As noted above, invasive species, particularly garlic mustard and multiflora rose, are concentrated along trails and old logging roads. In addition, garlic mustard threatens populations of goldenseal and showy orchis.

Management Recommendations: The primary management needs are to maintain the closed canopy conditions, allow the forest to continue to mature, and control the invasive species. Concentrations of garlic mustard can be pulled by hand and multiflora rose should be cut and herbicided. Control of invasive plant populations within the surrounding landscape will reduce the invasive species seed source but will require a major, long-term effort. Reducing local deer densities is recommended in order to dampen deer browse pressure on the understory and ground cover. Monitoring should be implemented to assess efforts to control non-native plant populations, to gauge the impact of deer herbivory, and evaluate understory and herbaceous composition. Within this site, care should be taken to protect the populations of showy orchis and goldenseal. These rare plant species are sensitive to soil and canopy disturbance and competition from invasive species. Maintaining this forest as a closed-canopy system will benefit these rare plants and also the diverse array of species that depend on the vernal pools nested within the forest.

1998 aerial photograph of Johnson Woods mesic southern forest.

7. Middle Hills
Natural Community Type: Mesic Southern Forest
Rank: G2G3 S3, imperiled to vulnerable globally and vulnerable within the state
Element Occurrence Rank: D
Size: 49 acres
Location: Compartment 1, Stand 69
Element Occurrence Identification Number: 19811

Site Description: This mesic southern forest occurs on steep end moraine with northerly aspects. The soils are coarse-textured, acidic (pH 5.5-6.0), loamy sands with areas of sandy clay throughout. A small ditched stream occurs along the northern edge of this forest and likely causes seasonal flooding along some of the flatter areas at the base of the steep hills. Lower elevation areas and steep hillsides are dominated by more mesic species while the hill tops are dominated by more dry-mesic species. This maturing forest is uneven-aged, starting to accrue late-successional characteristics, and characterized by high floristic diversity. Species composition, vegetative structure, and successional trajectory are driven by gap-phase dynamics, past selective logging, invasive species, and high levels of deer herbivory. The forest is characterized by a moderate volume of coarse woody debris both standing and downed and numerous windthrow gaps are scattered throughout. Vernal pools occur throughout the forest. A 72 cm (28 in) red oak (*Quercus rubra*) was cored and estimated to be over 94 years old.

The closed canopy is dominated by maples (*Acer* spp.), beech (*Fagus grandifolia*), and oaks (*Quercus* spp). Prevalent maples and oaks include sugar maple (*A. saccharum*), red maple (*A. rubrum*), red oak, and white oak (*Q. alba*). Red oak is locally dominant, likely the result of the past logging event. Additional canopy associates include basswood (*Tilia americana*), bitternut hickory (*Carya cordiformis*), and black oak (*Q. velutina*). White ash (*Fraxinus americana*) and American elm (*Ulmus americana*) were formerly important canopy components but have recently died due to emerald ash borer and Dutch elm's disease, respectively. Canopy composition is variable depending on slope, aspect, and local soil conditions. More mesic areas are dominated by sugar maple, beech, basswood, and bitternut hickory, while drier areas are characterized by a greater importance of canopy oaks. Diameters of the canopy cohort typically range from 40 to 60 cm (16 to 24 in) with some scattered 70 to 90 cm (28 to 35 in) trees. The subcanopy and tall shrub layer range from patchy to dense and are characterized by sugar maple, white ash, beech, ironwood (*Ostrya virginiana*), musclewood (*Carpinus caroliniana*), flowering dogwood (*Cornus florida*), American elm, blue ash (*Fraxinus quadrangulata*), and witch-hazel (*Hamamelis virginiana*). Invasive species are sparse to locally abundant in the understory and include multiflora rose (*Rosa multiflora*), tree-of-heaven (*Ailanthus altissima*), and autumn olive (*Elaeagnus umbellata*). The low shrub layer is characterized by maple-leaved (*Viburnum acerifolium*), prickly gooseberry (*Ribes cynosbati*), witch hazel, ironwood, and areas of dense maple seedlings. Vines occur scattered throughout the forest and include Virginia creeper (*Parthenocissus quinquefolia*), river grape (*Vitis riparia*), and poison-ivy (*Toxicodendron radicans*). The ground cover is diverse and characterized by blue cohosh (*Caulophyllum thalictroides*), sedges (*Carex* spp.), bloodroot (*Sanguinaria canadensis*), May apple (*Podophyllum peltatum*), long-awned wood grass (*Brachyelytrum erectum*), wood nettle (*Laportea canadensis*), lopseed (*Phryma leptostachya*), jumpseed (*Persicaria virginiana*), and violets (*Viola* spp.). Garlic mustard (*Alliara petiolata*) occurs locally. Beak grass (*Diarrhena* obovata, state threatened) (EO ID 20107) occurs in large, dense colonies in the northwestern portion of the forest along a vernal stream and along the North Country Trail. This rare plant is associated with forested stream and river banks and also occurs to the west of the mesic southern forest EO. In addition, ginseng (*Panax quinquefolius*, state threatened) (EO ID 20109) was documented just east of the southwestern portion of the EO and could potentially occur within the site.

Threats: Species composition, vegetative structure, and successional trajectory are strongly influenced by gap dynamics, past logging, invasive species, and deer herbivory. As noted above, invasive species that threaten this forest include multiflora rose, tree-of-heaven, autumn olive, and garlic mustard. The occurrence of invasive species corresponds strongly with areas that were logged. Intense and persistent deer browse is leading to a sparse herbaceous layer and a lack of recruitment for many species. Signs of anthropogenic disturbance were noted throughout the forest including cut stumps, foot trails in the western section, and channelization of a small stream that occurs along the northern edge of the forest. Some of the steeper slopes are impacted by erosion, especially above the stream at the eastern end of the stand.

Management Recommendations: The primary management needs are to maintain the closed canopy conditions, allow the forest to continue to mature, and control the invasive species. Concentrations of garlic mustard can be pulled by hand and multiflora rose, autumn olive, and tree-of-heaven should be cut and herbicided. Control of invasive plant populations within the surrounding landscape will reduce the invasive species seed source but will require a major, long-term effort. Reducing local deer densities is recommended in order to dampen deer browse pressure on the understory and ground cover. Monitoring should be implemented to assess efforts to control non-native plant populations, to gauge the impact of deer herbivory, evaluate understory and herbaceous composition, and evaluate erosion. Closing the portion of Johnson Road that passes by this EO would help reduce dumping and erosion associated with this road. Within this site, care should be taken to protect the populations of beak grass and any potential populations of ginseng. These rare plant species are sensitive to soil and canopy disturbance and competition from invasive species. Maintaining this forest as a closed-canopy system will benefit these rare plants and also the diverse array of species that depend on the vernal pools nested within the forest.

Middle Hills mesic southern forest. Photo by Jesse M. Lincoln.

1998 aerial photograph of Middle Hills mesic southern forest.

Vernal Pools Survey Results

A total of 221 potential vernal pools (PVPs) were identified and mapped in Middleville SGA through aerial photograph interpretation (Figure 11, See Page 60). These were distributed throughout the game area. Of these, 130 PVPs were mapped within the two subunits targeted for herptile field surveys. PVPs were identified and mapped within all seven of the dry-mesic southern forest and mesic southern forest natural community EOs documented in the game area.

A total of 12 potential vernal pools were surveyed in the field in 2014 (Figure 10, See Page 48). Ten PVPs were verified as actual vernal pools in the field, and one PVP needs additional information to determine its status (i.e., whether it is a vernal pool or not). An additional vernal pool that had not been mapped as a PVP was identified in the field during amphibian and reptile surveys. All of the vernal pools surveyed in the field were surrounded by upland deciduous forest within 30 meters (100 ft) of the pools. Eight of the 12 surveyed pools were classified as open vernal pools with little to no vegetation growing in the pools. One vernal pool was classified as a shrubby vernal pool, and two pools were classified as forested pools. Six of the confirmed vernal pools were surveyed on May 21st, 2014. The water levels in these pools were all full or mostly full (i.e., 75-100% of the pool basin filled with water). Nine of the pools were surveyed on July 24th and/or July 25th, 2014. Of these, one pool was full/mostly full, three pools were partially full (i.e., 50-74% full), two pools were less than half full (i.e., 25-49% full), and three pools were dry or mostly dry (i.e., 0-24% full). All but one of the pools surveyed were isolated basins or depressions and not connected to other wetlands or water bodies.

Visual encounter surveys and dipnetting surveys for rare amphibians and reptiles were conducted at all 12 vernal pools/potential vernal pools. Aquatic funnel or minnow trapping for larval amphibians was conducted at two vernal pools, which were located in and to the north of the Garbow Woods dry-mesic southern forest (EO ID 19802). Vernal pool indicator species were observed in six (50%) of the 12 surveyed vernal pools/potential vernal pools. These included observations of blue-spotted salamander larvae or adults in four pools, spotted salamander larvae in two pools, eastern tiger salamander larvae in one pool, and wood frog tadpoles in two pools. Other amphibian and reptile species observed in the surveyed vernal pools included green frogs (*Lithobates clamitans*) and western chorus frog (*Pseudacris triseriata*) tadpoles. Additional information about amphibians and reptiles that were documented in vernal pools in 2014 is provided in the amphibian and reptile results section that follows. In addition to herptiles, a number of invertebrates also were found in the pools. These included fingernail clams (Veneroida: Sphaeriidae), water boatmen (Corixidae), predaceous diving water beetles (Dytiscidae), and other aquatic beetles (Coleoptera).

Vernal pool. Photo by Yu Man Lee

Vernal pools occur throughout Middleville State Game Area and provide critical habitat for herptile and invertebrate species. Photos by Yu Man Lee.

Rare Animal Survey Results

Birds

We completed red-shouldered hawk surveys at 73 points within the game area (Figure 6). We observed two adult red-shouldered hawks near point count station 29 in mature forest east of Robertson Road and north of Garbow Road on April 16th, 2014. This observation occurred within Garbow Woods dry-mesic southern forest (EO ID 19802). Both adults were seen and responded to broadcast calls. A stick nest was also found near the point count station, but it was being used by great horned owl (*Bubo virginianus*; one juvenile was seen). The same area was surveyed on the following day, but no red-shouldered hawks were observed. Because we did not find an active nest, we did not consider the red-shouldered hawk observations as an element occurrence. Although potential habitat appeared to be present at many of the points, we did not observe red-shouldered hawks at any other locations. Red-tailed hawk (*Buteo jamaicensis*) was detected at two of the 73 points surveyed, with one active nest seen. We also saw a Cooper's hawk (*Accipiter cooperii*) at one point and heard barred owls (*Strix varia*) near three point-count stations. Both red-shouldered hawk and Cooper's hawk are considered SGCN in Michigan's Wildlife Action Plan (Eagle et al. 2005; Amy Derosier, personal communication, March 2015).

Forest songbird surveys were conducted at 57 points within forest stands (Figure 6). We recorded observations at new locations for both cerulean warbler and hooded warbler. Both species were previously known from the game area and data collected during these surveys were incorporated into existing element occurrences (Table 3). Hooded warbler was the most common of the two rare species observed, with 19 singing males being detected at 19 locations (Figure 9). New hooded warbler observations occurred at four general locations: 1) west of Soloman Road and south of 108th Street (within and near County Line Woods dry-mesic southern forest [EO ID 19807]); 2) east of Robertson Road and between Parmalee and Garbow roads (within Garbow Woods dry-mesic southern forest [EO ID 19802]); 3) east and west of Robertson Road and between Garbow and Crane roads (within and near North Country Forest dry-mesic southern forest [EO ID 19733]); and 4) west and slightly east of Engle Road and north of Grange Road, which is within and east of Soloman Woods dry-mesic southern forest occurrence (EO ID 19803). We documented three singing male cerulean warblers at three points. One of the new cerulean warbler locations was just north of Loftus Road between Soloman and Wood School Roads and immediately east of the Hills of Parmalee mesic southern forest (EO ID 19734). Two of the cerulean warblers were observed west of Engle Road between Grange and Loftus Roads, which is just southeast of the same mesic southern forest record (Figure 9). In 2003, cerulean warblers were documented within County Line Woods dry-mesic southern forest (EO ID 19807) (Figure 9).

We recorded a total of 49 bird species during point counts within Middleville SGA (Appendix 6), with several of these species having special conservation status (Tables 5 and 6). Two species, pileated woodpecker (*Dryocopus pileatus*) and wood thrush (*Hylocichla mustelina*), are considered featured species for habitat management by the Wildlife Division of the MDNR. The following ten bird species recorded in the game area are considered SGCN (Eagle et al. 2005; Amy Derosier, personal communication, March 2015): yellow-billed cuckoo (*Coccyzus americanus*), northern flicker (*Colaptes auratus*), Acadian flycatcher (*Empidonax virescens*), purple martin (*Progne subis*), wood thrush, blue-winged warbler (*Vermivora cyanoptera*), cerulean warbler, hooded warbler, eastern towhee (*Pipilo erythrophthalmus*), and field sparrow (*Spizella pusilla*). In addition, we observed four species (veery [*Catharus fuscescens*], wood thrush, blue-winged warbler, and cerulean warbler) that are identified as focal species for conservation efforts in the Landbird Habitat Conservation Strategy (Potter et al. 2007) of the Upper Mississippi River and Great Lakes Region Joint Venture. Cerulean warbler is a focal species of the DNR's Wildlife Action Plan (Amy Derosier, personal communication, March 2015).

Table 3. Previosuly known rare bird element occurrences at Middleville State Game Area. State status abbreviations are as follows: E, state endangered; T, state threatened; and SC, state special concern. Element occurrence (EO) rank abbreviations are as follows: B, good viability; C, fair viability; CD, fair to poor viability; and D, poor viability. An * indicates the EO was updated with information collected during 2014 surveys.

