Natural Features Inventory and Management Recommendations for Flat River State Game Area

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Cover Photo: Dry-mesic northern forest in Flat River State Game Area. Photo by Jesse M. Lincoln.

EXECUTIVE SUMMARY

Flat River State Game Area (SGA) is a large block of semi-continuous public land in southwest Lower Michigan, consisting of approximately 11,235 acres of Ionia and Montcalm Counties. Flat River SGA is important ecologically because it provides critical habitat for a myriad of game and non-game species and supports over 8,865 acres of forest and over 582 acres of high-quality forest, primarily lowland forest (hardwood-conifer swamp and floodplain forest). Because the landscape surrounding Flat River 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. In addition, the numerous and diverse wetlands, vernal pools, and lakes within the game area support a wide array of insect, herptile, avian, mammalian, plant, and aquatic species. Several creeks and a river pass through the game area and provide critical habitat for a diverse array of aquatic species.

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 Flat River SGA as part of the Integrated Inventory Project for the Michigan Department of Natural Resources (DNR) Wildlife Division.

Surveys resulted in 15 new element occurrences (EOs) and provided information for updating an additional ten EOs. In all, 23 species of greatest conservation need (SGCN) and 19 rare animal species have been recorded in Flat River SGA with 16 SGCN and ten rare animal species documented during the course of this project. In total, 35 EOs have been documented in Flat River SGA including 19 animal EOs, 3 plant EOs, and 13 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. Flat River SGA supports 13 high-quality natural community EOs. During the project, MNFI ecologists documented 11 new high-quality natural communities and also updated two known high-quality community EO. Seven different natural community types are represented in the 13 element occurrences surveyed including: bog (2 EOs), dry-mesic northern forest (1 EO), dry-mesic southern forest (2 EOs), floodplain forest (1 EO), hardwood-conifer swamp (5 EOs), hillside prairie (1 EO), and southern wet meadow (1 EO). 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.

Over the course of the project, three rare plant EOs were opportunistically documented. Two records for prairie buttercup (*Ranunculus rhomboideus*, state threatened) were updated and a new record for ginseng (*Panax quinquefolius*, state threatened) was documented.

In 2015, 172 potential vernal pools were identified and mapped from aerial photo interpretation, and 26 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 game area, 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 raptors. We conducted morning surveys for rare songbirds at 103 point-count locations within forest. These surveys resulted in updated records for two rare songbird species that occur in Flat River SGA: hooded warbler (*Setophaga citrina*, state special concern) and Louisiana waterthrush (*Seiurus motacilla*, state threatened). Rare raptor surveys were completed at 81 points resulting in the documentation of a new EO for red-shouldered hawk (*Buteo lineatus*, state threatened). Point-count surveys resulted in the documentation of 71 bird species including four SGCN: hooded warbler, Louisiana waterthrush, red-shouldered hawk, and red-headed woodpecker (*Melanerpes erythrocephalus*). A total of four rare bird species have been documented in the game area with three being recorded during the 2015 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. During the course of the project, two reptile EOs were updated, Blanding's turtles (*Emydoidea blandingii*, state special concern) and 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 three additional SGCN: pickerel frog (*Lithobates palustris*), blue racer (*Coluber constrictor foxii*), and northern ribbonsnake (*Thamnophis sauritus septentrionalis*). A total of five amphibian and reptile SGCN have been documented in the Flat River SGA, with all five being recorded during this project. In addition, two rare herptile species have been documented in the game area with both species being recorded in 2015.

Seven insect EOs of seven different rare insect species have been documented from Flat River SGA including Karner blue (*Lycaeides melissa samuelis*, federally endangered and state threatened), persius dusky wing (*Erynnis persius*, state threatened), swamp metalmark (*Calephelis mutica*, state special concern), regal fritillary (*Speyeria idalia*, state endangered and possibly extirpated from the state), Ottoe skipper (*Hesperia ottoe*, state threatened), Henry's elfin (*Incisalia henrici*, state threatened), and Great Plains spittlebug (*Lepyronia gibbosa*, state endangered). Karner blue, persius dusky wing, swamp metalmark, Ottoe skipper, and Great Plains spittlebug are currently listed as SGCN and Karner blue is a focal species of the DNR's Wildlife Action Plan. Black light surveys for rare insects in 2015 were focused on rare moths. No rare insect species were documented during the course of these surveys. However, Karner blue were documented in 2015 during a concurrent project focused on Karner blue.

We performed surveys for unionid mussels at 13 sites in the Flat River SGA with four sites in the Flat River main stem, seven in Dickerson Creek, and two in Wabasis Creek. A total of 13 unionid mussel species were found in this survey including five rare mussels and seven SGCN. Results included new EOs for eastern pondmussel (*Ligumia nasuta*, state endangered), round pigtoe (*Pleurobema sintoxia*, state special concern), and ellipse (*Venustaconcha ellipsiformis*, state special concern), and updating EOs for slippershell (*Alasmidonta viridis*, state threatened) and rainbow (*Villosa iris*, state special concern). Aquatic surveys in 2015 also documented two additional SGCN: cylindrical papershell (*Anodontoides ferussacianus*) and creek heelsplitter (*Lasmigona compressa*). Flat River SGA supports five rare mussel species and a total of eight aquatic SGCN.

Primary management recommendations for the Flat River SGA include 1) invasive species control focused in high-quality ecosystems, 2) the maintenance of the canopy closure of mature upland and lowland forest ecosystems, 3) the reduction of fragmentation and promotion of connectivity across the game area but focused in the vicinity of riparian corridors, 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, barrens, and prairie 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.

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, Steve Chadwick, Mark MacKay, Mark Sargent, John Niewoonder, Donna Jones, Maria Albright, and Jesse Bramer. Donna Jones and John Niewoonder conducted Integrated Forest Monitoring, Assessment, and Prescription System Stage 1 inventory in Compartments 1 and 2 and also provided information about rare species locations. Holly Vickers with the Michigan Department of Environmental Quality assisted with aquatic surveys. This report relies on data collected by many present and former Michigan Natural Features Inventory (MNFI) field scientists, especially: Gary Reese, Dennis Albert, and Bradford Slaughter. Additional assistance with field surveys was provided by Eric McCluskey. For their support and assistance throughout this project, we thank our MNFI colleagues, especially Rebecca Rogers, Ed Schools, Kraig Korroch, Sue Ridge, Nancy Toben, and Brian Klatt.

Jesse Lincoln fording Dickerson Creek. Photo by Joshua G. Cohen.

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INTRODUCTION

Flat River State Game Area (SGA) is a large block of semi-continuous public land in southwest Lower Michigan, consisting of approximately 11,235 acres of Ionia and Montcalm Counties. Flat River SGA is important ecologically because it provides critical habitat for a myriad of game and non-game species and supports over 8,865 acres of forest. Because the landscape surrounding Flat River 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 (Figure 1). In addition, the numerous and diverse high-quality wetlands, vernal pools, lakes, and streams within the game area support a wide array of insects, herptiles, avian, mammalian, plant, and aquatic species. Several creeks and a river pass through the game area and provide critical habitat for a diverse array of aquatic species. Flat River SGA's forested ecosystems and the wetlands nested within the forested matrix support several rare herptiles, avian, and plant species. Within Ionia and Montcalm Counties, natural cover constitutes 28% and 44% of the counties, respectively. In comparison, natural cover constitutes approximately 92% of Flat River SGA. Prior to this project, numerous rare species and high-quality natural communities had been documented in Flat River SGA (Tables 1-6). Before 2012, 18 element occurrences (EOs) had been documented for Flat River SGA composed of 16 rare species occurrences and two high-quality natural communities. Of those rare species occurrences, two were rare plant EOs, three were bird EOs, seven were insect EOs, two were rare herptiles, and two were aquatic EOs. Seventeen species were represented by these occurrences and two natural community types (Tables 1-6).

From 2012 to 2015, 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 Flat River 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 Flat River SGA, summarizes the findings of MNFI's surveys of Flat River SGA for high-quality natural communities and rare animal species, and discusses stewardship needs, opportunities, and priorities within the game area. The focus of this project and this report is on native biodiversity with an emphasis on rare species and high-quality ecosystems. Biodiversity stewardship considerations are included in the report and we acknowledge that the DNR manages for multiple values including wildlife management, hunting and other wildlife related recreation, as well as biodiversity and that the report does not necessarily reflect the planned management actions of the DNR. Specific management recommendations are provided for rare species and groups of rare species and 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**. Flat River SGA lies within two sub-subsections of the Ionia subsection (Subsection VI.4). The majority of the game area occurs within Greenville Moraines (Sub-Subsection VI.4.2) with just the eastern margin containing the Lansing Till Plain (Sub-Subsection VI.4.1) (Figure 2).

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 glacial outwash, 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 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.4.1), the largest sub-subsection in Lower Michigan, consists of rolling, loamy till plain or ground moraine and narrow bands of loamy end moraine (Figures 2 and 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

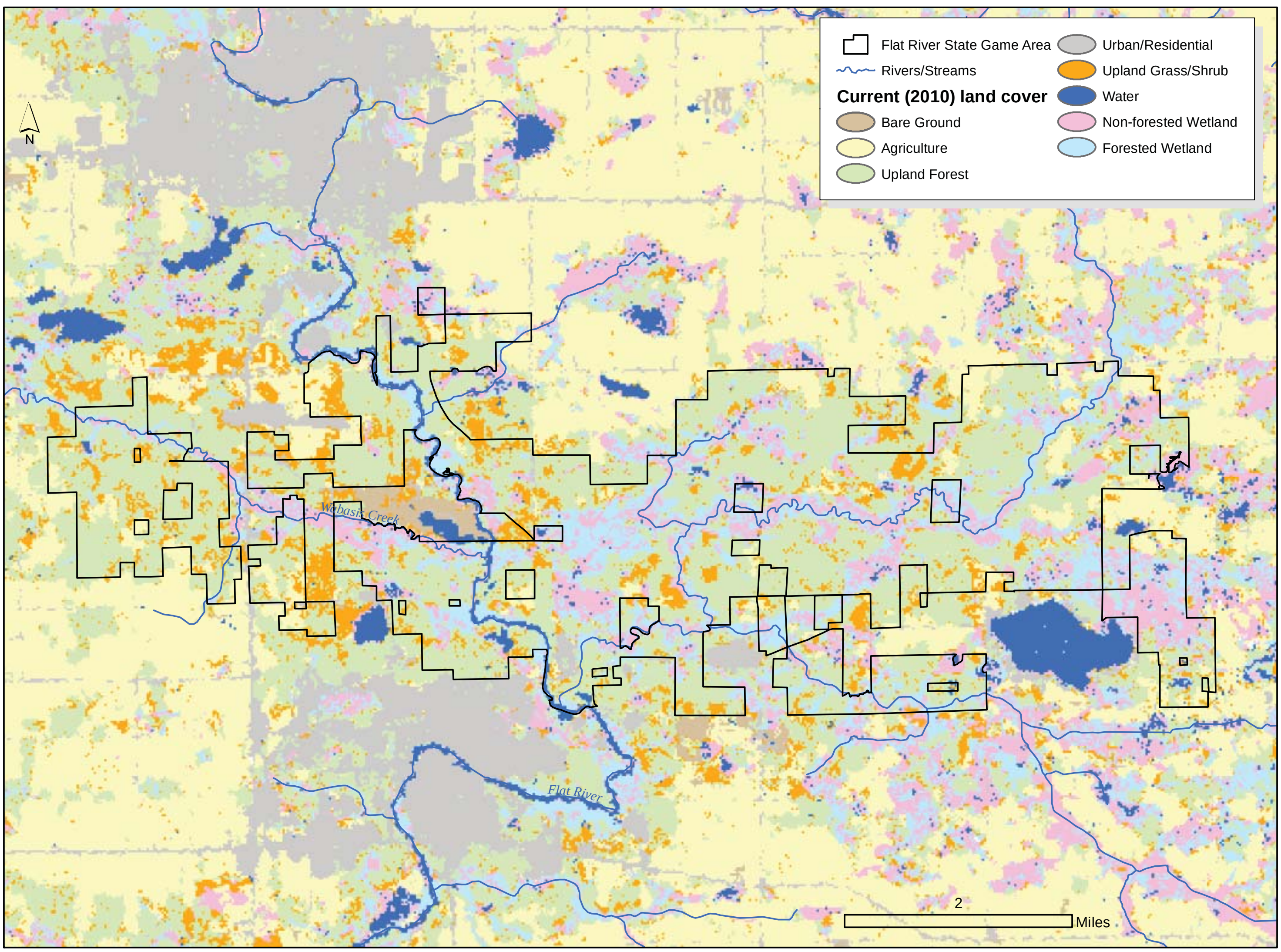


Figure 1. Current land cover of Flat River State Game Area.

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).

<u>Greenville Moraines</u>

The Greenville Moraines (VI.4.2) is characterized by coarse-textured end and ground moraines with localized areas of sandy glacial outwash (Figures 2 and 3). The terrain of the sub-subsection is generally hilly and dissected by outwash channels. The hills, up to 43 meters (140 ft) high, are moderately to steeply sloping. Both the ground moraine and end moraine are moderately to steeply sloping, but the ground moraine ridges are generally smaller than those of the end moraine. Streams within the sub-subsection occupy glacial outwash channels and numerous small kettle lakes, typically less than one square mile in area, are found on outwash, end moraine, and ground moraine. Soils are well drained and excessively drained sands and loamy sands on the uplands. Sand outwash deposits are common in lower slope positions and the majority of the outwash soils are poorly drained with shallow organics overlying sands. Historically, the upland vegetation was a mosaic of beech-sugar maple and oak-hickory forests. Oak-hickory forest was more common at the southern edge of the sub-subsection, whereas beech-sugar maple forest was more common to the north. This pattern was likely the result of gradual climatic changes that occur as the terrain rises northward into the adjacent

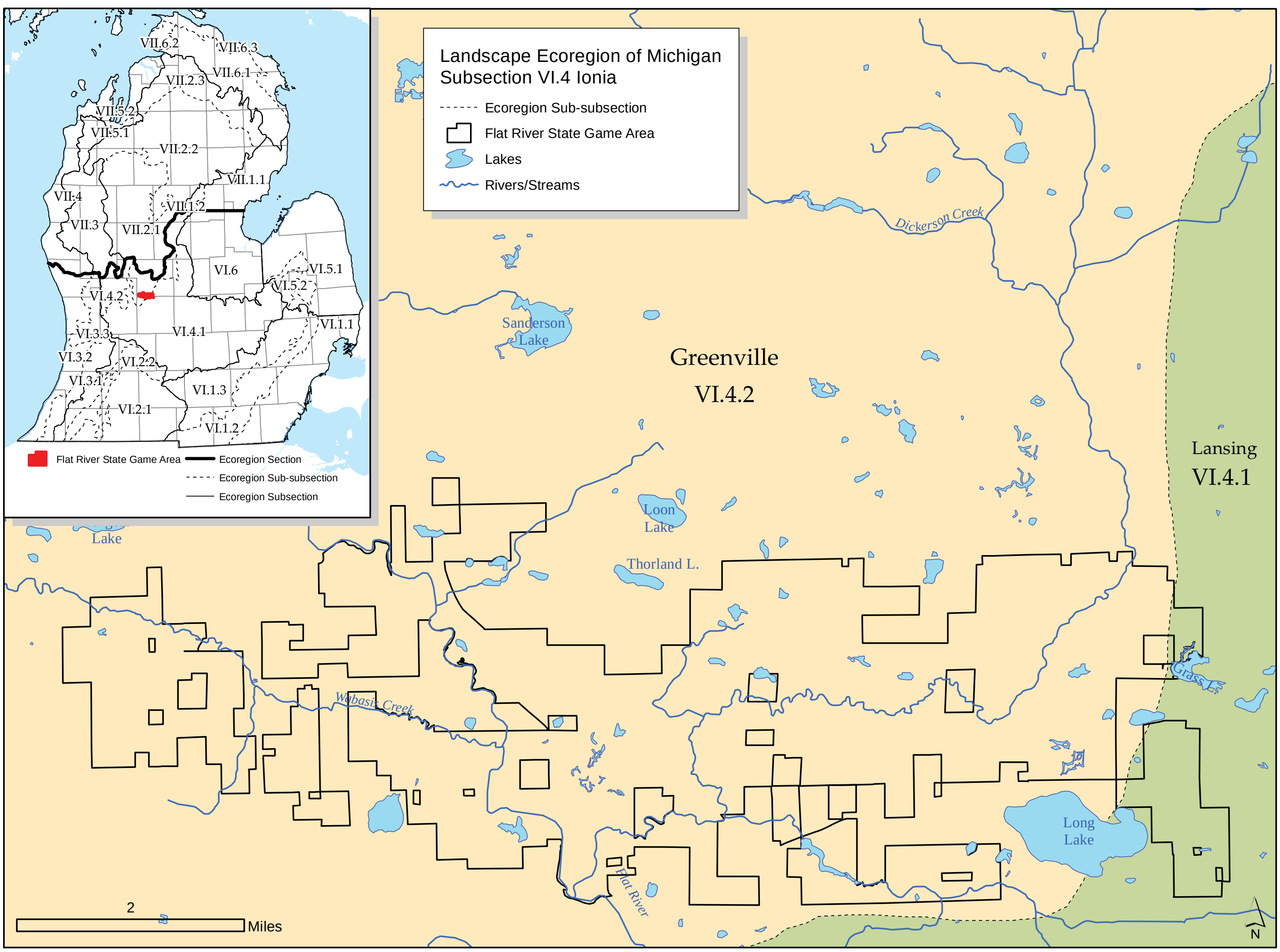


Figure 2. Ecoregions of Flat River State Game Area (Albert 1995)

Highplains Subsection (VII.2). White pine (*Pinus strobus*) was originally locally common on the drier upland sites, often growing with white oak (*Quercus alba*) in either open forests or savannas. Fires were probably important for maintaining these oak-pine and oak forests and savannas. Gap-phase dynamics or small-scale wind events were the primary driver in the closed-canopy mesic forests. The lowland vegetation contained elements of both deciduous hardwood swamp and hardwoodconifer and conifer swamps. Most of the swamp forests in the outwash channels were hardwoodconifer swamps containing hemlock (*Tsuga canadensis*), balsam fir (*Abies balsamea*), northern whitecedar (*Thuja occidentalis*), white pine, trembling aspen (*Populus tremuloides*), and paper birch (*Betula papyrifera*). Today, the sandy moraines of this sub-subsection remain largely forested, with oak-dominated forests most common. White pine-white oak forests have been largely eliminated and most oak savannas have closed in to become oak and oak-hickory forests. Most wetlands within the sub-subsection have not been significantly impacted by agricultural activities and many of the wetlands remain intact. Portions of this sub-subsection were farmed, both for row crops and pasture following logging, but much of the farmland has been abandoned due to low productivity and cold climate. Most agricultural activities in this sub-subsection have been concentrated in the uplands with the richest soils (Albert 1995).

Circa 1800 Vegetation

Interpretations of the General Land Office (GLO) surveyor notes by MNFI ecologists indicated that the Flat River 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 Flat River SGA. Circa 1800, the game area was predominantly forested with 57% of the area supporting forested ecosystems including White Pine-White Oak Forest (38%), Mixed Oak Forest (11%), White Pine-Mixed Hardwood Forest (7%), Oak-Hickory Forest (4%),

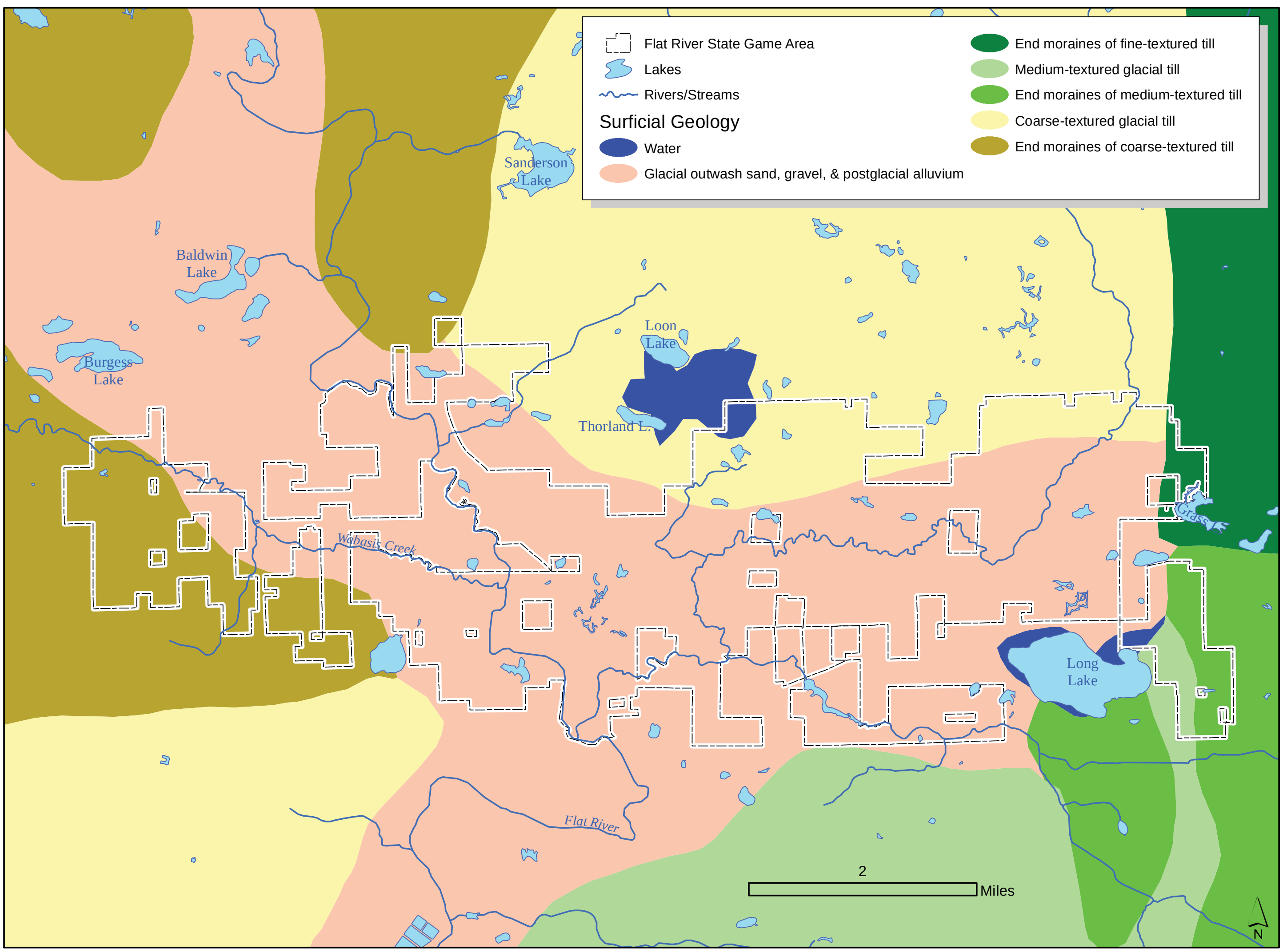


Figure 3. Surficial geology and relief of Flat River State Game Area (Farrand and Bell 1982, USGS 2009).

and Beech-Sugar Maple Forest (1%). A significant portion of the game area (25% of the area) supported savanna or barrens ecosystems including Black Oak Barren (13%), Mixed Oak Savanna (11%), and Oak-Pine Barrens (1%). Outwash channels and depressions historically supported forested swamps (16% of the area) with both Mixed Hardwood Swamp (8%) and Mixed Conifer Swamp (8%) occurring in the game area. The remainder of the game area (2% of the area) was characterized by open wetlands and lakes.

Forested systems were found on the rolling ground moraines and steep end moraines that occur throughout the game area. The most prevalent tree species recorded in this area by the GLO surveyors in the forested uplands were white oak (overwhelmingly the most common tree noted) and white pine (the second most common tree noted). Less frequently recorded trees were American beech (*Fagus grandifolia*), aspens (*Populus* spp.), maples (*Acer* spp.), basswood (*Tilia americana*), and oaks (*Quercus* spp.) including black oak (*Q. velutina*), bur oak (*Q. macrocarpa*), chinquapin oak (*Q. muehlenbergii*), and red oak (*Q. rubra*). Within the areas classified as upland forest, recorded diameters of trees ranged widely from 10 to 122 cm (4 to 48 in) with an average of 41 cm (16 in) (N = 325).

Within southern Michigan, oak savanna and barrens was common on areas of well-drained gently sloping moraine and outwash and localized on slopes with southern and western aspects. Within southern Michigan, oak savanna and oak forest and oak-pine barrens and oak-pine forest occurred in a shifting forest-savanna/barrens mosaic that varied in time and space depending on the frequency and intensity of fire disturbance events. Although mapped as predominantly forest on the circa 1800 map, much of the game area likely transitioned to and from forest to savanna/barrens over long periods of time. Small pockets of prairie inclusions likely occurred within this savanna/ barrens matrix. Repeated low-intensity fires, working in concert with drought and windthrow, maintained open

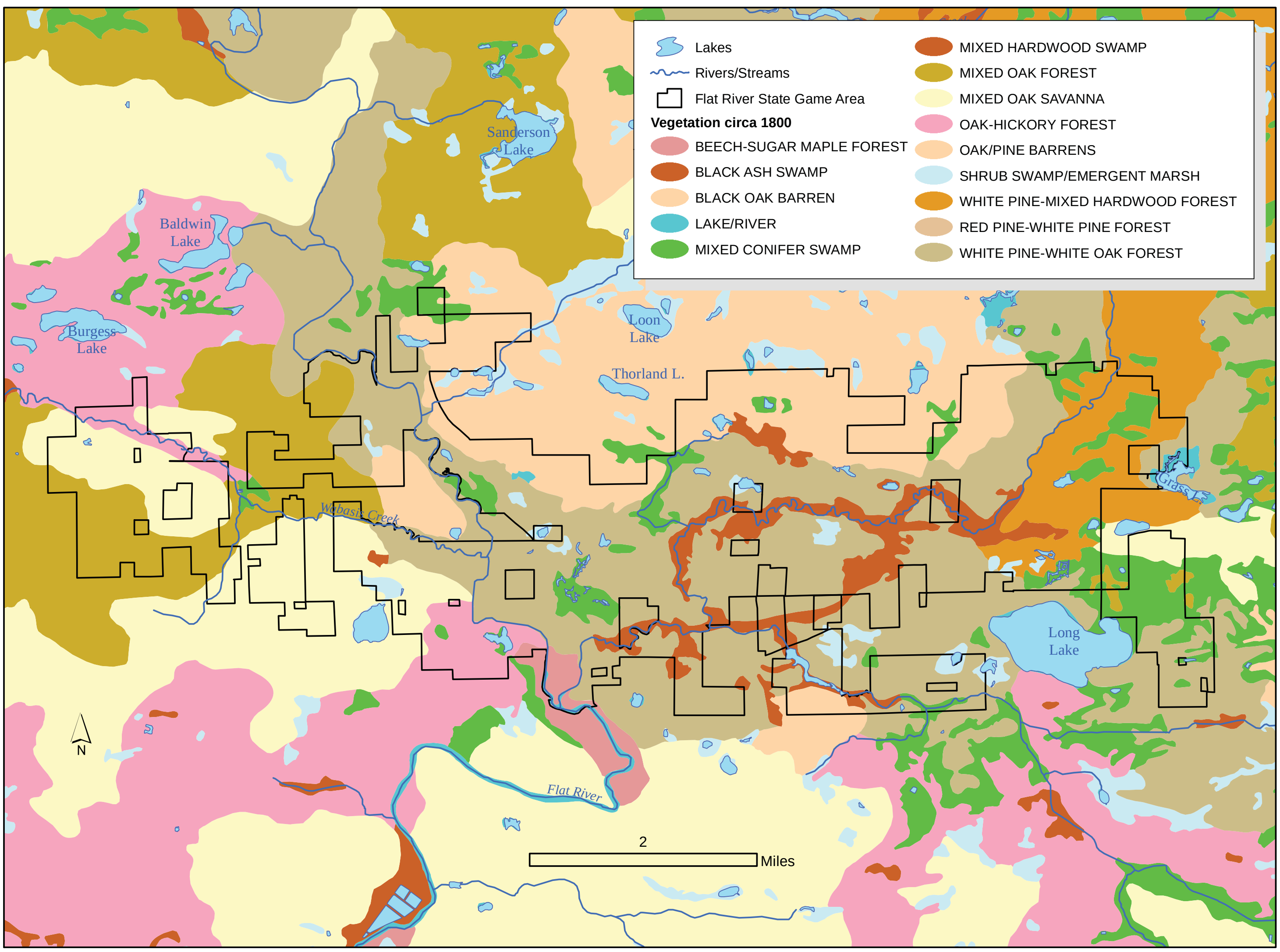


Figure 4. Circa 1800 vegetation of Flat River State Game Area (Comer et al. 1995).

conditions in these savanna/barrens 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 southern Michigan, Native Americans probably played a significant role in maintaining savanna/barrens 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. Sizable areas mapped as savanna or barrens occur in the northern, eastern, and western portions of the game area (Figure 4). The oak openings, oak barrens, and oak-pine barrens within and adjacent to the game area were characterized by scattered white oak as the overwhelming canopy dominant. In areas of oak-pine barrens, white pine was an important canopy associate. Additional canopy associates within the savanna and barrens included chinquapin oak, bur oak, black oak, and aspens. Within these savanna and barrens areas, recorded diameters of canopy trees ranged from 10 to 91 cm (4 to 36 in) with an average of 34 cm (14 in) (N = 176).

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 channels, and along lower slopes of moraines (Figure 4). Circa 1800 wetland cover types included Mixed Conifer Swamp (8% of the game area), Mixed Hardwood Swamp (8% of the game area), and Shrub Swamp/Emergent Marsh (2%). The Mixed Conifer Swamp class likely included rich tamarack swamp and hardwood-conifer swamp. Where the surveyors noted canopy composition of these swamps, tamarack (*Larix laricina*), white pine, maples (*Acer* spp.) and black ash (*Fraxinus nigra*) were prevalent canopy dominants with conifers more abundant in the Mixed Conifer Swamps and hardwoods more common in the Mixed Hardwood Swamps. Additional canopy associates included American elm (*Ulmus americana*), poplars (*Populus* spp.), and basswood. Within these forested swamps, recorded diameters of canopy trees ranged from 15 to 101 cm (6 to 40 in) with an average of 33 cm (13 in) (N = 45). MNFI's open wetland classification for the circa 1800 map is very broad because within these systems the surveyors gathered limited information; this paucity of data 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, and emergent marsh.

Current Land Cover

The land cover within the Flat River 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 Flat River 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, white pine, and sugar maple being harvested. In addition, where forests and wetlands occurred adjacent to agricultural lands, grazing was prevalent. Much of the game area consists of 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 or were converted to conifer plantations.

Current land cover in Flat River SGA is dominated by upland forest (63% of the game area) (Figure 1). This forest is primarily composed of mixed oak forest (dry-mesic southern forest), oak-conifer forest (dry-mesic northern forest), and early-successional forest. IFMAP stand types delineated in Flat River SGA that fall within the broad class of upland forest include Oak Types (26%), Mixed Upland Deciduous (16%), Aspen Types (8%), Planted Pines (8%), Northern Hardwoods (1.6%), Upland Mixed Forest (1.3%), White Pine (<1%), Upland Conifers (<1%), and Natural Mixed Pines (< 1%). These forests occur throughout the game area and are especially prevalent on rolling ground moraine and moderate to steep end moraine. Conifer plantations and mixed conifer forest are notably prevalent on the droughty soils and likely correspond to areas of former barrens. The majority of these forested systems within Flat River SGA are early-successional forest with over 78% of the total forested acreage being less than 100 years old and only 22% 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, many of the areas that once supported oak savanna, oak barrens, and oak-pine barrens 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-pine 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 significant portion of the game area (approximately 14%) is composed of open uplands that include Herbaceous Openland (9%), Low-Density Trees (3%), Upland Shrub (2%), Sand, Soil (<1%), and Bare/Sparsely Vegetated (<1%). Much of this open upland is likely abandoned agricultural lands and also likely formerly savanna or barrens.

Wetlands remain an important component of the game area with forested wetlands accounting for 15%, open wetlands accounting for 7%, and open water accounting for approximately 1% of the area. IFMAP stand types delineated in Flat River SGA that fall within the broad class of lowland forest include Lowland Deciduous (12%), Lowland Mixed Forest (1%), Lowland Aspen/Balsam Poplar (<1%), Lowland Conifers (<1%), and Tamarack (< 1%). These lowland forests occur throughout the game area and are especially prevalent along outwash channels, within depressions, and along the lower slopes of moraines. The majority of these lowland forested systems within Flat River SGA are early-successional forest with over 82% of the total forested acreage being less than 100 years old and only 18% being over 100 years. Open wetland types delineated in Flat River SGA by IFMAP stage 1 inventory include Lowland Shrub (4%), Marsh (2%), Bog (< 1%), and Treed Bog (< 1%). Wetlands throughout Flat River 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 small portion of Flat River SGA supports high-quality natural communities. In addition, compared to the surrounding fragmented landscape, Flat River SGA is characterized by a significant portion of natural cover. As noted above, 92% of the game area is natural cover. In comparison, only 31% of the Ionia subsection (VI.4) is natural cover. Prior to the 2014 survey effort, two natural community element occurrences (EO), a bog and a dry-mesic southern forest, were documented within Flat River SGA (Table 1). Surveys in 2014 and 2015 identified an additional eleven natural community EOs including bog (1 EO), dry-mesic northern forest (1 EO), dry-mesic southern forest (1 EO), floodplain forest (1 EO), hardwood-conifer swamp (5 EOs), hillside prairie (1 EO), and southern wet meadow (1 EO). These natural community EOs will be described in detail within the **Natural Community Results** section. Documented high-quality natural communities constitute close to 6% of Flat River SGA.

Forested wetlands are an important component of the Flat River State Game Area, accounting for 15% of the area. Photo by Joshua G. Cohen.