Common Name	Scientific Name	State Status	EO ID	EO Rank	Year First Observed	Year Last Observed
Henslow's sparrow	*Ammodramus henslowii*	E	16550	D	2007	2007
Grasshopper sparrow	*Ammodramus savannarum*	SC	16551	CD	2007	2007
Cerulean warbler*	*Setophaga cerulea*	T	13383	C	2003	2014
Hooded warbler*	*Setophaga citrina*	SC	13382	B	2003	2014

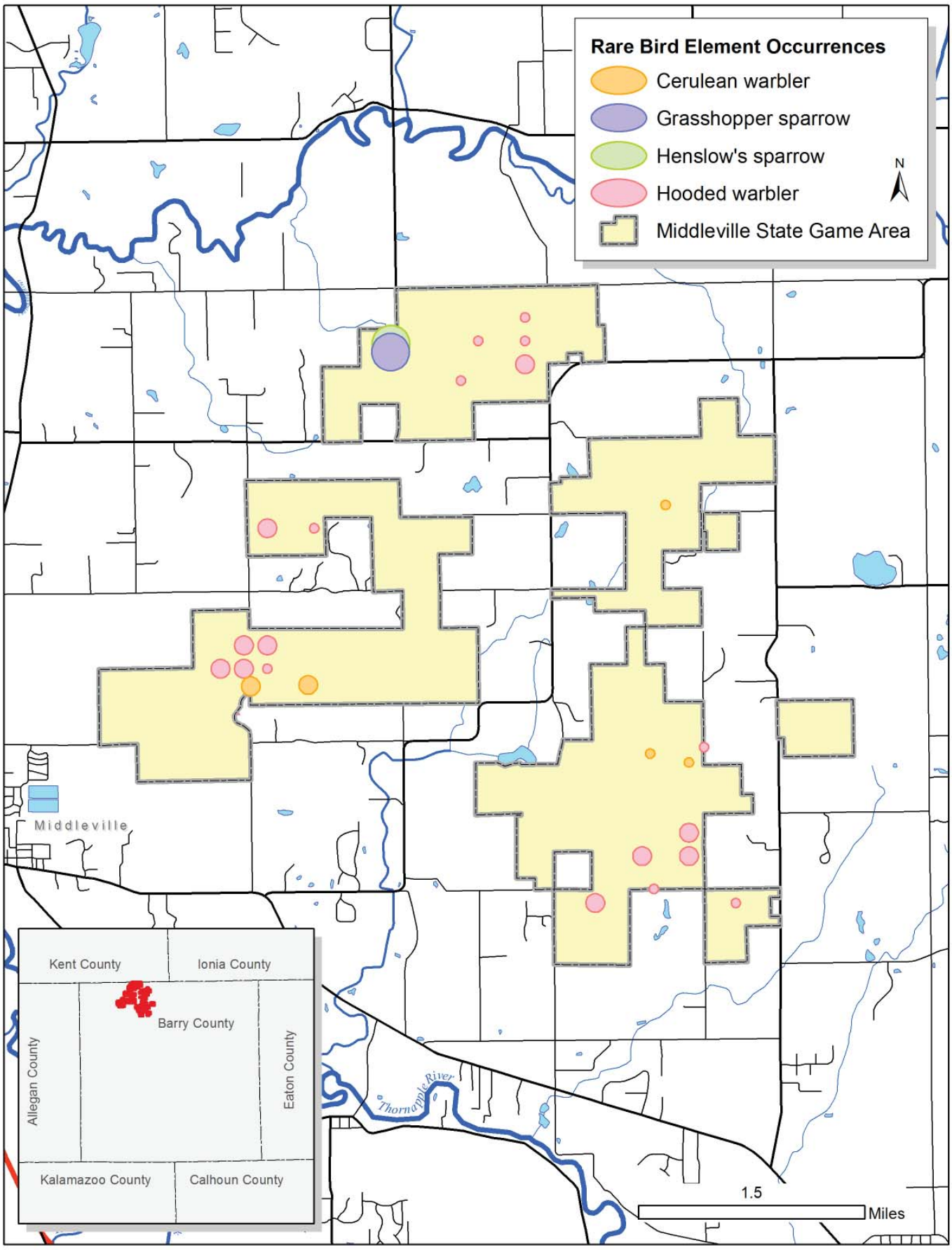


Figure 9. Rare bird element occurrences within Middleville State Game Area.

Reptiles and Amphibians

Amphibian and reptile surveys in Middleville SGA in 2014 documented observations of two rare species, the Blanding's turtle and eastern box turtle. Rare species observations in 2014 resulted in a new element occurrence (EO) of the Blanding's turtle and a new EO of the eastern box turtle in the game area (Table 4). Amphibian and reptile surveys in 2014 also documented observations of four additional current SGCN, the spotted salamander, blue-spotted salamander, eastern tiger salamander, and western chorus frog (*Pseudacris triseriata*) (Table 5).

Visual encounter surveys and basking surveys in 2014 documented Blanding's turtles at one site in Middleville SGA (Figure 10). Three adult Blanding's turtles were observed on May 21st, 2014 in a large inundated shrub swamp (Compartment 1, stand 99) that is adjacent to the northeastern portion of the North Country Forest dry-mesic southern forest (EO ID 19733, Compartment 1, stands 85 and 100) (Figure 10). Element occurrence specifications for the Blanding's turtle developed by NatureServe specify that EOs should be separated by 10 km (6 mi) or more along continuous riverine-riparian corridors, 10 km (6 mi) or more for mosaics of aquatic-wetland and undeveloped upland habitat, and/or barriers (i.e., busy highway, highway with obstructions, untraversable topography, or densely urbanized area lacking aquatic or wetland habitat) (Hammerson and Hall 2004). This site is located only about six km (4 mi) north of the nearest Blanding's turtle EO, but these sites are separated by over three km (2 mi) of active agricultural land and a busy, paved road. As a result, the Blanding's turtle observations at Middleville SGA in 2014 represent a new EO for the species (Table 4, MNFI 2015).

Amphibian and reptile surveys in 2014 did not document eastern box turtles or copperbelly water snakes at Middleville SGA. However, one adult eastern box turtle was found on July 30th, 2014 during a natural community survey of the County Line Woods dry-mesic southern forest (EO ID 19807) at the northern end of the game area (Figure 10). This was a new locality for eastern box turtles in the game area based on known occurrences in the Natural Heritage Database (MNFI 2015). Box turtles were last reported in 2002 from an old field east of Soloman Woods dry-mesic southern forest (EO ID 19803) at the southeast end of the game area (Figure 10). Element occurrence specifications for the eastern box turtle developed by NatureServe specify that sites separated by five km (3 mi) or more of suitable habitat, one km (0.6 mi) or more of unsuitable habitat, and/or barriers (i.e., busy highway; highway with obstructions; untraversable topography; a major river, lake, pond, or deep marsh; and urbanized area dominated by buildings and pavement) should constitute separate EOs, and sites that don't meet these specifications should be part of the same EO (Hammerson 2004). The two box turtle sites in Middleville SGA are separated by over five km (3 mi). As a result, the 2014 observation was designated a new eastern box turtle EO (Table 4, MNFI 2015).

Auditory or breeding frog call surveys within and around the Middleville SGA in 2014 did not document Blanchard's cricket frogs. However, it was raining and windy during the survey, which might have impacted frog calling and detection of the species (although other frog species were heard calling). Additional surveys for this species should be conducted in the game area in the future.

Dipnetting and aquatic funnel trapping surveys in 2014 were able to document larvae of the three target salamander SGCN. Blue-spotted salamander larvae were documented in four of the vernal pools that were surveyed, of which one was located in the Soloman Woods dry-mesic southern forest (EO ID 19803) and three were located in and to the north of Garbow Woods dry-mesic southern forest (EO ID 19802) east of Robertson Road in T4S R09W Section 7 (Figures 7, 8, and 10). Two adult blue-spotted salamanders also were found along the edge of one of the pools surveyed in Section 7 north of Garbow Woods (Figures 7, 8, and 10). Spotted salamander larvae were found in two of the same pools as the blue-spotted salamanders, of which one was located in Soloman Woods dry-mesic southern forest, and the other pool was in Garbow Woods dry-mesic southern forest (Figures 7, 8, and 10). Eastern tiger salamander larvae were found in only one of the vernal pools surveyed, which was located north of Garbow Woods dry-mesic southern forest east of Robertson Road in Section 7 (Figures 7, 8, and 10).

Amphibian and reptile surveys in 2014 also documented observations of other herptile species in the Middleville SGA. These included observations of one additional amphibian SGCN, the western chorus frog (Appendix 3). Western chorus frog tadpoles were documented in one of the vernal pools surveyed east of Soloman Road in T04S R09W Section 21 west of Soloman Woods dry-mesic southern forest (EO ID 19803). Eleven additional amphibian and reptile species were documented during herptile surveys (Appendix 3). These include the eastern American toad (*Anaxyrus americanus americanus*), gray treefrog (*Hyla versicolor/Hyla chrysoscelis*), American bullfrog (*Lithobates catesbeianus*), green frog (*Lithobates clamitans*), wood frog (*Lithobates sylvaticus*), spring peeper (*Pseudacris crucifer*), northern water snake (*Nerodia sipedon sipedon*), northern ribbon snake (*Thamnophis sauritus septentrionalis*), eastern garter snake (*Thamnophis sirtalis sirtalis*), painted turtle (*Chrysemys picta*), and snapping turtle (*Chelydra serpentina*).

Table 4. Newly documented and previously known rare reptile element occurrences at Middleville State Game Area. The state status abbreviation of SC signifies state special concern. EO rank abbreviations are as follows: AC, excellent, good or fair viability; and BC, good or fair estimated viability. * indicates the EO was newly documented in 2014.

Common Name	Scientific Name	State Status	EO ID	EO Rank	Year First Observed	Year Last Observed
Blanding's turtle*	*Emydoidea blandingii*	SC	20100	BC	2014	2014
Eastern box turtle	*Terrapene carolina carolina*	SC	8496	AC	2002	2002
Eastern box turtle*	*Terrapene carolina carolina*	SC	20106	AC	2014	2014

Eastern box turtle (*Terrapene carolina carolina*) was documented within the County Line Woods dry-mesic southern forest. Photo by Jesse M. Lincoln.

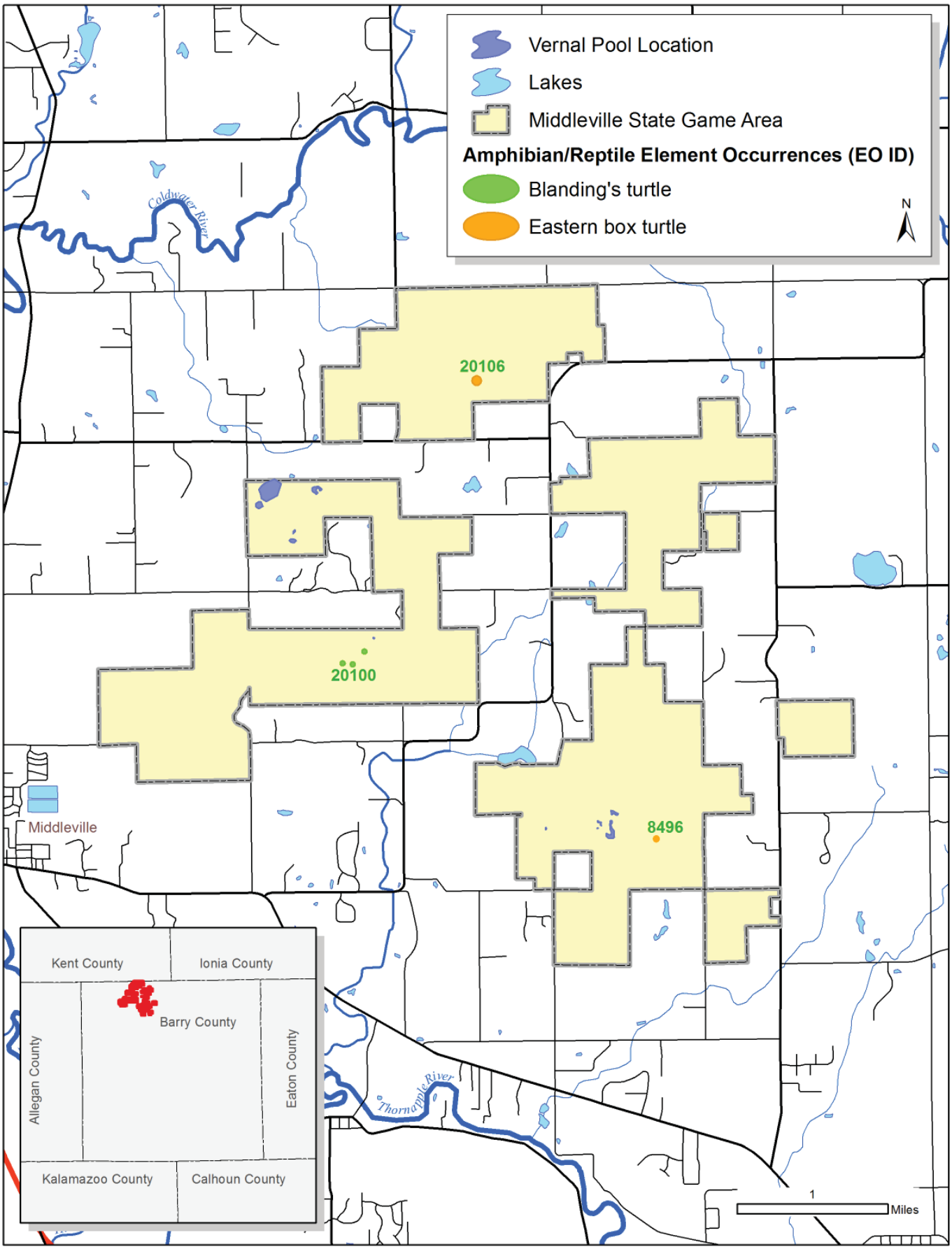


Figure 10. Rare amphibian and reptile element occurrences and verified vernal pools within and nearby Middleville State Game Area.

Vernal pools are providing critical breeding habitat within Middleville State Game Area for numerous SGCN salamanders including blue-spotted salamander (*Ambystoma laterale*) (adult above and larvae below left) and eastern tiger salamader (*Ambystoma tigrinum*) (larvae below right). Photos by Yu Man Lee.

Table 5. Rare species, Species of Greatest Conservation Need (SGCN), DNR focal species, and DNR featured species documented at Middleville State Game Area. State status abbreviations are as follows: T, state threatened; and SC, state special concern.

Common Name	Scientific Name	State Status	SGCN	DNR Focal Species	DNR Featured Species	Year Last Observed
BIRDS						
Yellow-billed cuckoo	*Coccyzus americanus*		X			2014
Northern flicker	*Colaptes auratus*		X			2014
Pileated woodpecker	*Dryocopus pileatus*				X	2014
Acadian flycatcher	*Empidonax virescens*		X			2014
Wood thrush	*Hylocichla mustelina*		X		X	2014
Eastern towhee	*Pipilo erythropthalmus*		X			2014
Purple martin	*Progne subis*		X			2014
Cerulean warbler	*Setophaga cerulea*	T	X	X		2014
Hooded warbler	*Setophaga citrina*	SC	X			2014
Field sparrow	*Spizella pusilla*		X			2014
Blue-winged warbler	*Vermivora cyanoptera*		X			2014
HERPTILES						
Blue-spotted salamander	*Ambystoma laterale*		X			2014
Spotted salamander	*Ambystoma maculatum*		X			2014
Eastern tiger salamander	*Ambystoma tigrinum*		X			2014
Blanding's turtle	*Emydoidea blandingii*	SC	X			2014
Eastern box turtle	*Terrapene carolina carolina*	SC	X	X		2014
Western chorus frog	*Pseudacris triseriata*		X			2014

Eastern tiger salamanders (*Ambystoma tigrinum*) were documented in a vernal pool in Middleville State Game Area. Photo by Yu Man Lee.

DISCUSSION

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

Invasive Species Control
Invasive species pose a major threat to species diversity and habitat heterogeneity within Middleville SGA. By out-competing 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 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 solar insolation (Bratton 1982). The lack of oak regeneration in the understory of the majority of the forested stands in Middleville SGA is likely due to the interaction of competition from invasive shrubs, fire suppression, and deer herbivory. Lastly, non-native invasive species often have no natural predators and spread aggressively through rapid sexual and asexual reproduction.

Although numerous invasive species occur within the game area, the species likely to pose the greatest threats because of their ability to invade and quickly dominate intact natural areas in southern Lower Michigan include garlic mustard (*Alliaria petiolata*), Japanese barberry (*Berberis thunbergii*), autumn olive (*Elaeagnus umbellata*), Morrow honeysuckle (*Lonicera morrowii*), multiflora rose (*Rosa multiflora*), hedge-parsley (*Torilis japonica*), and tree-of-heaven (*Ailanthus altissima*). Additionally, new invasive species that were not seen in Middleville SGA, such as Japanese knotweed (*Polygonum cuspidatum*) and Oriental bittersweet (*Celastrus orbiculata*), have great potential to erode biodiversity should they become established. Newly establishing invasive species should be removed as rapidly as possible, before they infest additional areas. Invasive species abstracts, which include detailed management guidelines, can be obtained at the following website: http://www.imapinvasives.org/GIST/ESA/index

Invasive species management at Middleville SGA should focus on controlling populations of pernicious invasive species within high-quality forests and also in the surrounding landscape. Prescribed fire can be employed as the primary mechanism for reducing invasive species in dry-mesic southern forests and targeted prescribed fire and spot treatment through cutting and/or herbicide application can be employed locally within priority high-quality natural community EOs. We encourage this multi-faceted approach and emphasize that improving the landscape context surrounding the high-quality natural areas is critical and that reducing background levels of invasive species will reduce the seed source for these invaders. Logging within nearby Fort Custer has been found to locally increase invasive species populations with areas of recent logging being associated with local dominance of garlic mustard (Michele Richards, personal communication, July 2010). Restricting future logging operations to winter months when the soils are frozen may limit the establishment and expansion of invasives, such as garlic mustard, that benefit from soil disturbance and can also reduce detrimental impacts to plant and animal species. We strongly encourage the implementation of monitoring within the high-quality natural communities and throughout actively managed areas to gauge the success of restoration activities at reducing invasive species populations. In addition, periodic early-detection surveys should be implemented to allow for the identification of invasive species that have yet to establish a stronghold within Middleville SGA.

Tree-of-heaven occurs locally within the game area. Concentrations of invasive trees and shrubs (i.e., multiflora rose, autumn olive, honeysuckles, Japanese barberry, and tree-of-heaven) within and adjacent to natural community element occurrences should be cut and herbicided. Photo by Jesse M. Lincoln.

Table 6. List of bird species having special status that were detected at Middleville State Game Area during 2014 surveys and general habitat requirements for these species.

Species	General Habitat Requirements	State Status[1]	Featured Species[2]	WAP SGCN[3]	JV Focal Species[4]
Yellow-billed cuckoo	Gaps, clearings, or wetlands within deciduous forest containing dense growth of shrubs/young trees.			X	
Northern flicker	Open woodlands, forest edges, savannas, orchards, and pastures or old fields with scattered trees.			X	
Pileated woodpecker	Mature mesic deciduous forest with dead or dying trees. Lowland and mixed hardwood-conifer forests also used.		X		
Acadian flycatcher	Wet forests, such as floodplains, but also occurs in mesic forests.			X	
Purple martin	Open and semi-open areas, usually near water. Nesting occurs almost exclusively in artificial nesting structures.			X	
Veery	Large tracts of moist forest, dense understory of deciduous trees/shrubs				X
Wood thrush	Large tracts of wet and mesic deciduous forest, sometimes dry forests		X	X	X
Blue-winged warbler	Open shrubby areas, forest openings, stream edges, and old fields with shrubs/small trees			X	X
Cerulean warbler[5]	Mature mesic to wet deciduous forest. Bottomland hardwood and floodplain forests preferred over uplands.	T		X	X
Hooded warbler	Mature mesic or wet deciduous forest with dense understories of shrubs/small trees.	SC		X	
Eastern towhee	Variety of shrubby areas, including second-growth forest, openings or edges of mature forests, and old fields succeeding to forest.			X	
Field sparrow	Variety of openings with grassy vegetation and scattered trees and shrubs, such as old fields.			X	

[1]Michigan listing status (T = state threatened, SC = state special concern).
[2]Identified as featured species for habitat management by MDNR Wildlife Division.
[3]Species of greatest conservation need in the Michigan Wildlife Action Plan (Eagle et al. 2005).
[4]Focal species in the Upper Mississippi River and Great Lakes Region Joint Venture Landbird Habitat Conservation Strategy (Potter et al. 2007).
[5]Identified as focal species for habitat management by MDNR Wildlife Division.

Forest Biodiversity and Fragmentation

The Middleville SGA supports over 3,900 acres of forest and over 750 acres of high-quality forest, primarily dry-mesic southern forest. Because the landscape surrounding Middleville SGA is dominated by agriculture and rural development (Figure 1), the large area of forest within the game area serves as an important island of biodiversity for the local region. Maintaining the forest canopy of mature forest systems will help ensure that high-quality habitat remains for the diverse array of plants and animals, including the many rare species and SGCN that utilize this forested island. The conservation significance of these forests is heightened by the documentation of numerous vernal pools within these forests and the recording during point-count surveys of forty-nine species of birds of which ten are SGCN and two are DNR featured species (Table 6 and Appendix 6).

Although Middleville SGA is relatively unfragmented compared to the surrounding landscape, its past history of agricultural development and abandonment and logging activity has resulted in a significant amount of native habitat fragmentation within the game area. As native forests become increasingly fragmented ecosystems, their dynamics shift from being primarily internally driven to being externally and anthropogenically driven. The effects of forest fragmentation on native plants and animals and ecosystem processes are drastic (Heilman et al. 2002). Fire regimes in fragmented landscapes are reduced because roads, agriculture, and development enhance modern forest fire suppression (Leahy and Pregitzer 2003). Forestry and wildlife management practices that focus on species- and stand-based management have directly and indirectly promoted landscape fragmentation and exacerbated edge effects through prescriptions that generate and maintain small discrete patches of habitats or stand types (Bresse et al. 2004). The small and insularized nature of forest fragments may make them too small to support the full array of species formerly found in the landscape (Rooney and Dress 1997). Local population extinctions within fragments are accelerated by reduced habitat and population size. Within fragmented forests, avian diversity is reduced by nest predation and nest parasitism and herptile diversity is reduced by the prevalence of mesopredators (e.g., raccoons, skunks, and opossums). Numerous neotropical migrant songbirds are dependent on interior forest habitat and are highly susceptible to nest parasitism and predation (Robinson et al. 1995, Heske et al. 2001, Heilman et al. 2002). Native plant diversity within forested fragments is threatened by low seedling survivorship, infrequent seed dispersal, high levels of herbivory, and growing prevalence of invasive species and native weeds, which thrive along the increasing edges and disperse throughout fragmented landscapes along roads and trails (Brosofske et al. 2001, Heilman et al. 2002, Hewitt and Kellman 2004).

In general, dampening the effects of forest fragmentation can be realized by decreasing forest harvest levels, halting the creation of new wildlife openings within forested landscapes, closing redundant forest roads, and limiting the creation of new roads. In addition, conversion of wildlife openings and old agricultural fields to forest and other native habitats such as oak savanna also can contributes to the increase of forest connectivity and decrease in forest fragmentation. We recommend that efforts to reduce fragmentation and promote connectivity be concentrated in the vicinity of existing wetlands and high-quality natural communities.

Fire as an Ecological Process

Much of the land within Middleville SGA historically supported fire-dependent ecosystems, namely dry-mesic southern forest and to a lesser extent oak openings. In the past, lightning- and human-set fires frequently spread over large areas of southern Michigan and other Midwestern states, helping to reduce colonization by trees and shrubs, fostering regeneration of fire-dependent species, and maintaining the open physiognomy or structure of many ecosystems (Curtis 1959, Dorney 1981, Grimm 1984). In the absence of frequent fires, open oak savanna and oak barrens have converted to closed-canopy forests dominated by shade-tolerant native and invasive species (Cohen 2001, Lee and Kost 2008). The conversion of oak savanna ecosystems to closed-canopy forest typically results in significant reductions in species and habitat diversity (Curtis 1959, McCune and Cottam 1985, McClain et al. 1993, Wilhelm 1991). Efforts to restore oak savanna within Middleville SGA will depend on the implementation of frequent prescribed fire.

Closed-canopy dry-mesic southern forests within Middleville SGA are also negatively impacted by fire suppression and are experiencing strong regeneration of thin-barked, shade-tolerant or mesophytic trees, such as red maple, and invasive shrubs such as honeysuckle, multiflora rose, and autumn olive. These native and invasive mesophytic species compete with oaks and hickories and contribute to the regeneration failure of oaks and hickories. Within oak-dominated forested ecosystems, a sustained, landscape-scale, fire-management program would reduce the density of shade-tolerant seedlings, saplings, and invasive shrubs and help facilitate increased recruitment of fire-adapted native shrubs, oaks, and hickories.

Plant communities benefit from prescribed fire in several ways. Depending on the season and intensity of a burn, prescribed fire may be used to decrease the cover of

invasive woody species, and increase the cover of native grasses and forbs (White 1983, Abrams and Hulbert 1987, Tester 1989, Collins and Gibson 1990, Glenn-Lewin et al. 1990, Anderson and Schwegman 1991). Prescribed fire helps reduce litter levels, allowing sunlight to reach the soil surface and stimulate seed germination and enhance seedling establishment (Daubenmire 1968, Hulbert 1969, Knapp 1984, Tester 1989, Anderson and Schwegman 1991, Warners 1997). Important plant nutrients (e.g., N, P, K, Ca, and Mg) are elevated following prescribed fire (Daubenmire 1968, Viro 1974, Reich et al. 1990, Schmalzer and Hinkle 1992). Burning has been shown to result in increased plant biomass, flowering, and seed production (Abrams et al. 1986, Laubhan 1995, Warners 1997, Kost and De Steven 2000). Prescribed fire can also help express and rejuvenate seed banks, which may be especially important for maintaining species diversity (Leach and Givnish 1996, Kost and De Steven 2000).

Although prescribed fire typically improves the overall quality of habitat for many animal species, its impact on rare animals should be considered when planning a burn. Larger, more mobile, and subterranean animals can temporarily move out of an area being burned. Smaller and less mobile species can die in fires; this includes some rare insects (Panzer 1998) and reptiles. Where rare invertebrates and herptiles are a management concern, burning strategies should allow for ample refugia to facilitate effective post-burn recolonization (Siemann et al. 1997). Insects and herptiles, characterized by fluctuating population densities, poor dispersal ability, and patchy distribution, rely heavily on unburned sanctuaries from which they can reinvade burned areas (Panzer 1988). Dividing large contiguous areas into two or more separate burn units or non-fire refugia that can be burned in alternate years or seasons can protect populations of many species. This allows unburned units to serve as refugia for immobile invertebrates and slow-moving herptile species, such as eastern box turtle. When burning relatively large areas, it may be desirable to strive for patchy burns by burning either when fuels are somewhat patchy or when weather conditions will not support hot, unbroken fire lines (such as can occur under atypically warm, dry weather and steady winds). These unburned patches may then serve as refugia, which can facilitate recolonization of burned patches by fire-sensitive species. In addition, burning under overcast skies and when air temperatures are cool (<13 °C or 55 °F) can help protect reptiles, because they are less likely to be found basking above the surface when conditions are cloudy and cool. Conducting burns during the dormant season (late October through March) may also help minimize impacts to reptiles.

We recommend the implementation of prescribed fire at a landscape-scale and the creation of large burn units (e.g., several hundred to one thousand acres in size). If resources for burning are limited, we recommend that prescribed fire be prioritized for high-quality and/or underrepresented, fire-dependent natural communities (e.g., high-quality dry-mesic southern forest and oak savanna restoration) and habitat immediately adjacent to these systems. Fire-suppressed sites should be burned using an initially aggressive fire-return interval.

We also recommend that the seasonality of burns be varied across the game area. Prescribed fire is often seasonally restricted to spring. Fires have the greatest impact on those plants that are actively growing at the time of the burn. Repeated fires at the same time of year impact the same species year after year, and over time, can lower floristic diversity (Howe 1994, Copeland et al. 2002). For example, forbs that flower in early spring often overwinter as a green rosette or may have buds very close to the soil surface and in the litter layer. Repeated burns in early spring can be detrimental to these species. Historically, fires burned in a variety of seasons, including spring, during the growing season, and fall (Howe 1994, Copeland et al. 2002, Petersen and Drewa 2006). The natural communities historically found at Middleville SGA, including dry-mesic southern forest and oak openings, likely burned primarily in late summer and early fall. Varying the seasonality of prescribed burns to match the full range of historical variability better mimics the natural disturbance regime and leads to higher biodiversity (Howe 1994, Copeland et al. 2002). In other words, pyrodiversity (that is, a diversity of burn seasons and fire intensity) leads to biodiversity.