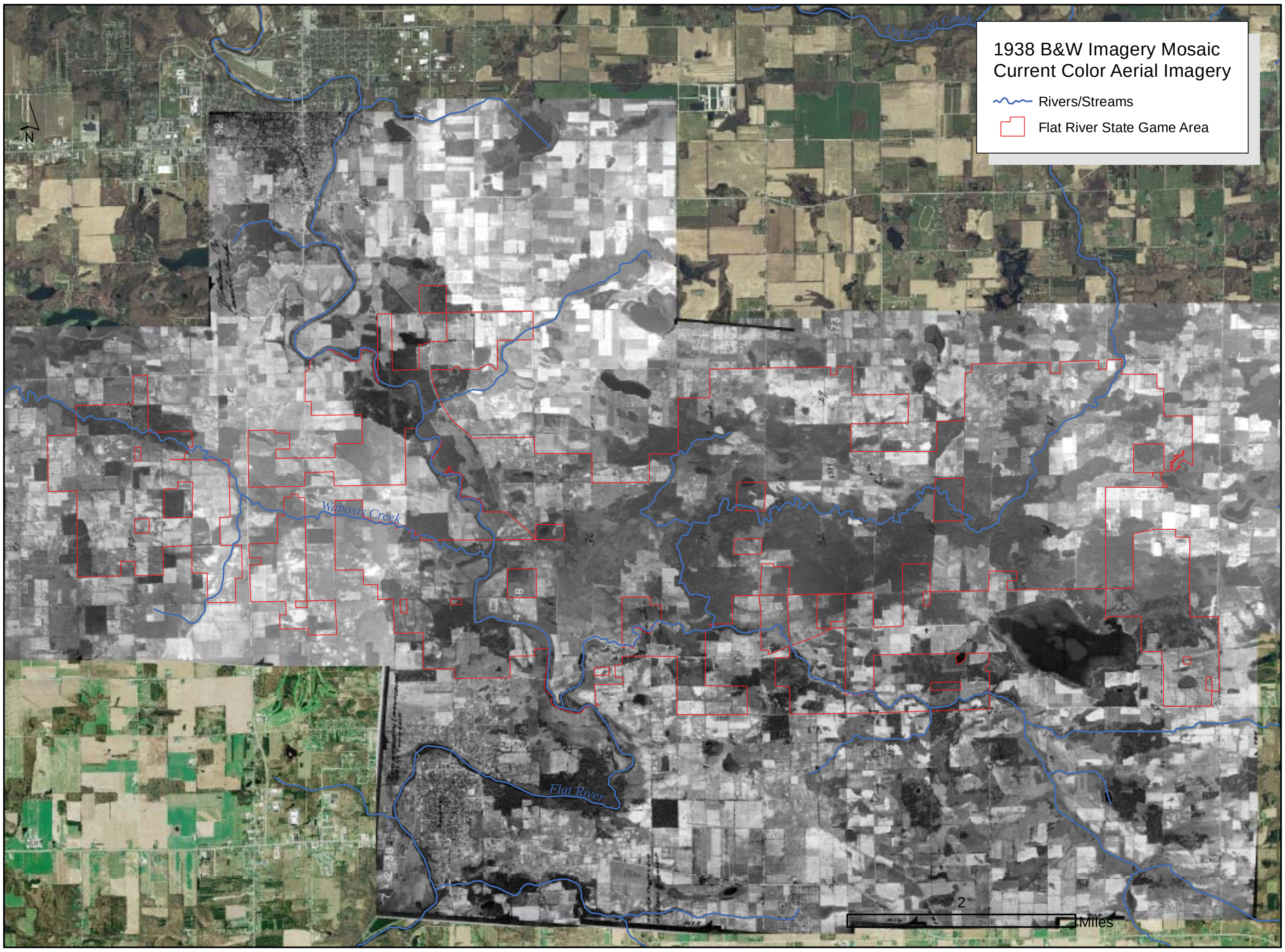


Figure 5. Mosaic of 1938 aerial photographs of Flat River State Game Area (MNFI 2014).

Current land cover in Flat River State Game Area is dominated by upland forest (63% of the game area) that is primarily composed of mixed oak forest, oak-conifer forest (dry-mesic northern forest pictured above), and early-successional forest. Photo by Jesse M. Lincoln.

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, Faber-Langendoen et al. 2015). If a site meets defined requirements for these three criteria (MNFI 1988) it is categorized as a high-quality example of that specific natural community type, entered into MNFI's database as an 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 (primarily from June to August of 2014) 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 2016a). 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 or wetlands 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). Although wood frogs, spotted salamanders, and blue-spotted salamanders can reproduce in wetlands other than vernal pools, successful production of juveniles may be much higher in vernal pools than in other wetlands that have permanent populations of fish or other predators. The eggs and/or larvae of these species appear to be more palatable to fish and other predators because they lack defense mechanisms (e.g., toxic compounds, mechanical or physiological barriers, behavioral responses) that protect them from predators (Grubb 1972, Kruse and Francis 1977, Formanowicz and Brodie 1982, Woodward 1983, Kats et al. 1988). Some species, such as wood frogs, will actually avoid breeding in habitats with fish (Hopey and Petranka 1994). Fairy shrimp occur only in waters that are free of fish populations, and spend their entire lives in a single vernal pool (Colburn 2004). Their eggs may require drying, flooding, and freezing to successfully hatch, and can survive in the sediment for several years (Colburn 2004).

Vernal pools also provide habitat for a number of other animal and plant species, including snakes, turtles, waterfowl, wetland birds, woodland birds, and mammals. Over 550 animal species have been found in vernal pools in the northeastern U.S. (Colburn 2004). Many animal species use vernal pools for food and water throughout the growing season, as breeding and nursery areas for development of their young, and as resting areas and stepping stones to travel to other areas with suitable habitat (Gibbs 1993, Semlitsch and Bodie 1998, Gibbs 2000, Mitchell et al. 2008). These species include white-tailed deer (*Odocoileus virginianus*), black bear (*Ursus americanus*), raccoon (*Procyon lotor*), great blue heron (*Area herodias*), wood duck (*Aix sponsa*), American black duck (*Anas rubripes*), barred owl (*Strix varia*), wild turkey (*Meleagris gallopavo*), American woodcock (*Scolopax minor*), painted turtle (*Chrysemys picta*), snapping turtle (*Chelydra serpentina*), eastern gartersnake (*Thamnophis sirtalis sirtalis*), northern ribbonsnake (*Thamnophis sauritus septentrionalis*), and northern watersnake (*Nerodia sipedon*) (Colburn 2004, Calhoun and deMaynadier 2008). Several endangered, threatened, or rare species in Michigan use vernal pools extensively, such as the state special concern Blanding's turtle (*Emydoidea blandingii*), state threatened spotted turtle (*Clemmys guttata*), state endangered small-mouthed salamander (*Ambystoma texanum*), 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).

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. 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, although they have been afforded some protection under the State of Michigan's recommended sustainable soil and water quality practices on forest land and the Sustainable Forestry Initiative (SFI) and Forest Stewardship Council's forest certification standards (Michigan Department of Natural Resources and Michigan Department of Environmental Quality 2009, Sustainable Forestry Initiative 2010, Forest Stewardship Council 2010). Additionally, limited information is available on their status, distribution, and ecology in the state. This information is critical for management and conservation of vernal pools in Michigan.

Potential and verified vernal pools were identified and mapped in Flat River SGA in 2015 using remote sensing and field sampling (Figure 6). 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. Knowing where vernal pools are located in the game area and the species and habitats found in and around them will help managers plan and implement appropriate management and protection of these 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 amphibian and reptile species targeted for surveys in 2015.

Potential vernal pools (PVPs) were identified and mapped across the game area using aerial photograph interpretation (Figure 6). 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 consisted of using ESRI ArcGIS software to visually examine available aerial imagery and other 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 summers of 2005, 2010, and 2012 (USDA-FSA Aerial Photography Field Office 2016). Topographic maps of the game area also were examined. 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 for spatial extent of the aerial 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 preliminary information about these polygons was included in the geodatabase.

A subset of the PVPs mapped in the game area was surveyed from May 3rd through September 16th, 2015 to verify, map, and collect data on vernal pools in the field (Figure 6). These surveys were primarily conducted during surveys for rare amphibians and reptiles. Most potential vernal 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 or has been destroyed; 3) visited in the field but status still uncertain or insufficient information; 4) visited in the field and is not a vernal pool or is some other wetland type; and 5) visited in the field and is not a vernal pool and no water is 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 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: 1) open pools; 2) sparsely vegetated pools; 3) shrubby pools, 4) forested pools, 5) marsh pools, and 6) 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 the Michigan Vernal Pool Database (MNFI 2016b), a statewide vernal pool geodatabase with locational information and ecological data about potential and field-verified vernal pools.

Rare Animal Survey Methods

We identified rare animal target species for surveys using historical distribution within Michigan, past occurrences in or near Flat River 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 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 (Derosier et al. 2015).

Bird Surveys

Given the presence of tracts of mature forest and results of previous surveys, we focused bird surveys in the game area on rare songbird species and rare raptors. Rare raptor surveys focused on red-shouldered hawk (*Buteo lineatus*, state threatened) and northern goshawk (*Accipiter gentilis*, state special concern), both DNR featured species. Contiguous forest stands at least 4 ha (10 ac) in area were considered potential habitat for target species. We generated a 250 m X 250 m grid of possible survey points that was overlaid over the potential survey stands. Raptor and songbird surveys were conducted at those points falling within the potential survey stands. Points were assigned unique identification numbers and uploaded to a GPS unit for field location. One-hundred sixty-two possible points were identified for Flat River SGA stands. In addition to surveying for rare raptors and songbirds, point-count sampling was used to gather baseline information about the forest bird community, including relative abundance and species richness.

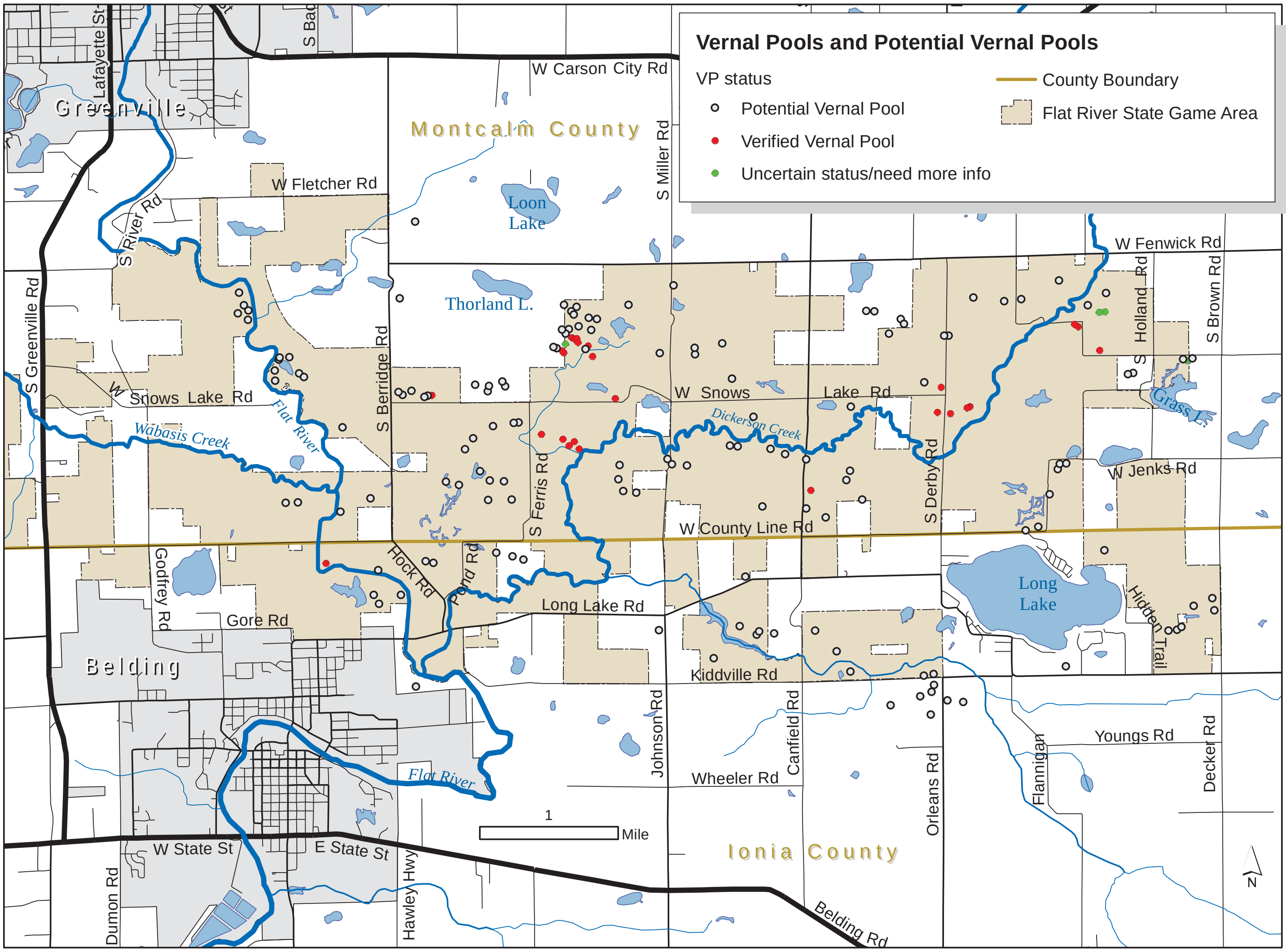


Figure 6. Potential vernal pools and verified vernal pools in Flat River State Game Area.

We conducted three minute raptor surveys at systematically located point-count stations (Figure 7) (Mosher et al. 1990, Anderson 2007, Bruggeman et al. 2011). Each three minute point count consisted of two minutes of broadcasts (one minute for red-shouldered hawk and one minute for northern goshawk) and one minute of silent listening. Surveys were conducted during April 15th to May 14th, 2015. At each station the following data were recorded: whether or not a red-shouldered hawk or northern goshawk was detected; all other raptor sightings or vocalizations; other bird observations; and other rare animal species detections or potential habitats. If a rare raptor was observed, the vicinity surrounding the point was searched for potential nests. While walking and driving between station locations, we also visually inspected trees for stick nests.

We targeted forest bird surveys toward detecting cerulean warbler (*Dendroica cerulea*, state threatened), hooded warbler (*Setophaga citrina*, state special concern), and Louisiana waterthrush (*Seiurus motacilla*, state threatened), which had all been previously recorded in the game area (Table 3). Forest bird point counts were conducted at the same systematically located points used for raptor surveys (Figure 7). 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 2nd to July 30th, 2015 between sunrise and four hours after sunrise. In addition to surveying for these three rare species, we gathered data on all birds seen or heard during each 10 minute point count. We recorded the species and number of individuals observed during three independent periods (2 min, 3 min, and 5 min) for a total of 10 minutes at each station (Ralph et al. 1995). Use of the three survey periods provides flexibility in making comparisons with other surveys (e.g., North American Breeding Bird Surveys) and commonly used protocols. Each bird observation was assigned to one of four distance categories (0-25 m, 25-50 m, 50-100 m, or >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

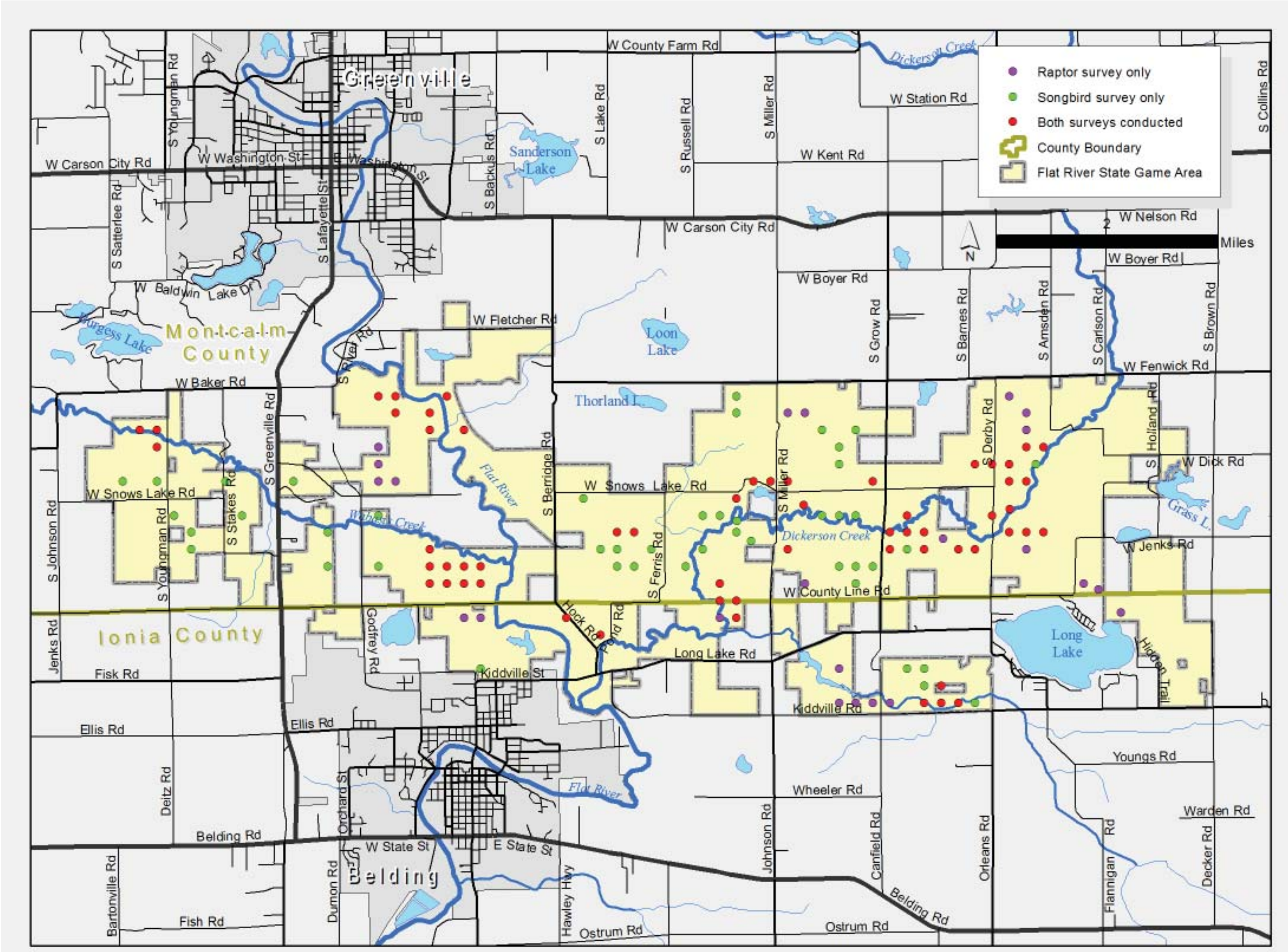


Figure 7. Locations of forest songbird and raptor point counts conducted in Flat River State Game Area in 2015.

point-count station, we noted if the site appeared suitable for cerulean warbler, hooded warbler, and Louisiana waterthrush and recorded any invasive plant species seen.

In addition to prior records within the game area for songbirds, two rare grassland birds were documented in the landscape surrounding Flat River SGA. Dickcissel (*Spiza americana*, state special concern) and grasshopper sparrow (*Ammodramus savannarum*, state special concern) are known from the surrounding area (Table 3). However, we did not conduct surveys for these two grassland birds because 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 Flat River SGA in 2015: 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), spotted turtle (*Clemmys guttata*, state threatened), and eastern massasauga (*Sistrurus catenatus*, state special concern and proposed as federally threatened) (Appendix 3). These species have been identified as Species of Greatest Conservation Need (SGCN) in Michigan's updated Wildlife Action Plan, with eastern massasauga and eastern box turtle identified as focal or priority SGCN for conservation actions (Derosier et al. 2015). These species were targeted for surveys because they had been previously documented in or near the game area, or they had potential to occur within the game area due to the species' range within the state and presence of suitable habitat for the species (Table 4). Surveys in 2015 also had potential for detecting several additional amphibian and reptile SGCN in Michigan's Wildlife Action Plan (Derosier et al. 2015) (Appendix 3). These included the pickerel frog (*Lithobates palustris*), eastern musk turtle (*Sternotherus odoratus*), blue racer (*Coluber constrictor foxii*), northern ribbonsnake (*Thamnophis sauritus septentrionalis*), and smooth green snake (*Opheodrys vernalis*) (Derosier et al. 2015). Visual encounter surveys, basking surveys, breeding frog call surveys, and dipnetting 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 sites at 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 and 2015.

Visual encounter surveys were conducted from May 3rd through September 16th, 2015 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 17 different areas with suitable habitats for target species within the Flat River SGA (Figure 8). Survey areas included 16 lowland or wetland stands (identified and mapped through stage 1 IFMAP inventory), 18 vernal pools, and 14 surrounding forested or open upland stands. Survey sites were visited one to four times during the field season. Visual encounter surveys were conducted during daylight hours and under appropriate weather conditions when target species were expected to be active and/or visible [i.e., between 60-80°F (16-27°C), 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 and rocks), inspecting retreats, and looking for basking, resting, and/or active individuals on the surface or under cover.

Basking surveys were conducted between May 3rd and September 16th, 2015 to search for Blanding's turtles and other turtles and snakes. We conducted basking surveys at six survey sites containing open and/or shrubby wetlands or waterbodies that appeared to provide suitable habitat for Blanding's turtles (Figure 8). Basking surveys were conducted during daylight hours and under appropriate weather conditions when target species were expected to be active and/or visible [i.e., between 60-80°F (16-27°C), wind less than 15 mph, no or light precipitation]. 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.

Breeding frog call surveys were conducted for Blanchard's cricket frog on June 12th, 2015. These surveys were completed at 20 sites throughout Flat River SGA and on adjacent private lands. Sites were comprised of permanent lakes and ponds and surrounding open wetlands located near roads (Figure 8). We conducted frog call surveys along roads in the evening or at night (5:30 PM to 1:00 AM) 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). All frog species heard calling during the survey were recorded.

Dipnetting surveys were conducted in eight vernal pools (Figure 8) to document amphibian species occurring in the pools. Surveys were focused particularly on vernal pool indicator species including the wood frog (*Lithobates sylvaticus*), blue-spotted salamander (*Ambystoma laterale*), and spotted salamander (*Ambystoma maculatum*). These species primarily breed in vernal pools (Harding 1997, Colburn 2004, Calhoun and deMaynadier 2008). Dipnetting surveys were conducted on May 3rd, 2015. Dipnetting consisted of using a small aquarium net to take multiple sweeps through the water column and along the substrate and cover objects (e.g., woody debris, emergent vegetation, and submergent vegetation) in the pools to try to capture adults and larvae of target species and other amphibians. Amphibian larvae were identified to the lowest taxonomic level possible. Invertebrates captured during dipnetting surveys also were identified if possible and recorded 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.

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 species were encountered and recorded spatial locations with a Garmin GPS or Ashtech unit. Whenever possible, photos of rare species and their habitat were taken for supporting documentation.

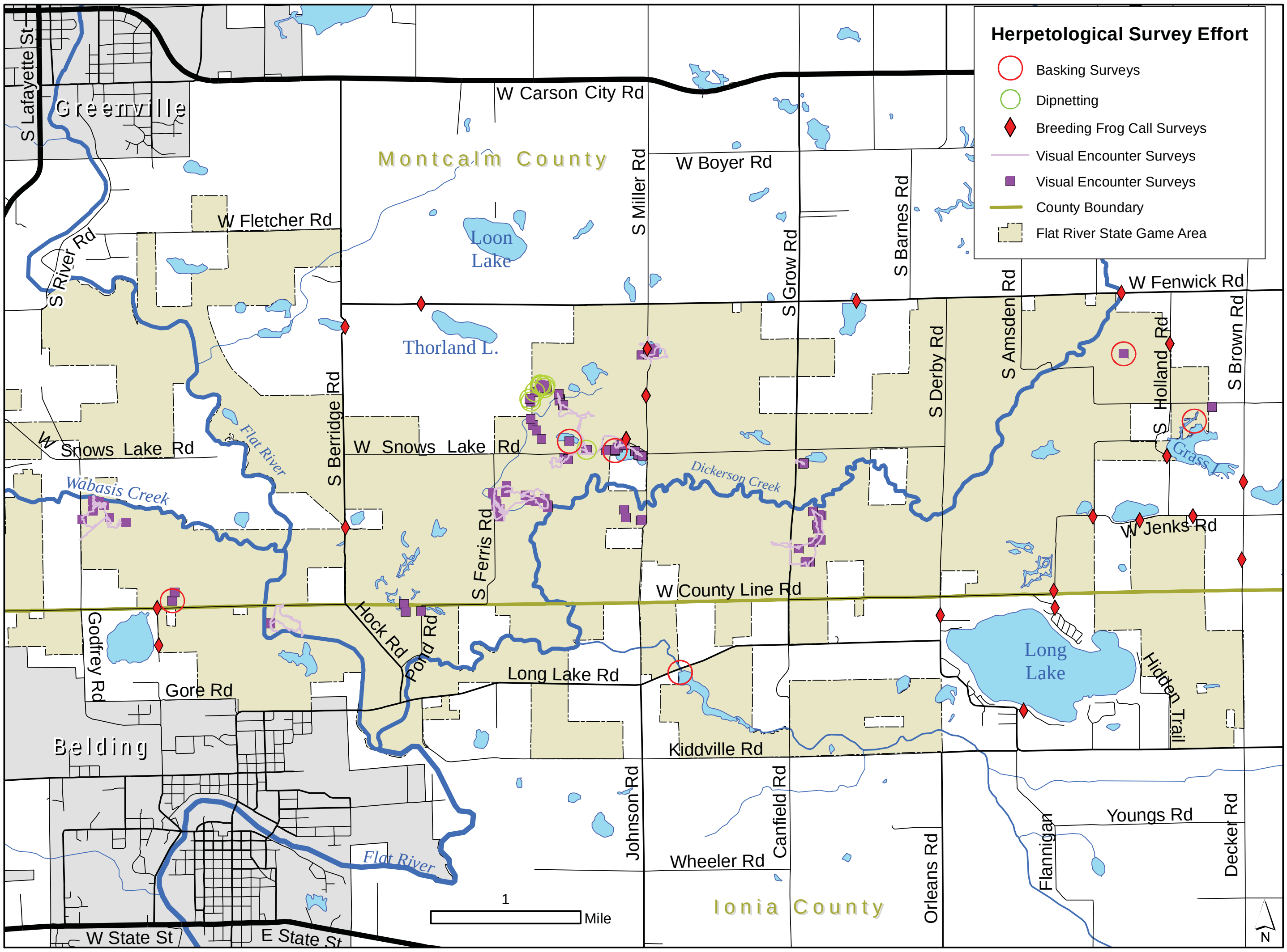


Figure 8. Locations of reptile and amphibian surveys conducted in and nearby Flat River State Game Area in 2015.

Insect Surveys

We identified rare insect target species using historical distribution within Michigan, past occurrences in or near Flat River SGA (Table 5), and the presence of potential remaining habitat within the game area determined by natural community element occurrences, IFMAP descriptions, aerial photography, and on-the ground knowledge of the game area from past surveys. We also did not choose to survey for the Karner blue (*Lycaeides samuelis*) for this project because a concurrent survey project addressed this survey need (Monfils and Cuthrell 2015). In addition, we did not to survey for species which we felt had been thoroughly surveyed for in the past and which we did not find occurrences (Persius duskywing, *Erynnis persius*) or where habitat had been clearly destroyed, eliminated, or modified (e.g., the Ottoe skipper, *Hesperia ottoe*, and swamp metalmark, *Calephelis mutica*).

Areas that received survey attention for rare moth surveys included those sites that supported remnant prairie or sites with a prairie plant component. Areas containing large patches of blazing star (*Liatris aspera* and/or *Liatris scariosa*) were identified at three locations within the game area. Moth species targeted included the blazingstar borer moth (*Papaipema beeriana*, state special concern) and the maritime sunflower borer moth (*P. maritima*, state special concern). Moth surveys utilized the technique known as blacklighting. This consisted of a standard mercury-vapor and 15 watt UV light powered by a portable generator. A 2 m X 2 m metal conduit frame supporting a large white sheet was used as a collecting surface. Moths that were attracted to the lights were collected directly off the sheet or off the ground near the sheet. The setup was placed in the field in a central location with larval host plants on all sides to maximize the likelihood of collecting adults. These locations were recorded using a hand-held GPS unit and *Papaipema* moth survey forms were completed for each site (Appendix 5). Blacklighting occurred at three sites in the area containing the host plant of the targeted moths.

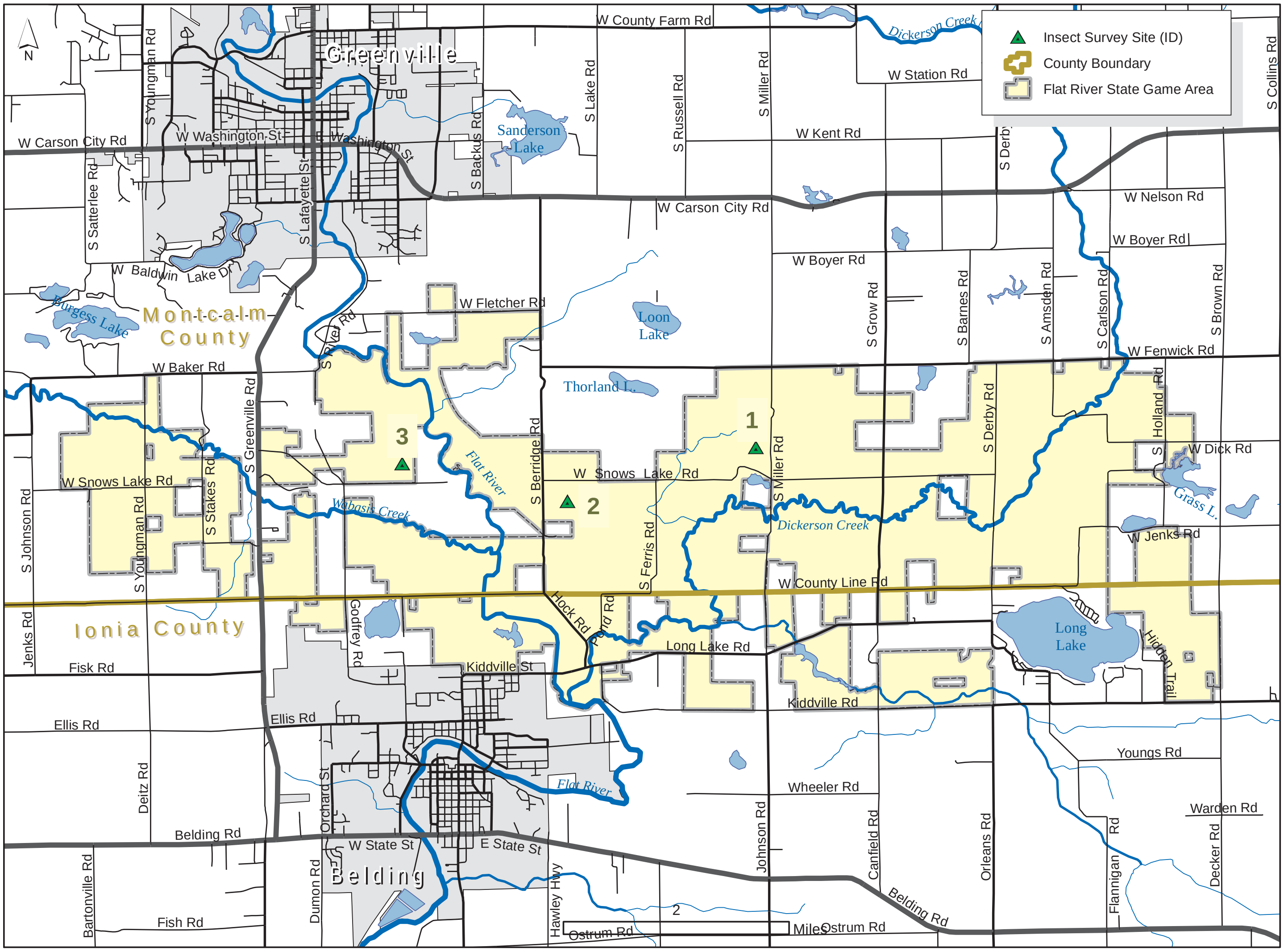


Figure 9. Locations of insect surveys conducted in Flat River State Game Area in 2015.

The first site was located in an area of prairie vegetation along the Powerline ROW north of Snows Lake Road known as Karner Trail (Figure 9). This site contained a population of more than 200 fruiting rough blazing-star (*Liatris aspera*) plants. Sampling occurred from 8:00 PM to 12:15 AM on September 14th, and September 15th, 2015.

A second site was located west of the first parking lot on Miller Road south of Fenwick Road (Figure 9). This site contained old field vegetation with approximately 75 fruiting rough blazing-star. A total of four hours of sampling occurred from 8:00 PM to 12:00 AM on September 15th, 2015.

The third site that was sampled for rare moths was an area of old field vegetation along Bluebird Lane, east of Berridge Road (Figure 9). This site contained about 100 fruiting rough blazing-star along a woodland edge. Sampling was again limited to a four hour window from 8:00 PM to 12:00 AM on September 16th, 2015.

Mussel Surveys

Flat River SGA is located fully within the Flat River watershed. The three largest streams within the game area are the main stem of the Flat River and its tributaries Dickerson Creek and Wabasis Creek. The Flat River flows into the Grand River just downstream of Lowell, MI. The Grand River is the second largest river in Michigan and supports diverse fish and unionid mussel communities. The Grand River is a potential source for fish and mussel species to colonize habitats and exchange genes among populations in the Flat River watershed, although there are four dams between Flat River SGA and the confluence of the Flat and Grand Rivers. Dams and other barriers to fish passage interfere with gene flow among mussel populations and prevent colonization of new habitats. A review of pre-1960 occurrence data from the University of Michigan, Museum of Zoology (UMMZ) Mollusk Collection revealed the main stem of the Flat River supported twelve mussel species historically, and Wabasis Creek supported nine (Appendix 6). No mussel occurrence data for Dickerson Creek was documented at the UM

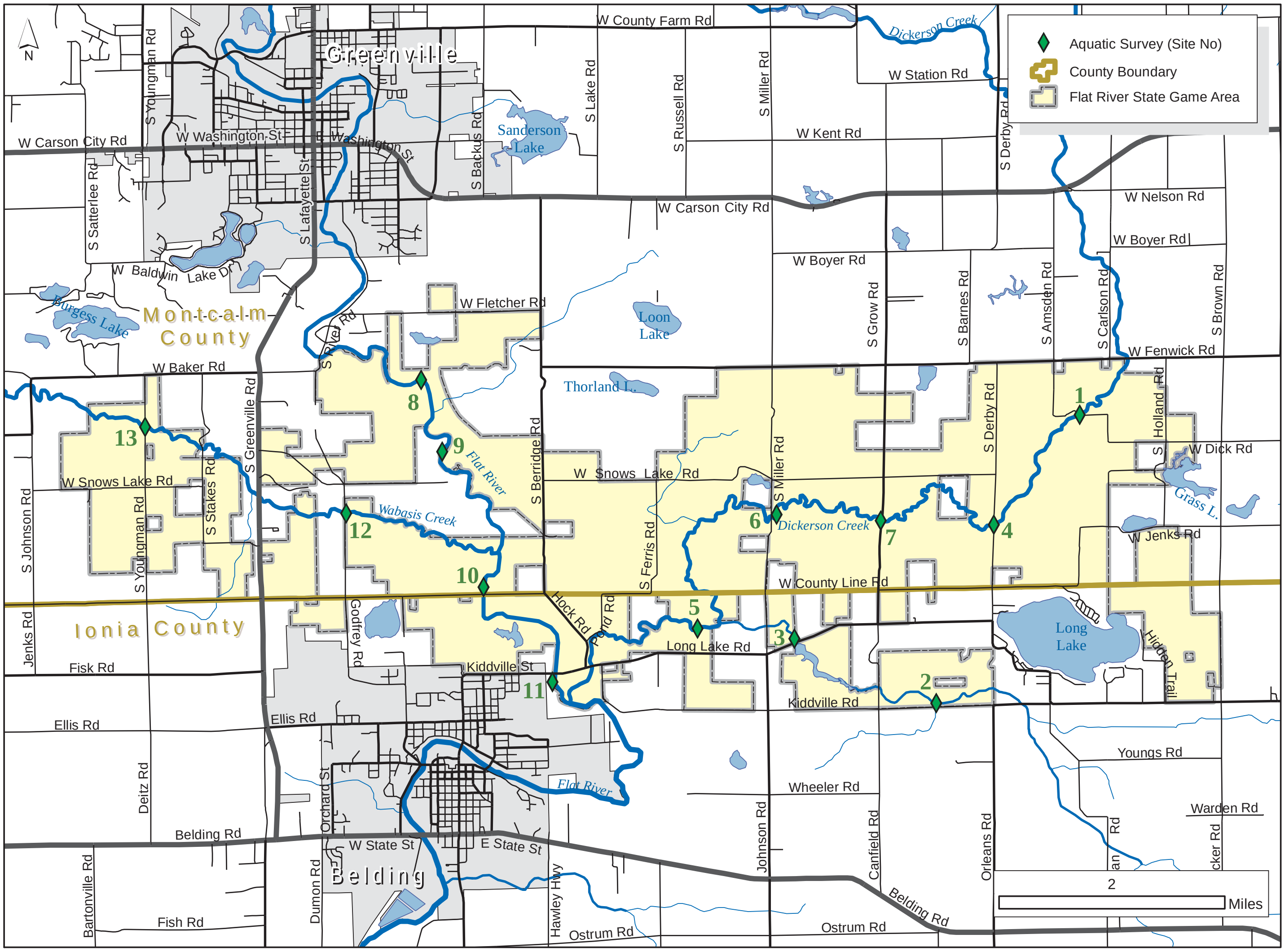


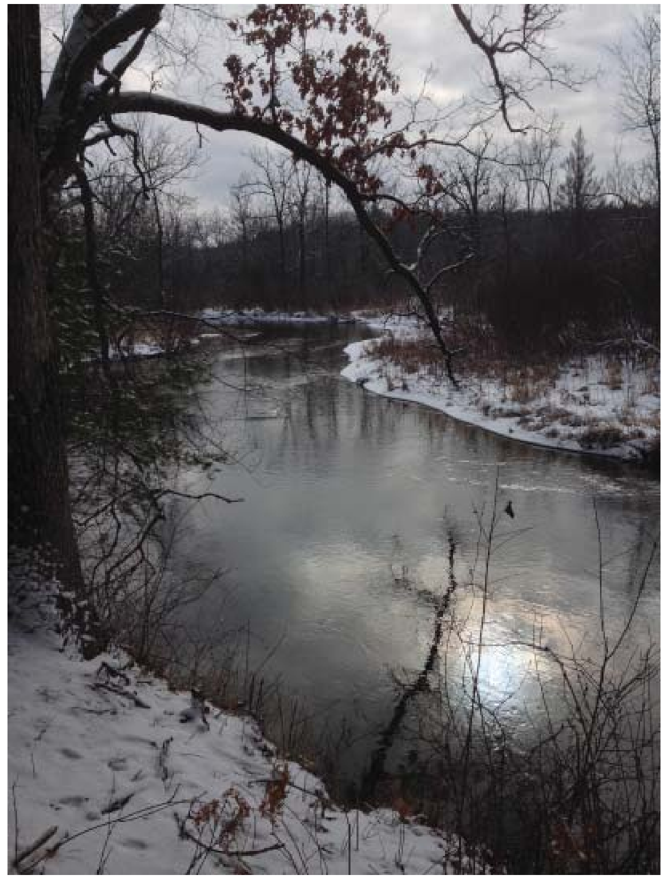
Figure 10. Locations of aquatic surveys conducted in Flat River State Game Area in 2015.