Repeated early spring burns are of particular concern in dry-mesic southern forest and degraded oak savanna where a goal for prescribed burning is control of woody species. Prior to bud break and leaf flushing, the vast majority of energy in a woody plant is stored in roots as carbohydrate reserves (Richburg 2005). As plants expand energy to make leaves, flowers and fruits, these carbohydrate reserves diminish, reaching a seasonal low during flowering and fruiting. As fall approaches, energy root reserves are replenished. Thus, when woody species are top-killed by early spring fires, they are able to resprout vigorously using large energy stores, a phenomenon seen frequently with sassafras, black locust, and sumac (Cohen et al. 2009). However, if burns are conducted later in the spring after leafout, or during the growing season, energy reserves are already partially depleted, and resprouting vigor is lower, particularly for clonal species like sassafras, sumac, and black locust (Axelrod and Irving 1978, Reich et al. 1990, Sparks et al. 1998).

Resource managers restrict prescribed fire to the early spring for numerous reasons including ease of controlling burns, greater windows of opportunity for conducting burns because suitable burning conditions are often most

prevalent this time of year, and to reduce the probability of detrimentally impacting fire-sensitive animal species, such as herptiles (e.g., eastern box turtle). Although these are all legitimate reasons, we feel that the long-term benefits of diversifying burn seasonality across the game area outweigh the costs and that ultimately, successful restoration of fire-dependent ecosystems at Middleville SGA will depend on expansion of the burn season beyond early spring. Several techniques for reducing the risk to fire-sensitive species can be employed during burns in the summer and fall. For example, burn specialists can establish rotating refugia within large burn units and avoid burning within and around rotted logs, vernal pools, and seepage areas.

Oak Savanna Restoration

Although no high-quality oak openings or oak barrens were documented during the course of the surveys, oak savanna occurred on approximately 3% of Middleville SGA. MNFI ecologists noted that the eastern portion of Garbow Woods dry-mesic southern forest (EO ID 19802) contains an inclusion of fire-suppressed oak barrens that has transitioned to dry southern forest but retains numerous barrens indicator plant species. Several stands within the game area support savanna flora in the ground cover and may have supported savanna systems in the past. These stands include Compartment 1, Stands 261, 272, 278, and 293. In addition, several rare animal species associated with oak savanna and prairie ecosystems have been documented in Middleville SGA including eastern box turtle, Henlsow's sparrow, and grasshopper sparrow. Henslow's sparrow and grasshopper sparrow, last documented in the game area in 2007, depend on large grassland complexes, and likely historically occurred in patches of large prairie within oak savanna complexes. Eastern box turtle likely historically used oak savanna and prairie habitat for nesting, foraging, dispersal, mating, gestation, parturition, and/or overwintering. Pursuing targeted restoration of oak savanna remnants within Middleville SGA is recommended because these rare ecosystems support a high-level of biodiversity and numerous rare species. Restoration of oak savanna ecosystems is also beneficial to numerous game species [e.g., wild turkey (*Meleagris gallopavo*) and white-tailed deer (*Odocoileus virginianus*)]. As noted above, savanna ecosystems in Middleville SGA were historically concentrated in the northern portion of the game area (Figures 4) but patches of remnant savanna species persists locally throughout the game area. Oak savanna restoration efforts that combine repeated prescribed fire application in conjunction with mechanical thinning are most likely to succeed where populations of relict savanna plants persist [i.e., the eastern portion of Garbow Woods dry-mesic southern forest (EO ID 19802) and in Compartment 1, Stands 261, 272, 278, and 293] (Lettow et al. 2014).

The first management step for oak savanna restoration is the restoration of the savanna physiognomy through prescribed fire and/or selective cutting or girdling. Where canopy closure has degraded the savanna character, resource managers can selectively cut or girdle the majority of trees (White 1986), leaving between 10 and 60% canopy closure. When possible, using prescribed fire to reduce understory coverage before thinning operations is recommend, and several prescribed fires may be necessary to control invasives and mesophytic species in the understory. However, many degraded savannas that have been long deprived of fire often contain a heavy overstory and understory component of shade-tolerant species that cannot initially be controlled by prescribed fire alone but need to be removed by mechanical thinning (Abella et al. 2001, Peterson and Reich 2001). Many of the shade-tolerant shrubs in the understory of oak savanna remnants are invasive species that require intensive management to eliminate. Where enough fine fuels remain, repeated understory burns can be employed to control the undesirable underbrush (Apfelbaum and Haney 1991). Some species such as autumn olive, honeysuckles, and red maple can be controlled with repeated burns. However, mechanical thinning or girdling in conjunction with application of specific herbicides may be necessary to eliminate tenacious invasive shrubs. To maximize the effectiveness of woody species removal, herbicide should be immediately applied directly to the cut stump or girdled bole, and efforts should be concentrated during appropriate stages in plant growth cycles (i.e., when root metabolite levels are lowest late in the growing season or during the winter) (Reinartz 1997, Solecki 1997). The process of restoring the open canopy conditions and eliminating the understory should be conducted gradually, undertaken over the course of several years taking care to minimize colonization by invasive plants, which can respond rapidly to increased levels of light and soil disturbance. As noted by Botts et al. (1994), too rapid a reduction in canopy can lead to severe encroachment of weedy species. Managers should also be mindful that cutting remnant barrens and failing to apply prescribe fire soon after mechanical treatment can actually expedite the loss of barrens through forest succession. The incremental opening of the canopy, especially when preceded by multiple prescribed fires and followed by repeated prescribed fires, can result in the germination of savanna species dormant in seedbanks during fire suppression, reduce competition for savanna species, and also create suitable seed beds for oak regeneration.

Fire is the single most significant factor in preserving oak savanna ecosystems. Once savanna conditions have been re-established, the reintroduction of annual fire is essential for the maintenance of open canopy conditions.

In some instances prairie grasses may need to be seeded or planted to provide an adequate fuel matrix to support frequent burns (Botts et al. 1994, Packard 1997a, 1997b). Seed and plant donors should come from local sources and similar vegetative communities (Apfelbaum et al. 1997). In addition to maintaining open canopy conditions, prescribed fire promotes internal vegetative patchiness and high levels of grass and forb diversity, deters the encroachment of woody vegetation and invasive species, and limits the success of dominants (Bowles and McBride 1998, Leach and Givnish 1999, Abella et al. 2001). Numerous studies have indicated that fire intervals of one to three years bolster graminoid dominance, increase overall grass and forb diversity, and remove woody cover of saplings and shrubs (White 1983, Tester 1989, Abella et al. 2001). Once the oak savanna structure has been securely established, burning at longer time intervals can be employed to allow for seedling establishment and the persistence of desirable woody plants. Apfelbaum and Haney (1991) recommend gaps of five to ten years to allow for canopy cohort recruitment. Varying the burn interval from year to year and by season can increase the diversity of savanna remnants. Resource managers in southwestern Michigan face a complex management dilemma. Following decades of fire suppression, oak savanna communities have converted to closed-canopy oak systems. Many of these dry southern and dry-mesic southern forests provide critical habitat for forest-dwelling species, such as neotropical migrant birds. Within Middleville SGA, forested ecosystems provide nesting habitat for hooded warbler and cerulean warbler. Conversion of these closed-canopy oak forests to oak savannas would likely favor species that are generalists and edge-dwellers. Robinson (1994) expressed concern that fire management and savanna restoration may exacerbate the formidable problems of forest fragmentation in the Midwest (e.g., cowbird parasitism and nest predation by mesopredators such as raccoons). In addition, the high proportion of edge-like habitat of savannas leaves them susceptible to invasion by aggressive invasive and native plants (Solecki 1997). Conversion of oak forest to oak savanna requires a long-term commitment to invasive species control and fire restoration (Peterson and Reich 2001). Resource managers must weigh the costs and benefits of each option and regionally prioritize where to manage for oak savanna systems. Savanna remnants selected for restoration should be large in size, with good landscape context, and have a high probability of success. Due to the high levels of biodiversity within these landscapes and the rarity of many of the fire-dependent communities and species, sustained conservation efforts within oak savanna landscapes are likely to pay rich dividends (Leach and Givnish 1999).

Fire suppression within fire-dependent dry-mesic southern forests across Middleville State Game Area is resulting in strong regeneration of thin-barked, shade-tolerant or mesophytic trees and shrubs and contributing to the regeneration failure of oaks. Photo by Jesse M. Lincoln.

Setting Stewardship Priorities

This report provides site-based assessments of seven natural community EOs that occur in Middleville SGA. Detailed site descriptions, threats, management needs, and restoration opportunities specific to each individual site have been discussed. The baseline information presented in the current report provides resource managers with an ecological foundation for prescribing site-level biodiversity stewardship, monitoring these management activities, and implementing landscape-level biodiversity planning to prioritize management efforts. Threats such as invasive species and fire suppression are common across Middleville SGA. Because the list of stewardship needs for the game area (Table 7) may outweigh available resources, prioritizing activities is a pragmatic necessity. We provide the following framework for prioritizing stewardship efforts across all high-quality natural community EOs within Middleville SGA in order to facilitate difficult decisions regarding the distribution of finite stewardship resources. In general, prioritization of stewardship within these natural community EOs should focus on the highest quality and largest forests. Biodiversity is most easily and effectively protected by preventing high-quality sites from degrading, and invasive plants are much easier to eradicate when they are not yet well established, and their local population size is small. Within Middleville SGA, we recommend that stewardship efforts be focused in forested communities that harbor high levels of biodiversity and provide habitat for numerous rare plant and animal species. We also recommend the prioritization of stewardship in forests that include vernal pools and other wetland inclusions, so that management efforts impact the upland and wetland interface. Sites that meet these criteria include North Country Forest* (dry-mesic southern forest, EO ID 19733), Hills of Parmalee* (mesic southern forest, EO ID 19734), County Line Woods (dry-mesic southern forest, EO ID 19807), and Soloman Woods (dry-mesic southern forest, EO 19803) (Table 8). The highest priority sites within this subset of natural community EOs are highlighted by an asterisk.

Monitoring

We recommend that monitoring be implemented at Middleville SGA, concentrated within the high-quality natural communities but also throughout actively managed areas. Monitoring can help inform adaptive management by gauging the success of restoration at meeting the goals of reducing invasive species populations, limiting woody encroachment in understories of fire-prone forests, and fostering regeneration of oak saplings in fire-dependent ecosystems. Assessing the impacts of prescribed fire on herptile populations should also be a component of the burning program, especially following potential burns in the summer and fall, and can help direct adaptive management. In addition, monitoring deer densities and deer herbivory will allow for the assessment of whether deer browsing threatens floristic structure and composition and whether active measures to reduce local deer populations are needed.

Closed-canopy forest in Middleville State Game Area provides critical habitat for interior-forest obligates and species dependent on the numerous vernal pools nested within the forest. Photo by Jesse M. Lincoln.

Table 7. Summary of management recommendations for natural community element occurrences for the Middleville State Game Area.

Site Name	Community Type	Management Recommendations
County Line Woods	Dry-mesic Southern Forest	• Maintain closed canopy • Apply prescribed fire to reduce invasive species and native mesophytic species • Cut and herbicide invasive shrubs • Hand pull garlic mustard • Girdle or cut subcanopy and understory red maple, sassafras, and black cherry • Monitor following fire and for invasives, oak regeneration, and deer herbivory
Garbow Woods	Dry-mesic Southern Forest	• Maintain closed canopy • Apply prescribed fire to reduce invasive species and native mesophytic species • Cut and herbicide invasive shrubs focusing on reducing levels of multiflora rose • Hand pull garlic mustard • Girdle or cut subcanopy and understory mesophytic species, especially red maple and black cherry • Monitor following fire and for invasives, oak regeneration, and deer herbivory • Consider oak barrens restoration in eastern portion using repeated prescribed fire and mechanical thinning
North Country Woods	Dry-mesic Southern Forest	• Maintain closed canopy • Apply prescribed fire to reduce invasive species and native mesophytic species • Cut and herbicide invasive shrubs • Hand pull garlic mustard • Girdle or cut subcanopy and understory mesophytic species, especially red maple and black cherry • Monitor following fire and for invasives, oak regeneration, and deer herbivory
Soloman Woods	Dry-mesic Southern Forest	• Maintain closed canopy • Apply prescribed fire to reduce invasive species and native mesophytic species • Cut and herbicide invasive shrubs • Hand pull garlic mustard • Girdle or cut subcanopy and understory red maple, black cherry, and sassafras • Monitor following fire and for invasives, oak regeneration, and deer herbivory • Manage for oak barrens in adjacent stands using repeated prescribed fire and mechanical thinning
Hills of Parmalee	Mesic Southern Forest	• Maintain closed canopy • Cut and herbicide invasive shrubs • Hand pull garlic mustard • Protect population of ginseng • Monitor to evaluate invasives, understory and herbaceous composition, and deer herbivory
Johnson Woods	Mesic Southern Forest	• Maintain closed canopy • Cut and herbicide invasive shrubs • Hand pull garlic mustard • Protect populations of showy orchis and goldenseal • Monitor to evaluate invasives, understory and herbaceous composition, and deer herbivory
Middle Hills	Mesic Southern Forest	• Maintain closed canopy • Cut and herbicide multiflora rose, autumn olive, and tree-of-heaven • Hand pull garlic mustard • Protect population of beak grass • Consider closing road passing through forest to limit associated erosion and dumping • Monitor to evaluate invasives, understory and herbaceous composition, and deer herbivory

Table 8. Stewardship priorities for Middleville State Game Area natural community element occurrences with the highest priorities highlighted with asterisks.

Site Name	Community Type	EO ID	EO Rank	Year First Observed	Year Last Observed	Global Rank	State Rank
County Line Woods	Dry-mesic Southern Forest	19807	C	2013	2013	G4	S3
North Country Woods*	Dry-mesic Southern Forest	19733	BC	2013	2013	G4	S3
Soloman Woods	Dry-mesic Southern Forest	19803	C	2013	2013	G4	S3
Hills of Parmalee*	Mesic Southern Forest	19734	C	1987	2013	G4	S3

Vernal Pools Discussion and Management Recommendations

Despite their small size and temporary nature, vernal pools can be incredibly diverse and productive wetlands. Due to increased awareness of the ecological significance of vernal pools, there has been growing interest in identifying, mapping, monitoring, and protecting these small but valuable wetlands in Michigan. In 2014, 221 potential vernal pools were identified and mapped from aerial photo interpretation (Figure 11), and 12 vernal pools were surveyed and verified in the field in Middleville SGA (Figure 10). Although we were able to survey only a small number of vernal pools in the field in 2014, the survey and mapping of potential and actual vernal pools in the game area provide baseline information on the potential status, distribution, and ecology of vernal pools in the game area. This information will help natural resource planners and managers develop and implement appropriate management of these critical wetlands. However, Lee et al. (2014) documented a 27% commission error rate (false positives) and a 12% omission error rate (false negatives) for mapping potential vernal pools from aerial photograph interpretation in several study areas in southeast Michigan. It is very likely that some of the potential vernal pools mapped in the game area are not vernal pools in the field, and that there are additional vernal pools in the field that were not mapped as potential vernal pools. Thus, additional surveys are warranted to verify and map vernal pools in the field to obtain more accurate information on the status and distribution of vernal pools in the game area.