Mollusk Collection or Natural Heritage Database. Although several listed mussel species have been documented in the Flat River watershed, only one has previously been recorded within the Flat River SGA (Table 6). A historical (1927) occurrence of the state threatened slippershell (*Alasmidonta viridis*) is located in the Flat River main stem almost directly east of the Greenville Airport (Figure 15). A historical (1934) occurrence of rainbow (*Villosa iris*), a species of special concern, is located just outside of the game area in Wabasis Creek at the M-91 crossing (Figure 15). Aquatic surveys targeting rare unionid mussels were performed at 13 sites within Flat River SGA, between August 20th and September 30th, 2015. Four sites were located in the Flat River main stem, seven in Dickerson Creek, and two in Wabasis Creek (Figure 10).

Aquatic surveys were performed to determine the presence/absence and abundance of unionid mussels at each site, as well as document stream water chemistry and physical habitat characteristics. Additional taxa including aquatic snails, fish, crayfish, and fingernail clams were recorded as incidental finds. Presence/absence was documented for non-native gastropods and bivalves as well [e.g., zebra mussel (*Dreissena polymorpha*) and Asian clam (*Corbicula fluminea*)]. Three waterways within the game area provide potential habitat for unionid mussels: the main stem of the Flat River, Dickerson Creek including the south branch, and Wabasis Creek.

Surveys took place in wadeable habitats (less than approximately 70 cm deep). The search area at each site was measured to standardize sampling effort among sites and allow unionid mussel density estimates to be made. The search area typically extends from bank to bank in order to include the widest range of microhabitats. Live unionids and shells were located with a combination of visual and tactile means. Glass bottom buckets were used to facilitate visual detection. Tactile searches through the substrate were made to help ensure that buried individuals were being detected, including smaller sized unionid mussels. Live individuals were identified to species and placed back into the substrate anterior end down (siphon end up) in the immediate vicinity of where they were found. Shells were also identified to species. The number of shells and live individuals was determined for each unionid mussel species at each site. Gastropod shells were collected by hand and brought back to the lab for identification. Fish were located and identified visually through glass bottom buckets. Latitude and longitude of survey sites were recorded with handheld Garmin GPS units (Table 7).

Habitat data were recorded to describe and document stream conditions at the time of the surveys. The substrate within each search area was characterized by estimating percent composition of each of the following six particle size classes (diameter): boulder (>256 mm); cobble (256-64 mm); pebble (64-16 mm); gravel (16-2 mm); sand (2-0.0625 mm); and silt/clay (<0.0625 mm) (Hynes 1970). Woody debris, aquatic vegetation, exposed solid clay substrate, and eroded banks were noted when observed. The percentage of the search area with pool, riffle, and run habitat, and a rough characterization of current speed were estimated visually. Water conductivity and pH were recorded with an Oakton handheld meter. Water alkalinity and hardness were measured with LaMotte kits (models 4491-DR-01 and 4824-DR-LT-01).



Wabasis Creek. Photo by Jesse M. Lincoln.

Dickerson Creek. Photo by Peter J. Badra.

RESULTS

During the Integrated Inventory Project at Flat River SGA, MNFI documented 16 new EOs and provided information for updating an additional 10 EOs (Tables 1-6). Data compiled on these EOs was entered into MNFI's Biotics database (MNFI 2016a). In total, 16 SGCN were documented during the project including ten different rare animal species (Table 8). The locations in Flat River SGA of all natural community and rare species occurrences (both new and prior occurrences) are illustrated in Figures 11 through 15. In addition, MNFI scientists mapped the location of 26 vernal pools within the game area (Figure 6). 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, reptiles and amphibians, and mussels.

Natural Community Survey Results

MNFI ecologists documented eleven new high-quality natural communities in the Flat River SGA and also updated two known high-quality community EO. Flat River SGA supports thirteen high-quality natural community EOs (Table 1 and Figure 11). 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. Seven different natural community types are represented in the thirteen element occurrences surveyed including: bog (2 EOs), dry-mesic northern forest (1 EO), dry-mesic southern forest (2 EOs), floodplain forest (1 EO), hardwood-conifer swamp (5 EOs), hillside prairie (1 EO), and southern wet meadow (1 EO).

In addition, MNFI ecologists visited two former natural community element occurrence, an emergent marsh around Grass Lake (Compartment 5, Stands 109, 117, and 121) and a dry-mesic southern forest (Compartment 5, Stands 145). Both of these former element occurrences were evaluated during this project and then removed from MNFI's database since they failed to meet the criteria required of exemplary natural communities. The dry-mesic southern forest was determined to be too young to qualify as a high-quality dry-mesic southern forest. The emergent marsh was removed from the database because it was determined to be degraded as a result of changes in hydrology due to extensive ditching and water level changes caused by the road to the east. The wetland complex around Grass Lake however, does have important zones of unusual habitat, including poor fen. Small pockets of poor fen still occur in Stand 121 and in the surrounding private property. Blanding's turtle was documented within this wetland.

Over the course of the project, one new rare plant EO for ginseng (*Panax quinquefolius*, state threatened) was opportunistically documented and two known populations of prairie buttercup (*Ranunculus rhomboideus*, state threatened) were updated (Table 2). The general location of plant EOs within the game area is illustrated along with the natural community EOs in Figure 11.

The following site summaries contain a detailed discussion for each of the thirteen 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 14. 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 7 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

Table 1. Newly documented and previously known natural community element occurrences for the Flat River State Game Area. EO rank abbreviations are as follows: BC, good or fair estimated viability; C, fair estimated viability; and CD, fair or poor estimated viability. * indicates that the EO was newly documented 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
Dickerson Bog**	Bog	3663	BC	1987	2014	G3G5	S4
Flat River Bogs*	Bog	19970	BC	2014	2014	G3G5	S4
Wabasis Forest*	Dry-mesic Northern Forest	20103	C	2015	2015	G4	S3
Hadicks Lake West**	Dry-mesic Southern Forest	3327	C	1989	2014	G4	S3
Tanager's Demise*	Dry-mesic Southern Forest	19969	C	2014	2014	G4	S3
Dickerson Floodplain*	Floodplain Forest	19964	C	2014	2014	G3?	S3
Derby Swamp*	Hardwood-Conifer Swamp	19966	C	2014	2014	G4	S3
Dickerson Swamp*	Hardwood-Conifer Swamp	19968	CD	2014	2014	G4	S3
Grow Swamp*	Hardwood-Conifer Swamp	19965	C	2014	2014	G4	S3
Miller Swamp*	Hardwood-Conifer Swamp	20104	BC	2014	2014	G4	S3
Race Lake Swamp*	Hardwood-Conifer Swamp	19967	C	2014	2014	G4	S3
Fenwick Hillside Prairie*	Hillside Prairie	19983	BC	2014	2014	G3	S1
Flat River Meadow*	Southern Wet Meadow	19971	BC	2014	2014	G4?	S3

Fenwick Hillside Prairie. Photo by Jesse M. Lincoln.

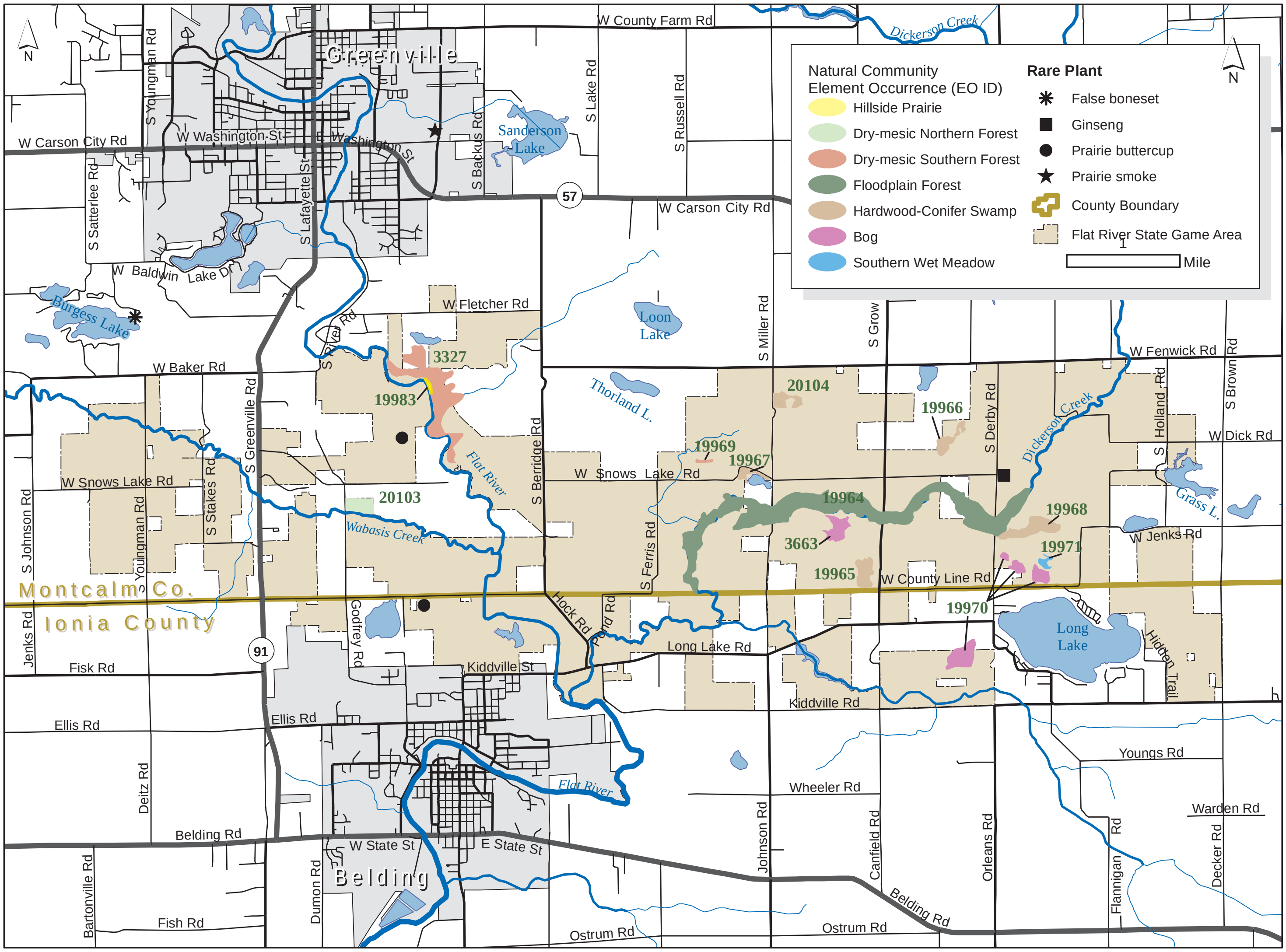


Figure 11. Natural community and rare plant element occurrences in Flat River State Game Area.

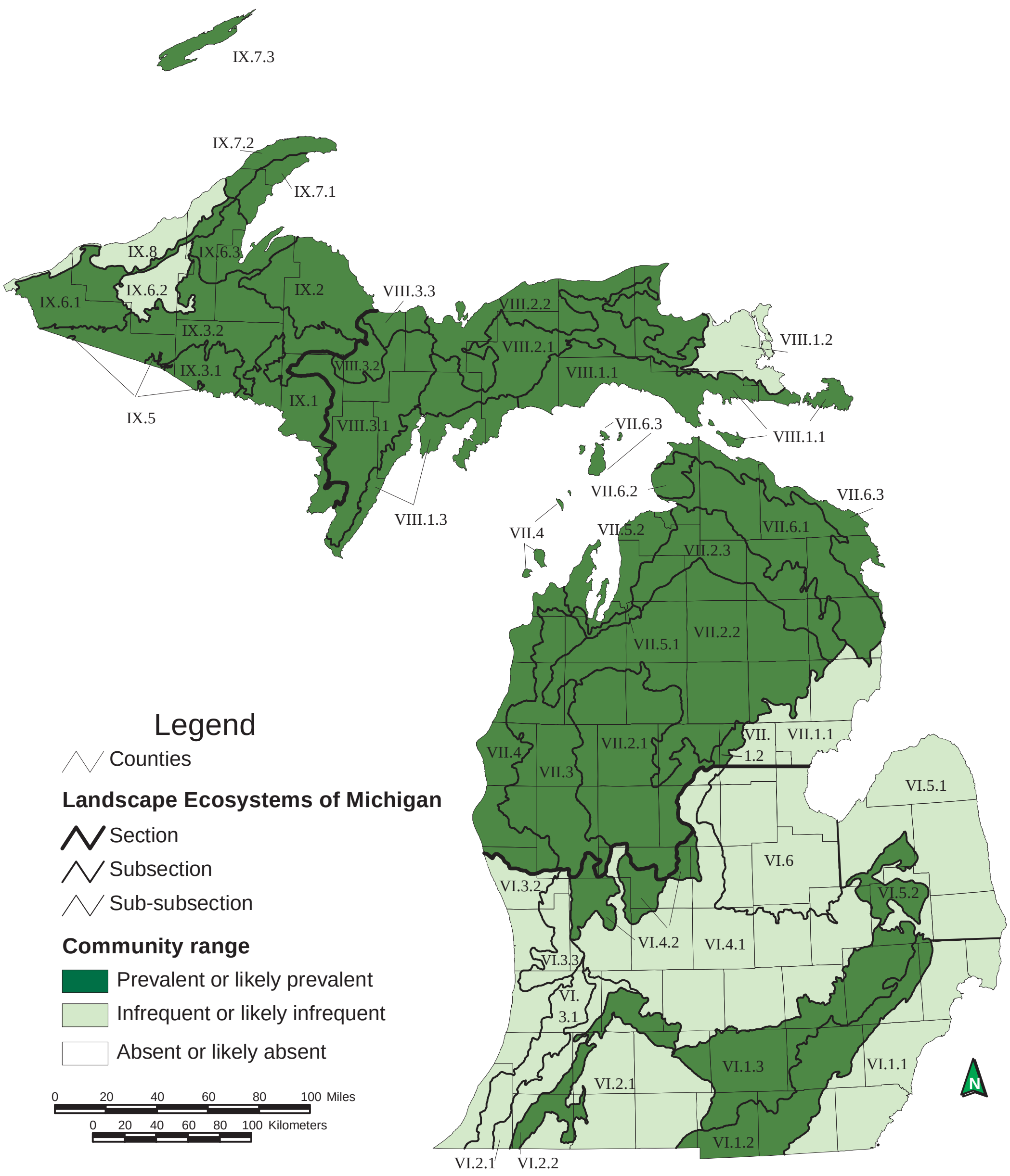
Table 2. Newly documented and previosuly known rare plant element occurrences at Flat River State Game Area and in the vicinity. State status abbreviations are as follows: T, state threatened; and SC, state special concern. EO rank abbreviations are as follows: C, fair estimated vi ability; CD, fair or poor estimated viability; D, poor estimated viability; E, verified extant, and H, historical. An * indicates the EO was newly documented in 2014, ** indicates the EO was updated during this project, and [1] indicates that the record is from nearby private land.

Common Name	Scientific Name	State Status	EO ID	EO Rank	Year First Observed	Year Last Observed
Prairie smoke[1]	*Geum triflorum*	T	5705	E	1890	1992
False boneset[1]	*Kuhnia eupatorioides*	SC	8528	H	1941	1941
Ginseng*	*Panax quinquefolius*	T	20141	D	2014	2014
Prairie buttercup**	*Ranunculus rhomboideus*	T	15790	CD	2005	2012
Prairie buttercup**	*Ranunculus rhomboideus*	T	18995	C	1992	2012

SITE SUMMARIES

BOG

Overview: Bog is a nutrient-poor peatland characterized by a continuous carpet of sphagnum moss, a species-poor herbaceous layer, low ericaceous, evergreen shrubs, and widely scattered and stunted conifers. Though much more prevalent in the north, bogs occur throughout Michigan in kettle depressions within pitted outwash plains and moraines and in shallow depressions on glacial outwash plains and glacial lakeplains. Bogs often develop on the margins of lakes and slowly colonize the lake basin. Soils are extremely acidic to very strongly acidic, saturated peat. Natural processes that influence species composition and community structure include peat accumulation, insect outbreaks, flooding by beaver, windthrow, and occasional fires. Bogs are dominated by sphagnum mosses (*Sphagnum* spp.), few-seed sedge (*Carex oligosperma*), ericaceous shrubs such as leatherleaf (*Chamaedaphne calyculata*), bog rosemary (*Andromeda glaucophylla*), bog laurel (*Kalmia polifolia*), low sweet blueberry (*Vaccinium angustifolium*), highbush blueberry (*V. corymbosum*), large cranberry (*V. macrocarpon*), and small cranberry (*V. oxycoccos*), and scattered trees, especially conifers such as black spruce (*Picea mariana*), tamarack (*Larix laricina*), and pines (*Pinus* spp.). Insectivorous plants are characteristic of bogs and include round-leaved sundew (*Drosera rotundifolia*), pitcher-plant (*Sarracenia purpurea*), and bog bladderwort (*Utricularia geminiscapa*) (Kost et al. 2007, Cohen et al. 2014).



Map 1. Distribution of bog in Michigan (Albert et al. 2008).

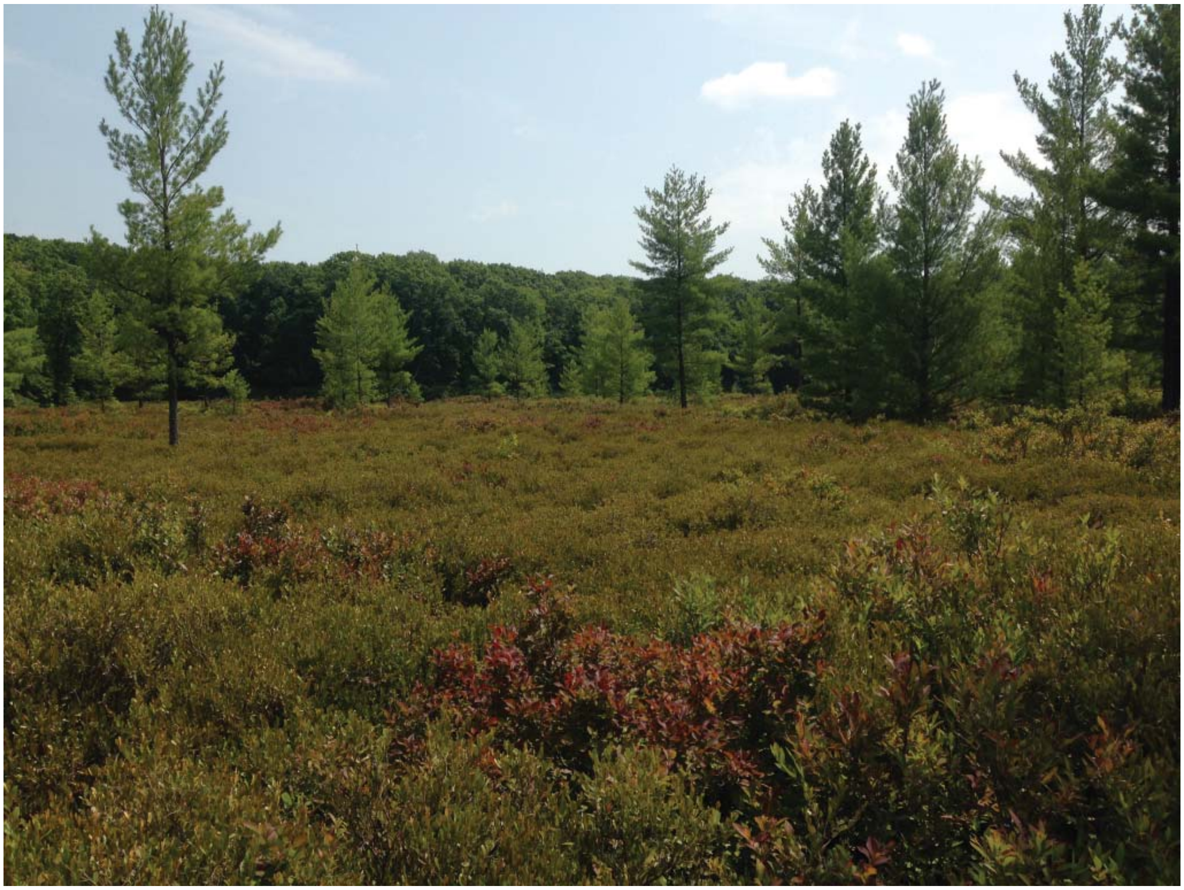
1. **Dickerson Bog**
Natural Community Type: Bog
Rank: G3G5 S4, vulnerable to secure globally and secure within the state
Element Occurrence Rank: BC
Size: 21 acres
Location: Compartment 4, Stand 75
Element Occurrence Identification Number: 3663 (EO Update)

Site Description: Dickerson Bog is a small bog that occupies a depression within pitted outwash and is surrounded by dry-mesic southern forest. The bog occurs just south of Dickerson Creek and its associated floodplain forest (Dickerson Floodplain EO ID 19964). Soils are acidic peats (pH 4.0-4.5). The bog surrounds a small paludified island that supports dense tree cover with white pine (*Pinus strobus*), red maple (*Acer rubrum*), and tall shrubs, especially highbush blueberry (*Vaccinium corymbosum*). Structural diversity of the bog is further increased by scattered clumps of tall shrubs and the moat that rings the bog. Areas of the moat that hold water seasonally are functioning as a vernal pool. Sphagnum hummock and hollow microtopography within the bog provide microsite diversity by creating small-scale gradients in soil moisture and soil chemistry.

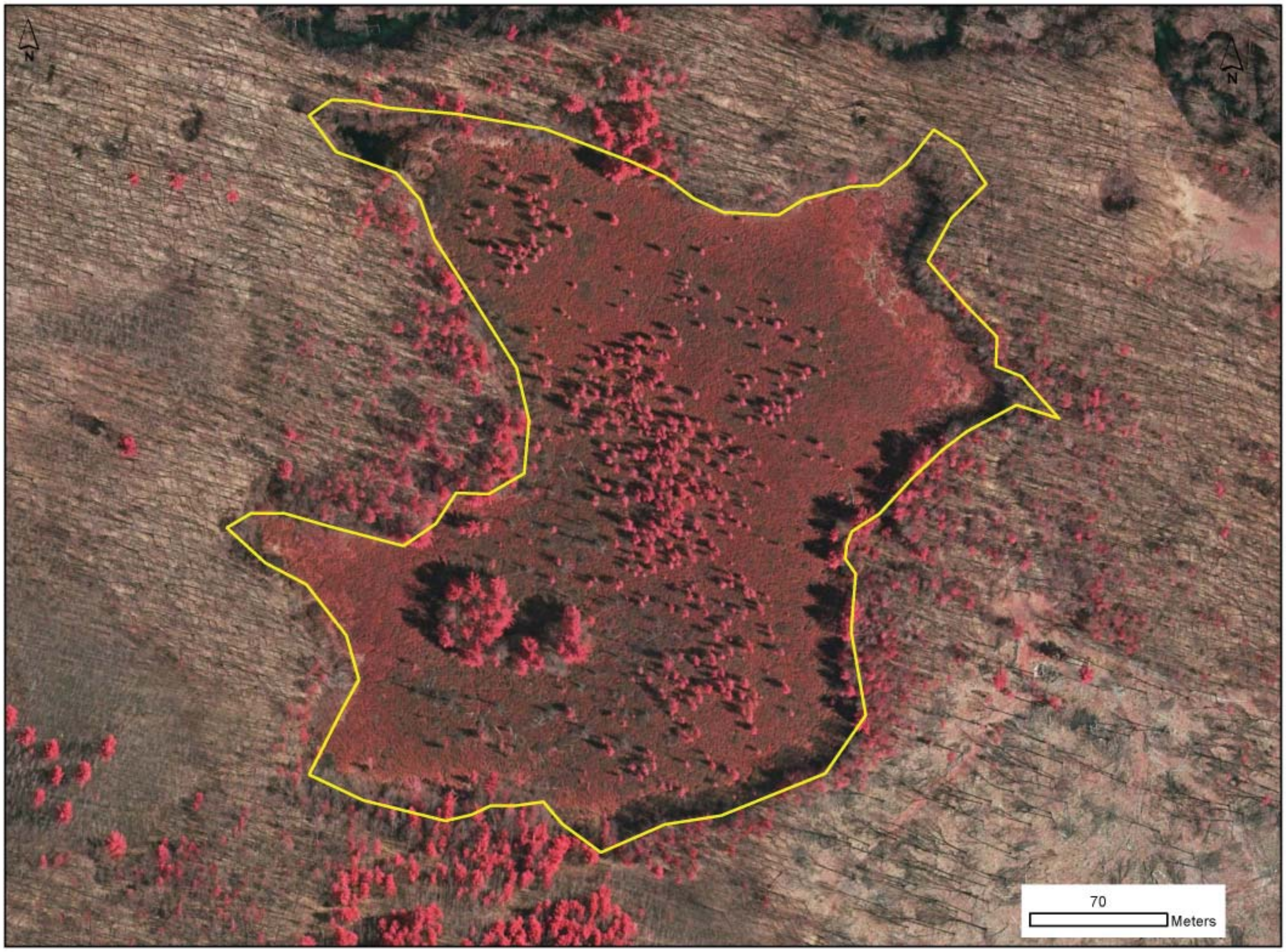
The Dickerson Bog is characterized by a continuous carpet of sphagnum moss, a species-poor herbaceous layer, a dense low shrub layer, scattered tall shrubs, widely scattered and stunted trees, and a shallow moat. Characteristic species of the herbaceous layer include few-seed sedge (*Carex oligosperma*), tussock sedge (*C. stricta*), wild calla (*Calla palustris*), marsh St. John's-Wort (*Triadenum fraseri*), northern bugle weed (*Lycopus uniflorus*), marsh cinquefoil (*Comarum palustre*), and wool-grass (*Scirpus cyperinus*). The bog is ringed by a narrow, shallow moat that is mostly dominated by blue-joint (*Calamagrostis canadensis*) and three-way sedge (*Dulichium arundinaceum*) with lake sedge (*Carex lacustris*) prevalent locally. Leatherleaf (*Chamaedaphne calyculata*) dominates the low shrub layer with associates including highbush blueberry and low sweet blueberry (*Vaccinium angustifolium*). Scattered tall shrubs occur throughout the bog and include highbush blueberry, black chokeberry (*Aronia prunifolia*), and mountain holly (*Ilex mucronata*). As noted above, a small paludified island occurs within the bog and is characterized by an overstory of white pine and red maple with an understory of highbush blueberry and red maple.

Threats: Species composition and vegetative structure of the bog are largely driven by natural processes. Reed canary grass (*Phalaris arundinacea*) has established locally within the narrow moat along the northeastern margin of the bog. In addition, fire suppression throughout the general landscape may have altered the fire regime of the bog.

Management Recommendations: The main management recommendations are to retain an intact buffer of natural communities surrounding the wetland to minimize the threat of hydrological alteration and to control the reed canary grass. The bog should be allowed to burn if prescribed fire or wildfires enter the wetland basin. Monitoring should be implemented following invasive species control efforts and fire events.



Dickerson Bog. Photos by Bradford S. Slaughter.



1998 aerial photograph of Dickerson Bog.

2. Flat River Bogs
Natural Community Type: Bog
Rank: G3G5 S4, vulnerable to secure globally and secure within the state
Element Occurrence Rank: BC
Size: 50 acres
Location: Compartment 4, Stand 216; and Compartment 5, Stands 102, 115, and 122
Element Occurrence Identification Number: 19970 (New EO)

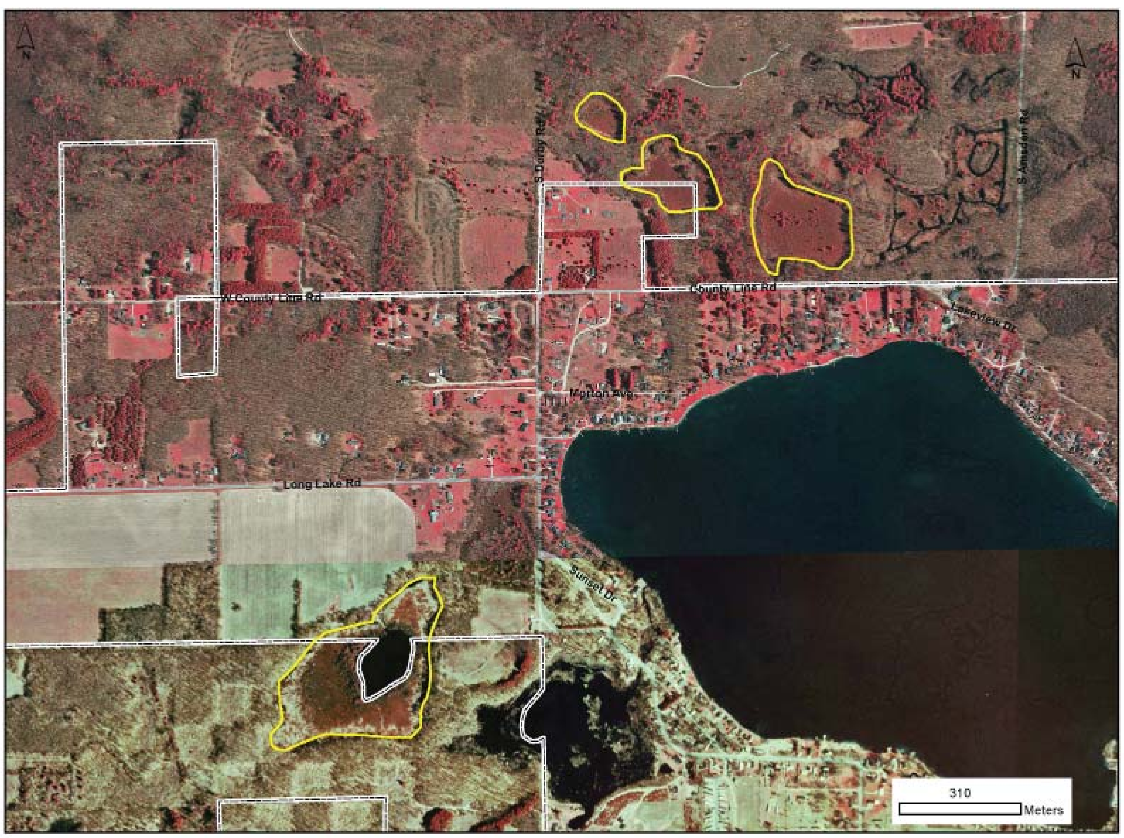
Site Description: The series of bogs occupy kettle depressions within a morainal landscape. The bog polygons formed through lake-filling and are characterized by well-developed sphagnum hummocks and hollows. These sphagnum hummocks and hollows provide microsite diversity by creating small-scale gradients in soil moisture and soil chemistry. In addition, numerous animal trails occur throughout and provide linear features that increase the overall structural diversity. Soils are deep (> 1 meter), saturated acidic peats with well-developed fibric to sapric structure. The fibric peats on the sphagnum hummocks tend to be very strongly acidic (pH 4.0) while the hemic and sapric peats throughout the profile are strongly acidic (pH 4.5).

The Flat River Bogs are characterized by a continuous carpet of sphagnum moss, a species-poor herbaceous layer, a dense low shrub layer, scattered patches of dense tall shrubs, widely scattered and stunted trees, and a moat dominated by tall shrubs and submergent vegetation. Characteristic species of the herbaceous layer include few-seed sedge (*Carex oligosperma*), three-way sedge (*Dulichium arundinaceum*), Virginia chain-fern (*Woodwardia virginica*), blue-joint (*Calamagrostis canadensis*), and wool-grass (*Scirpus cyperinus*). Wiregrass sedge (*Carex lasiocarpa*), lake sedge (*C. lacustris*), three-way sedge, and bluejoint grass are locally abundant in wet and young portions of the bog depressions and in the moats along the perimeter of the bogs. Leatherleaf (*Chamaedaphne calyculata*) dominates the low shrub layer with associates including Canada blueberry (*Vaccinium myrtilloides*), black chokeberry (*Aronia prunifolia*), red maple (*Acer rubrum*), and white pine (*Pinus strobus*). The understory is patchy to dense and is dominated by highbush blueberry (*Vaccinium corymbosum*) with additional tall shrubs including winterberry (*Ilex verticillata*), poison sumac (*Toxicodendron vernix*), black chokeberry, and sapling white pine and red maple. Scattered and stunted trees include white pine, tamarack (*Larix laricina*), black spruce (*Picea mariana*), and red maple.

Threats: Species composition and vegetative structure of the bog are largely driven by natural processes. Portions of the bog are bordered by agricultural fields, which may have altered the hydrology locally. In addition, fire suppression throughout the general landscape may have altered the fire regime of the bog. Reed canary grass (*Phalaris arundinacea*) is locally common within one of the bog polygons.

Management Recommendations: The main management recommendations are to retain an intact buffer of natural communities surrounding the wetland to minimize the threat of hydrological alteration and to control the reed canary grass. The bog should be allowed to burn if prescribed fire or wildfires enter the wetland basin. Monitoring should be implemented following invasive species control efforts and fire events.

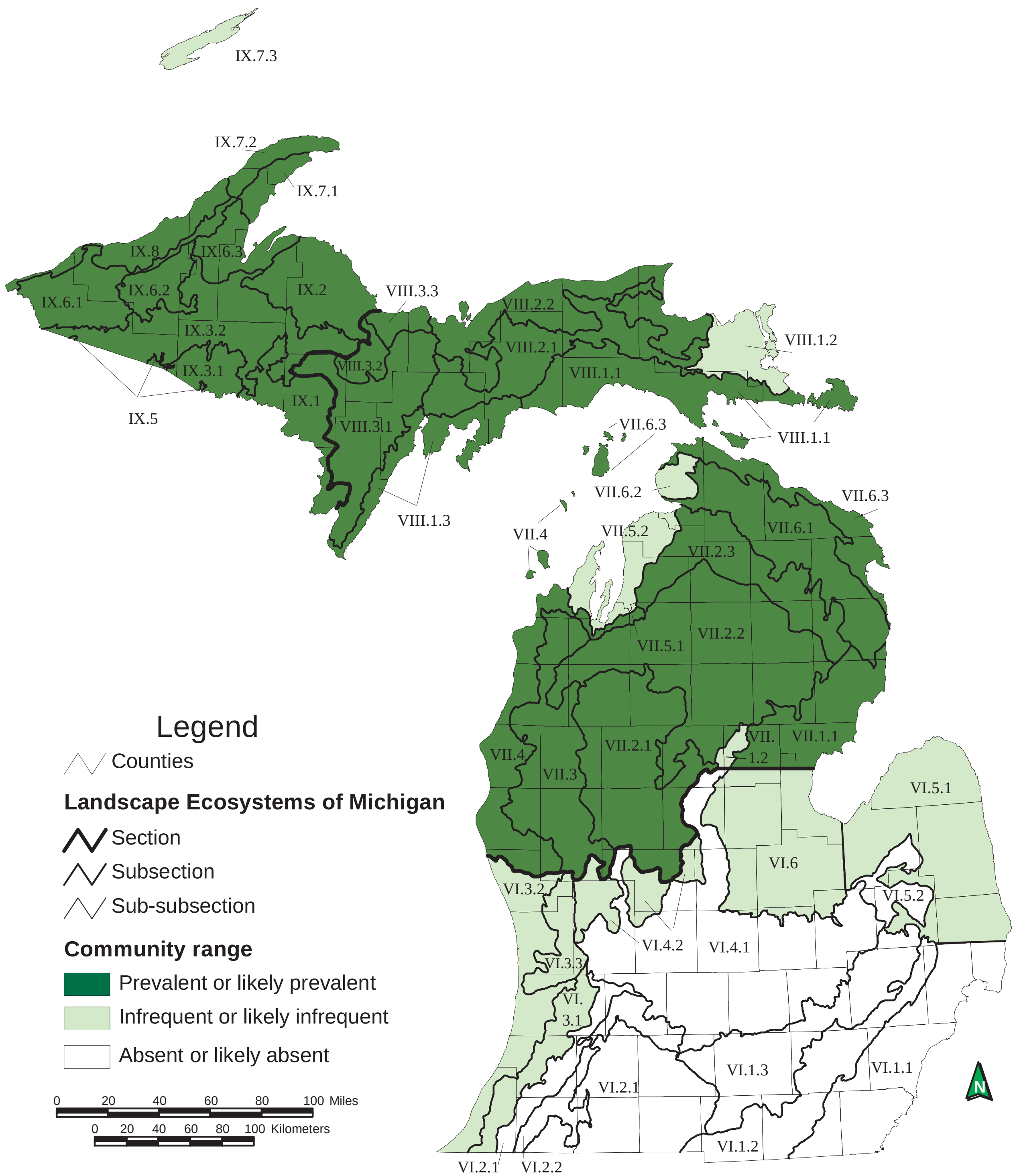
Flat River Bogs. Photo by Joshua G. Cohen.



1998 aerial photograph of Flat River Bogs

DRY-MESIC NORTHERN FOREST

Overview: Dry-mesic northern forest is a pine or pine-hardwood forest found throughout the Upper Peninsula and northern Lower Peninsula and less frequently in the southern Lower Peninsula. The community occurs principally on sandy glacial outwash plains, sandy glacial lakeplains, and less often on inland dune ridges, coarse-textured moraines, and thin glacial drift over bedrock. Dry-mesic northern forest develops on extremely to very strongly acidic sands or loamy sands. Dry-mesic northern forest historically originated in the wake of catastrophic fire and was maintained by frequent low-intensity ground fires. Natural processes that influence species composition and community structure include fire, windthrow, and insect outbreaks. The canopy is dominated by white pine (*Pinus strobus*) with associates including red pine (*P. resinosa*), hemlock (*Tsuga canadensis*), white oak (*Quercus alba*), and red oak (*Q. rubra*) (Kost et al. 2007, Cohen et al. 2014).



Map 2. Distribution of dry-mesic northern forest in Michigan (Albert et al. 2008).

3. Wabasis Forest
Natural Community Type: Dry-Mesic Northern Forest
Rank: G4 S3, apparently secure globally and vulnerable within the state
Element Occurrence Rank: C
Size: 19 acres
Location: Compartment 2, Stand 46
Element Occurrence Identification Number: 20103 (New EO)

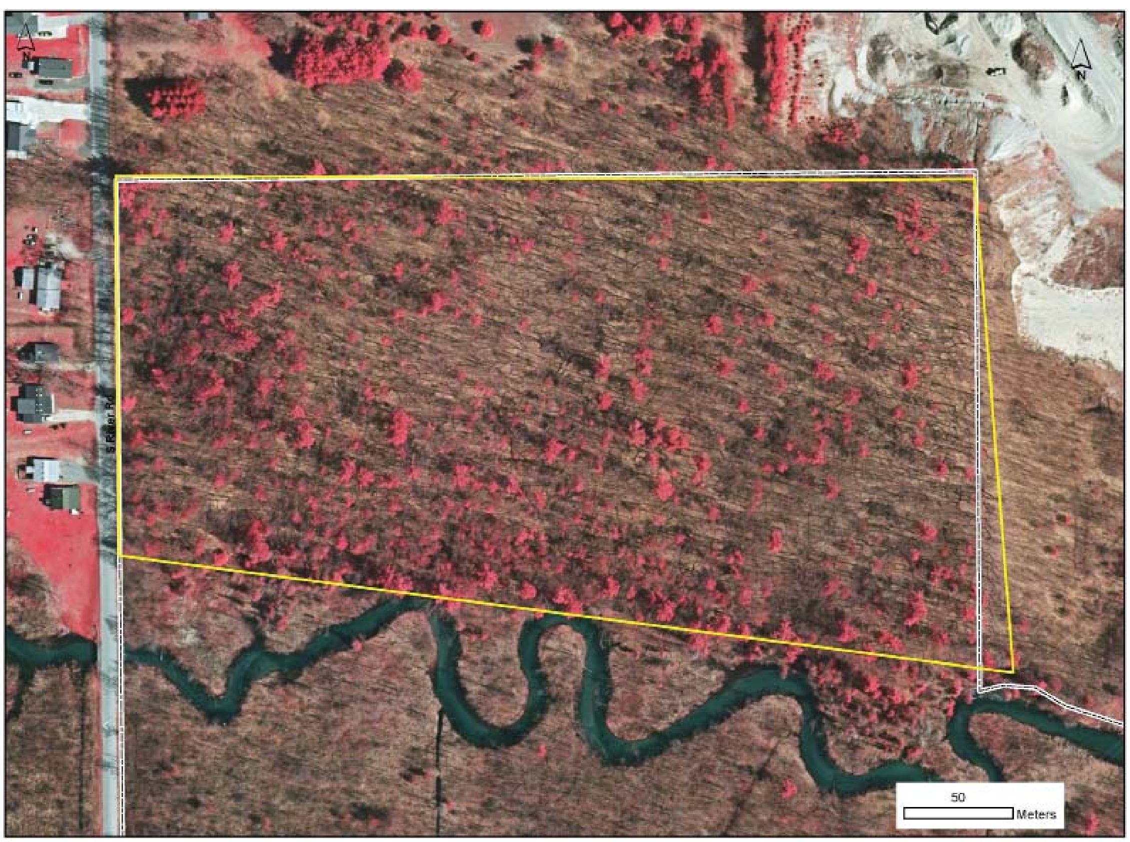
Site Description: This small, mature dry-mesic northern forest occurs on moderately steep, south-facing slopes overlooking a young hardwood-conifer swamp and northern shrub thicket that flank Wabasis Creek. This system occurs within a broad outwash channel the forms the basin for Flat River and Wabasis Creek. The soils are acidic sands to loamy sands (pH 5.5-6.0) and there is thick leaf litter throughout. A 61.1 cm black oak (*Quercus velutina*) was cored and estimated to be 128 years old. Scattered windthrow has generated small canopy gaps throughout the forest. In addition, there is abundant coarse woody debris in the form of snags and downed debris. Many mature trees have large cavities that provide important wildlife habitat. Wabasis Forest represents the most intact example of an upland forest with a significant amount of white pine in the super canopy in the Flat River SGA. In addition, this site is one of the southernmost examples of this more northerly system as pine becomes less competitive further south.

The closed canopy is dominated by white pine (*Pinus strobus*) and oaks (*Quercus* spp.), especially black oak and white oak (*Quercus alba*), with scattered red maple (*Acer rubrum*). White pine is prevalent in all strata, and is especially notable in the supercanopy. Canopy trees typically range from 35 to 65 cm with scattered supercanopy white pine reaching 100 cm. Due to decades of fire suppression, the subcanopy is trending towards dominance by mesophytic species (i.e., red maple). Deer herbivory is also likely shifting community composition and vegetative structure. The shrub layer is sparse to dense and characterized by sassafras (*Sassafras albidum*), witch-hazel (*Hamamelis virginiana*), American elm (*Ulmus americana*), white pine, gray dogwood (*Cornus foemina*), serviceberry (*Amelanchier* sp.), and black cherry (*Prunus serotina*). Gray dogwood can be dense to dominant in places. Invasives are rare in the core of the stand and include autumn olive (*Elaeagnus umbellata*) and Morrow honeysuckle (*Lonicera morrowii*). The low shrub layer is characterized by maple-leaved (*Viburnum acerifolium*), prickly gooseberry (*Ribes cynosbati*), black cherry, and gray dogwood. Vines occur throughout the forest and include Virginia creeper (*Parthenocissus quinquefolia*), grapes (*Vitis* spp), and poison-ivy (*Toxicodendron radicans*). The ground cover is characterized by Pennsylvania sedge (*Carex pensylvanica*), hairy sweet-cicely (*Osmorhiza claytonii*), bracken fern (*Pteridium aquilinum*), bluestem goldenrod (*Solidago caesia*), May-apple (*Podophyllum peltatum*), clustered-leaved tick-trefoil (*Hylodesmum glutinosum*), and wood anemone (*Anemone quinquefolia*).

Threats: Species composition, vegetative structure, and successional trajectory are strongly influenced by gap dynamics, past logging, fire suppression, invasive species, and deer herbivory. As noted above, invasive species are sparse in the understory and include autumn olive and Morrow honeysuckle. Fire suppression has led to mesophytic invasion and the prevalence of red maple in the understory and subcanopy.

Management Recommendations: The primary management need is the reintroduction of fire as a prevalent disturbance factor. 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. Reducing local deer population levels 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 and white pine regeneration and response of the forest to fire management.

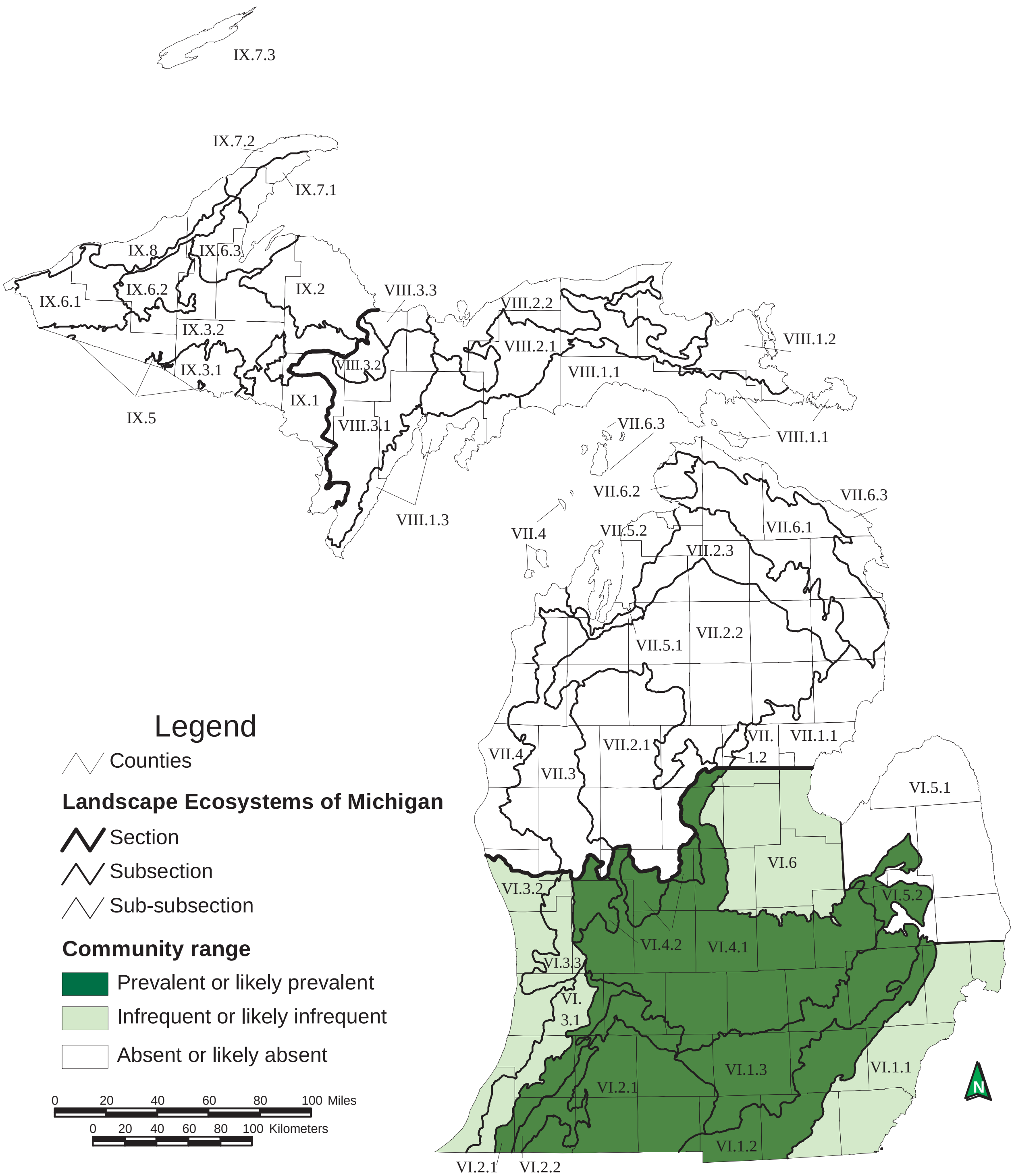
Wabasis Forest dry-mesic northern forest. Photo by Jesse M. Lincoln.



1998 aerial photograph of Wabasis Forest dry-mesic northern forest.

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

4. Hadicks Lake West
Natural Community Type: Dry-Mesic Southern Forest
Rank: G4 S3, apparently secure globally and vulnerable within the state
Element Occurrence Rank: C
Size: 114 acres
Location: Compartment 2, Stands 42 and 6, and adjacent private land
Element Occurrence Identification Number: 3327 (EO Update)

Site Description: Hadicks Lake West dry-mesic southern forest occurs on rolling topography within an outwash channel occupied by the Flat River. Soils of the dry-mesic southern forest range from fine- to medium-textured loams (pH 6.5) near the river and transition to loamy sands and sands with gravel (pH 5.5 to 6.5) with increased elevation above and distance from the river. A high-quality hillside prairie (Fenwick Hillside Prairie EO ID 19983) occurs along the western margin of this dry-mesic southern forest along steep slopes above the river where the river turns from east to south. Several vernal pools occur within this forest.

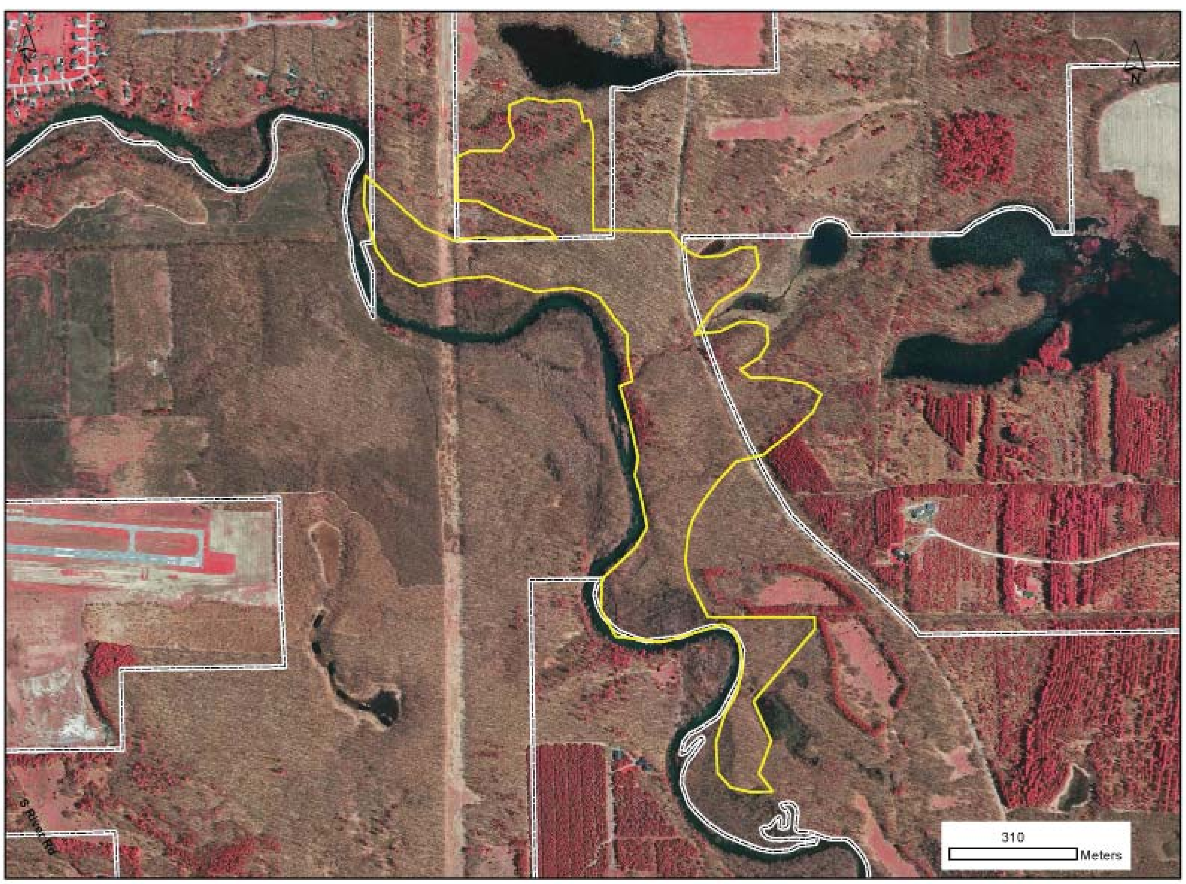
The closed canopy is dominated by oaks (*Quercus* spp.), primarily white oak (*Q. alba*), black oak (*Q. velutina*), and red oak (*Q. rubra*). Along the steep riverbanks above the Flat River, supercanopy white pine (*Pinus strobus*) occurs locally. Towards the southern end of the complex there is a small mesic inclusion where sugar maple (*Acer saccharum*) occurs as a canopy dominant. Species composition, vegetative structure, and successional trajectory vary greatly as a result of the changes in soils and topography. Loamy soils at low elevation near the river and along small streams throughout support mesophytic species such as maples (*Acer* spp.), basswood (*Tilia americana*), and white ash (*Fraxinus americana*). Away from the river, soils are much sandier and the canopy is dominated by oaks with red oak and white oak prevalent in areas of loamy sand and black oak dominant in the sandiest areas further from the river. White pine occasionally enters the supercanopy and increases in importance in the drier areas. The subcanopy and tall shrub layer are characterized by oaks, ironwood (*Ostrya virginiana*), red maple, sassafras (*Sassafras albidum*), witch-hazel (*Hamamelis virginiana*), and black cherry (*Prunus serotina*). Oak regeneration is common in the understory but faces competition from red maple and black cherry, which are increasing in dominance as a result of fire suppression. Invasives are sparse to locally abundant in the understory and include multiflora rose (*Rosa multiflora*), autumn olive (*Elaeagnus umbellata*), and Morrow honeysuckle (*Lonicera morrowii*). The low shrub layer is characterized by low sweet blueberry (*Vaccinium angustifolium*), prickly gooseberry (*Ribes cynosbati*), white ash, and ironwood. Vines occur throughout the forest and include Virginia creeper (*Parthenocissus quinquefolia*) and poison-ivy (*Toxicodendron radicans*). The ground cover is characterized by Pennsylvania sedge (*Carex pensylvanica*), clustered-leaved tick-trefoil (*Hylodesmum glutinosum*), naked-flower tick-trefoil (*Hylodesmum nudiflorum*), nodding fescue (*Festuca subverticillata*), and black oatgrass (*Piptochaetium avenaceum*). The herbaceous layer is lush in places but deer browse, fire suppression, and a closed canopy and subcanopy (particularly with maples) are limiting diversity.

The forest is bisected by an old railroad bed in the eastern portion of the EO. Where canopy openings have been maintained along the railroad, there are several barrens species, including: big bluestem (*Andropogon gerardii*), birdfoot violet (*Viola pedata*), wild lupine (*Lupinus perennis*), New Jersey tea (*Ceanothus americanus*), and butterfly milkweed (*Asclepias tuberosa*). The presence of these species suggests that portions of this complex may have historically supported oak barrens.

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 common in the understory but faces competition from red maple and black cherry, which are increasing in dominance as a result of fire suppression. As noted above invasive shrubs are sparse to locally abundant in the understory. In addition, deer densities are high and contribute to a lack of reproduction of many plants and an overall lower species diversity.

Management Recommendations: The primary management need is the reintroduction of fire as a prevalent disturbance factor. 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 complement the use of fire to control invasive shrubs. 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.

Hadicks Lake West dry-mesic southern forest. Photo by Jesse M. Lincoln.



1998 aerial photograph of Haddicks Lake West dry-mesic southern forest.

5.Tanager's Demise
Natural Community Type: Dry-Mesic Southern Forest
Rank: G4 S3, apparently secure globally and vulnerable within the state
Element Occurrence Rank: C
Size: 3 acres
Location: Compartment 2, Stand 41
Element Occurrence Identification Number: 19969 (New EO)

Site Description: Tanager's Demise is a dry-mesic southern forest occurring on a low esker within a narrow drainage channel passing through a morainal landscape. The forest is maturing with moderate to large coarse woody debris including snags and downed logs of long-lived species of varying size and decay classes. A 74.4 cm lightning-struck white oak (*Quercus alba*) was noted. Species composition, vegetative structure, and successional trajectory are driven by gap-phase dynamics and are also influenced by past selective logging and current fire suppression and deer browse pressure. A 56.2 cm white oak was cored and estimated to be over 135 years old. The soils of the dry-mesic southern forest are characterized by a thin layer (2 cm) of acidic (pH 6.0-6.3) sandy organics in the A horizon overlying fine-textured, acidic (pH 5.0-5.5) sands.

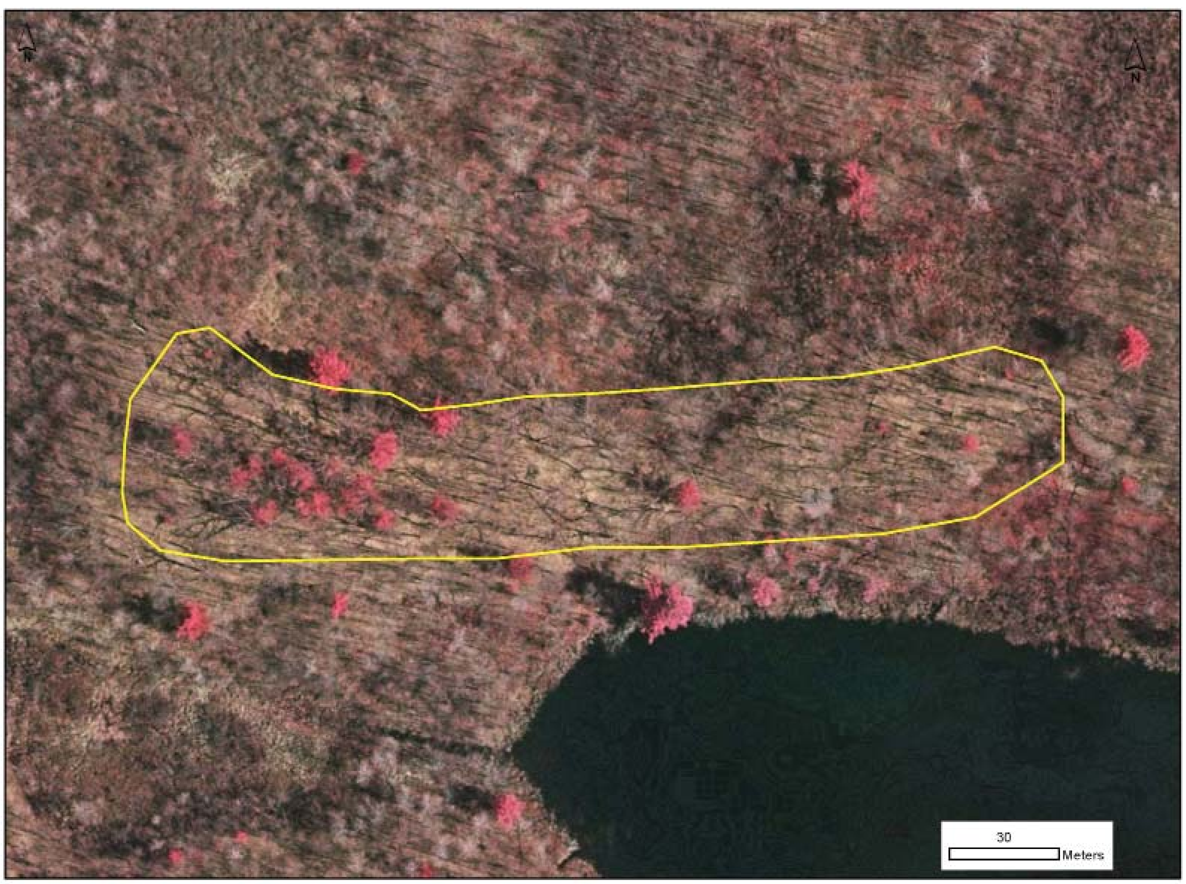
The closed canopy is dominated by white oak, black oak (*Q. velutina*), and red oak (*Q. rubra*) with white pine (*Pinus strobus*) occurring along the wetland margins. Diameters of the canopy cohort typically range from 50 to 70 cm with some scattered 70 to 80 cm oaks. A white pine on the edge of the forest was measured to be 102.2 cm. The subcanopy is composed of scattered red maple (*Acer rubrum*), white oak, serviceberry (*Amelanchier* sp.), and black cherry (*Prunus serotina*). The understory is characterized by white oak, hazelnut (*Corylus americana*), serviceberry, black cherry, and red maple. Huckleberry (*Gaylussacia baccata*), white oak, viburnums (*Viburnum* spp.), and Canada blueberry (*Vaccinium myrtilloides*) are common in the low shrub layer. The ground cover is characterized by Pennsylvania sedge (*Carex pensylvanica*), bracken fern (*Pteridium aquilinum*), clustered-leaved tick-trefoil (*Hylodesmum glutinosum*), wintergreen (*Gaultheria procumbens*), and white oak seedlings.

During surveys of the site, a Cooper's hawk (*Accipiter cooperii*) was observed with a scarlet tanager (*Piranga olivacea*) in its talons and another scarlet tanager mobbing the hawk.

Threats: Species composition, vegetative structure, and successional trajectory are strongly influenced by gap dynamics, fire suppression, deer herbivory, and past selective logging. Morrow honeysuckle (*Lonicera morrowii*) is locally common in the northeastern portion of the forest. The prevalence of understory and subcanopy red maple and black cherry indicate that the forest is fire suppressed.

Management Recommendations: The primary management needs are to maintain the closed canopy conditions, allow the forest to continue to mature, and reintroduce fire as a prevalent disturbance factor. In addition, reducing local deer densities will dampen deer browse pressure on the understory and ground cover. Morrow honeysuckle should be controlled through cutting and/or herbicide if burning does not eliminate it. Monitoring should be implemented for efforts to control non-native plant populations, to gauge the impact of deer herbivory, and evaluate oak regeneration.

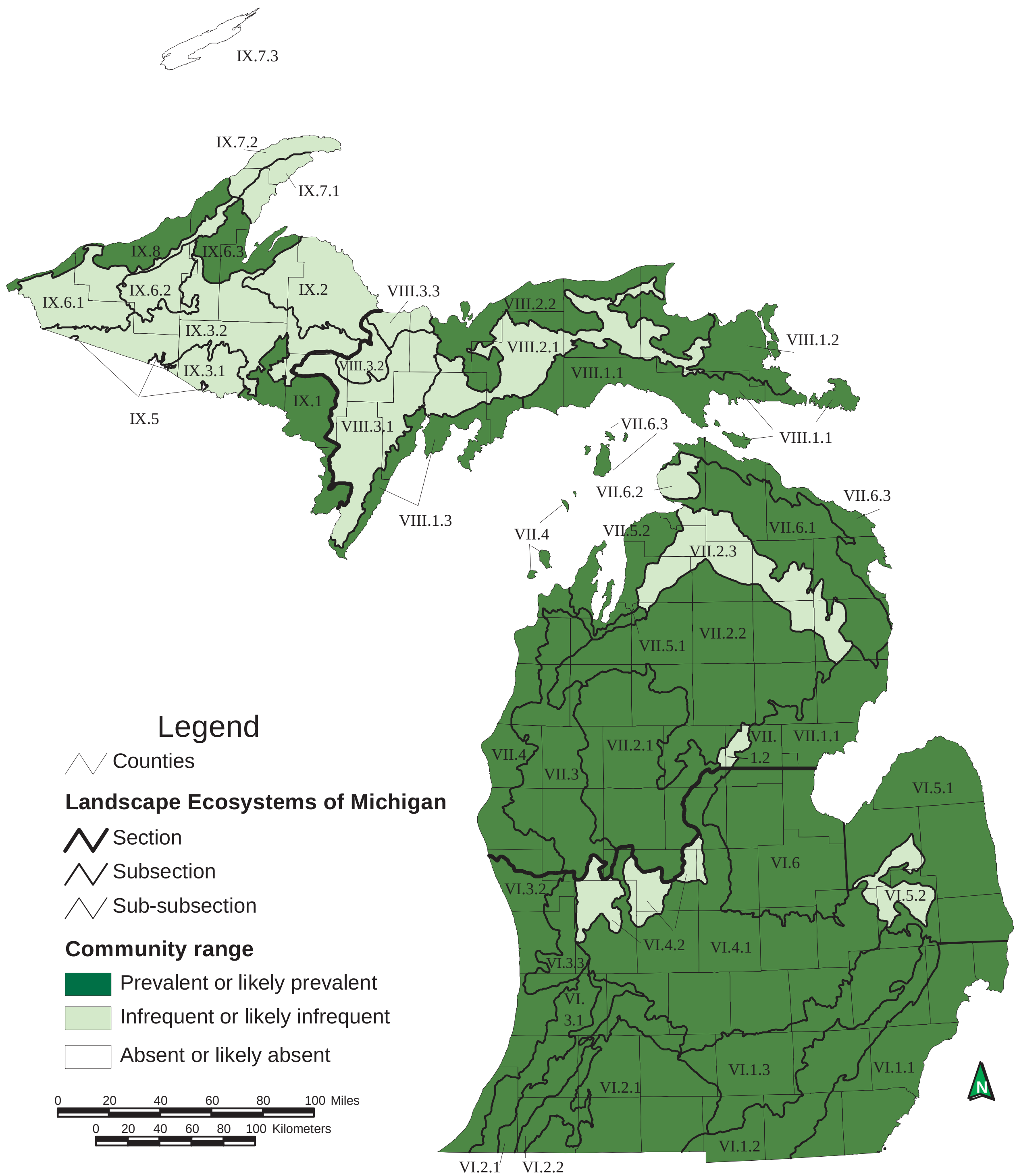
Tanager's Demise dry-mesic southern forest. Photo by Joshua G. Cohen.



1998 aerial photograph of Tanager's Demise dry-mesic southern forest.

FLOODPLAIN FOREST

Overview: Floodplain forest is a bottomland, deciduous or deciduous-conifer forest community occupying low-lying areas adjacent to streams and rivers of third order or greater, and subject to periodic over-the-bank flooding and cycles of erosion and deposition. Species composition and community structure vary regionally and are influenced by flooding frequency and duration. Silver maple (*Acer saccharinum*) and green ash (*Fraxinus pennsylvanica*) are typically major overstory dominants, although green ash is declining in importance with the spread of emerald ash borer (*Agrilus planipennis*). Floodplain forests occur along major rivers throughout the state, but are most extensive in the Lower Peninsula. Species richness is greatest in the southern Lower Peninsula, where many floodplain species reach the northern extent of their range (Kost et al. 2007, Cohen et al. 2014).



Map 4. Distribution of floodplain forest in Michigan (Albert et al. 2008).