Ideally, vernal pool surveys in the future should consist of multiple visits to each pool within a year and across several years (i.e., 2-3 years). Vernal pools should be surveyed at least two to three times within a year if possible, consisting of one to two visits in early spring to collect data when the pools are full and survey for vernal pool indicator species, and one visit in late summer or early fall to verify pool drying. Multiple visits to each pool within a year and across several years are recommended because vernal pool hydrology and ecology can very significantly within a year and between years. For example, fairy shrimp (*Eubranchipus* spp.) are mainly found in flooded vernal pools in early spring until mid to late May, or when water temperatures reach 20 °C to 22 °C (68 °F to 72 °F), which can vary in terms of the timing depending on local weather conditions in the spring (Colburn 2004). Fairy shrimp also may not be observed every year in a given pool (Colburn 2004, Calhoun and deMaynadier 2008). Vernal pool hydrology (e.g., hydroperiod or how long a pool holds water) also can vary significantly from year to year depending on annual weather conditions (i.e., shorter hydroperiod during drier years, longer hydroperiod in wetter years). It is important to note that most of the vernal pools that were surveyed in 2014 were visited only once in the spring or summer due to limited time and resources. Additional surveys of these pools within a year, particularly in late summer or early fall, and across multiple years are needed to verify drying and obtain more complete and accurate information on their status, ecology, and faunal composition.

Recommendations for the conservation and management of vernal pools include the following. In order to protect vernal pools accurately identifying and mapping them is critical. It is also important to become familiar with the characteristics of vernal pools and learn to identify them during all times of year because vernal pools are small, highly variable, and can be difficult to detect during certain times of the year. Activities that disturb soils or tree canopies in and near vernal pools should be avoided or minimized, particularly during critical time periods for most amphibians (i.e., March through July) (Thomas et al. 2010). Equipment use and canopy alteration can impact water quality and quantity and shift vegetation, resulting in changes to microhabitat that can pose serious problems for many amphibians (Semlitsch et al. 1988; deMaynadier and Hunter 1995, 1998, 1999; Waldick et al. 1999). The State of Michigan's sustainable soil and water quality practices for forest lands recommend no disturbance to the vernal pool depression, limiting use of heavy equipment within 30 meters (100 ft) or at least one tree length of the pool to avoid creating deep ruts, and maintaining at least 70% canopy closure within the 30-meter (100 ft or 1.4 ac) buffer (Michigan DNR and Michigan DEQ 2009). Maintaining a larger buffer (e.g., 31-122 m or 100-400 ft or up to 13 ac) with at least 50% canopy cover around vernal pools and implementing management practices that protect the forest floor and provide woody debris would maintain suitable habitat for vernal pool-dependent amphibians and invertebrates (Calhoun and deMaynadier 2008). Construction of roads and landings and applications of chemicals (e.g., herbicides and/or pesticides) should be avoided within the 30-meter buffer around a vernal pool, and minimized within the larger buffer (Calhoun and deMaynadier 2008). Natural cover, wetland areas, and drainage connections should be maintained as much as possible between groups of vernal pools and between vernal pools and other wetlands, so that animals may continue to disperse between scattered vernal pools and wetlands (Calhoun and deMaynadier 2008). It also is important to note that vernal pools are highly diverse and variable across the landscape. For example, vernal pool indicator or obligate species occur in some vernal pools and not others. Additional information about the ecology of individual vernal pools in the game area would help inform the development and implementation of appropriate and more site-specific management of vernal pools within the game area.

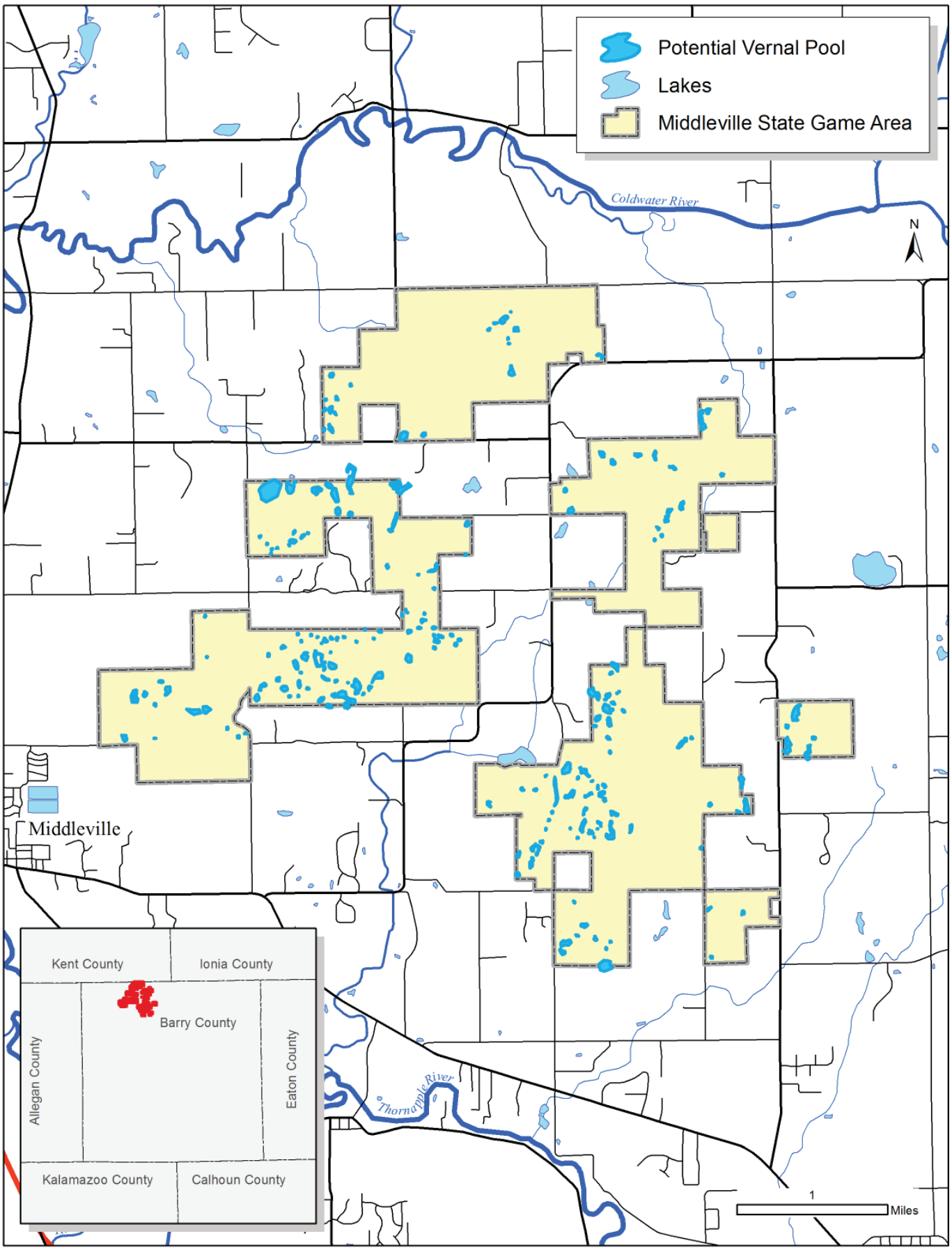


Figure 11. A total of 221 potential vernal pools were identified and mapped from aerial photo interpretation within Middleville State Game Area.

Rare Animal Discussion and Management Recommendations

Birds

Middleville SGA is characterized by large blocks of forest within a landscape consisting of agricultural land, residential development, and small forest fragments. These large blocks of forest are providing valuable nesting habitat for rare songbird species and other Neotropical migrant songbirds. We observed two rare songbird species (cerulean warbler and hooded warbler) during point count surveys, and both of these species are known to occur in landscapes dominated by mature deciduous forest. Although Michigan represents the northern edge of the breeding range for these species, cerulean and hooded warblers can be locally common breeders in forested landscapes of the southern Lower Peninsula. We documented 49 bird species using forested tracts of the game area (Appendix 6). Recorded bird species included two MDNR featured species, ten SGCN, and four species (veery, wood thrush, blue-winged warbler, and cerulean warbler) identified as focal species in the Landbird Habitat Conservation Strategy (Potter et al. 2007) for the Upper Mississippi River and Great Lakes Region Joint Venture. In addition, cerulean warbler is a focal species of the DNR's Wildlife Action Plan (Amy Derosier, personal communication, March 2015).

Forest management at Middleville SGA should consider the habitat needs of the rare songbird species we observed. Cerulean warbler is considered an area-sensitive species and, within the core of its breeding range, typically occupies forest tracts that are 3,000 ha (7413 acres) or larger (Hamel 2000). Hamel (1992) noted that the needs of cerulean warbler may be compatible with low-intensity timber management (e.g., single-tree selective removal) that mimics natural forest gaps. Such low-intensity management may also be compatible with hooded warbler breeding habitat. Hooded warblers nest in small trees or shrubs in the understory of mature deciduous forest (Dunn and Garrett 1997), and we regularly observed them in areas of dense young trees and shrubs associated with blowdowns.

The maintenance and expansion of mature forest blocks within the game area would benefit cerulean and hooded warblers and other forest-interior species, such as Acadian flycatcher and wood thrush. Activities that reduce the cover of mature forest or increase fragmentation could reduce the value of Middleville SGA to forest-interior nesting songbirds. We observed brown-headed cowbirds (*Molothrus ater*) at 44% of the point-count stations surveyed in the game area. Cowbirds thrive in fragmented landscapes and reduce the reproductive success of forest-breeding songbirds through nest parasitism. Efforts to reduce forest fragmentation could decrease nest parasitism by brown-headed cowbirds on rare and declining forest songbirds.

Periodic bird surveys are recommended to monitor use of Middleville SGA by rare species. We detected a pair of adult red-shouldered hawks that responded to broadcast calls, indicating territorial behavior. However, we were unable to find an active nest. Given the presence of red-shouldered hawks in suitable nesting habitat, additional surveys should be conducted to determine if the species is nesting within the game area. We also suggest conducting songbird point counts periodically to monitor use of the game area by the rare species we documented. These surveys would allow us to determine if the stands where rare songbirds were observed continue to be occupied over time and would provide an opportunity to monitor the effects of management actions on these species. Because rare species often are not detected even when present, additional surveys would also help determine if rare songbirds occur at sites where the habitat appeared suitable, but they were not observed.

Reptiles and Amphibians

Amphibian and reptile surveys in Middleville SGA in 2014 documented a total of 17 different species (Appendix 3). These include two listed or rare species, four additional SGCN, and eleven common species. Surveys were not able to document two rare amphibian and reptile species targeted for surveys in 2014, the copperbelly water snake and Blanchard's cricket frog. Some suitable habitat for these species appears to be available in Middleville SGA. Additional surveys for these species should be conducted in the future to determine if they occur in the game area.

Surveys in 2014 documented a new occurrence of Blanding's turtles in Middleville SGA. This species had not been documented in the game area prior to 2014. Although Blanding's turtles were observed in only one wetland during surveys in 2014, potential exists for this species to occur throughout the game area given the extent of suitable habitat available. The Blanding's turtle occurrence has been ranked as having good to fair viability or probability of persistence into the foreseeable future (i.e., at least 20-30 years, Table 4). Although the size of the Blanding's turtle population in Middleville SGA is unknown, this population has at least good to fair probability of persisting into the foreseeable future because of extensive suitable habitat available at this site, protected status of this site, and the long-lived nature of this species. Continued surveys, research, and monitoring are needed to evaluate the extent and/or condition of the Blanding's turtle population and habitat in the game area as well as threats facing this population.

An additional occurrence of eastern box turtles was documented in Middleville SGA during MNFI's natural community surveys in 2014. This occurrence, located at

the northern end of the game area, expanded the known extent of eastern box turtles in the game area. Prior to the 2014 surveys, the species had only been documented in the southeast portion of the game area (MNFI 2015). Potential exists for this species to occur throughout the game area given the extent of suitable habitat available within and adjacent to the game area. Both box turtle occurrences in the game area are considered to be viable and likely to persist into the foreseeable future (i.e., at least 20-30 years) because of extensive suitable habitat available at this site, protected status of this site, long-lived nature of this species, and history of this species' occurrence in the game area (since at least 2002, Table 4). However, because of uncertainty due to limited information on potential population size or species abundance at these sites (i.e., only one box turtle documented in each area), both occurrences have been ranked as having excellent, good, or fair viability or probability of persistence (i.e., EO rank AC, Table 4). Additional information regarding the potential size, extent, and/or condition of these eastern box turtle populations and habitat in the game area as well as threats facing these populations would help refine or clarify the estimated viability rank of these occurrences. Continued surveys, research, and monitoring are needed to obtain additional information on eastern box turtle populations in the game area.

The most critical conservation need for the Blanding's turtle and eastern box turtle is protection and management of landscape complexes of suitable wetland and adjacent upland habitats (Hyde 1999, Lee 1999, NatureServe 2015). Blanding's turtles inhabit clean, shallow waters with abundant aquatic vegetation and soft, muddy bottoms over firm substrates (Ernst et al. 1994). This species utilizes a variety of temporary and permanent wetlands and waterbodies including ponds, marshes, swamps, bogs, wet prairies, fens, river backwaters, embayments, sloughs, slow-moving rivers, protected coves, and lake shallows and inlets (Kofron and Schreiber 1985, Ernst et al. 1994, Harding 1997). It is important to protect clusters of small wetlands (i.e., <0.4 ha or 1 ac) within habitat complexes for this species since it frequently uses multiple small wetlands (Joyal et al. 2001). Blanding's turtles also require open and forested upland habitats for locating mates, nesting, basking, aestivating, and dispersing (Rowe and Moll 1991, Harding 1997, Joyal et al. 2001, NatureServe 2015). They prefer to nest in open, sunny areas with moist but well-drained sandy or loamy soil, but also will use lawns, gardens, plowed fields, or road edges for nesting if suitable natural nesting habitat is not available (Harding 1997). Blanding's turtles also make frequent movements and may travel considerable distances over land to locate mates, nest sites, and aestivation sites (Harding 1997, Joyal et al. 2001, NatureServe 2015). Maintaining large and small wetland systems connected to suitable upland habitats is crucial for Blanding's turtles (Harding 1997, Joyal et al. 2001). Maintaining good water quality in wetland habitats also would be beneficial to this species. This can be accomplished by maintaining natural buffers around wetlands, minimizing roads near wetlands, restricting use of pesticides in or near wetlands, and using only herbicides approved for use in open water when working in and adjacent to wetlands.