6. Dickerson Floodplain
Natural Community Type: Floodplain Forest
Rank: G3? S3, vulnerable throughout range
Element Occurrence Rank: C
Size: 347 acres
Location: Compartment 3, Stands 125, 133, and 131; Compartment 4, Stands 51 and 103; Compartment 5, Stands 34 and 83.
Element Occurrence Identification Number: 19964 (New EO)

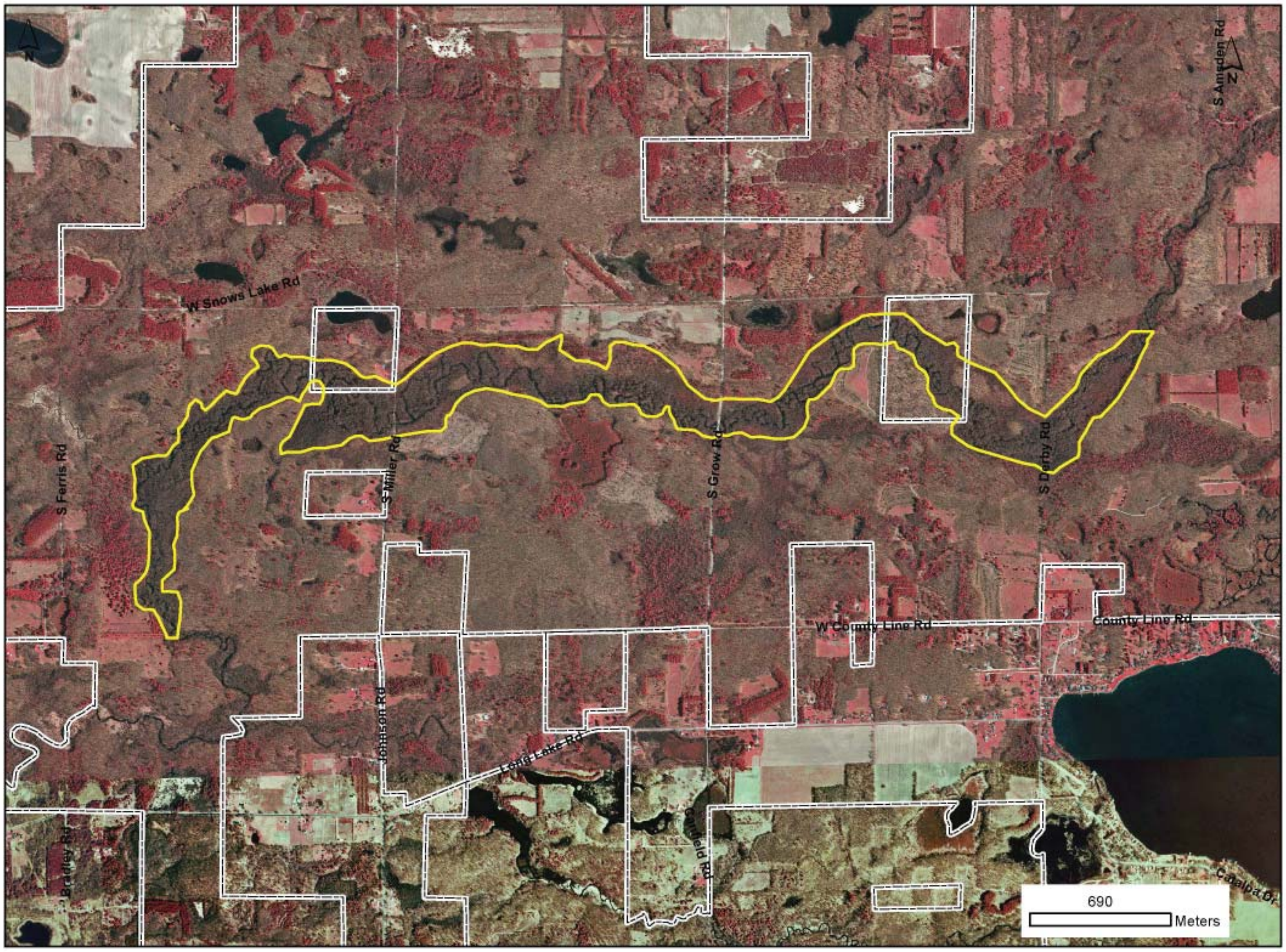
Site Description: Dickerson Floodplain is a large floodplain forest that occurs along a five mile stretch of floodplain along Dickerson Creek within a drainage channel passing through a morainal landscape. The site is characterized by infrequent over-the-bank flooding. Characteristic fluvial landforms include an extensive first bottom, a low levee, numerous oxbow channels (both active and inactive), and areas of backswamp. The soils are highly variable and strongly correlated with fluvial landforms. The floodplain soils are characterized by high nutrient availability and an abundance of soil water throughout much of the growing season. Scattered windthrow has generated small canopy gaps and a moderate volume of coarse woody debris. Coarse woody debris, tree hummocks, and tip-up mounds provide important substrate for plant establishment, especially in inundated portions of the floodplain. Downed logs within the floodplain also serve as basking sites for herptiles and thorough fares for small animals. In addition, numerous snags occur throughout the floodplain and provided important habitat for cavity nesting species. The first bottom and former channels/oxbows were flooded during the late June survey with water depths ranging from 10 to 100 cm and high water marks on the trees were as high as 60 cm. Water depths were found to be greater with increasing proximity to the river channel. Species composition, vegetative structure, and successional trajectory are strongly influenced by over-the-bank flooding and gap dynamics. Numerous creek channels branch off of Dickerson Creek. Several second bottoms on small eskers occur within the floodplain forest and support small pockets of high-quality dry-mesic southern forest. A 51.5 cm bur oak (*Quercus macrocarpa*) was cored and estimated to be over 100 years old.

The first bottom is the most extensive zone within the floodplain forest. The closed canopy is dominated by silver maple (*Acer saccharinum*) with canopy associates including swamp white oak (*Quercus bicolor*), bur oak, green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*), and basswood (*Tilia americana*). Canopy ash has been killed by the emerald ash borer and numerous ash snags occur throughout. Diameters of the canopy cohort typically range from 30 to 60 cm with some scattered 60 to 90 cm silver maple and oak species. A seven-trunked silver maple was measured to have a diameter at breast height of 189.5 cm. The understory is diverse and patchy. Understory associates include musclewood (*Carpinus caroliniana*), prickly-ash (*Zanthoxylum americanum*), spicebush (*Lindera benzoin*), and sapling American elm and green ash. Sprouting ash are also common in the low shrub layer along with wild red raspberry (*Rubus strigosus*). The ground cover is diverse with characteristic species including wood nettle (*Laportea canadensis*), sedges (*Carex* spp.), sensitive fern (*Onoclea sensibilis*), fowl manna grass (*Glyceria striata*), Virginia wild rye (*Elymus virginicus*), false nettle (*Boehmeria cylindrica*), purple meadow rue (*Thalictrum dasycarpum*), skunk cabbage (*Symplocarpus foetidus*), white grass (*Leersia virginica*), mad-dog skullcap (*Scutellaria lateriflora*), calico aster (*Symphyotrichum lateriflorum*), Pennsylvania sedge (*Carex pensylvanica*), and violets (*Viola* spp.). Vines are prevalent within the floodplain and include poison-ivy (*Toxicodendron radicans*) and wild yam (*Dioscorea villosa*). Areas of backswamp are characterized by white pine (*Pinus strobus*), red maple (*Acer rubrum*), black ash (*Fraxinus nigra*), basswood, musclewood, tag alder (*Alnus rugosa*), skunk cabbage, and jewelweed (*Impatiens capensis*).

Threats: Species composition, vegetative structure, and successional trajectory are strongly influenced by gap dynamics and over-the-bank-flooding but they are also impacted by invasive species and past logging. Emerald ash borer has killed the canopy ash within this floodplain forest generating numerous snags, light gaps, and ash coarse woody debris. Locally common invasive species include reed canary grass (*Phalaris arundinacea*) and multiflora rose (*Rosa multiflora*) with autumn olive (*Elaeagnus umbellata*) occurring infrequently along the levee. Reed canary grass is locally prevalent along the creek margin near road junctions and multiflora rose occurs occasionally near road junctions. In addition, reed canary grass was noted to be encroaching where the canopy is opening due to ash mortality from emerald ash borer. Three north-south roads (Derby Road, Grow Road, and Miller Road) intersect the floodplain forest, cross over Dickerson Creek, and locally impact the hydrology and vegetation of the floodplain forest. Scattered cut stumps occur within the floodplain forest. Deer browse is prevalent throughout the floodplain forest. Localized off-road vehicle damage was noted.

Management Recommendations: The primary management recommendations are to maintain the mature floodplain forest and the hydrology of the river, prevent alterations to hydrology in adjacent wetlands (e.g., avoid ditching, damming, and diking), reduce local deer populations, eliminate off-road vehicle activity, control invasive species through cutting and herbiciding, monitor for invasives and deer browse, and retain an intact buffer of natural communities surrounding the floodplain forest.

Dickerson Floodplain Forest. Photos by Joshua G. Cohen.

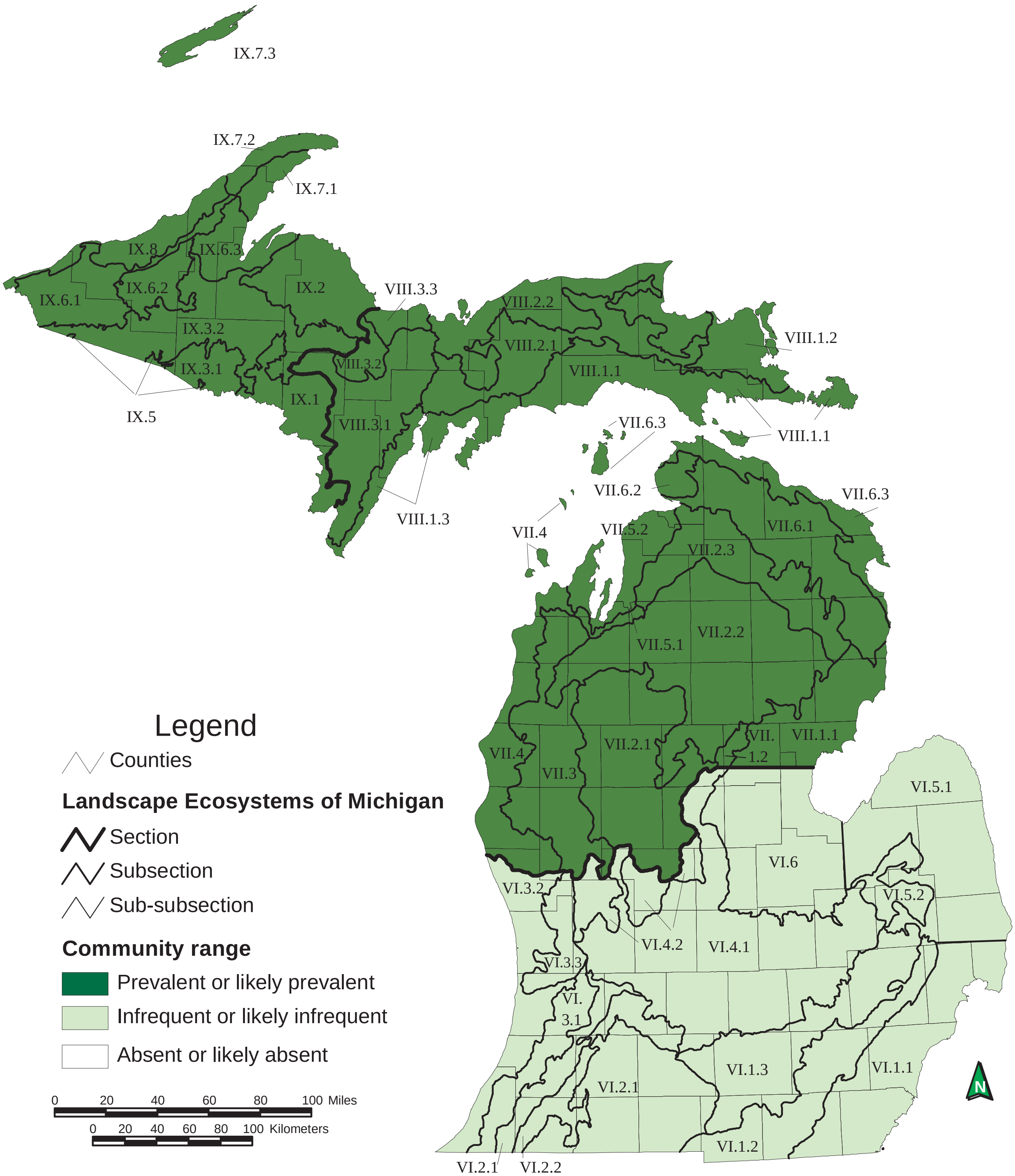


1998 aerial photograph of Dickerson Floodplain Forest.

Dickerson Floodplain Forest. Photo by Joshua G. Cohen.

HARDWOOD-CONIFER SWAMP

Overview: Hardwood-conifer swamp is a minerotrophic forested wetland dominated by a mixture of lowland hardwoods and conifers, occurring on organic (i.e., peat) and poorly drained mineral soils throughout Michigan. The community occurs on a variety of landforms, often associated with headwater streams and areas of groundwater discharge. Species composition and dominance patterns can vary regionally. Windthrow and fluctuating water levels are the primary natural disturbances that structure hardwood-conifer swamp (Kost et al. 2007, Cohen et al. 2014).



Map 5. Distribution of hardwood-conifer swamp in Michigan (Albert et al. 2008).

7. Derby Swamp
Natural Community Type: Hardwood-Conifer Swamp
Rank: G4 S3, apparently secure globally and vulnerable within the state
Element Occurrence Rank: C
Size: 17 acres
Location: Compartment 4, Stand 97
Element Occurrence Identification Number: 19966 (New EO)

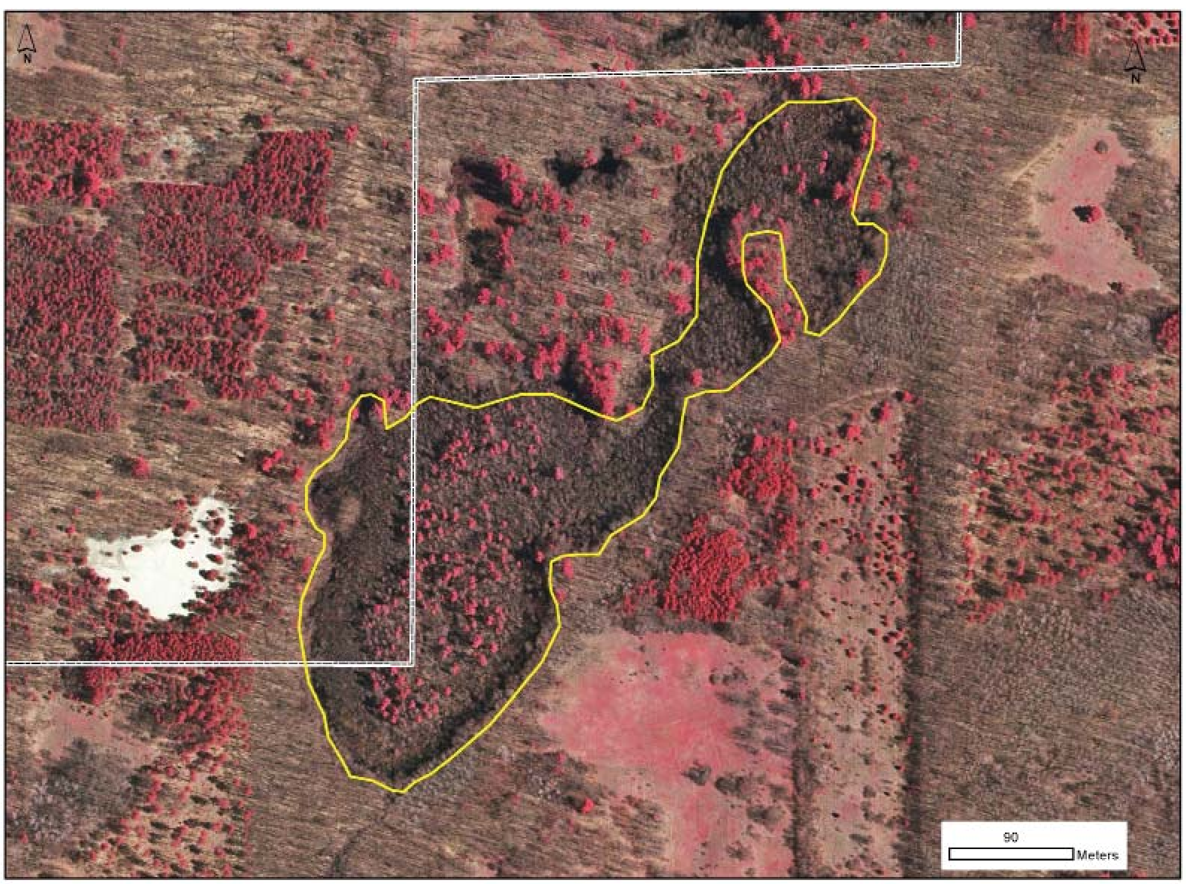
Site Description: The Derby Swamp is a maturing hardwood-conifer swamp that occurs on a flat, poorly drained depression within a morainal landscape. The swamp is characterized by sphagnum hummock and hollow topography along with tip-up mounds from windthrow. The diverse microtopography results in small-scale gradients in soil moisture and soil chemistry, which contributes to high species diversity. Many of the hollows were inundated during the growing season with standing water reaching a half a meter. The soils are deep (> 1 meter), inundated to saturated, acidic (pH 5.0-6.5) peats that range from fibric on the tree mounds and sphagnum hummocks (pH 5.0) and hemic to sapric in the hollows (pH 6.0-6.5). Numerous windthrows within the swamp create light gaps and pit and mound topography and contribute to a moderate coarse woody debris load. Downed logs within the swamp provide substrate for vegetation to establish and grow. A 34.8 cm white pine (*Pinus strobus*) was cored and estimated to be over 78 years old and a 28.3 cm tamarack (*Larix laricina*) was cored and estimated to be 128 years old. Where groundwater seepage is prevalent along the edge of the swamp and the adjacent upland, water accumulates locally and forms a moat. Portions of this wetland basin support inclusions of southern shrub-carr and southern wet meadow. In addition, there is a small upland inclusion within the wetland that is dry-mesic northern forest dominated by white pine.

This hardwood-conifer swamp is dominated by white pine, tamarack, and red maple (*Acer rubrum*) with associates including American elm (*Ulmus americana*) and black ash (*Fraxinus nigra*). Canopy trees typically range in diameter from 10 to 30 cm with some large white pine reaching 40 to 80 cm. Large white pine are most prevalent along the swamp margin. The understory is characterized by winterberry (*Ilex verticillata*), highbush blueberry (*Vaccinium corymbosum*), and tag alder (*Alnus rugosa*), with associates including black ash, poison sumac (*Toxicodendron vernix*), and hazelnut (*Corylus americana*). The understory is locally dense with areas dominated by highbush blueberry. Common species of the low shrub layer are winterberry, poison sumac, highbush blueberry, and spicebush (*Lindera benzoin*). The ground cover is diverse with characteristic species including cinnamon fern (*Osmunda cinnamomea*), royal fern (*Osmunda regalis*), skunk cabbage (*Symplocarpus foetidus*), northern bugle weed (*Lycopus uniflorus*), false nettle (*Boehmeria cylindrica*), and fowl manna grass (*Glyceria striata*). Scattered sphagnum hummocks and tip-up mounds occur throughout the swamp and support Canada mayflower (*Maianthemum canadense*), goldthread (*Coptis trifolia*), starflower (*Trientalis borealis*), and wild sarsaparilla (*Aralia nudicaulis*). Species prevalent in the hollows include cinnamon fern, royal fern, calico aster (*Symphyotrichum lateriflorum*), and sedges (*Carex* spp.). Vines are common within the swamp and include Virginia creeper (*Parthenocissus quinquefolia*) and poison-ivy (*Toxicodendron radicans*).

Threats: Species composition and floristic structure are influenced primarily by the seasonally fluctuating water table and windthrow. Threats to the swamp include invasive species encroachment and high levels of deer herbivory.

Management Recommendations: The main management recommendations are to allow natural processes to operate unhindered, prevent alterations to hydrology in adjacent wetlands (e.g., avoid ditching, damming, and diking), reduce local deer populations, monitor for invasives and deer browse, and to retain an intact buffer of natural communities surrounding the hardwood-conifer swamp.

Derby Swamp hardwood-conifer swamp. Photo by Joshua G. Cohen.



1998 aerial photograph of Derby Swamp hardwood-conifer swamp.

8. **Dickerson Swamp**
Natural Community Type: Hardwood-Conifer Swamp
Rank: G4 S3, apparently secure globally and vulnerable within the state
Element Occurrence Rank: CD
Size: 35 acres
Location: Compartment 5, Stand 83
Element Occurrence Identification Number: 19968 (New EO)

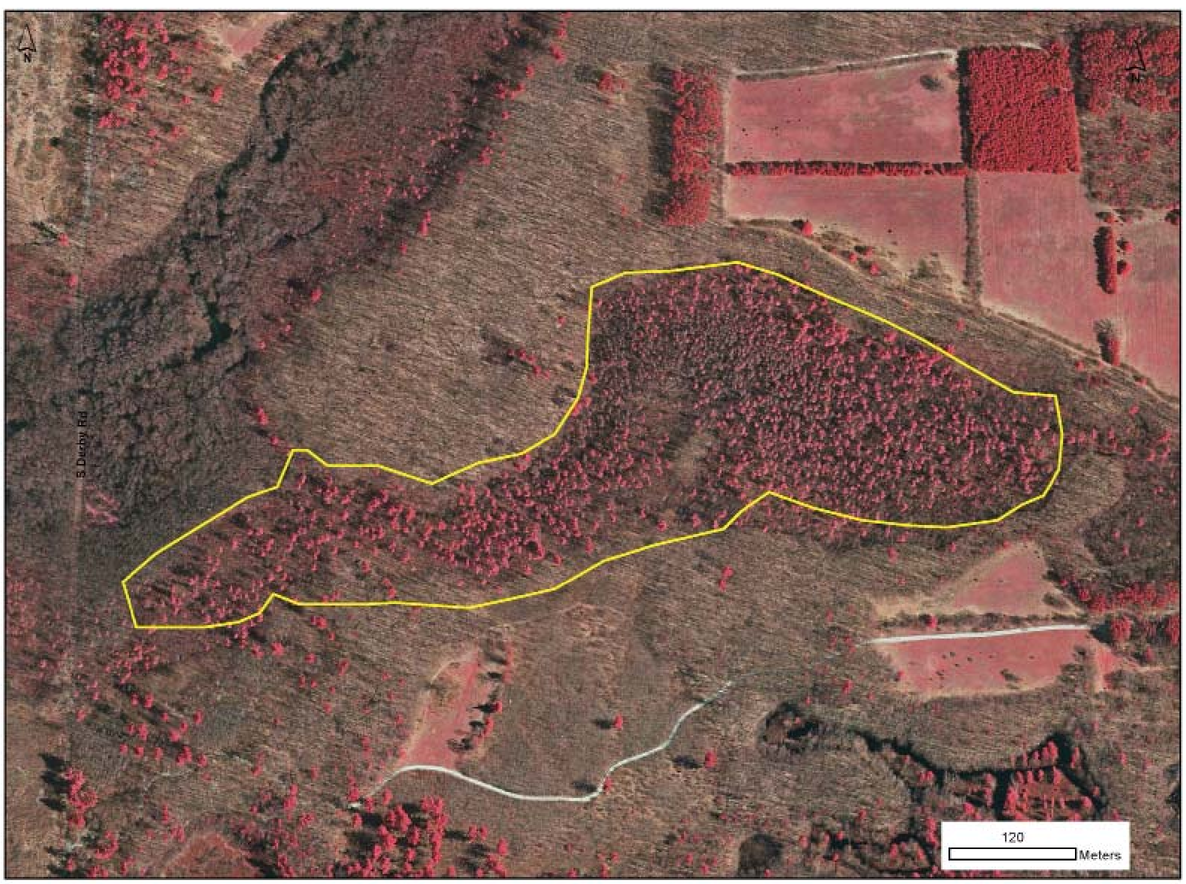
Site Description: The Dickerson Swamp is a young hardwood-conifer swamp that occurs in a drainage channel within a morainal landscape. The western portion of the swamp occurs as backswamp along the floodplain of Dickerson Creek. The swamp is characterized by developing sphagnum hummock and hollow topography along with tip-up mounds from windthrow. The diverse microtopography results in small-scale gradients in soil moisture and soil chemistry, which contributes to high species diversity. The soils are deep (> 1 meter), inundated to saturated, slightly acidic (pH 6.5-6.8) sapric peats. Numerous windthrows within the swamp create light gaps and pit and mound topography and contribute to a moderate coarse woody debris load. Downed logs within the swamp provide substrate for vegetation to establish and grow.

The Dickerson Swamp is dominated by white pine (*Pinus strobus*), yellow birch (*Betula alleghaniensis*), and red maple (*Acer rubrum*) with canopy associates including black ash (*Fraxinus nigra*) and tamarack (*Larix laricina*). Many of the canopy ash trees are dead due to the emerald ash borer. Canopy trees typically range in diameter from 20 to 40 cm with some large white pine reaching 40 to 60 cm, especially near the upland margin. The understory is dense and diverse and is characterized by poison sumac (*Toxicodendron vernix*), winterberry (*Ilex verticillata*), musclewood (*Carpinus caroliniana*), highbush blueberry (*Vaccinium corymbosum*), spicebush (*Lindera benzoin*), and tag alder (*Alnus rugosa*). Common species of the low shrub layer are highbush blueberry, hazelnut (*Corylus americana*), and huckleberry (*Gaylussacia baccata*). Vines are common within the swamp and include Virginia creeper (*Parthenocissus quinquefolia*), river grape (*Vitis riparia*), and poison-ivy (*Toxicodendron radicans*). The ground cover is diverse with characteristic species including cinnamon fern (*Osmunda cinnamomea*), skunk cabbage (*Symplocarpus foetidus*), sedges (*Carex* spp.), sensitive fern (*Onoclea sensibilis*), and wood nettle (*Laportea canadensis*). Additional common species include rough goldenrod (*Solidago rugosa*), marsh-marigold (*Caltha palustris*), purple meadow rue (*Thalictrum dasycarpum*), fowl manna grass (*Glyceria striata*), calico aster (*Symphyotrichum lateriflorum*), jumpseed (*Persicaria virginiana*), and golden ragwort (*Packera aurea*). Scattered sphagnum hummocks and tip-up mounds occur throughout the swamp. Characteristic species on the sphagnum hummocks include starflower (*Trientalis borealis*), wintergreen (*Gaultheria procumbens*), goldthread (*Coptis trifolia*), and partridge-berry (*Mitchella repens*).

Threats: Threats to the swamp include invasive species encroachment and high levels of deer herbivory. Deer browse was noted throughout and autumn olive (*Elaeagnus umbellata*) occurs locally on the peat hummocks. Canopy ashes have died due to emerald ash borer.

Management Recommendations: The main management recommendations are to allow natural processes to operate unhindered, prevent alterations to hydrology in adjacent wetlands (e.g., avoid ditching, damming, and diking), control invasive species through cutting and herbiciding, reduce local deer populations, monitor for invasives and deer browse, and to retain an intact buffer of natural communities surrounding the hardwood-conifer swamp.

Dickerson Swamp hardwood-conifer swamp. Photo by Joshua G. Cohen.



1998 aerial photograph of Dickerson Swamp hardwood-conifer swamp.

9. **Grow Swamp**
Natural Community Type: Hardwood-Conifer Swamp
Rank: G4 S3, apparently secure globally and vulnerable within the state
Element Occurrence Rank: C
Size: 22 acres
Location: Compartment 4, Stand 130
Element Occurrence Identification Number: 19965 (New EO)

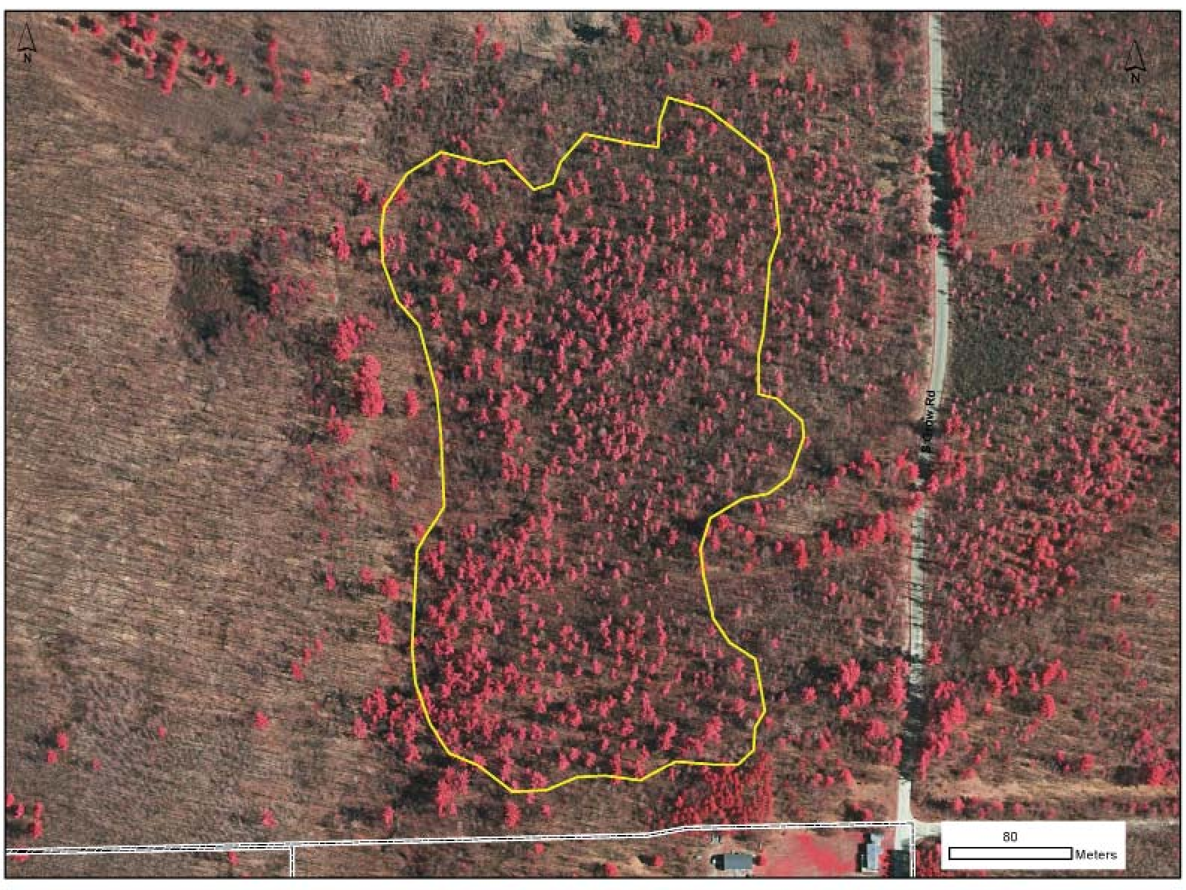
Site Description: Grow Swamp is a young hardwood-conifer swamp that occurs on a flat, poorly drained depression within a morainal landscape. The swamp is characterized by developing sphagnum hummock and hollow topography along with tip-up mounds from windthrow. The diverse microtopography results in small-scale gradients in soil moisture and soil chemistry, which contributes to high species diversity. The soils are deep (> 1 meter), inundated to saturated, circumneutral to alkaline (pH 7.0-7.3) peats that range from hemic to sapric. Numerous windthrows within the swamp create light gaps and pit and mound topography and contribute to a moderate coarse woody debris load. Downed logs within the swamp provide substrate for vegetation to establish and grow. A 53.8 cm white pine (*Pinus strobus*) was cored and estimated to be over 96 years old. A stream passes through the hardwood-conifer swamp.

The canopy is dominated by white pine, yellow birch (*Betula alleghaniensis*), red maple (*Acer rubrum*), and tamarack (*Larix laricina*). Scattered black ash (*Fraxinus nigra*) snags occur throughout. Canopy trees typically range in diameter from 20 to 50 cm with some large white pine reaching 50 to 60 cm. The understory is characterized by musclewood (*Carpinus caroliniana*), prickly-ash (*Zanthoxylum americanum*), tag alder (*Alnus rugosa*), winterberry (*Ilex verticillata*), highbush blueberry (*Vaccinium corymbosum*), and hazelnut (*Corylus americana*). Common species of the low shrub layer are wild black currant (*Ribes americanum*), gray dogwood (*Cornus foemina*), spicebush (*Lindera benzoin*), and black ash seedlings. The ground cover is diverse with characteristic species including cinnamon fern (*Osmunda cinnamomea*), skunk cabbage (*Symplocarpus foetidus*), royal fern (*Osmunda regalis*), wood nettle (*Laportea canadensis*), jewelweed (*Impatiens capensis*), and fowl manna grass (*Glyceria striata*). Additional common species include mad-dog skullcap (*Scutellaria lateriflora*), naked miterwort (*Mitella nuda*), dwarf raspberry (*Rubus pubescens*), marsh-marigold (*Caltha palustris*), calico aster (*Symphyotrichum lateriflorum*), sedges (*Carex* spp.), goldthread (*Coptis trifolia*), rough goldenrod (*Solidago rugosa*), and wood anemone (*Anemone quinquefolia*). Scattered sphagnum hummocks and tip-up mounds occur throughout the swamp.

Threats: Threats to the swamp include invasive species encroachment and high levels of deer herbivory. Deer browse was noted throughout and deer browse is likely impacting floristic composition and vegetative structure. Multiflora rose (*Rosa multiflora*) is locally common within the swamp. This swamp has been historically logged as manifest by scattered cut stumps. Emerald ash borer has impacted the black ash (*Fraxinus nigra*) with much of the canopy ash dying from this invasive pest.

Management Recommendations: The main management recommendations are to allow natural processes to operate unhindered, prevent alterations to hydrology in adjacent wetlands (e.g., avoid ditching, damming, and diking), control invasive species through cutting and herbiciding, reduce deer densities within the larger landscape, monitor for invasives and deer browse, and to retain an intact buffer of natural communities surrounding the hardwood-conifer swamp.

Grow Swamp hardwood-conifer swamp. Photo by Joshua G. Cohen.



1998 aerial photograph of Grow Swamp hardwood-conifer swamp.

10. Miller Swamp
Natural Community Type: Hardwood-Conifer Swamp
Rank: G4 S3, apparently secure globally and vulnerable within the state
Element Occurrence Rank: CD
Size: 16 acres
Location: Compartment 4, Stand 2
Element Occurrence Identification Number: 20104 (New EO)

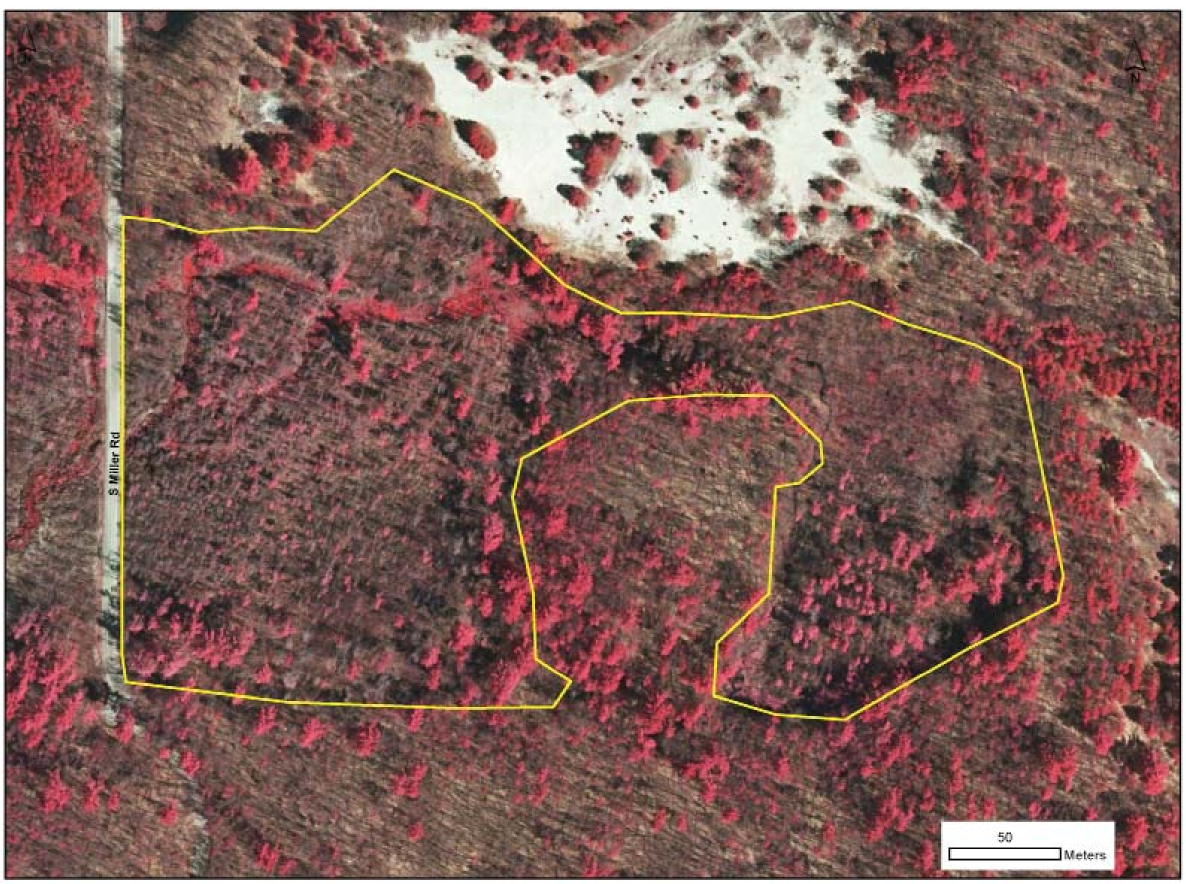
Site Description: Miller Swamp is a maturing hardwood-conifer swamp that occurs in a flat, poorly drained depression within a morainal landscape. The swamp is characterized by sphagnum hummock and hollow topography. The diverse microtopography results in small-scale gradients in soil moisture and soil chemistry, which contributes to high species diversity. The soils are deep (> 1 meter), saturated, circumneutral (pH 7.5) sapric peats. Old logs were observed within the peat profile, indicating that historically this wetland was a forested wetland. Near the margins of the swamp, groundwater seeps from the adjacent steep uplands and rainwater collects at the base of the slopes and creates pools of standing stagnant water over deep muck. These areas tend to be closed canopy and dominated by white pine (*Pinus strobus*) and red maple (*Acer rubrum*) with a sparse shrub layer and a very diverse ground layer where the standing water gives way to peat covered hummocks. Elsewhere, the hydrology is influenced by a small stream that forms in the eastern lobe of the swamp and traverses throughout the northern portion. The zone along the stream is characterized by a sparse canopy of tamarack (*Larix laricina*) and a dense shrub layer and a diverse ground layer. The stream is crossed by Miller Road to the west where the alterations to hydrology have likely increased the water levels. Zones influenced by increased water levels are more similar to a shrub-carr and may have historically been prairie fen. There are also inclusions within the swamp where deep seeps are ringed with floating peat mats dominated by wiregrass sedge (*Carex lasiocarpa*) and shrubby cinquefoil (*Dasiphora fruticosa*).

As noted, the canopy is variable with dominants including white pine, red maple, and tamarack. Canopy associates include green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*), and trembling aspen (*Populus tremuloides*). Canopy trees typically range in diameter from 20 to 40 cm with some larger white pine, red maple, and tamarack reaching 40 to 80 cm. Canopy conditions range from open to closed but are predominantly open. There are multiple vegetative zones throughout the swamp. The southwest corner and northeast lobe are characterized by: a closed canopy with white pine, red maple, and trembling aspen; a subcanopy with American elm, red maple, green ash, and choke cherry (*Prunus virginiana*); an understory with poison sumac (*Toxicodendron vernix*), winterberry (*Ilex verticillata*), and highbush blueberry (*Vaccinium corymbosum*); and a rich ground layer with cinnamon fern (*Osmunda cinnamomea*), skunk cabbage (*Symplocarpus foetidus*), rough-leaved goldenrod (*Solidago patula*), and calico aster (*Symphyotrichum lateriflorum*). The central portion of the swamp was not forested in 1938 and may be fire suppressed prairie fen with young, sparsely spaced white pine and tamarack and a dense shrub layer with winterberry, tag alder (*Alnus rugosa*), poison sumac, and willows (*Salix* spp.). Areas near the small stream are characterized by a sparse canopy of tamarack and a dense shrub layer with poison sumac, winterberry, tag alder, willows, and silky dogwood (*Cornus amomum*). The ground cover is very diverse with characteristic species including broad-leaved cat-tail (*Typha latifolia*), boneset (*Eupatorium perfoliatum*), Joe-pye-weed (*Eutrochium maculatum*), dwarf raspberry (*Rubus pubescens*), groundnut (*Apios americana*), marsh fern (*Thelypteris palustris*), sensitive fern (*Onoclea sensibilis*), rough goldenrod (*Solidago rugosa*), marsh-marigold (*Caltha palustris*), purple meadow rue (*Thalictrum dasycarpum*), swamp-betony (*Pedicularis lanceolata*), marsh skullcap (*Scutellaria galericulata*), blue-joint (*Calamagrostis canadensis*), cinnamon fern (*Osmunda cinnamomea*), fowl manna grass (*Glyceria striata*), purple avens (*Geum rivale*), jewelweed (*Impatiens capensis*), and royal fern (*Osmunda regalis*).

Threats: Threats to the swamp include invasive species encroachment, high levels of deer herbivory, and altered hydrology. Miller Road passes through the complex and has likely locally disrupted the wetland's hydrology. Invasives noted within the swamp include multiflora rose (*Rosa multiflora*), autumn olive (*Elaeagnus umbellata*), Japanese barberry (*Berberis thunbergii*), and bittersweet nightshade (*Solanum dulcamara*). Narrow-leaved cat-tail (*Typha angustifolia*), reed canary grass (*Phalaris arundinacea*), purple loosestrife (*Lythrum salicarea*), and reed (*Phragmites australis*) occur along the road adjacent to the swamp. Canopy ash within the swamp is dead due to emerald ash borer.

Management Recommendations: The main management recommendations are to allow natural processes to operate unhindered, prevent alterations to hydrology in adjacent wetlands (e.g., avoid ditching, damming, and diking), control and monitor for invasives, monitor deer browse, and to retain an intact buffer of natural communities surrounding the hardwood-conifer swamp. Closing Miller Road and removing the impoundment further downstream would benefit this wetland.

Miller Swamp hardwood-conifer swamp. Photo by Jesse M. Lincoln.



1998 aerial photograph of Miller Swamp hardwood-conifer swamp.

11. **Race Lake Swamp**
Natural Community Type: Hardwood-Conifer Swamp
Rank: G4 S3, apparently secure globally and vulnerable within the state
Element Occurrence Rank: C
Size: 9 acres
Location: Compartment 3, Stand 111
Element Occurrence Identification Number: 19967 (New EO)

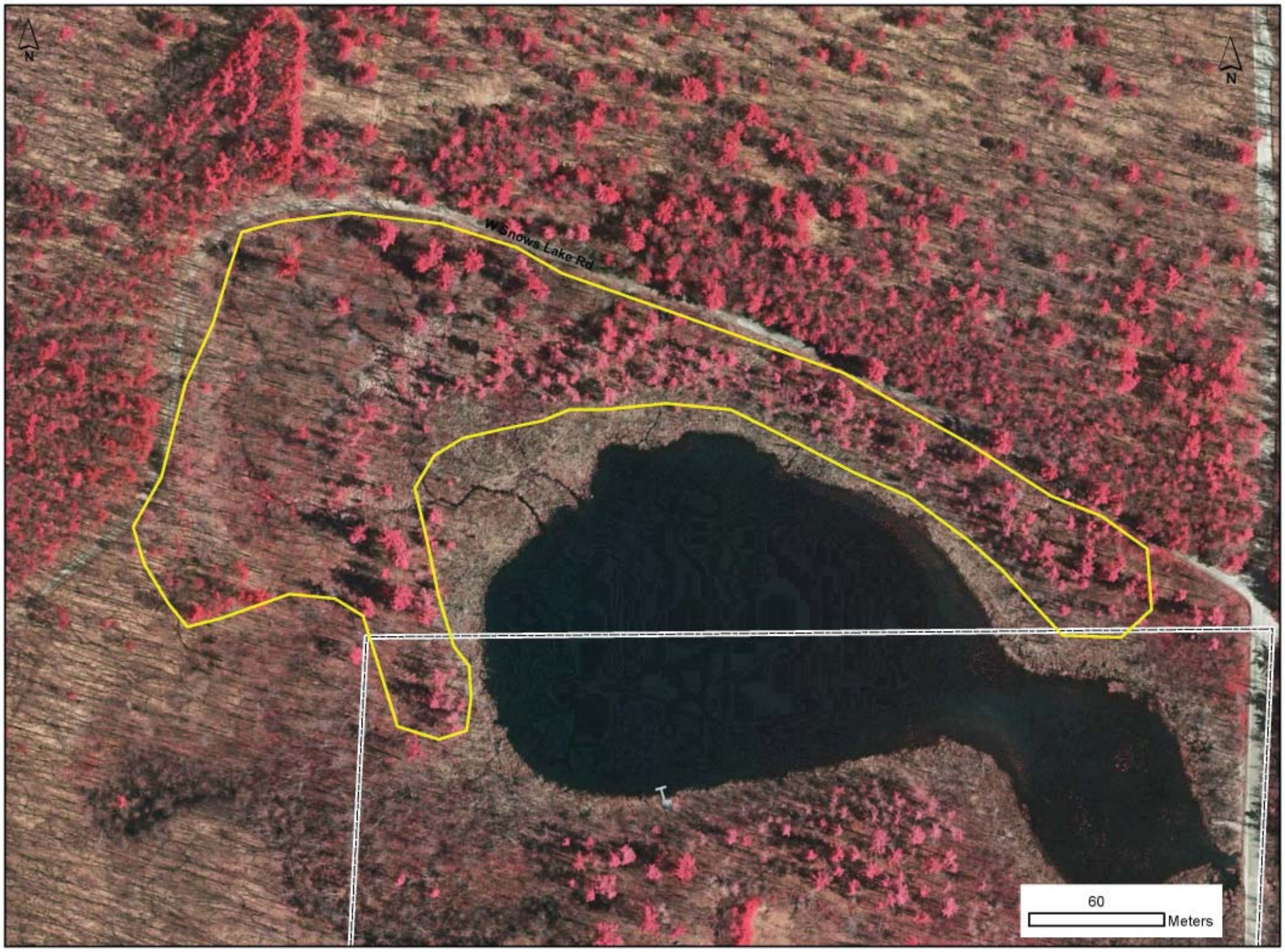
Site Description: Race Lake Swamp is a maturing hardwood-conifer swamp that occurs on a flat, poorly drained depression within a morainal landscape along the northern and western shores of Race Lake. The swamp is characterized by sphagnum hummock and hollow topography along with tip-up mounds from windthrow. The diverse microtopography results in small-scale gradients in soil moisture and soil chemistry, which contributes to high species diversity. The soils are deep (> 1 meter), saturated, circumneutral (pH 7.0) peats that range from hemic to sapric. Old logs were observed within the peat profile, indicating that historically much of this wetland was a forested wetland. Numerous windthrows within the swamp create light gaps and pit and mound topography and contribute to a moderate coarse woody debris load. Downed logs within the swamp provide substrate for vegetation to establish and grow. A 39.5 cm white pine (*Pinus strobus*) was cored and estimated to be over 120 years old and a 34.5 cm tamarack (*Larix laricina*) was cored and estimated to be 115 years old. Groundwater seepage is prevalent along the western edge of the swamp. Several creeks pass through this hardwood-conifer swamp and feed into Race Lake. Along the lake edge, the hardwood-conifer swamp transitions locally to shrubby prairie fen and some of the western portion of swamp contains inclusions of southern hardwood swamp. Some tamarack occurring on the sedge mat close to the lake margin appear to have been flood-killed. This swamp was notable for the high floristic diversity as well as a high diversity and activity of birds observed during the course of the survey.

This hardwood-conifer swamp is dominated by white pine, tamarack, and red maple (*Acer rubrum*) with canopy associates including yellow birch (*Betula alleghaniensis*) and swamp white oak (*Quercus bicolor*). Canopy trees typically range in diameter from 20 to 40 cm with some large white pine, red maple, and swamp white oak reaching 40 to 70 cm. Canopy conditions range from open to closed but are predominantly open. The understory layer is diverse and locally dense where the canopy is open. Prevalent tall shrubs include poison sumac (*Toxicodendron vernix*), winterberry (*Ilex verticillata*), pussy willow (*Salix discolor*), gray dogwood (*Cornus foemina*), musclewood (*Carpinus caroliniana*), prickly-ash (*Zanthoxylum americanum*), highbush blueberry (*Vaccinium corymbosum*), and tag alder (*Alnus rugosa*). Common tree saplings in the understory layer include black ash (*Fraxinus nigra*), trembling aspen (*Populus tremuloides*), red maple, and basswood (*Tilia americana*). The invasive Japanese barberry (*Berberis thunbergii*) is locally common in the understory. Common species of the low shrub layer are black raspberry (*Rubus occidentalis*), common blackberry (*R. allegheniensis*), spicebush (*Lindera benzoin*), bog birch (*Betula pumila*), alder-leaved buckthorn (*Rhamnus alnifolia*), shrubby cinquefoil (*Dasiphora fruticosa*), and wild black currant (*Ribes americanum*). The ground cover is very diverse with characteristic species including broad-leaved cat-tail (*Typha latifolia*), boneset (*Eupatorium perfoliatum*), Joe-pye-weed (*Eutrochium maculatum*), skunk cabbage (*Symplocarpus foetidus*), dwarf raspberry (*Rubus pubescens*), groundnut (*Apios americana*), marsh fern (*Thelypteris palustris*), sensitive fern (*Onoclea sensibilis*), rough goldenrod (*Solidago rugosa*), marsh-marigold (*Caltha palustris*), purple meadow rue (*Thalictrum dasycarpum*), swamp-betony (*Pedicularis lanceolata*), marsh skullcap (*Scutellaria galericulata*), fragrant bedstraw (*Galium triflorum*), false asphodel (*Triantha glutinosa*), blue-joint (*Calamagrostis canadensis*), cinnamon fern (*Osmunda cinnamomea*), fowl manna grass (*Glyceria striata*), purple avens (*Geum rivale*), jewelweed (*Impatiens capensis*), and royal fern (*Osmunda regalis*).

Threats: Threats to the swamp include invasive species encroachment, high levels of deer herbivory, and altered hydrology. Snows Lake Road passes just north of the site and has likely locally disrupted the wetland's hydrology. The invasive narrow-leaved cat-tail (*Typha angustifolia*) occurs along a narrow stretch along the road. Invasives noted within the swamp include narrow-leaved cat-tail, Japanese barberry, autumn olive (*Elaeagnus umbellata*), glossy buckthorn (*Frangula alnus*), Canada thistle (*Cirsium arvense*), and bittersweet nightshade (*Solanum dulcamara*). Cut stumps are scattered throughout the swamp, which was historically logged. Canopy ash within the swamp is dead due to emerald ash borer. This die-off has generated numerous snags, light gaps, and ash coarse woody debris.

Management Recommendations: The main management recommendations are to allow natural processes to operate unhindered, prevent alterations to hydrology in adjacent wetlands (e.g., avoid ditching, damming, and diking), control and monitor for invasives, reduce local deer populations, monitor deer browse, and retain an intact buffer of natural communities surrounding the hardwood-conifer swamp. Closing Snows Lake Road in Section 30 would benefit this wetland.

Race Lake Swamp hardwood-conifer swamp. Photos by Joshua G. Cohen.

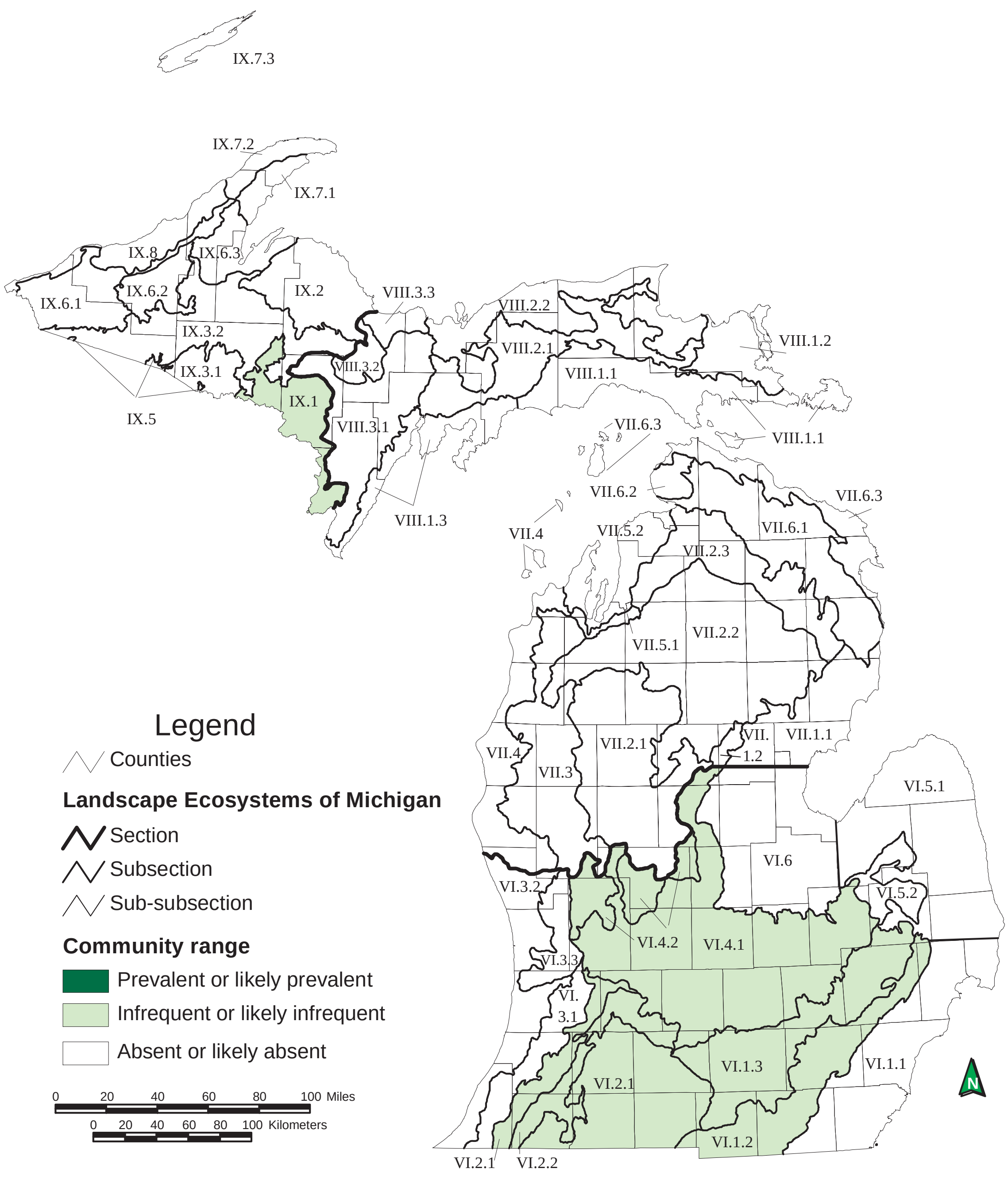


1998 aerial photograph of Race Lake Swamp hardwood-conifer swamp.

Race Lake Swamp hardwood-conifer swamp. Photo by Joshua G. Cohen.

HILLSIDE PRAIRIE

Overview: Hillside prairie is a native prairie or savanna community that occurs on moderate to steep exposed slopes and crests of hills associated with river valleys, streams, or kettle lakes. The community is almost always found on south- to west-facing slopes, where exposure to sunlight is highest, and is usually surrounded by oak savanna or oak forest. Hillside prairie typically occurs on strongly acidic to circumneutral loamy sands or sandy loams that are often mixed with gravel. Soil erosion and occasional fire maintain species composition and open conditions. Dominant species are little bluestem (*Schizachyrium scoparium*), porcupine grass (*Hesperostipa spartea*), and big bluestem (*Andropogon gerardii*). These species are associated with a variety of graminoids, forbs, shrubs, and occasional trees, including Pennsylvania sedge (*Carex pensylvanica*), summer grape (*Vitis aestivalis*), flowering dogwood (*Cornus florida*), white oak (*Quercus alba*), harebell (*Campanula rotundifolia*), kitten-tails (*Besseya bullii*, state endangered), round-lobed hepatica (*Hepatica americana*), bastard-toadflax (*Comandra umbellata*), and side-oats grama (*Bouteloua curtipendula*, state endangered). Today, hillside prairie is nearly extirpated from Michigan due to changes in land use and colonization by shrubs and trees (Kost et al. 2007, Cohen et al. 2014).



Map 6. Distribution of hillside prairie in Michigan (Albert et al. 2008).

12. **Fenwick Hillside Prairie**
Natural Community Type: Hillside Prairie
Rank: G3 S1, vulnerable globally and critically imperiled within the state
Element Occurrence Rank: BC
Size: 2 acres
Location: Compartment 2, Stand 42
Element Occurrence Identification Number: 19983 (New EO)

Site Description: The Fenwick Hillside Prairie occurs on a steep, west-facing slope over the Flat River within a broad glacial outwash channel. The system occurs in a matrix of dry-mesic southern forests and fire-suppressed oak barrens. The site is characterized by galleries of open prairie that are separated by patches of trees and shrubs that dominate on more gradual slopes. Soils of the hillside prairie are alkaline (pH > 8.0), loamy sands with gravel, and the soils are exposed in several areas. Areas at the base of the slope are sloughing into the river due to natural erosive action of the river. Deer trails throughout the hillside prairie are contributing to highly-localized erosion leading to patches of exposed soil and gravel.

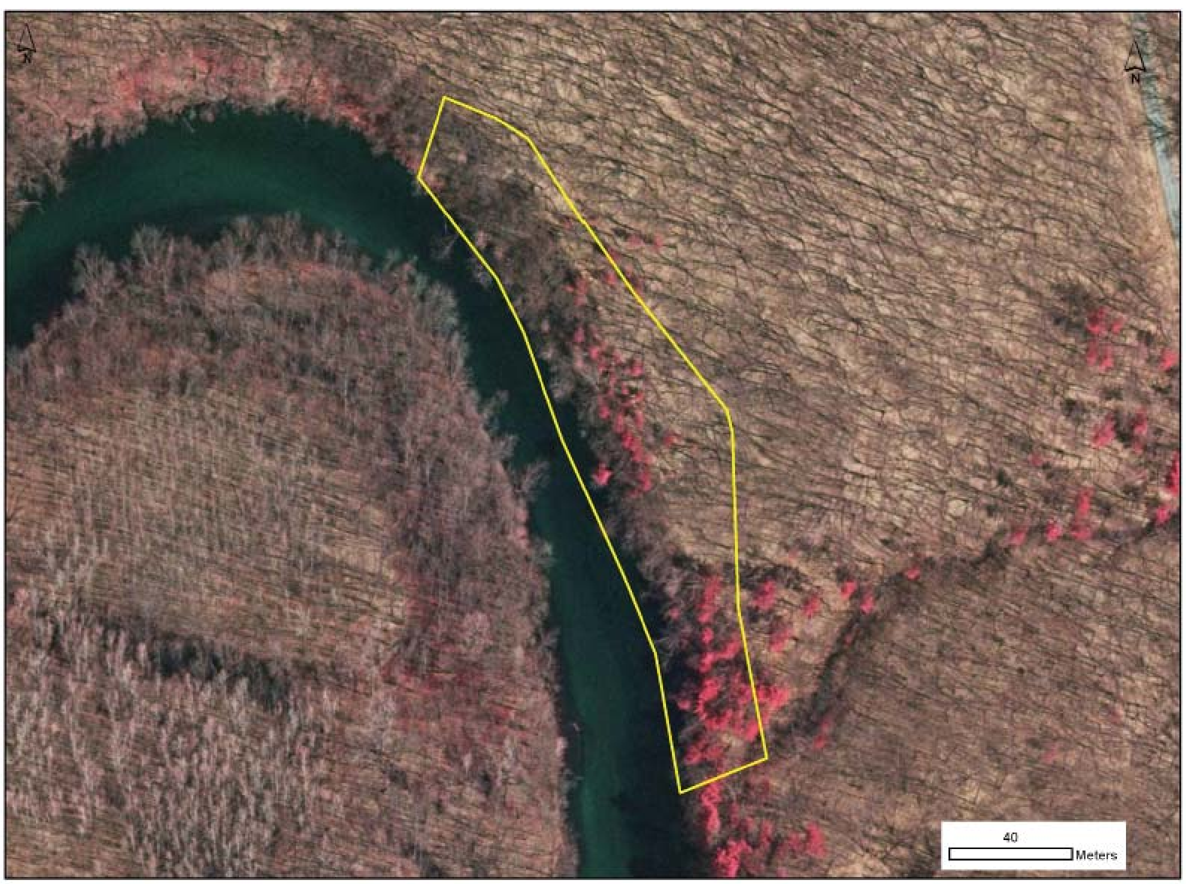
The hillside prairie is characterized by variable canopy coverage with some areas supporting 50% canopy coverage and scattered open galleries dominated by prairie grasses. Prevalent grasses include big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), porcupine grass (*Hesperostipa spartea*), cordgrass (*Spartina pectinata*), and panic grasses (*Dichanthelium* spp.). Characteristic forbs include woodland sunflower (*Helianthus divaricatus*), butterfly-weed (*Asclepias tuberosa*), hoary puccoon (*Lithospermum canescens*), hog-peanut (*Amphicarpaea bracteata*), wild-bergamot (*Monarda fistulosa*), wood-betony (*Pedicularis canadensis*), smooth false foxglove (*Aureolaria flava*), and starry false solomon-seal (*Maianthemum stellatum*). These prairie/savanna species extend into the adjacent forest at the top of the slope. This forest was likely an oak savanna historically and has become a closed forest system as the result of prolonged fire suppression. Within the hillside prairie, areas with greater canopy coverage are primarily dominated by white oak (*Quercus alba*) and black oak (*Q. velutina*) as well as bigtooth aspen (*Populus grandidentata*) and occasionally basswood (*Tilia americana*). The subcanopy is dominated by sassafras (*Sassafras albidum*), basswood, and oaks. The shrub layer is dominated by autumn olive (*Elaeagnus umbellata*), sassafras, musclewood (*Carpinus caroliniana*), basswood, white pine (*Pinus strobus*), and oak saplings. Autumn olive is occasionally dense and suppressing herbaceous vegetation.

Hillside prairie is critically imperiled in Michigan. Only 11 hillside prairies have been documented in Michigan. This is a particularly important example of this community type as it is the only example within the Flat River watershed. Many hillside prairies have been lost to development or protracted woody encroachment. Thus, this example is regionally significant.

Threats: The site is fire suppressed resulting in an increased dominance of invasive species and woody encroachment from oaks, bigtooth aspen, sassafras, and autumn olive. As noted above, where autumn olive is dense in the understory, it is outcompeting herbaceous species.

Management Recommendations: The main management recommendations are to reduce encroaching woody vegetation by targeted removal of shrubs and small trees from the highest quality openings. Woody removal should focus on autumn olive, sassafras, and bigtooth aspen and include cutting stumps and treating the cut stumps with herbicide. In addition, we recommend the reintroduction of fire as a prevalent disturbance factor. Prescribed fire should include the hillside prairie and the surrounding forest to the east, especially towards the railroad.

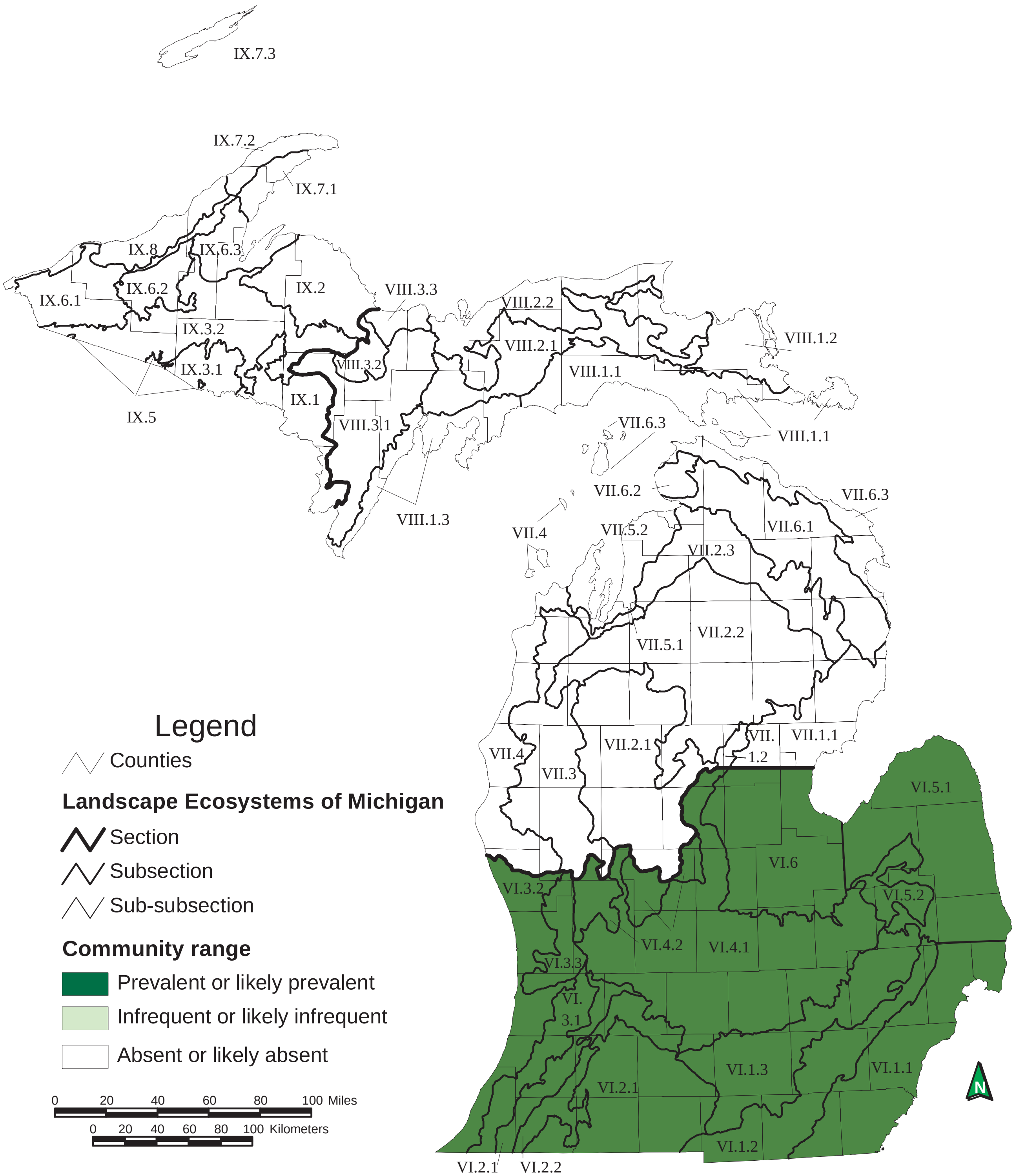
Fenwick Hillside Prairie. Photo by Jesse M. Lincoln.



1998 aerial photograph of Fenwick Hillside Prairie.

SOUTHERN WET MEADOW

Overview: Southern wet meadow is a groundwater-influenced, sedge-dominated wetland that occurs in the central and southern Lower Peninsula. Southern wet meadow occurs along lakes and streams and occupies abandoned glacial lakebeds. Natural processes that influence species composition and community structure include seasonal flooding, flooding by beaver, and fire. The community typically develops on circumneutral sapric peat. Sedges in the genus *Carex*, in particular tussock sedge (*C. stricta*) and lake sedge (*C. lacustris*), dominate the community. Common associates include blue-joint (*Calamagrostis canadensis*), marsh bellflower (*Campanula aparinoides*), common boneset (*Eupatorium perfoliatum*), joe-pye-weed (*Eutrochium maculatum*), northern bugle weed (*Lycopus uniflorus*), goldenrods (*Solidago* spp.), and asters (*Symphyotrichum* spp.) (Kost et al. 2007, Cohen et al. 2014).



Map 7. Distribution of southern wet meadow in Michigan (Albert et al. 2008).

13. Flat River Meadow
Natural Community Type: Southern Wet Meadow
Rank: G4? S3, apparently secure globally and vulnerable within the state
Element Occurrence Rank: BC
Size: 5.5 acres
Location: Compartment 5, Stand 116
Element Occurrence Identification Number: 19971 (New EO)

Site Description: The Flat River Meadow is a small southern wet meadow occurring in a poorly drained depression within a morainal landscape. The soils of the southern wet meadow are deep (> 1 meter), saturated to inundated, acidic (pH 4.5-5.0) hemic to sapric peats. Species composition, vegetative structure, and successional trajectory are influenced by season water level fluctuation. Water levels in the southern wet meadow fluctuate seasonally, reaching their peak in spring and lows in late summer, but typically remain at or near the soil's surface throughout the year. The wet meadow appears to be gradually transitioning towards bog with sphagnum hummocks developing and an ericaceous shrub layer increasing on the sphagnum hummocks.

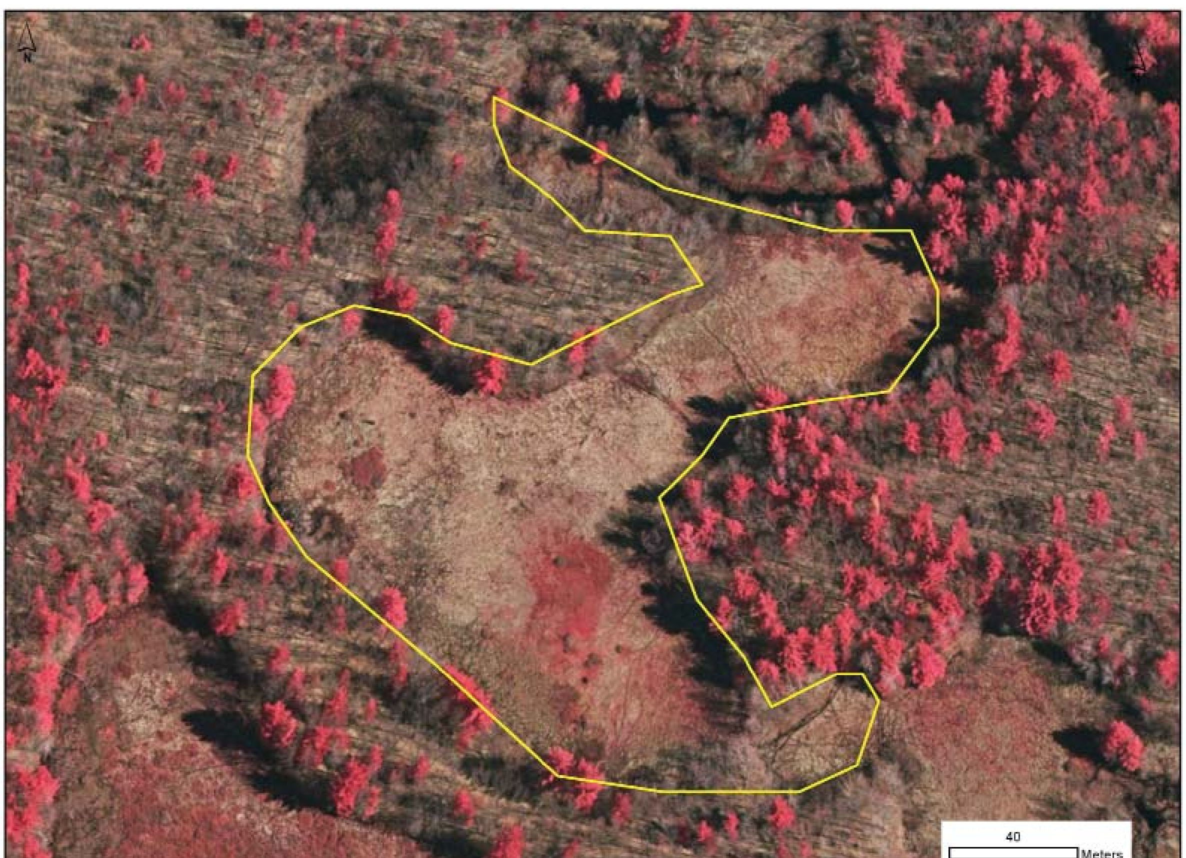
The southern wet meadow is dominated by lake sedge (*Carex lacustris*) and few-seed sedge (*Carex oligosperma*) with graminoid associates including blue-joint (*Calamagrostis canadensis*), wool-grass (*Scirpus cyperinus*), soft-stemmed rush (*Juncus effuses*), and broad-leaved cat-tail (*Typha latifolia*). Characteristic forbs include wild calla (*Calla palustris*), marsh St. John's-Wort (*Triadenum fraseri*), and water smartweed (*Persicaria amphibia*). Sphagnum hummocks are developing locally and support patches of ericaceous shrubs including leatherleaf (*Chamaedaphne calyculata*) and highbush blueberry (*Vaccinium corymbosum*). The scattered understory is characterized by highbush blueberry, poison sumac (*Toxicodendron vernix*), red maple (*Acer rubrum*), and white pine (*Pinus strobus*). White pine and red maple also occur as infrequent canopy trees.