The eastern box turtle is Michigan's only truly terrestrial turtle (Harding 1997, Hyde 1999). It typically occurs in forested habitats with sandy soils near waterbodies or wetlands such as streams, ponds, lakes, marshes, or swamps (Tinkle et al. 1979). Box turtles also may be found in or along the edges of open upland and wetland habitats. Similar to the Blanding's turtle, maintaining large, contiguous landscape complexes of forest and wetland habitats is essential for maintaining populations of this species. Access to open, sunny, sandy nesting areas also is essential for population viability (Harding 1997).

Minimizing mortality or loss of adult and juvenile Blanding's turtles and eastern box turtles is important for maintaining viable populations of these species. Long-lived vertebrates, such as Blanding's turtles and eastern box turtles, have life histories that are characterized by delayed sexual maturity, low annual recruitment rates, and high adult survival rates (Congdon et al. 1993 and 1994). Populations of these species require high annual adult and juvenile survivorship (e.g., over 93% adult and over 72% juvenile survivorship for Blanding's turtles) to maintain stable populations due to these life history characteristics (Congdon et al. 1993). Long-term demographic studies of Blanding's turtle and other turtle species have reported that even small increases in adult and subadult or juvenile mortality (e.g., <10% increase in annual mortality of mature females or only 2-3% increase in annual mortality overall) could lead to population declines (Brooks et al. 1991, Congdon et al. 1993 and 1994). Habitat loss and fragmentation, nest predation, road mortality, and illegal collection can impact adult and/or juvenile survival and threaten the viability of Blanding's turtle and eastern box turtle populations. Habitat fragmentation can lead to increased populations of meso-predators, such as raccoons, skunks, opossums, and foxes, which can result in increased turtle nest predation and reduced or minimal population recruitment (Temple 1987). Predator control and protecting nest sites are potential management strategies that could help increase recruitment. Road mortality can pose a substantial threat to Blanding's turtles and eastern box turtles. Blanding's turtles are particularly threatened by road mortality because of their tendency to make frequent and long distance migrations over land (Joyal et al. 2001).

Fencing (e.g., silt fencing) could be installed along roads where turtle road mortality is an issue. These turtle species also are vulnerable to collection for personal collection, commercial pet trade, and/or consumption (e.g., Asian turtle markets) (Harding 1997). These populations may be particularly vulnerable to collection because they are on readily accessible public land. Research and monitoring are needed to determine whether these threats are facing the Blanding's turtle, eastern box turtle, and other turtle populations in Middleville SGA. Additional management and monitoring may be needed to address these threats and monitor the impact and effectiveness of management efforts.

The eastern box turtle and Blanding's turtle may be vulnerable to certain habitat management activities, such as prescribed burning and mechanical vegetation control or removal. These management practices are important for maintaining and restoring suitable wetland and upland habitats for these and other herptile species. Adjusting the timing and/or manner in which these management practices are conducted can reduce the potential for adversely impacting herptiles. Conducting these management practices in early spring before amphibian and reptile species emerge (e.g., March – early/mid-April), in the fall after species have entered their hibernacula (e.g., mid to late October), or after the species have left a particular area or habitat would minimize the potential for adversely impacting these species. For example, conducting management activities in open upland habitats in early spring (April – early May) or mid to late summer (July – early August) prior to or after the turtle nesting season (primarily late May –June) and before turtle hatchlings emerge (late August – early October) would minimize the potential for harming Blanding's turtles, eastern box turtles, and other turtles. If prescribed burning needs to occur during the active season, burning later in the spring when turtles are more active may reduce the potential for adversely impacting them. Extending the management interval (e.g., burning every 5 years instead of every 1-2 years), and/or conducting management on only a portion of the available habitat at a site and leaving some refugia also can help reduce adverse impacts to turtle populations. Kingsbury and Gibson (2012) and Mifsud (2014) provide general habitat management guidelines and recommendations for amphibians and reptiles.

In addition to rare herptile species, a number of frogs and salamanders were found in Middleville SGA in 2014, including four current SGCN, the spotted salamander, blue-spotted salamander, eastern tiger salamander, and western chorus frog. Frogs and salamanders are important components of forest and wetland ecosystems. These species can represent significant biomass and important components of food chains (Burton and Likens 1975). Frogs and salamanders also can serve as important bioindicators of ecosystem health because of their amphibious life cycles and permeable skin and eggs. Many of the frogs and salamanders documented in the game area in 2014 were found in forested and open canopy vernal pools and adjacent forests. Spotted salamanders, blue-spotted salamanders, and other amphibian species require or prefer vernal pools for breeding, but they only inhabit these pools for a few days to a couple of weeks per year. These species spend the majority of their time in the upland forest or open uplands surrounding the breeding pools, and readily travel about 125 meters (400 ft) or more from the breeding pools (Semlitsch 1998). Spotted and blue-spotted salamanders are considered to be forest management–sensitive species, and require relatively undisturbed upland forests with temporary woodland ponds (Wilbur 1977, Downs 1989a and 1989b, DeGraaf and Rudis 1983, Van Buskirk and Smith 1991, deMaynadier and Hunter 1998, Petranka 1998, Knox 1999). Guerry and Hunter (2002) found that spotted salamanders and blue-spotted hybrid salamanders are more likely to occur in breeding ponds that are in more forested landscapes and are within or adjacent to forests. Homan et al. (2004) also found that spotted salamanders (and wood frogs) appear to have critical habitat thresholds in which species occupancy or probability of occurrence declines significantly below a certain level of suitable habitat, which was about 30% forest cover. *Ambystomatid* salamanders, such as the spotted and blue-spotted salamanders, also return to same ponds to breed (Semlitsch et al. 1993). The main threats to spotted and blue-spotted salamanders are habitat loss and degradation, land use, and acidification of breeding ponds.

Based on the ecology and habitat needs of spotted and blue-spotted salamanders and other pool-breeding amphibians, the following forest management recommendations have been developed for these species. Activities that disturb soils or tree canopies in and near vernal pools should be avoided or minimized, particularly during critical time periods for most amphibians (i.e., March through July) (Thomas et al. 2010). The State's sustainable soil and water quality practices for forest lands recommend no disturbance to the vernal pool depression, limiting use of heavy equipment within 30 meters (100 ft) or at least one tree length of the pool to avoid creating deep ruts, and maintaining at least 70% canopy closure within the 30-meter (100 ft) buffer (Michigan DNR and Michigan DEQ 2009). Because many of the pool-breeding salamanders and frogs travel 125 meters (400 ft) or more from the breeding pools into the surrounding forest (Semlitsch 1998), extending the buffer zone at least to 125 meters or greater [e.g., 140 to 180 meters (450-600 ft)] around the pools would enhance conservation of pool-

breeding salamanders and frogs (Semlitsch 1998, Calhoun and deMaynadier 2004, Massachusetts Natural Heritage and Endangered Species Program 2007).

Finally, because many herp species are cryptic and difficult to detect in the field, particularly if they are rare, additional surveys and monitoring are needed to determine the status and distribution of rare herp species and other SGCN that have been documented or have potential to occur at Middleville SGA. Additional surveys for the Blanchard's cricket frog should be conducted as weather conditions were not ideal during surveys for this species in 2014. Blanchard's cricket frog inhabits the open edges of permanent ponds, lakes, floodings, bogs, seeps, and slow-moving streams and rivers (Harding 1997). They also will utilize shallow, temporary pools near larger, permanent waterbodies, and prefer open or partially vegetated mud flats, muddy or sandy shorelines, and mats of emergent aquatic vegetation in shallow water (Harding 1997). Although this species has not been documented in the immediate vicinity of the game area, populations of this species are known to the south and north of the game area. Potential exists for this species to occur within or adjacent to the game area since suitable habitat appears to be available across the game area. Suitable habitat for copperbelly water snakes also appears to be available in the game area. Copperbelly water snakes require extensive wetland-upland habitat complexes consisting of multiple and diverse shallow, seasonally flooded wetlands and permanent wetlands and waterbodies embedded within a forested upland matrix with limited barriers or hazards and terrestrial corridors between wetlands that provide safe passage for snakes (Roe et al. 2004, Roe et al. 2006, USFWS 2008). Although this species has not been documented in the vicinity of the game area and is known to be extant at only a small number of sites in southern Michigan, potential exists for this species to occur at additional sites in the state. Additional reconnaissance for this species should continue in the game area if possible. The gray ratsnake (*Pantherophis spiloides*, state special concern) also has potential to occur in the game area. This species, which can be difficult to detect, typically occurs in forested habitats, primarily deciduous or mixed forests, but also utilizes adjacent open or shrubby habitats including old fields, prairies, and edges of swamps, marshes, and bogs (Fitch 1963, McAllister 1995, Harding 1997, Ernst and Ernst 2003). This species is only known from a small number of sites in the state, and would benefit from targeted, systematic surveys.

The numerous inundated shrub swamps nested within the forests of Middleville State Game Area provide important habitat for a wide array of herptile species. Photo by Joshua G. Cohen.

CONCLUSION

During the Integrated Inventory Project at Middleville SGA, MNFI documented 12 new element occurrences (EOs) and updated an additional three EOs (Tables 1-4). In total, 16 SGCN were documented during the project including four rare animal species (Table 5). Surveys for exemplary natural communities resulted in five new high-quality natural communities and one known high-quality community was updated (Table 1). Six natural communities were surveyed in 2013 including: dry-mesic southern forest (4 EOs) and mesic southern forest (2 EOs). We assessed the current ranking, classification, and delineation of these occurrences and detailed the vegetative structure and composition, ecological boundaries, landscape and abiotic context, threats, management needs, and restoration opportunities. For each natural community EO, a detailed site description, threats assessment, and management discussion is provided.

Over the course of the project, five new rare plant EOs were opportunistically documented (Table 2). Newly documented rare plant species include four records for ginseng (*Panax quinquefolius*, state threatened) and one record for beak grass (*Diarrhena obovata*, state threatened). The site descriptions for natural community EOs include discussion of rare plant populations when they occur within the high-quality natural communities.

Employing aerial photo interpretation, MNFI scientists identified and mapped 221 potential vernal pools in Lost Nation SGA. During the 2014 field season, 12 vernal pools were surveyed and verified. These survey and mapping results provide baseline information on vernal pool status, distribution, and ecology in the game area, which will facilitate the development and implementation of appropriate management of these wetlands.

Four rare bird species have been documented in the game area and two rare bird species were recorded during the 2014 breeding season (Table 3). We updated EOs for cerulean warbler (*Setophaga cerulea*, state threatened) and hooded warbler (*Setophaga citrina*, state special concern). A total of ten avian SGCN were documented in Middleville SGA during the 2014 breeding season (Table 5).

During the course of the project, two new reptile EOs were documented, a Blanding's turtle EO and an eastern box turtle EO. A total of six amphibian and reptile SGCN have been documented in the Middleville SGA, with all six being recorded during this project (Tables 4 and 5).

Primary management recommendations for the Middleville SGA include 1) invasive species control focused in high-quality forests, 2) the maintenance of the canopy closure of mature forest ecosystems, 3) the reduction of fragmentation and promotion of connectivity across the game area but focused in the vicinity of wetlands and high-quality natural communities, 4) the use of landscape-scale prescribed fire focused in high-quality natural communities and with rotating non-fire refugia where fire-sensitive rare species occur, 5) the opportunistic restoration of oak savanna ecosystems, and 6) the careful prioritization of management efforts in the most critical habitats. Monitoring of these management activities is recommended to facilitate adaptive management.

Invasive species pose a major threat to species diversity and habitat heterogeneity within Middleville SGA. Although numerous invasive species occur within the game area, the species likely to pose the greatest threats because of their ability to invade and quickly dominate intact natural areas include garlic mustard (*Alliaria petiolata*), Japanese barberry (*Berberis thunbergii*), autumn olive (*Elaeagnus umbellata*), Morrow honeysuckle (*Lonicera morrowii*), multiflora rose (*Rosa multiflora*), hedge-parsley (*Torilis japonica*), and tree-of-heaven (*Ailanthus altissima*). Invasive species management at Middleville SGA should focus on controlling populations of pernicious invasive species within high-quality natural communities and also in the surrounding landscape. Managers should bear in mind that invasive plants are much easier to eradicate when they are not yet well established, and their local population size is small. The primary mechanisms for reducing invasive species are landscape-scale prescribed fire and targeted prescribed fire and spot treatment through cutting and/or herbicide application within priority high-quality natural community EOs.

Much of the land within Middleville SGA historically supported fire-dependent ecosystems, such as dry-mesic southern forest and to a lesser extent oak openings. Fire historically helped to reduce colonization by mesophytic trees and shrubs, fostered regeneration of fire-dependent species, and maintained the open structure of many ecosystems. In the absence of frequent fires, open oak savanna and oak barrens have converted to closed-canopy forests dominated by shade-tolerant native and invasive species. This conversion of fire-dependent open savanna ecosystems to closed-canopy forest typically results in significant reductions in diversity at the species and habitat levels. Several of the rare species documented in Middleville SGA and in the surrounding area depend on these fire-dependent habitats. In addition, due to fire suppression, closed-canopy forests within Middleville SGA are experiencing strong regeneration of thin-barked, shade-tolerant mesophytic trees and invasive shrubs and failure of oak to regenerate.

Within forested ecosystems, a sustained, landscape-scale, fire-management program would reduce the density of shade-tolerant understory and help facilitate increased recruitment of fire-adapted native species. Efforts to restore oak barrens and oak savanna within Middleville SGA will depend on the implementation of frequent prescribed fire. Savanna ecosystems in Middleville SGA were historically concentrated in the northern portion of the game area. Pursuing restoration of oak savanna remnants is recommended because these rare ecosystems support a high-level of biodiversity and numerous rare species.