Threats: Species composition, vegetative structure, and successional trajectory are influenced by season water level fluctuation and fire suppression. No invasive species were noted during the course of the survey.

Management Recommendations: The main management recommendations are to allow natural processes to operate unhindered, retain an intact buffer of natural communities surrounding the wetland to preserve its hydrology, burn the wet meadow with the surrounding uplands, and monitor for invasive species and following prescribed fire.

Flat River Meadow. Photo by Joshua G. Cohen.

Flat River Meadow. Photo by Joshua G. Cohen.



1998 aerial photograph of Flat River Meadow.

Vernal Pools Survey Results

A total of 172 potential vernal pools (PVPs) were identified and mapped in the Flat River SGA through aerial photograph interpretation (Figure 6). These PVPs were distributed throughout the game area. Several PVPs were identified and mapped within two natural community EOs in the game area including Dickerson Bog (EO ID 3663) and Hadicks Lake West dry-mesic southern forest (EO ID 3327).

A total of 26 vernal pools were verified in the field and 4 PVPs need additional information to confirm their status (i.e., whether they are vernal pools or not) (Figure 6). Of the 26 vernal pools verified in the field, 21 had been identified and mapped from aerial photos, and five were encountered in the field during vernal pool and/or amphibian and reptile surveys. Of the four potential vernal pools that need additional information to confirm their status, three had been identified and mapped from aerial photos, and one was encountered in the field during surveys. Potential vernal pools that need additional information to determine their status consisted of PVPs that were wet in the spring and need additional visits in late summer or early fall to verify their drying, or were dry in the fall and need additional visits in the spring to confirm their status and pool boundaries.

We also collected some basic information about the physical and ecological characteristics of vernal pools verified in the field. Most (23 of 26 or 88%) of the vernal pools verified in the field were surrounded by upland deciduous forest or upland mixed forest within 30 meters (100 ft) of the pools. A small number (n=7) of the pools also were surrounded by lowland forest, grassland or open habitat, or emergent wetlands. Eighteen (69%) of the 26 verified vernal pools were classified as open or sparsely vegetated vernal pools with little to no vegetation growing in the pools. Six (23%) of the pools were classified as forested vernal pools, one was classified as a marshy vernal pool, and one was half open and half shrubby. Eighteen (69%) of the verified vernal pools were isolated basins or depressions and not connected to other wetlands or water bodies. Twenty-five of the 26 verified vernal pools had no inlet or outlet, and one vernal pool had a temporary inlet/outlet. The verified vernal pools ranged in size or area from 58 to 14,761 m^2 (0.01 to 3.6 ac), and averaged 1335 m^2 (0.3 ac) in area. Vernal pool depths ranged from 15 cm (6 in) to 1 m (3 ft). Fourteen (54%) of the 26 vernal pools had no disturbances within 30 m (100 ft) of the pool. Disturbances within 30 m (100 ft) around the remaining twelve pools included dirt roads (n=10), minor logging historically (n=1), and light development (<25% developed, n=1). Similarly, 19 (73%) of the 26 vernal pools did not appear

Vernal pools occur throughout Flat River State Game Area and provide critical habitat for herptile and invertebrate species. Forested vernal pool pictured above. Photo by Yu Man Lee.

Open vernal pool pictured above and open/shrubby vernal pool pictured below. Photos by Yu Man Lee.

to have any disturbances within or immediately adjacent to the pool basin. Refuse dumping was documented within or adjacent to six of the vernal pools. Multiflora rose (*Rosa multiflora*) was documented immediately adjacent to one vernal pool.

Visual encounter surveys and/or dipnetting surveys documented a Blanding's turtle in one vernal pool (Pool ID MNFI7-15). In addition, vernal pool indicator species were documented in 12 (46%) of the 26 verified vernal pools and in one PVP that was surveyed but needs additional information to determine its status. These indicator species include wood frog adults/recent metamorphs and/or tadpoles in 11 (42%) of the verified vernal pools, and blue-spotted salamander egg masses in 5 (19%) of the verified vernal pools. A wood frog adult and blue-spotted salamander egg masses were found in the PVP. Other amphibian and reptile species observed in the vernal pools include green frogs (*Lithobates clamitans*) and eastern red-backed salamanders (*Plethodon cinereus*). Eastern red-backed salamander is considered a featured species for habitat management by the Wildlife Division of the MDNR. Additionally, fingernail clams (Veneroida: Sphaeriidae) were found in 15 of the verified vernal pools, of which 9 were dry or in the dry portions of these pools, which provided further evidence that these were vernal pools. In addition to herptiles and fingernail clams, a number of invertebrates also were found in the pools. These included mosquito larvae (Culicidae), springtails (Collembola), water fleas (*Daphnia*), seed shrimp (Ostracoda), phantom midges (Chaoboridae), water boatmen (Corixidae), water strider (Gerridae), water mites (Hydrachnidiae), caddisfly larvae (Trichoptera), aquatic sow bugs (Asellidae), predacious diving water beetles (Dytiscidae), other aquatic beetles (Coleoptera), millipedes (Diplopoda), bladder snails (Physidae), rams-horn snails (Planorbidae), and crayfish (Decapoda).

Wood frog tadpoles in a vernal pool. Photo by Yu Man Lee.

Observed vernal pool indicators include blue-spotted salamander egg masses (above) and wood frog metamorph (below). Photos by Yu Man Lee.

Vernal pool associates observed include eastern red-backed salamander (above) and green frog (below). Photos by Yu Man Lee.

Rare Animal Survey Results

Birds

We completed rare raptor surveys at 81 points within the game area (Figure 7). Red-shouldered hawks were detected at 20 of the points visited. We found two active red-shouldered hawk nests, which are both considered part of the same new element occurrence (EOID 20486) (Figure 12). Although we only found two nests, having observations at 25% of the survey stations indicates more nesting territories could occur in the game area. No red-shouldered hawk element occurrences had been documented within the game area prior to our 2015 surveys (Table 3). Both of the nests successfully hatched chicks, with one nest having three young and the second nest having four young during nest productivity checks conducted on May 31st, 2015. We did not detect any northern goshawks but found a possible old nest just south of the Flat River and north of the Greenville Airport. There was no sign of activity but the nest was in good condition.

Forest songbird surveys were conducted at 103 points within forest stands (Figure 7). Three rare forest-nesting songbird species were previously documented within the game area (Table 3). We recorded hooded warbler and Louisiana waterthrush at new locations during point counts (Figure 12); however, we did not reconfirm the presence of cerulean warbler within the game area. We recorded three singing male hooded warblers at three locations. Two of these observations (north of Dickerson Creek) are considered part of the existing element occurrence from 2003 (EOID 13427), whereas the third observation (just west of Youngman Road) represents a new occurrence for the species (EOID 20542) (Figure 12). We recorded two singing male Louisiana waterthrushes at two separate new locations adjacent to Dickerson Creek (Figure 12). Both of the new Louisiana waterthrush observations are considered part of the existing element occurrence (EOID 13426) first documented in 2003.

We recorded a total of 71 bird species during point counts within Flat River SGA (Appendix 8). The five most commonly detected species were red-eyed vireo (*Vireo olivaceus*; 82% of points), American robin (*Turdus migratorius*; 64% of points), eastern wood-pewee (*Contopus virens*; 62% of points), ovenbird (*Seiurus aurocapilla*; 54% of points), and black-capped chickadee (*Poecile atricapillus*; 50% of points). Sixteen species were regularly observed (25-50% of points surveyed): Acadian flycatcher (*Empidonax virescens*), American crow (*Corvus brachyrhynchos*), blue jay (*Cyanocitta cristata*), brown-headed cowbird (*Molothrus ater*), cedar waxwing (*Bombycilla cedrorum*), common yellowthroat (*Geothlypis trichas*), great crested flycatcher (*Myiarchus crinitus*), mourning dove (*Zenaida macroura*), northern cardinal (*Cardinalis cardinalis*), rose-breasted grosbeak (*Pheucticus ludovicianus*), red-bellied woodpecker (*Melanerpes carolinus*), scarlet tanager (*Piranga olivacea*), tufted titmouse (*Baeolophus bicolor*), veery (*Catharus fuscescens*), white-breasted nuthatch (*Sitta carolinensis*), and wood thrush (*Hylocichla mustelina*). Fourteen (20%) of the species were detected at 10 to 25% of the survey points and 37 species (52%) were detected at less than 10% of the survey points. On average, we recorded 12.5 bird species per point count station.

Several of the bird species detected have special conservation status (Appendix 9). The following nine species are considered featured species for habitat management by the Wildlife Division of the MDNR: wood duck (*Aix sponsa*), mallard (*Anas platyrhynchos*), ring-necked pheasant (*Phasianus colchicus*), wild turkey (*Meleagris gallopavo*), red-shouldered hawk, red-headed woodpecker (*Melanerpes erythrocephalus*), pileated woodpecker (*Dryocopus pileatus*), eastern bluebird (*Sialia sialis*), and wood thrush. Red-shouldered hawk and red-headed woodpecker are also considered SGCN (Derosier et al. 2015), as are hooded warbler and Louisiana waterthrush. In addition, we observed four species (red-headed woodpecker, veery, wood thrush, and Louisiana waterthrush) that are considered focal species for conservation efforts under the Landbird Habitat Conservation Strategy of the Upper Mississippi River and Great Lakes Region Joint Venture (Potter et al. 2007).

Red-shouldered hawk nest found just north of Dickerson Creek. Photo by Michael J. Monfils.

Three red-shouldered hawk young observed in a nest found north of Dickerson Creek during 2015 surveys conducted in Flat River State Game Area. Photo by David Cuthrell.

Table 3. Newly documented and previously known rare bird element occurrences at Flat River State Game Area and in the vicinity. State status abbreviations are as follows: T, state threatened, and SC, state special concern. Element occurrence (EO) rank abbreviations are as follows: BC, good or fair estimated viability; C, fair viability; CD, fair to poor viability; D, poor viability; and E, verified extant. An * indicates the EO was newly documented in 2015, ** indicates the EO was updated during this project, and [1] indicates that the record is from nearby private land.

Common Name	Scientific Name	State Status	EO ID	EO Rank	Year First Observed	Year Last Observed
Grasshopper sparrow[1]	*Ammodramus savannarum*	SC	15638	CD	2005	2005
Red-shouldered hawk*	*Buteo lineatus*	T	20486	C	2015	2015
Osprey[1]	*Pandion haliaetus*	SC	19920	E	2014	2014
Louisiana waterthrush**	*Seiurus motacilla*	T	13426	C	2003	2015
Cerulean warbler	*Setophaga cerulea*	T	13425	BC	2003	2003
Hooded warbler**	*Setophaga citrina*	SC	13427	E	2003	2015
Dickcissel[1]	*Spiza americana*	SC	16560	D	2007	2007

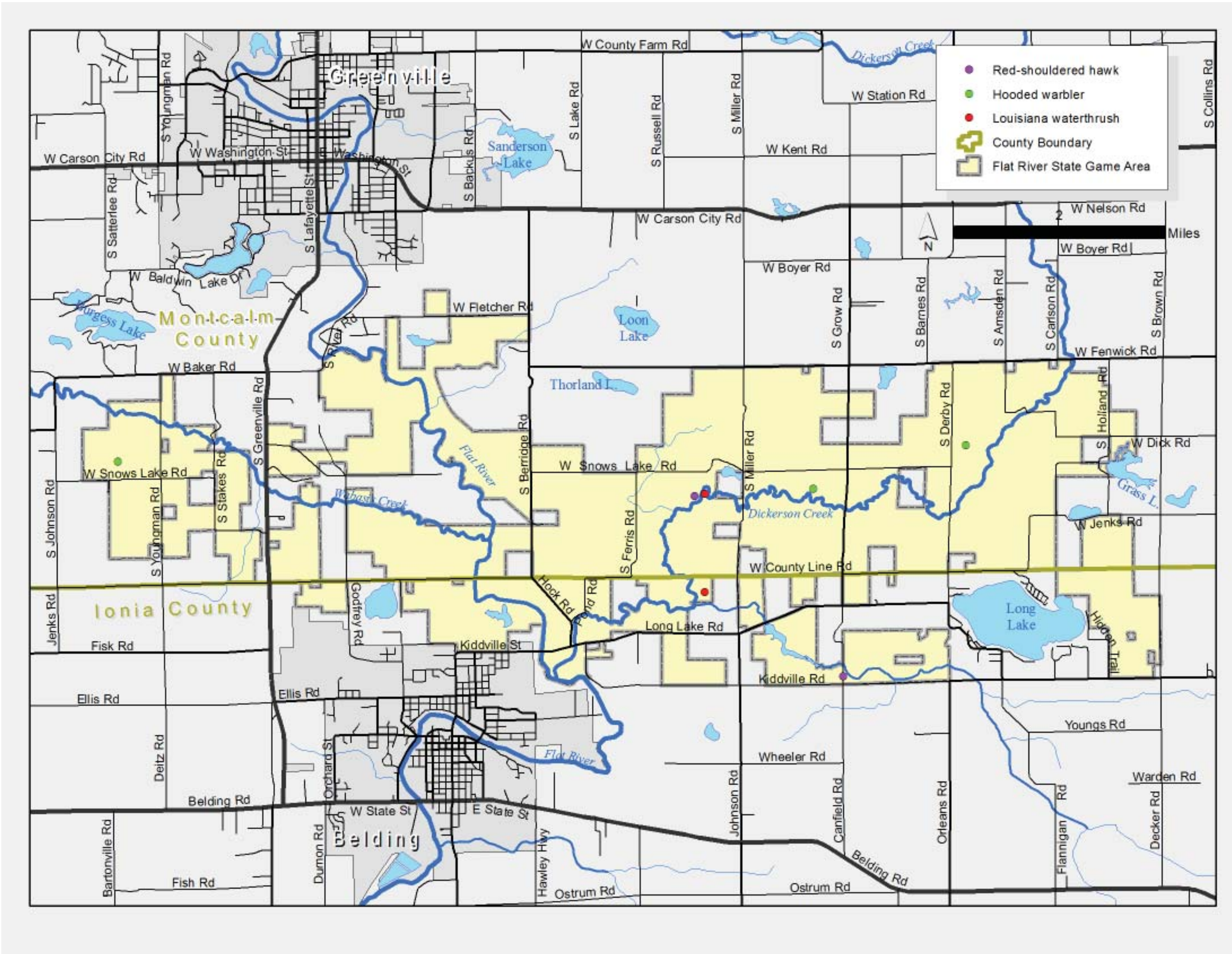


Figure 12. Rare bird element occurrences within Flat River State Game Area.

Table 4. Rare herptile element occurrences at Flat River State Game Area and in the vicinity. State status abbreviations are as follows: SC, state special concern. Element occurrence (EO) rank abbreviations are as follows: AB, excellent to good viability, and B, good viability. An ** indicates the EO was updated during this project.

Common Name	Scientific Name	State Status	EO ID	EO Rank	Year First Observed	Year Last Observed
Blanding's turtle**	*Emydoidea blandingii*	SC	523	AB	2000	2015
Eastern box turtle**	*Terrapene carolina carolina*	SC	2925	B	2000	2015

Reptiles and Amphibians

Amphibian and reptile surveys conducted in 2015 within the Flat River SGA documented 18 species. Two of these 18 species, Blanding's turtle and eastern box turtle, are state special concern. These observations resulted in updated element occurrences (EOs) for Blanding's turtle and eastern box turtle in the game area (Table 4). Three additional SGCN, pickerel frog, blue racer, and northern ribbon snake, were recorded during 2015 surveys (Appendix 3).

Visual encounter surveys and basking surveys documented Blanding's turtles at four sites in Flat River SGA (Figure 13). One adult Blanding's turtle was observed on May 3rd, 2015, basking or resting in an open vernal pool (Pool ID MNFI7-15) in an upland oak forest stand (Compartment 3, Stand 29) between Fenwick and Snows Lake Roads and west of Miller Road (Figure 13). Six Blanding's turtles were observed on June 23rd, basking on logs in a large flooding and emergent wetland (Compartment 5, Stands 65 and 75) between Fenwick, Dick, Holland, and Carlson Roads (Figure 13). Twenty-seven Blanding's turtles were observed basking on logs throughout Stand 72 in Compartment 3 (west of Miller Road) on May 14th, 2015. An additional Blanding's turtle was observed on June 23rd, basking on a log in a potential vernal pool/wetland in a lowland hardwood stand (Compartment 5, Stand 51) to the west of the flooding (Figure 13). An adult male Blanding's turtle was found basking on ground vegetation on the north of Race Lake (Compartment 4, Stand 111) on September 14th, 2015 (Figure 13). In addition to these locations, MDNR staff at Flat River SGA reported finding Blanding's turtles at five additional locations within and around the game area. These include the following observations: 1) several observations of Blanding's turtles in 2010 and 2013 by Hadicks Lake; 2) one observation by the flooding/wetland between Fenwick and Dick Roads in 2014; 3) one observation east of the game area headquarters north of Kiddeville Road in 2015; 4) one observation southeast of the intersection of Grow and Snows Lake Roads in 2012; and 5) one observation around Grass Lake in 2015 (Figure 13).

The Blanding's turtle observations documented during surveys in 2015 and additional observations/sites reported by MDNR staff were used to revise and update known EOs within and around the Flat River SGA. Prior to surveys in 2015, three different Blanding's turtle EOs, comprised of four different locations, had been documented within and around the game area. The last observed dates for these EOs were 2000 and 2003 (MNFI 2016a). Element occurrence specifications developed by NatureServe for Blanding's turtle 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). All Blanding's turtle sites documented in the Flat River SGA in 2015, including the sites reported by MDNR staff, fall within 10 km (6 mi) of mosaics of aquatic-wetland and undeveloped upland habitat and/or within 10 km (6 mi) of continuous riverine-riparian corridors. As a result, the three previously documented Blanding's turtle element occurrences within the Flat River game area were combined into one large EO or population (Table 3, Figure 13) (MNFI 2016a).

No live eastern box turtles were found during MNFI's visual encounter surveys in Flat River SGA in 2015, but an empty box turtle shell was found during visual encounter surveys on June 26th, 2015 in an upland shrub stand (Compartment 2, Stand 62) (Figures 13). The shell was found about 0.5 km (0.3 mi) east of where a box turtle was observed in 2000 on River Road where Wabasis Creek crosses the road (MNFI 2016a). In addition to these locations, MDNR staff at Flat River SGA reported finding eastern box turtles at four additional locations within the game area. These eastern box turtle observations were reported south of Wabasis Creek east of M-91 and west of River Road in 2008, south of Bricker Road west and east/north of Flat River in 2006 and 2010, and east of Smokey Run Flooding in 2012 (Figure 13).

Eastern box turtle observations in the Flat River SGA documented prior to and during surveys in 2015 were used to update and expand the known box turtle EOs within the game area (Figure 13). Element occurrence specifications developed by NatureServe for the eastern box turtle 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. Sites that don't meet these specifications should be part of a single EO (Hammerson 2004). All known observations of eastern box turtle from the Flat River SGA are separated by less than five km (3 mi) of suitable habitat. As a result, all the documented sites represent one eastern box turtle EO or population within the Flat River SGA (Table 3) (MNFI 2016a).

Eastern massasaugas were not documented during visual encounter surveys in the Flat River SGA in 2015. However suitable habitat for massasaugas was recorded within the game area. Eastern massasaugas in Michigan utilize a variety of wetland habitats, including bogs, fens, peatlands, shrub carr/thickets, wet meadows, emergent marshes, moist grasslands, wet prairies, floodplain forests,

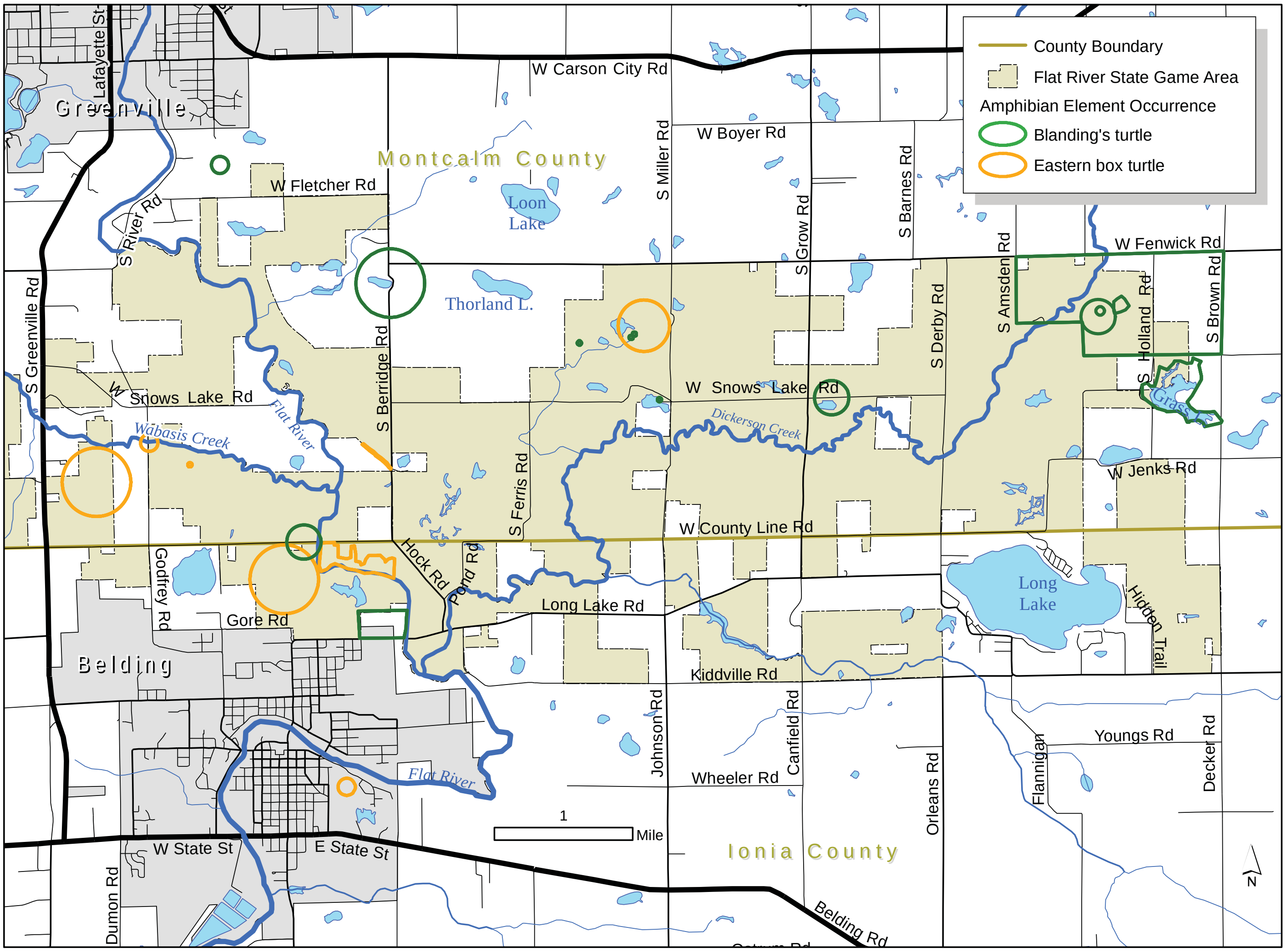


Figure 13. Rare reptile element occurrences within and nearby Flat River State Game Area.

and forested swamps (Reinert and Kodrich 1982, Hallock 1991, Weatherhead and Prior 1992, Johnson 1995, Harding 1997, Johnson et al. 2000, Ernst and Ernst 2003, Harvey and Weatherhead 2006, Marshall et al. 2006, Moore and Gillingham 2006). Areas that were surveyed that provide suitable habitat for massasaugas include open or shrubby wetlands and/or adjacent open uplands at the following locations: 1) along the north side of Race Lake (i.e., fen/wet meadow and Race Lake hardwood-conifer swamp, EO ID 19967, Compartment 4, Stand 111); 2) north side of Grass Lake (lowland shrub/fen, Compartment 5, Stand 21); 3) south of Wabasis Creek and east of River Road (Compartment 2, Stand 52); 4) along the creek that crosses S. Ferris Road south of W. Snows Lake Road and flows into Dickerson Creek (wet meadow, Compartment 3, Stand 44); 5) south of Dickerson Creek east of Grow Road and north of County Line Road (lowland deciduous forest, Compartment 4, Stand 125); and 6) along the small creek that crosses Miller Road about 0.5 km (0.3 mi) south of W. Fenwick Road (Compartment 4, Stands 2 and 98) (see Figure 8).

Spotted turtles were not documented during visual encounter surveys in the Flat River SGA in 2015. However, suitable habitat for spotted turtles was available within the game area. Spotted turtles require clean, shallow, slow-moving bodies of water with muddy or mucky bottoms and some aquatic and emergent vegetation (Ernst et al. 1994, Harding 1997). They utilize a variety of shallow wetlands including shallow ponds, wet meadows, swamps, bogs, fens, sedge meadows, wet prairies, shallow cattail marshes, sphagnum seepages, small woodland streams, and roadside ditches (Ernst et al. 1994, Harding 1997). They also utilize terrestrial habitats, particularly during the mating and nesting seasons, including open fields and woodlands (Ward et al. 1976, Lee 2000). Areas with suitable habitat for spotted turtles include many of the same areas that provide suitable habitat for Blanding's turtles and eastern massasaugas, including the following locations: 1) the north side of Race Lake (i.e., Race Lake hardwood-conifer swamp, EO ID 19967, and shrubby prairie fen, Compartment 4, Stand 111); 2) the north side of Grass Lake (lowland shrub/fen, Compartment 5, Stand 21); 3) along the creek that crosses S. Ferris Road south of W. Snows Lake Road and flows into Dickerson Creek (wet meadow, Compartment 3, Stand 44); 4) Flat River Bogs, EO ID 19970, north and west of Long Lake (Compartment 5, Stands 102, 115, and 122, and Compartment 4, Stand 216);


Basking Blanding's turtle documented along the fen-like margin of Race Lake. Photo by Yu Man Lee.

5) Dickerson Bog, EO ID 3663, Compartment 4, Stand 75); and 6) Flat River Meadow, southern wet meadow EO ID 19971, Compartment 5, Stand 116). Some of the vernal pools and hardwood-conifer swamps with standing water and an open canopy or canopy gaps also provide suitable habitat for spotted turtles.

Breeding frog call surveys within and around the Flat River SGA in 2015 did not document Blanchard's cricket frogs. Suitable or potential habitat for this species appears to be available within and adjacent to the game area though. Blanchard's cricket frogs inhabit the open edges of permanent ponds, lakes, floodings, bogs, seeps, and slow-moving streams and rivers (Harding 1997, Lee et al. 2000). They prefer open or partially vegetated mud flats, muddy or sandy shorelines, and mats of emergent aquatic vegetation in shallow water (Harding 1997, Lee et al. 2000). Areas that appear to provide suitable habitat for Blanchard's cricket frogs within the game area include the shoreline, shallow water, and/or open wetland areas in or around the following waterbodies: 1) the flooding and wetlands between Fenwick, Holland, Dick, and Carlson Roads (Compartment 5, Stands 59, 65, and 75); 2) Grass Lake (Compartment 5); 3) the small lake to the west of Snows Lake and Carlson Roads (Compartment 5, Stands 57 and 63); 4) Race Lake (Compartment 3); and 5) the flooding/emergent wetland north of the intersection of South County Line and Ranney Roads (Compartment 2, Stand 94). Other permanent waterbodies in the game area also may provide suitable habitat for Blanchard's cricket frogs.

As noted earlier, visual encounter surveys and dipnetting surveys in and around vernal pools in the Flat River SGA in 2015 documented wood frogs, blue-spotted salamanders, green frogs, red-backed salamanders, and a Blanding's turtle. Wood frog adults, recent metamorphs, and/or tadpoles were observed in 12 of the vernal pools/potential vernal pools that were surveyed. These pools were located in an upland deciduous forest stand north of Mud Lake and west of Smokey Run Flooding (Compartment 3, Stand 29), in lowland and upland forest stands southeast of the intersection of S. Ferris and W. Snows Lake Roads (Compartment 3, Stands 43 and 79), and in a mixed upland deciduous forest stand north of the Flat River and south of

S. County Line Road (Compartment 2, Stand 122). Blue-spotted salamander egg masses were observed in six of the vernal pools/potential vernal pools that were surveyed, all located in upland deciduous (oak) forest north of Mud Lake and west of the Smokey Run Flooding (Compartment 3, Stand 29) (Figure 6). Green frog adults were documented in two of the vernal pools that were surveyed, and two red-backed salamanders were observed under woody debris along the edge of a dry vernal pool. The Blanding's turtle was observed basking or resting on a small mound in a vernal pool located in an upland oak forest stand north of Mud Lake (Compartment 3, Stand 29) (Figure 6).

Visual encounter, basking, and/or breeding frog call surveys in the Flat River SGA in 2015 documented 12 other amphibian and reptile species in the game area in addition to the species already mentioned. These included observations of three additional SGCN, the pickerel frog, blue racer, and northern ribbonsnake (Appendix 3). Two pickerel frogs were observed on July 3, 2015 in an emergent wetland (Compartment 3, Stand 44) along a stream that crosses S. Ferris Road and flows into Dickinson Creek. A blue racer was observed on June 24, 2015 on the north side of Race Lake (Compartment 3, Stand 111). MDNR staff at Flat River SGA also reported recent observations of blue racers at separate locations within the game area (John Niewoonder, personal communication, November 24, 2015). These observations were at sites west of Flat River at the end of Baker Road and east of the Greenville Airport, northeast of Snows Lake and Berridge Roads intersection, south of Smokey Run Flooding, and along Dickinson Creek east of Ferris Road and southwest of the intersection of Snows Lake and Grow Roads. Northern ribbonsnakes were observed on June 24th and June 26th on the north side of Race Lake (Compartment 3, Stand 111), and on September 13th south of Dickinson Creek and east of Grow Road (Compartment 4, Stand 125). Nine additional amphibian and reptile species were documented during herptile surveys in the game area in 2015 (Appendix 3). These included the eastern American toad (*Anaxyrus americanus americanus*), gray treefrog (*Hyla versicolor/ Hyla chrysoscelis*), American bullfrog (*Lithobates catesbeianus*), spring peeper (*Pseudacris crucifer*), northern leopard frog (*Lithobates pipiens*), painted turtle (*Chrysemys picta*), northern map turtle (*Graptemys geographica*), eastern spiny softshell (*Apalone spinifera spinifera*), and snapping turtle (*Chelydra serpentina*).

Eastern box turtle shell found during 2015 herptile surveys. Photo by Yu Man Lee.

In addition to Eastern box turtle and Blanding's turtle, herptile surveys documented three additional Species of Greatest Conservation Need, pickerel frog (pictured above), northern ribbonsnake, and blue racer. Photo by Yu Man Lee.

Table 5. Previously known rare insect element occurrences at Flat River State Game Area. State and federal status abbreviations are as follows: E, state or federally endangered; T, state threatened; and SC, state special concern. Element occurrence (EO) rank abbreviations are as follows: E, verified extant; F, failed to find; and H, historical.

Common Name	Scientific Name	State Status	Federal Status	EO ID	EO Rank	Year First Observed	Year Last Observed
Swamp metalmark	*Calephelis mutica*	SC		6772	H	1953	1953
Persius dusky wing	*Erynnis persius*	T		11586	H	1954	1954
Ottoe skipper	*Hesperia ottoe*	T		11599	F	1953	2001
Henry's elfin	*Incisalia henrici*	T		10163	H	1954	1955
Great Plains spittlebug	*Lepyronia gibbosa*	E		1825	E	2002	2002
Karner blue	*Lycaeides melissa samuelis*	T	E	9493	BC	1992	2015
Regal fritillary	*Speyeria idalia*	E		8195	H	1965	1965

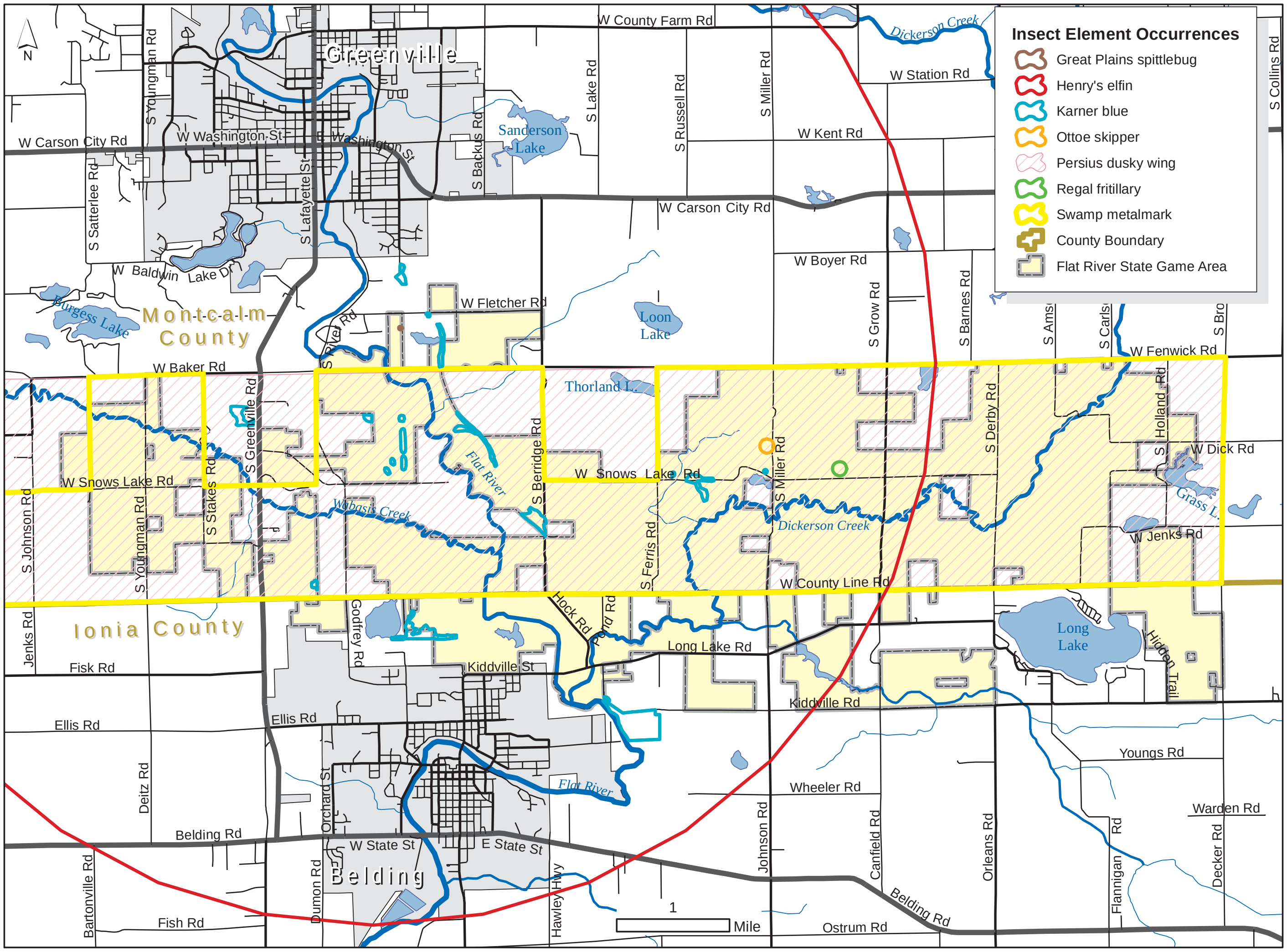


Figure 14. Rare insect element occurrences within and nearby Flat River State Game Area.