We recommend the implementation of prescribed fire at a landscape-scale and the creation of large burn units (e.g., several hundred to one thousand acres in size). We recommend that prescribed fire be prioritized for high-quality and/or underrepresented fire-dependent natural communities (e.g., dry-mesic southern forest and oak savanna) and immediately adjacent systems. Where rare herptiles are a management concern, burning strategies should include the use of multiple subunits managed on a rotational basis and allow for ample refugia to facilitate effective post-burn recolonization

The Middleville SGA supports over 3,900 acres of forest and over 750 acres of high-quality forest, primarily dry-mesic southern forest. The large area of forest within the game area serves as an important island of biodiversity for the local region, which is dominated by agricultural lands and rural development. Maintaining the canopy of mature forest and avoiding additional forest fragmentation will help ensure that high-quality habitat remains for the diverse array of plants and animals, including the many rare species and SGCN that utilize this forested island. Dampening the effects of forest fragmentation within this landscape can be realized by decreasing forest harvest levels, halting the creation of new wildlife openings within forested landscapes, closing redundant forest roads, and limiting the creation of new roads. In addition, conversion of wildlife openings and old agricultural fields to forest and other native habitats such as oak savanna can also contribute to the increase of forest and native habitat connectivity and decrease in forest fragmentation. We recommend that efforts to reduce fragmentation be concentrated in the vicinity of wetlands and existing high-quality natural communities.

In general, prioritization of stewardship within Middleville SGA should focus on the highest quality and largest forests. Biodiversity is most easily and effectively protected by preventing high-quality sites from degrading. Within Middleville SGA, we recommend the following 1) that stewardship efforts be focused in forested communities that harbor high levels of biodiversity and provide habitat for numerous rare plant and animal species; 2) that management efforts focus on forested sites that include vernal pools and other wetland inclusions; and 3) that canopy closure be maintained in the highest-quality and largest forest ecosystems. Critical to any effective management strategy is the adaptive capacity to modify stewardship activities and priorities following monitoring.

Pursuing restoration of oak savanna remnants is recommended because these rare ecosystems support a high-level of biodiversity and numerous rare species. Photo by Jesse M. Lincoln.

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Appendix 1. Vernal Pool Monitoring Form.

Michigan Natural Features Inventory

MICHIGAN STATE UNIVERSITY EXTENSION

Michigan Vernal Pools Project

Volunteer Vernal Pool Monitoring Form

http://mnfi.anr.msu.edu/vernalpools/ - Contact MNFI at (517) 284-6200

QC Date:
QC Initials:
Date Entered:

1a) Observer Information ☐ Visit 1 ☐ Visit 2 ☐ Visit 3 Time: from ☐AM ☐PM to ☐AM ☐PM

Name(s): Date:

1b) Property Information Ownership? ☐ Public ☐ Private Landowner/Manager Name:

Site name: Address:

Plot # City: State: Zip:

2a) Vernal Pool Location Was pool mapped as a Potential Vernal Pool (PVP)? ☐ Yes ☐ No

Pool ID #: New Pool ID #:

Township/Range/Section/1/4 info :

County:

Method for locating pool?

☐ GPS ☐ Topo Map ☐ Google Earth ☐ Air Photo

Enter coordinates in Decimal Degrees (e.g. Latitude: 44.764322 Longitude: -72.654222)

Latitude: Longitude:

For verification of PVP's location please enter names and coordinates for the nearest crossroads. Record as Decimal Degrees as shown above.

Latitude: Longitude:

Crossroad names:

2b) Brief Site Directions to Pool **

**** Written site directions to pool** (This should include: (1) description of a logical starting point; (2) the distance from the starting point to pool; (3) the direction of travel; and (4) distinctive landmarks and water bodies.): For example 'Enter Robinhood Park on the trailhead at Jordan Road. Follow the trail west approximately 1/2 mi. This is the first pool on your left, just behind a low stone wall.'

3a) Pool Type Is this a Vernal Pool? ☐ Yes ☐ No ☐ Not Sure Pool Photo Numbers:

☐ Open Pool ☐ Sparsely Vegetated Pool ☐ Shrubby Pool

☐ Forested Pool ☐ Marsh Pool ☐ Other (describe):

3b) Presence of Inlet or Outlet

Is this pool connected to or part of another water feature? ☐ culvert ☐ lake ☐ open/emergent/shrubby wetland

☐ No, pool is isolated ☐ Yes, pool is connected to: (check **ALL** that apply) ☐ stream ☐ ditch ☐ forested wetland ☐ vernal pool

If inlet/outlet is present, indicate type: ☐ permanent ☐ temporary ☐ do not know ☐ none

3c) Surrounding Habitat (within 100 feet of pool) (check **ALL** that apply)

☐ Upland Deciduous Forest ☐ Lowland Deciduous Forest
☐ Upland Coniferous Forest ☐ Lowland Coniferous Forest
☐ Upland Mixed Forest ☐ Lowland Mixed Forest
☐ Floodplain ☐ Grassland or open
☐ Emergent Wetland (marsh, bog)

Disturbances:

☐ Agriculture
☐ Road/driveway
☐ paved
☐ dirt/gravel
☐ Powerline right-of-way
☐ Light development (<25%)
☐ Intensive development (>25%)
☐ Minor logging (> or = 70% canopy remaining)
☐ Major logging (< or = 70% canopy remaining)
☐ Other:
☐ No disturbances

4a) Approximate Maximum Pool Depth

☐ Ankle-deep (<6") ☐ Hip-deep (2-3 ft)
☐ Shin-deep (6-12") ☐ Chest-deep (3-4 ft)
☐ Knee-deep (12-24") ☐ Deeper than 4 ft

4b) Water Level at Time of Survey (check one)

☐ Full/Nearly full 75-100% ☐ Less than half 25-49%
☐ Partially full 50-74% ☐ Dry/mostly dry 0-24%

4c) Water temperature (*F):

4d) Approximate Size of Pool (at maximum capacity - at widest and longest points)

Width: feet

Length: feet

Size determined by: ☐ Pacing ☐ Measuring ☐ Using GPS

4e) Substrate (when dry - check **ALL** that apply)

☐ Leaf litter ☐ Sand - Gravel ☐ Unknown
☐ Bedrock ☐ Muck - Peat ☐ Other:
☐ Loam ☐ Silt - Clay

Funding for this project was provided by the US Environmental Protection Agency along with the Michigan Department of Environmental Quality

Appendix 1. Vernal Pool Monitoring Form (continued).

4f) Vegetation in Pool

Are trees (trees = or > 4" in diameter) present in the basin? (check one)

☐ No ☐ Yes, within pool basin ☐ Yes, but only at the edge

# of trees only within the pool basin? ☐ live and/or ☐ dead/snags

% Cover within the pool (check one):

Floating vegetation: ☐ 0% ☐ 1 to 9% ☐ 10 to 25% ☐ 26 to 50% ☐ >50%

Emergent vegetation: ☐ 0% ☐ 1 to 9% ☐ 10 to 25% ☐ 26 to 50% ☐ >50%

Shrubs: ☐ 0% ☐ 1 to 9% ☐ 10 to 25% ☐ 26 to 50% ☐ >50%

4h) Cover (Any material in the pool that can provide egg attachment sites and offer concealment to adults and/or larvae; check all that apply):

☐ Shrubs ☐ Submergent vegetation

☐ Branches, twigs ☐ Logs or large woody debris

☐ Sphagnum moss ☐ Emergent vegetation (grasses, cattails)

☐ Algae ☐ Other:

☐ Leaf litter

Tree canopy over pool basin (when leaves are fully out): ☐ 0% ☐ 1 to 9% ☐ 10 to 25% ☐ 26 to 50% ☐ >50%

4g) Pool Disturbance (in pool, immediately adjacent or along shore of pool - check all that apply)

☐ Dumping - Refuse ☐ Filling ☐ Invasive Species Present

☐ Ditching - Draining ☐ Sediment ☐ Purple loosestrife ☐ Garlic mustard

☐ Agricultural runoff ☐ Vehicle ruts ☐ Reed canary grass ☐ Other:

☐ Cultivation - Livestock ☐ Presence of rock pile or other anthropogenic disturbance ☐ No disturbances

5) Indicator Species and Additional Species (if other species are observed please list below in blank fields under Fingernail Clams)

Provide a photograph of each indicator species (adults, juveniles/larvae, or egg masses) observed. **Photos of species observed are required.**

Species Observed	Adults	Tadpoles/Larvae	Egg Masses			Photo? Yes	Notes/Photo ID#
			Number	Estimated	Counted		
Wood Frog				☐	☐	☐	
Spotted Salamander				☐	☐	☐	
Blue-spotted Salamander				☐	☐	☐	
Fairy Shrimp							
Fingernail Clams							
				☐	☐	☐	
				☐	☐	☐	
				☐	☐	☐	
				☐	☐	☐	
				☐	☐	☐	
				☐	☐	☐	
				☐	☐	☐	

Were any of the following observed? (check **ALL** that apply)

☐ Fish: (indicate all lengths observed) ☐ ≤ 3" ☐ > 3" ☐ Green frogs: ☐ tadpoles ☐ adults

☐ Bullfrogs: ☐ tadpoles ☐ adults ☐ Other:

Comments:

Draw diagram of pool (include landmarks, location of indicated species, north arrow and area surveyed if entire pool was not surveyed):

Funding for this project was provided by the US Environmental Protection Agency along with the Michigan Department of Environmental Quality

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Appendix 2. Vernal Pool Types.

VERNAL POOL TYPES:

1) **Open Pool** – "Classic" vernal pool, rooted/live trees, shrubs and/or non-woody herbaceous or persistent emergent plants covering <10% of the ground within pool basin


2) **Sparsely Vegetated Pool** – Rooted/live trees, shrubs, and/or non-woody herbaceous or persistent emergent plants covering 10% to < 30% of the ground within pool basin


3) **Shrubby Pool** – Pool dominated by shrubs – Vegetation covers ≥ 30% of the ground with shrubs comprising ≥ 30% of the uppermost vegetation layer within pool basin.


Appendix 2. Vernal Pool Types (continued).

4) **Forested Pool** – Pool dominated by trees - Vegetation covers ≥ 30% of the ground with rooted/live trees comprising ≥ 30% of the uppermost vegetation layer in pool basin. For example, forested swamp pool, pool within larger forested swamp, floodplain pool.

5) **Marsh Pool** – Pool dominated by non-woody herbaceous or persistent emergent plants – Non-woody herbaceous and/or persistent emergent plants comprise 30 – 50% of the uppermost vegetation layer in pool basin. Trees and shrubs may be present but < 30% cover.

Appendix 3. List of amphibian and reptile species known to occur or with potential to occur in Middleville State Game Area. Each species' status at federal and state levels and within the game area is provided along with general habitat associations.

Amphibian/ Reptile	Common Name[1,3]	Scientific Name[1]	US Status	State Status	WAP SGCN[2]	Rare Species Survey Target 2014	Species Found During 2014 Surveys	Species Found During Surveys Prior to 2014	General Habitats[3,4]
Amphibian	Eastern Newt / Central Newt	*Notophthalmus viridescens louisianensis*							Small, permanent ponds, temporary ponds, and shallows of large lakes, river sloughs and backwaters with abundant aquatic vegetation
Amphibian	Blue-spotted Salamander **	*Ambystoma laterale*			X**	X	X		Deciduous and coniferous forests from moist bottomlands to dry uplands; ponds that retain water into midsummer essential
Amphibian	Spotted Salamander	*Ambystoma maculatum*			X	X	X		Moist closed canopy deciduous or mixed forests, temporary/semi-permanent ponds within or adjacent to woods. Avoid cutover forests and those subject to flooding.
Amphibian	Eastern Tiger Salamander **	*Ambystoma tigrinum*			X**	X	X		Forests, marshes, and grasslands; breeding - permanent and semi-permanent ponds
Amphibian	Eastern Red-backed Salamander	*Plethodon cinereus*							Deciduous, coniferous, and mixed forests
Amphibian	Four-toed Salamander **	*Hemidactylium scutatum*			X**				Moist deciduous, coniferous, or mixed forests, usually in vicinity of spring-fed creeks, sphagnum seepages, bogs, or boggy ponds
Amphibian	Eastern American Toad	*Anaxyrus [Bufo] americanus americanus*					X		Open forests, forest edges, prairies, marshes, and meadows
Amphibian	Fowler's Toad	*Anaxyrus [Bufo] fowleri*			X				Open woods and fields, particularly those with sandy soils, prairies, savannas, and forests in sand dunes.
Amphibian	Blanchard's Cricket Frog	*Acris blanchardi*		T	X	X			Open, muddy edges of permanent ponds, lakes, bogs, and slow-moving streams or rivers with abundant aquatic vegetation, including fens and wet or sedge meadows
Amphibian	Spring Peeper	*Pseudacris crucifer*					X		Temporary and permanent ponds, marshes, floodings, and ditches, as well as forests, old fields, shrubby areas
Amphibian	Western Chorus Frog **	*Pseudacris triseriata*			X**		X		Marshes, wet meadows, swales, and other open habitats, also mesic forests and swamp forests
Amphibian	Gray Treefrog	*Hyla versicolor/Hyla chrysoscelis*					X		Temporary ponds, swamps, floodings, shallow edges of permanent lakes, and sloughs, surrounded by forested or open habitats
Amphibian	American Bullfrog	*Lithobates [Rana] catesbeianus*					X		Permanent waterbodies - river backwaters, sloughs, lakes, farm ponds, impoundments, marshes, shallow Great Lakes bays; abundant emergent and submergent vegetation
Amphibian	Green Frog	*Lithobates [Rana] clamitans*					X		Ponds, lakes, swamps, sloughs, impoundments, and slow streams
Amphibian	Pickerel Frog	*Lithobates [Rana] palustris*			X				Bogs, fens, ponds, streams, springs, sloughs, and lake coves; cool clear waters, grassy stream banks
Amphibian	Northern Leopard Frog	*Lithobates [Rana] pipiens*			X				Open wetland habitats including marshes, bogs, lake and stream edges, and sedge meadows, and adjacent open uplands including hay fields, lawns; breed in shallow temporary ponds, stream backwaters, and marsh pools
Amphibian	Wood Frog	*Lithobates [Rana] sylvaticus*					X		Moist, forested habitats (deciduous, coniferous, and mixed); breeding - vernal ponds, floodings, forested swamps, and quiet stream backwaters
Reptile	Snapping Turtle	*Chelydra serpentina*					X		Permanent waterbodies including shallow, weedy Great Lakes inlets and bays; muddy ponds, lakes, sloughs and slow streams with dense aquatic vegetation
Reptile	Eastern Musk Turtle	*Sternotherus odoratus*							Permanent waterbodies - ponds, lakes, marshes, sloughs, rivers; highly aquatic

Appendix 3. List of amphibian and reptile species known to occur or with potential to occur in Middleville State Game Area. Each species' status at federal and state levels and within the game area is provided along with general habitat associations (continued).

Amphibian/ Reptile	Common Name[1,3]	Scientific Name[1]	US Status	State Status	WAP SGCN[2]	Rare Species Survey Target 2014	Species Found During 2014 Surveys	Species Found During Surveys Prior to 2014	General Habitats[3,4]
Reptile	Spotted Turtle	*Clemmys guttata*		T	X				Shallow ponds, wet meadows, tamarack swamps, bogs, fens, marshes, sphagnum seepages, slow streams; require clear shallow water with mud/muck bottom and ample aquatic and emergent vegetation
Reptile	Eastern Box Turtle	*Terrapene carolina carolina*		SC	X	X	X	X	Deciduous or mixed forests, esp. with sandy soils, also adjacent old fields, pastures, dunes, marshes, and bog edges
Reptile	Blanding's Turtle	*Emydoidea blandingii*		SC	X	X	X		Shallow, weedy waters - ponds, marshes, forested and shrub swamps, wet meadows, lake inlets and coves, rivers backwaters, embayments, sloughs, vernal pools
Reptile	Northern Map Turtle	*Graptemys geographica*							Larger lakes, rivers, reservoirs, oxbow sloughs, open marshes, Great Lakes bays and inlets; also smaller lakes and streams and ponds
Reptile	Painted Turtle	*Chrysemys picta*					X		Quiet, slow-moving permanent water bodies with soft bottom substrates, abundant aquatic vegetation, and basking sites; temporarily occupy vernal ponds, imoundments, ditches and faster streams and rivers
Reptile	Five-lined Skink	*Plestiodon [Eumeces] fasciatus*							Moist but not wet, forested or partially forested habitats with ample cover and basking sites - stumps, logs, rock outcrops, wood or brush piles, sawdust piles, fallen bark; moist not wet habitats
Reptile	Northern Water Snake	*Nerodia sipedon sipedon*					X		Permanent water bodies - rivers, streams sloughs, lakes, ponds, bogs, marshes, swamps, wet meadows, impoundments; also utilize shallow, small temporary ponds and wetlands including vernal pools and shrub swamps
Reptile	Copperbelly Water Snake	*Nerodia erythrogaster neglecta*	LT	E	X	X			Wetlands, generally shallow wetlands, including shrub swamps; emergent wetlands; and temporary or permanent, palustrine open water wetland, usually associated with mature or second-growth forests but occasionally in more open situations; also forested swamps, woodland pools, and floodplain forests as well as small lakes, slow-moving rivers and streams, oxbows, and sloughs.
Reptile	Queen Snake *	*Regina septemvittata*		SC	X				Warm, shallow, rocky-bottomed streams with abundance of crayfish; also edges of ponds, lakes, marshes, ditches and canals, open to mostly forested but totally shaded sites are avoided; often bask at water's edge or in overhanging shrubbery or tree branches.
Reptile	Brown Snake	*Storeria dekayi*							Variety of habitats from dense forests and shrubby habitats to open prairies, meadows, and marshes; prefer areas with moist soils but also found on dry hillsides, pine forests, and railroad embankments
Reptile	Northern Red-bellied Snake	*Storeria occipitomaculata occipitomaculata*							Deciduous or mixed forests, and adjacent fields, pastures, road embankments, marshes and sphagnum bogs
Reptile	Eastern Garter Snake	*Thamnophis sirtalis sirtalis*					X		Almost any natural habitats - open and forested habitats and moist grassy places - edges of ponds, lakes, streams ditches,
Reptile	Northern Ribbon Snake	*Thamnophis sauritus septentrionalis*					X		Edges of lakes, ponds, streams, marshes, especially with grasses, sedges and low shrubs, open sunny areas/habitats
Reptile	Northern Ring-necked Snake	*Diadophis punctatus edwardsii*			X				Moist, shady forests and adjacent open habitats including old fields, grassy dunes; often found under leaf litter or cover or in burrows

Appendix 3. List of amphibian and reptile species known to occur or with potential to occur in Middleville State Game Area. Each species' status at federal and state levels and within the game area is provided along with general habitat associations (continued).

Amphibian/ Reptile	Common Name[1,3]	Scientific Name[1]	US Status	State Status	WAP SGCN[2]	Rare Species Survey Target 2014	Species Found During 2014 Surveys	Species Found During Surveys Prior to 2014	General Habitats[3,4]
Reptile	Eastern Hog-nosed Snake **	*Heterodon platirhinos*			X**				All types of terrestrial habitats - from open pine or deciduous forests to old fields, meadows, and pastures. Prefer sandy, well-drained soils.
Reptile	Blue Racer	*Coluber constrictor foxii*			X				Dry sunny, open habitats with access to cover - old fields, hedgerows, shrub thickets, open forests, forest edges, also grassy lake borders and marshes
Reptile	Gray Ratsnake *	*Pantherophis spiloides*		SC	X				In or near forests, and adjacent open habitats - shrubby fields, pastures, marsh and bog edges
Reptile	Eastern Milk Snake	*Lampropeltis triangulum triangulum*							Open forests, bogs, swamps, forest edges, marshes, lakeshores, old fields, and pastures
Reptile	Smooth Green Snake	*Opheodrys vernalis*			X				Moist grassy places including prairie remnants and savannahs, meadows, old fields, pastures, roadsides, marsh and lake edges, also open deciduous and pine forests
Reptile	Eastern Massasauga	*Sistrurus catenatus catenatus*	C	SC	X				Open and forested wetlands including shrub swamps, bogs, fens, marshes, wet or sedge meadows, moist prairie, and forested swamps, and adjacent open and forested upland habitats including prairies, old fields, meadows, shrub thickets, and deciduous, coniferous, and mixed forests.

Key:
U.S. Status: LE = Federally Endangered; LT = Federally Threatened; C = Federal Candidate
State Status: E = State Endangered; T = State Threatened; SC = State Special Concern
WAP SGCN - Wildlife Action Plan Species of Greatest Conservation Need
* - Rare species not targeted for surveys in 2014 due to low likelihood or probability of detecting the species given available methods and resources for surveys.
** - Species was a SGCN in 2014 but has been removed or proposed for removal as a SGCN by the Michigan DNR as of February 2015.

Listed/rare amphibian and reptile species and/or SGCN targeted for surveys and documented in Middleville SGA in 2014.
Additional listed/rare amphibian and reptile species and/or SGCN that were not documented in Middleville State Game Area during surveys in 2014 but have been documented prior to 2014.
Additional amphibian and reptile species that have been documented in Lost Nation SGA during MNFI surveys in 2014 and/or prior to 2014.

Sources:
[1]Crother, B. I. (ed.). 2012. Scientific and Standard English Names of Amphibians and Reptiles of North America North of Mexico, With Comments Regarding Confidence In Our Understanding. SSAR Herpetological Circular 39:1-92.
[2]Eagle, A.C., E.M. Hay-Chmielewski, K.T. Cleveland, A.L. Derosier, M.E. Herbert, and R.A. Rustem, eds. 2005. Michigan's Wildlife Action Plan. Michigan Department of Natural Resources, Lansing, Michigan. 1592 pp.
[3]Harding, J.H. 1997. Amphibians and Reptiles of the Great Lakes Region. The University of Michigan Press, Ann Arbor, MI. 378 pp.
[4]Harding, J.H. and J.A. Holman. 1992. Michigan Frogs, Toads, and Salamanders. Michigan State University, Cooperative Extension Service, East Lansing, MI. 144 pp.

Appendix 4. State Lands Inventory Special Animal Survey Form - Herps

I. LOCATION INFORMATION

Site Name _____ Stand Number(s)_____ Date_____

Observer(s)_____ Stand classifications_____

Quad_____County_____ Town, Range, Sec_____

Directions/access _____

_____

GPS Unit Type & #: _____ GPS Waypoint(s): _____ GPS Track(s): _____

II. SURVEY INFORMATION

Time Start _____ Time End _____ Weather: Air Temp – Start_____End _____ RH – Start_____ End_____

Sky Code – Start _____ End _____ Wind Code - Start _____ End _____ Precip Code - Start_____ End _____

Target species/group & survey method_____

Target/rare species found? Yes No Comments: _____

Habitat for target species/group found? Yes No Comments: _____

Species found (common or rare)	Number	Location (GPS, landmarks)	Notes (habitat, behavior, condition, etc.)

Survey comments (area surveyed, potential for other rare species, revisit warranted, photos taken? etc.)

_____

_____

_____

III. GENERAL SITE DESCRIPTION (describe in relation to species surveyed for – presence, quantity, and quality of appropriate habitat, crayfish burrows, hostplants/nectar sources, dominant vegetation, natural communities, habitat structure, etc.)

_____

_____

_____

_____

IV. MANAGEMENT CONSIDERATIONS

Threats (e.g., ORV's, excessive mt. bike use, grazing, structures, past logging, plantations, development, erosion, ag, runoff, hydrologic alteration, etc.) _____

_____

Exotic species (plants or animals)_____

_____

Stewardship Comments _____

_____

Appendix 4. State Lands Inventory Special Animal Survey Form - Herps (continued)

V. LISTED ANIMAL OR PLANT SPECIES or COMMUNITY EOS _____

_____

_____

VI. ADDITIONAL ASSOCIATED SPECIES FOUND

Species found (common or rare)	Number	Location (GPS, landmarks)	Notes (habitat, behavior, condition, etc.)

VII. Map/drawing of general area surveyed and approximate locations of suitable habitat and/or rare species found

Wind Codes (Beaufort wind scale):

0 = Calm (< 1 mph) smoke rises vertically

1 = Light air (1-3 mph) smoke drifts, weather vane inactive

2 = Light breeze (4-7 mph) leaves rustle, can feel wind on face

3 = Gentle breeze (8-12 mph) leaves and twigs move, small flag extends

4 = Moderate breeze (13-18 mph) moves small tree branches, twigs & leaves, raises loose paper

5 = Strong breeze (19-24 mph) small trees sway, branches move, dust blows

6 = Windy (> 24 mph) larger tree branches move, whistling

Precipitation Codes:

0 = None

1 = Mist

2 = Light rain or drizzle

3 = Heavy rain

4 = Snow/hail

Sky Codes:

0 = Sunny/clear to few clouds (0-5%)

1 = Mostly sunny (5-25% cloud cover)

2 = Partly cloudy, mixed variable sky (25-50%)

3 = Mostly cloudy (50-75%)

4 = Overcast (75-100%)

5 = Fog or haze

Global and State Element Ranking Criteria

GLOBAL RANKS

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

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

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

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

G5 = secure: common; widespread.

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

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

G? = incomplete data.

STATE RANKS

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

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

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

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

S5 = common and widespread in the state.

SX = community is presumed to be extirpated from the state. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered.

S? = incomplete data.

Appendix 6. List of bird species detected during 57 point counts conducted in forested areas of Middleville State Game Area during 2014. State status (T = threatened, SC = special concern) and the proportion of points having detections are provided for each species. Bird species considered as Michigan DNR featured species, Michigan DNR focal species, species of greatest conservation need (SGCN), and focal species of the Upper Mississippi River and Great Lakes Region Joint Venture (JV) are indicated with an "X."

Common Name	Scientific Name	State Status	Featured Species	Focal Species	SGCN	JV Focal Species	Prop. of Points
Acadian flycatcher	*Empidonax virescens*				X		0.63
Alder flycatcher	*Empidonax alnorum*						0.02
American crow	*Corvus brachyrhynchos*						0.30
American goldfinch	*Spinus tristis*						0.12
American redstart	*Setophaga ruticilla*						0.26
American robin	*Turdus migratorius*						0.23
Black-capped chickadee	*Poecile atricapillus*						0.37
Blue jay	*Cyanocitta cristata*						0.30
Blue-gray gnatcatcher	*Polioptila caerulea*						0.14
Blue-headed vireo	*Vireo solitarius*						0.02
Blue-winged warbler	*Vermivora cyanoptera*				X	X	0.05
Brown creeper	*Certhia americana*						0.02
Brown-headed cowbird	*Molothrus ater*						0.44
Canada goose	*Branta canadensis*						0.02
Cedar waxwing	*Bombycilla cedrorum*						0.18
Cerulean warbler	*Setophaga cerulea*	T		X	X	X	0.04
Chipping sparrow	*Spizella passerina*						0.05
Common grackle	*Quiscalus quiscula*						0.02
Common yellowthroat	*Geothlypis trichas*						0.02
Downy woodpecker	*Picoides pubescens*						0.33
Eastern towhee	*Pipilo erythrophthalmus*				X		0.09
Eastern wood-pewee	*Contopus virens*						0.84
Field sparrow	*Spizella pusilla*				X		0.02
Gray catbird	*Dumetella carolinensis*						0.05
Great crested flycatcher	*Myiarchus crinitus*						0.14
Hairy woodpecker	*Picoides villosus*						0.14
Hooded warbler	*Setophaga citrina*	SC			X		0.32
Indigo bunting	*Passerina cyanea*						0.18
Mourning dove	*Zenaida macroura*						0.05
Northern cardinal	*Cardinalis cardinalis*						0.35
Northern flicker	*Colaptes auratus*				X		0.07
Ovenbird	*Seiurus aurocapilla*						0.51
Pileated woodpecker	*Dryocopus pileatus*		X				0.16
Purple martin	*Progne subis*				X		0.02
Rose-breasted grosbeak	*Pheucticus ludovicianus*						0.44
Red-bellied woodpecker	*Melanerpes carolinus*						0.32
Red-eyed vireo	*Vireo olivaceus*						0.74
Red-tailed hawk	*Buteo jamaicensis*						0.04
Red-winged blackbird	*Agelaius phoeniceus*						0.04
Ruby-throated hummingbird	*Archilochus colubris*						0.09
Sandhill crane	*Grus canadensis*						0.12
Scarlet tanager	*Piranga olivacea*						0.54
Tufted titmouse	*Baeolophus bicolor*						0.63
Veery	*Catharus fuscescens*					X	0.18
White-breasted nuthatch	*Sitta carolinensis*						0.49
Wood thrush	*Hylocichla mustelina*		X		X	X	0.47
Yellow warbler	*Setophaga petechia*						0.18
Yellow-billed cuckoo	*Coccyzus americanus*				X		0.11
Yellow-throated vireo	*Vireo flavifrons*						0.30