Insects

No rare moths were recorded in the state game area during the blacklight surveys. We did find a total of six species of moths in the genus Papaipema. All of the following documented moth species occur fairly commonly: *Papaipema limpida*, *P. Inquaesita*, *P. ptersii*, *P. rigida*, and *P. arctivorens*.

Insect surveys focused on blacklighting in barrens/ prairie remnants for rare moths of the Papaipema genus. Photo by David L. Cuthrell.

Mussels and Aquatic Species

Aquatic surveys were performed at 13 sites within Flat River SGA between August 20th and September 30th, 2015. Four sites were in the Flat River main stem, seven were in Dickerson Creek, and two were in Wabasis Creek (Figure 10). A canoe was put-in at Baker Road and used to access Sites 8 and 9 on the main stem of the Flat River. Take-out was at the Long Lake Road crossing. Locations of sites are given in Table 7 and numbers of each species found at each site are given in Table 9.

A total of 13 unionid mussel species were found including one state endangered, one state threatened, and three species of special concern (Table 6). All five of these mussels are species of greatest conservation need (SGCN). One shell of the state endangered eastern pondmussel (*Ligumia nasuta*) was found at Site 9 in the main stem of the Flat River several hundred meters upstream of the quarry. This species was not previously documented in the Flat River watershed and the occurrence is a new EO record (EO ID 20568). The state threatened slippershell (*Alasmidonta viridis*) was found at six survey sites. It was at two of the seven sites surveyed in Dickenson Creek, three of the four sites in the Flat River main stem, and one of two sites in Wabasis Creek. Though no live individuals were detected, several slippershell shells were relatively freshly dead with both valves still connected by an intact hinge ligament and very little wear. These six observations of slippershell result in an update of the historical (1927) EO record (EO ID 17762) in the Flat River main stem (Figure 15). The rainbow (*Villosa iris*), a species of special concern, was found at six of the 13 sites surveyed (Figure 15). It was particularly abundant in the Flat River main stem, where it was found at all four sites and as many as 21 shells were found at Site 9. It was also found at two of the seven sites in Dickerson Creek. Although empty shells were relatively abundant, no live individuals were found. These observations result in an update to a 1934 EO record (EO ID 18452), extending it into Flat River SGA. The species of special concern, ellipse (*Venustaconcha ellipsiformis*) was present at nine of the 13 sites surveyed (Figure 15). Live individuals were found at six of the nine sites, including all four of the Flat River main stem sites. This results in a new EO record for ellipse (EO ID 20591) (Figure 15). One shell of the species of special concern, round pigtoe (*Pleurobema* sintoxia) was found at one site in Dickerson Creek resulting in a new EO for this species (EO ID 20569) (Figure 15). Occurrences of two additional SGCN, cylindrical papershell (*Anodontoides ferussacianus*) and creek heelsplitter (*Lasmigona compressa*), were also documented in this survey (Table 8).

Of the 13 mussel species observed in 2015, the fatmucket (*Lampsilis siliquoidea*) and eastern pondmussel had not been documented historically in the Flat River watershed. Two species with historical records in the watershed were not found in this survey of the SGA, the special concern and SGCN elktoe (*Alasmidonta marginata*), and giant floater (*Pyganodon grandis*) (Appendix 6). Site 12 in Wabasis Creek had the greatest number of mussel species represented by live individuals and the highest overall abundance of mussels. No live mussels or shells were found at Sites 6 and 7 in Dickerson Creek. An unusually large proportion of mussel species in the Flat River main stem were represented by empty shells rather than live individuals. In contrast, mussel species richness in Wabasis Creek was largely represented by live individuals (Table 9).

Eleven species of aquatic snails (Gastropoda) were documented, with the highest number of species at Site 8 in the Flat River main stem (Table 10). They were found at all aquatic survey sites except Site 6 in Dickerson Creek. Site 5 in Dickerson Creek had an especially high abundance (on the order of $100s/m^2$) of liver elimia (*Elimia livescens*). The Flat River main stem had notably high abundance ($100s/m^2$) of the banded mysterysnail (*Viviparus georgianus*), a non-native species in Michigan. One freshwater limpet species, creeping ancylid (*Ferrissa rivularis*), was observed at two sites in the Flat River main stem. None of the gastropods found are state listed, special concern, or SGCN, and all are native to Michigan except banded mysterysnail. Photographs of snail species observed during aquatics surveys are provided in Appendix 10.

Fingernail clams (Sphaeriidae) were found at all thirteen sites surveyed. Crayfish were found at four of the seven sites surveyed in Dickerson Creek and two sites in the main stem of the Flat River. Four species of fish were noted during the survey. None of these are state listed, special concern, or SGCN. Johnny darter (*Etheostoma nigrum*) was the most abundant and frequently encountered. This species was found in all three rivers surveyed. Live zebra mussels were found in the Flat River main stem at Sites 8, 9, and 10, though none were attached to native unionid mussels (Table 9). No Asian clams were observed.

Stream substrate was generally favorable for unionid mussels (a mix of pebble, gravel, sand, and silt) with the exception of Sites 4, 6, and 7 in Dickerson Creek (Table 11). The substrate composition at these sites was dominated (>50%) by loose sand, which appeared to not be stable enough to allow unionid mussels to maintain a normal position (anterior-foot end down/posterior-siphon end up). Only one mussel shell was found at Site 4. No live mussels or mussel shells were found at Sites 6 or 7.

Stream morphology at survey sites was primarily run, with a small component of pool and/or riffle at six of the sites (Table 12) (Photos 18-22). Fish cover, in the form of

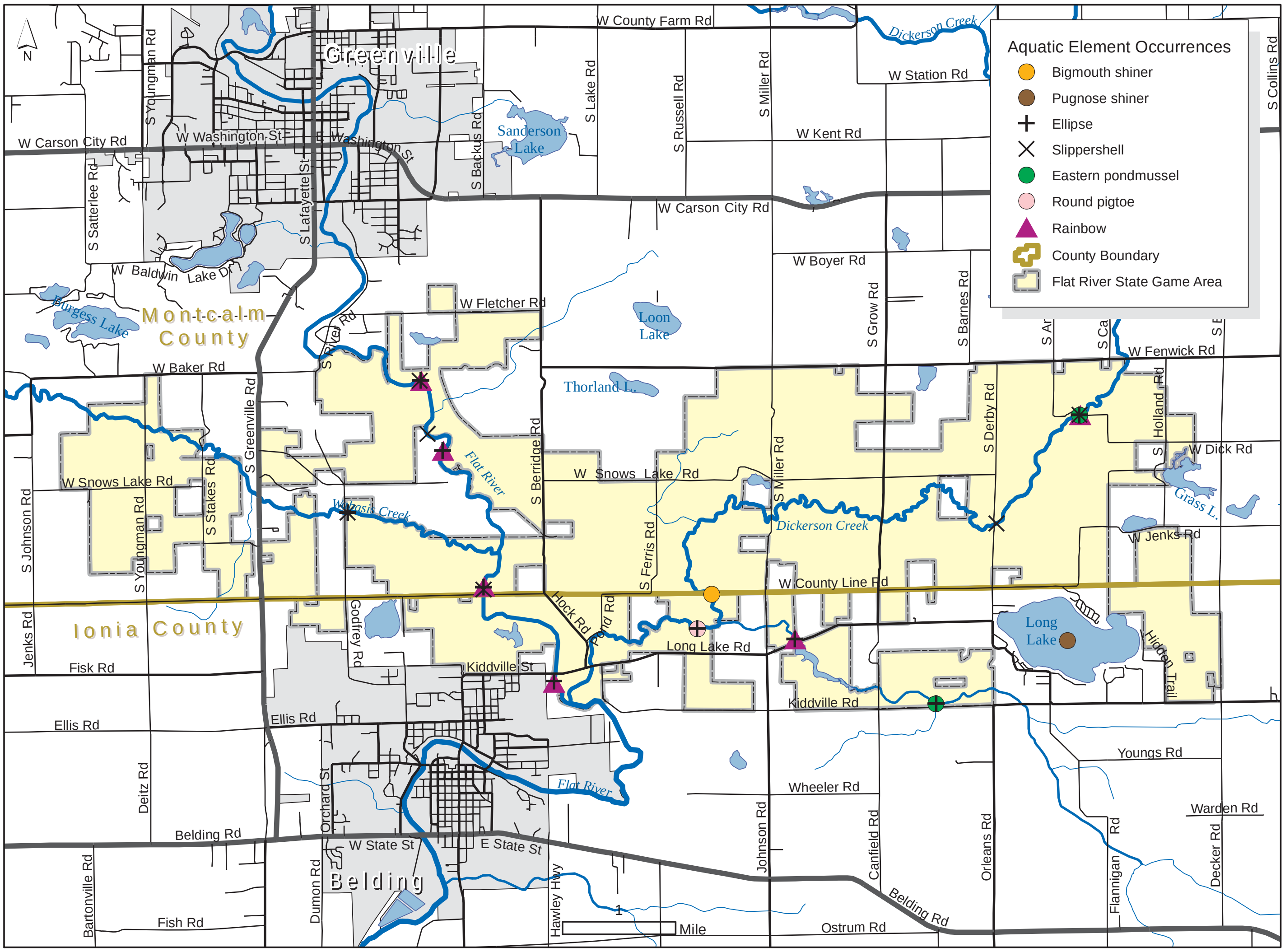


Figure 15. Rare aquatic element occurrences within Flat River State Game Area.

Table 6. New and previously known rare mussel and fish element occurrences at Flat River 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: E, verified extant; and H, historical. An * indicates the EO was newly documented in 2015 and ** indicates the EO was updated during this project.

Common Name	Scientific Name	State Status	EO ID	EO Rank	Year First Observed	Year Last Observed
Slippershell**	*Alasmidonta viridis*	T	17762	E	1927	2015
Eastern pondmussel*	*Ligumia nasuta*	E	20568	E	2015	2015
Round pigtoe*	*Pleurobema sintoxia*	SC	20569	E	2015	2015
Ellipse*	*Venustaconcha ellipsiformis*	SC	20591	E	2015	2015
Rainbow**	*Villosa iris*	SC	18452	E	1934	2015
Bigmouth shiner	*Notropis dorsalis*	SC	15519	H	1927	1927

Table 7. Locations of mussel survey sites within Flat River State Game Area, Summer 2015.

Site #	Waterbody	Access	Latitude (N)	Longitude (W)
1	Dickerson Creek	Dick Rd.	43.14190	85.11930
2	S. Branch Dickerson Creek	Kiddville Rd. near small tributary	43.10510	85.14500
3	S. Branch Dickerson Creek	Long Lake Rd.	43.11360	85.16970
4	Dickerson Creek	S. Derby Rd.	43.12790	85.13460
5	Dickerson Creek	400m hike north of Long Lake Rd.	43.11500	85.18670
6	Dickerson Creek	Johnson/Miller Rd.	43.12950	85.17260
7	Dickerson Creek	Grow/Canfield Rd.	43.12860	85.15440
8	Flat River	Canoe*/ENE of airport	43.14723	85.23469
9	Flat River	Canoe*/~600m N of quarry	43.13800	85.23110
10	Flat River	Bricker Rd.	43.12060	85.22410
11	Flat River	Long Lake Rd.	43.10834	85.21215
12	Wabasis Creek	River Rd.	43.13019	85.24803
13	Wabasis Creek	Youngman Rd.	43.14150	85.28310

* Canoe put-in at Baker Rd. north of Greenville Municipal Airport and take-out at Long Lake Rd.

Table 8. Rare species, Species of Greatest Conservation Need (SGCN), DNR featured species, and DNR focal species documented at Flat River State Game Area. State and federal status abbreviations are as follows: E, state or federally endangered; T, state threatened; and SC, state special concern.

Common Name	Scientific Name	State Status	Federal Status	SGCN	DNR Featured Species	DNR Focal Species	Year Last Observed
AQUATIC SPECIES							
Slippershell	*Alasmidonta viridis*	T		X			2015
Cylindrical papershell	*Anodontoides ferussacianus*			X			2015
Eastern pondmussel	*Ligumia nasuta*	E		X			2015
Creek heelsplitter	*Lasmigona compressa*			X			2014
Round pigtoe	*Pleurobema sintoxia*	SC		X			2015
Ellipse	*Venustaconcha ellipsiformis*	SC		X			2015
Rainbow	*Villosa iris*	SC		X			2015
Bigmouth shiner	*Notropis dorsalis*	SC		X			1927
BIRDS							
Wood duck	*Aix sponsa*				X		2015
Mallard	*Anas platyrhynchos*				X		2015
Red-shouldered hawk	*Buteo lineatus*	T		X	X		2015
Pileated woodpecker	*Dryocopus pileatus*				X		2015
Wood thrush	*Hylocichla mustelina*				X		2015
Red-headed woodpecker	*Melanerpes erythrocephalus*			X	X		2015
Wild turkey	*Meleagris galloparvo*				X		
Louisiana waterthrush	*Parkesia motacilla*	T		X			2015
Ring-necked pheasant	*Phasianus colchicus*				X		2015
Cerulean warbler	*Setophaga cerulea*	T		X		X	2003
Hooded warbler	*Setophaga citrina*	SC		X			2015
Eastern bluebird	*Sialia sialis*				X		2015
HERPTILES							
Blue racer	*Coluber constrictor foxii*			X			2015
Blanding’s turtle	*Emydoidea blandingii*	SC		X			2015
Pickerel frog	*Lithobates palustris*			X			2015
Eastern red-backed salamander	*Plethodon cinereus*				X		
Eastern box turtle	*Terrapene carolina carolina*	SC		X		X	2015
Northern ribbonsnake	*Thamnophis sauritus septentrionalis*			X			2015
INSECTS							
Swamp metalmark	*Calephelis mutica*	SC		X			1953
Persius dusky wing	*Erynnis persius*	T		X			1954
Ottoe skipper	*Hesperia ottoe*	T		X			2001
Henry's elfin	*Incisalia henrici*	T					1955
Great Plains spittlebug	*Lepyronia gibbosa*	E		X			2002
Karner blue	*Lycaeides melissa samuelis*	T	E	X	X	X	2015
Regal fritillary	*Speyeria idalia*	E					1965

Table 9. Numbers of unionid mussels (#), relative abundance (RA), and density (D = individuals/m^2) by site number during surveys conducted in Flat River State Game Area in 2015. The number of unionid shells (S) found is given in parentheses. Status in Michigan is listed in parentheses after the scientific name (E = state endangered; T = state threatened; SC = state special concern).

		1			2			3			4			5		
Species	Common name	#	RA	D	#	RA	D	#	RA	D	#	RA	D	#	RA	D
Slippershell	*Alasmidonta viridis* (T)	S(1)									S(1)					
Cylindrical papershell	*Anodontoides ferussacianus*				1	0.25	0.01									
Spike	*Elliptio dilatata*	S[1]			3	0.75	0.02	1	0.13	0.01				7	1.00	0.05
Wabash pigtoe	*Fusconaia flava*	S						6	0.75	0.05				S		
Fatmucket	*Lampsilis siliquoidea*							S								
Pocketbook	*Lampsilis ventricosa*															
Creek heelsplitter	*Lasmigona compressa*															
Fluted-shell	*Lasmigona costata*	S(1)														
Eastern pondmussel	*Ligumia nasuta* (E)															
Round pigtoe	*Pleurobema sintoxia* (SC)													S(1)		
Strange floater	*Strophitus undulatus*															
Ellipse	*Venustaconcha ellipsiformis* (SC)	S(1)			S(3)			1, S(3)	0.13	0.01				S(5)		
Rainbow	*Villosa iris* (SC)	S(1)						S(3)								
	Total # individuals and density	0		0.00	4		0.03	8		0.06	0		0.00	7		0.05
	# species live	0			2			3			0			1		
	# species live or shell	6			3			5			1			4		
	Area searched (m^2)	128			128			128			128			128		
Asian clam	*Corbicula fluminea*															
Zebra mussel	*Dreissena polymorpha*															

[1] One live spike was also found outside the measured search area.

		6			7			8			9			10		
Species	Common name	#	RA	D	#	RA	D	#	RA	D	#	RA	D	#	RA	D
Slippershell	*Alasmidonta viridis* (T)							S(9)			S(1)			S(2[3])		
Cylindrical papershell	*Anodontoides ferussacianus*							S(2)								
Spike	*Elliptio dilatata*										S(2)			2, S(6)	0.67	0.02
Wabash pigtoe	*Fusconaia flava*							S(3)			1	0.17	0.01	S(2)		
Fatmucket	*Lampsilis siliquoidea*															
Pocketbook	*Lampsilis ventricosa*							S(2)			S(1)			S(1)		
Creek heelsplitter	*Lasmigona compressa*															
Fluted-shell	*Lasmigona costata*										S(1)					
Eastern pondmussel	*Ligumia nasuta* (E)										S(1)					
Round pigtoe	*Pleurobema sintoxia* (SC)															
Strange floater	*Strophitus undulatus*							S(1)								
Ellipse	*Venustaconcha ellipsiformis* (SC)							2[2], S(30)	1.00	0.02	5, S(20)	0.83	0.07	1, S(25)	0.33	0.01
Rainbow	*Villosa iris* (SC)							S(6)			S(21)			S(4)		
	Total # individuals and density	0		0.00	0		0.00	2		0.02	6		0.08	3		0.02
	# species live	0			0			1			2			2		
	# species live or shell	0			0			7			8			6		
	Area searched (m^2)	200			150			128			76			128		
Asian clam	*Corbicula fluminea*															
Zebra mussel	*Dreissena polymorpha*							L			L			L		

[2] An additional live ellipse was found outside the measured search area.

[3] One slippershell shell was fresh dead with two halves still connected by the hinge ligament.

		11			12			13		
Species	Common name	#	RA	D	#	RA	D	#	RA	D
Slippershell	*Alasmidonta viridis* (T)				S(2)					
Cylindrical papershell	*Anodontoides ferussacianus*				1	0.03	0.01	S(1)		
Spike	*Elliptio dilatata*	S(2)			1	0.03	0.01			
Wabash pigtoe	*Fusconaia flava*	S(5)						S(2[4])		
Fatmucket	*Lampsilis siliquoidea*									
Pocketbook	*Lampsilis ventricosa*				4	0.13	0.03	2	0.50	0.02
Creek heelsplitter	*Lasmigona compressa*	S(1)			1	0.03	0.01			
Fluted-shell	*Lasmigona costata*				1	0.03	0.01	1	0.25	0.01
Eastern pondmussel	*Ligumia nasuta* (E)									
Round pigtoe	*Pleurobema sintoxia* (SC)									
Strange floater	*Strophitus undulatus*				1	0.03	0.01	1	0.25	0.01
Ellipse	*Venustaconcha ellipsiformis* (SC)	3, S(17)	1.00	0.02	21, S(9)	0.70	0.16			
Rainbow	*Villosa iris* (SC)	S(4)								
	Total # individuals and density	3		0.02	30		0.23	4		0.03
	# species live	1			7			3		
	# species live or shell	5			8			5		
	Area searched (m^2)	128			128			128		
Asian clam	*Corbicula fluminea*									
Zebra mussel	*Dreissena polymorpha*									

[4] Including one shell with two external annular rings, indicating reproduction has taken place within the past three years

The state threatened slippershell (*Alasmidonta viridis*) was found in Dickerson Creek, the Flat River main stem (pictured below), and Wabasis Creek. Photos by Peter J. Badra.

Rainbow (*Villosa iris*, state special concern) was found at six of the thirteen sites surveyed and was particularly abundant in the Flat River main stem. Photo by Peter J. Badra.

Table 10. Species observed incidentally by site number during mussel surveys conducted in Flat River State Game Area in 2015. An "X" indicates at least one individual of the taxa was detected at a site.

Common Name	Species/Taxa	1	2	3	4	5	6	7	8	9	10	11	12	13
Snails	Gastropoda	X	X	X	X	X		X	X	X	X	X	X	X
Pointed campeloma	*Campeloma decisum*		X	X	X	X			X	X	X	X	X	
Liver elimia	*Elimia livescens*			X	X	X			X	X	X	X	X	
Golden fossaria	*Fossaria obrussa*		X											
Two-ridge rams-horn	*Helisoma anceps*		X	X		X			X	X	X	X	X	
Tadpole physa	*Physella gyrina*		X						X		X	X		
Bellmouth rams-horn	*Planorbella campanulata*				X									
Marsh rams-horn	*Planorbella trivolvis*			X	X				X		X	X	X	
Sharp hornsnail	*Pleurocera acuta*												x	X
Marsh pondsnail	*Stagnicola elodes*			X					X					
Banded mysterysnail	*Viviparus georgianus**								X	X	X	X	X	
Limpets (Ancylidae)														
Creeping ancylid	*Ferrissia rivularis*								X			X		
Fingernail clams	Sphaeriidae	X	X	X	X	X	X	X	X	X	X	X	X	X
Mottled sculpin	*Cottus bairdii*	X				X				X				
Johnny darter	*Etheostoma nigrum*	X	X			X						X	X	
Blackside darter	*Percina maculata*					X				X				
Northern hogsucker	*Hypentelium nigricans*												X	
Crayfish	Decapoda	X	X	X		X					X	X		

* Native to the Mississippi River drainage and southern U.S.

Ellipse (*Venustaconcha ellipsiformis*, state special concern) was present at nine of the thirteen sites surveyed. Photo by Peter J. Badra.

Table 11. Substrate characteristics by mussel survey sites in Flat River State Game Area during 2015.

Site #	Boulder	Cobble	Pebble	Gravel	Sand	Silt
1	2	3	20	30	35	10
2				10	50	40
3				20	50	30
4				10	60[1]	30
5	1	4	25	25	30	15
6					60[1]	40
7					75[1]	25
8[2]				45	45	10
9			25	35	30	10
10	2	3	10	20	45	20
11		15	20	25	30	10
12			10	20	40	30
13			10	30	35	25

[1] Soft sand, easy to sink into on foot

[2] Lots of coarse woody debris (bark)

Table 12. Physical habitat characteristics and measures taken at mussel survey sites in Flat River State Game Area during 2015.

Site #	Current speed	Aquatic vegetation?	Woody debris?	Eroded banks?	%Pool	%Riffle	%Run
1	slow	Y	Y	N			100
2	slow	Y	Y	N	10		90
3	slow	Y	Y	Y*	20	10	70
4	slow	N	Y	Y	15		85
5	slow	Y	Y	N			100
6	slow	N	Y	N			100
7	slow	N	Y	Y	20		80
8	slow/med.	Y	Y	N			100
9	slow/med.	Y	Y	N			100
10	slow/med.	Y	Y	N		10	90
11	slow/med.	Y	Y	N			100
12	slow/med.	Y	Y	N	20		80
13	slow	Y	Y	Y			100

* Erosion possibly from dam releases approximately 50 m upstream

Table 13. Water temperature and chemistry measures collected at mussel survey sites in Flat River State Game Area in 2015.

Site #	pH	Conductivity (µS)	Alkalinity (mg/l CaCO3)	Hardness (mg/l)	Water temp. (C)
1	6.62	550	76*	96*	14.1
2	9.04	567	68*	92*	13.4
3	8.18	455	72*	96*	16.5
4	8.35	525	220	220	15.0
5	8.33	508	180	196	16.0
6	8.25	514	168	212	16.0
7	8.27	518	196	216	16.0
8	8.66	500	208	224	16.3
9	7.82	484	200	220	18.6
10	8.65	493	216	216	19.2
11	8.80	522	68*	92*	14.6
12	8.46	516	52*	100*	16.2
13	8.10	538	52*	132*	18.4

* Water samples collected on September 30, 2015, all others collected from August 20 to September 24, 2015.

For each site, the substrate, physical habitat, and water temperature and chemistry were characterized. Photos by Peter J. Badra.

aquatic vegetation and woody debris, was found at nearly all sites. The Flat River, appropriately, has the slow moving current of a low gradient river system. The banks of the South Branch of Dickerson Creek at Site 3 (Long Lake Rd.) were eroded, presumably from water releases from the dam approximately 50 m upstream of the survey site. Three other sites had banks that were moderately eroded with no apparent direct cause nearby. Water clarity was high and visibility very good at all sites at the time of surveys, except for Site 3 in the South Branch of Dickerson Creek. Visibility was poor at this site due to suspended silt/clay. There was a light rain earlier in the day (August 25th, 2015) that likely caused the turbidity. These conditions made detection of live mussels and shells more difficult at Site 3. There is a marked difference in water hardness and alkalinity among some sites surveyed. The lower values came from water samples that were collected September 30th, 2015, while all others were from water samples collected from August 20th to September 24th, 2015. Water chemistry measures are provided in Table 13.

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 natural communities, 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 and barrens 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 Flat River 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). Advanced regeneration in the understory of the forested stands in Flat River SGA is influenced by 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 Japanese barberry (*Berberis thunbergii*), autumn olive (*Elaeagnus umbellata*), Morrow honeysuckle (*Lonicera morrowii*), multiflora rose (*Rosa multiflora*), narrow-leaved cat-tail (*Typha angustifolia*), glossy buckthorn (*Frangula alnus*), reed canary grass (*Phalaris arundinacea*), purple loosestrife (*Lythrum salicarea*), and reed (*Phragmites australis*). A localized patch of Japanese knotweed (*Polygonum cuspidatum*) was found on the eastern edge of the Canfield Road ROW between Long Lake and Kiddville Roads. Species like knotweed that have yet to spread and new invasive species that were not seen in Flat River SGA, such as 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 Flat River SGA should focus on controlling populations of pernicious invasive species within high-quality forests and wetlands and also in the surrounding landscape. Prescribed fire can be employed as the primary mechanism for reducing invasive species at the landscape scale in dry-mesic 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 in southern Michigan has been found to locally increase invasive species populations with areas of recent logging being associated with local dominance of garlic mustard (*Alliaria petiolata*) (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 Flat River SGA.

Forest Biodiversity and Fragmentation
The Flat River SGA supports over 8,865 acres of upland and lowland forest and over 582 acres of high-quality forest, primarily lowland forest (hardwood-conifer swamp and floodplain forest). Only 136 acres of high-quality upland forest was documented in the game area, constituting just 1.5% of the forested acreage. Because the landscape surrounding Flat River 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 seventy-one species of birds of which four are SGCN and nine are DNR featured species (Appendix 8).

Although Flat River 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 targeting large blocks of mature, contiguous forest and limiting timber harvest in those and adjacent stands, closing redundant forest roads, limiting the creation of new roads, and halting the creation of new wildlife openings within forested landscapes. In addition, conversion of wildlife openings and old agricultural fields to forest and other native habitats such as oak savanna or barrens can also contribute 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, riparian corridors, and high-quality natural communities.

Fire as an Ecological Process

Much of the land within Flat River SGA historically supported fire-dependent ecosystems, including oak barrens, oak-pine barrens, oak openings, dry-mesic southern forest, and dry-mesic northern forest. 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, prairie and open oak savanna and 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 and prairie 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 savanna, barrens, and prairie within Flat River SGA will depend on the implementation of frequent prescribed fire.

Closed-canopy dry-mesic forests within Flat River 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 white pine and contribute to the regeneration failure of oaks. 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 white pine.

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). Many host plants for rare insect species are fire-dependent plant species.

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 1998). 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 forests, the hillside prairie remnant, and oak savanna and barrens 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 Flat River SGA, including dry-mesic forest, barrens, and savanna, 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 forest, prairie remnants, and degraded oak savanna and barrens 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 expend 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 Flat River 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.

Savanna, Barrens, and Prairie Restoration

Although no high-quality oak openings or oak barrens were documented during the course of the surveys, oak savanna and barrens ecosystems historically occurred on approximately 25% of Flat River SGA (Figure 4). Pockets of prairie likely occurred throughout these savanna and barrens ecosystems. As noted above, surveys in 2014 documented a remnant hillside prairie within the game area. In addition, MNFI ecologists observed several degraded remnants of savanna and barrens. Stands within the game area that support savanna/barrens flora in the ground cover and may have supported savanna/barrens systems in the past. These stands include: Compartment 2, Stands 9, 24, 27, 35, 36, and 42; Compartment 3, Stands 1, 4, and 181; Compartment 4, Stands 21 and 22; and Compartment 5, Stand 89. Compartment 2 has many significant areas that support savanna and prairie vegetation. One of the more significant areas is associated with the powerline corridor in Stand 35. Adjacent forests in stands 9, 24, 27, and 36 are areas that were likely historically barrens but have converted to closed-canopy forest as a result of fire suppression. These stands are adjacent to Karner blue occupied areas, have pockets of barrens vegetation, have not been tilled, and have minimal invasive species cover. These stands are therefore excellent candidates for concentrated barrens restoration. We recommend prescribing fire for these stands and also thinning them following burning to remove maple and cherry. Also within Compartment 2, the northern portion of Stand 42 between the river and the railroad bed has many barrens species at the margins and would be an excellent location for barrens management. Within Compartment 3, Stands 4 and 181 are open areas that were previously tilled but have retained several characteristic barrens species. Stand 4 in particular may be a logical restoration target since the adjacent forested stand, Stand 1, is characterized

Restoration of degraded barrens, prairie, and savanna is a high stewardship priority for Flat River State Game Area. Photo by Joshua G. Cohen.

by many openings supporting barrens species. Barrens restoration targets in Compartment 4 include Stands 21 and 22. These stands are excellent candidates for barrens restoration because of their large area, the lack of historic tilling, the presence of existing openings with barrens vegetation, and limited invasive species cover. Additional openings in Compartment 4 include stands 42, 207, and 212. These openings, however, were historically tilled, face serious pressure from off-road vehicles, and have a high component of invasive species. These stands may be useful sites for collecting seed for barrens restoration projects throughout the game area. A similar site for seed collection occurs in Stand 89 of Compartment 5. This stand is an abandoned agricultural field that supports several characteristic barrens species but has high invasive species cover that likely prohibits successful restoration to barrens.

Several rare animal species associated with oak savanna, barrens, and prairie ecosystems have been documented in Flat River SGA and in the surrounding area including eastern box turtle, grasshopper sparrow, dickcissel, Karner blue, persius dusky wing, regal fritillary, Ottoe skipper, Great Plains spittlebug, and Henry's elfin. Dickcissel and grasshopper sparrow depend on large grassland complexes, and historically occurred in patches of large prairie within oak savanna complexes. Eastern box turtle historically used oak savanna and prairie habitat for nesting, foraging, dispersal, mating, gestation, parturition, and/or overwintering. Both eastern box turtle and Karner blue are focal species of the DNR's Wildlife Action Plan. Rare savanna, barrens, and prairie plants recorded from Flat River SGA and in the surrounding area include prairie buttercup (*Ranunculus rhomboideus*, state threatened), false boneset (*Kuhnia eupatorioides*, state special concern), and prairie smoke (*Geum triflorum*, state threatened). Pursuing targeted restoration of savanna, barrens, and prairie remnants within Flat River SGA is recommended because these rare ecosystems support a high-level of biodiversity and numerous rare species. Restoration of these ecosystems is also beneficial to numerous game species, including wild turkey (*Meleagris gallopavo*) and white-tailed deer (*Odocoileus virginianus*). 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 (Lettow et al. 2014).

The first management step for oak savanna and barrens restoration is the restoration of the savanna/barrens physiognomy through prescribed fire and/or selective cutting or girdling. Where canopy closure has degraded the savanna/barrens 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 and barrens 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 savanna/barren 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 savanna/barrens and failing to apply prescribe fire soon after mechanical treatment can actually expedite the loss of savanna/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/barren species dormant in seedbanks during fire suppression, reduce competition for savanna/barren species, and also create suitable seed beds for oak regeneration.

Fire is the single most significant factor in preserving savanna, barrens, and prairie ecosystems. Once open-canopy conditions have been re-established, the reintroduction of annual fire is essential for the maintenance of floristic composition and structure. 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 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, barrens, and prairie remnants.

Resource managers in southern Michigan face a complex management dilemma. Following decades of fire suppression, oak savanna, barrens, and prairie communities have converted to closed-canopy systems. Many of these dry-mesic forests provide critical habitat for forest-dwelling species, such as neotropical migrant birds. Within Flat River SGA, forested ecosystems provide nesting habitat for hooded warbler, Louisiana waterthrush, and red-shouldered hawk. Conversion of these closed-canopy forests to savanna, barrens, or prairie 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, barrens, and prairies leaves them susceptible to invasion by aggressive invasive and native plants (Solecki 1997). Conversion of forest to savanna, barrens, or prairie 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 savanna, barrens, and prairie systems. Savanna, barrens, and prairie 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 savanna, barrens, and prairie landscapes are likely to pay rich dividends (Leach and Givnish 1999).

Riparian corridors provide critical habitat for a diverse array of species in the Flat River SGA. We recommend maintaining closed-canopy ecosystems in riparian areas, such as along Dickerson Creek. Photo by Joshua G. Cohen.

Table 14. Summary of management recommendations for natural community element occurrences for the Flat River State Game Area.

Site Name	Community Type	Management Recommendations
Dickerson Bog	Bog	• Maintain intact buffer of natural communities surrounding bog • Protect hydrology • Control reed canary grass • Monitor for invasives
Flat River Bogs	Bog	• Maintain intact buffer of natural communities surrounding bog • Protect hydrology • Control reed canary grass • Monitor for invasives
Wabasis Forest	Dry-mesic Northern Forest	• Maintain closed canopy • Apply prescribed fire to reduce invasive species and native mesophytic species • Cut and herbicide invasive shrubs • Girdle or cut subcanopy and understory mesophytic species, especially red maple, black cherry, and sassafras • Monitor following fire and for invasives, advanced regeneration, and deer herbivory
Hadicks Lake West	Dry-mesic Southern Forest	• Maintain closed canopy • Apply prescribed fire to reduce invasive species and native mesophytic species • Cut and herbicide invasive shrubs • Girdle or cut subcanopy and understory mesophytic species, especially red maple, black cherry, and sassafras • Monitor following fire and for invasives, oak regeneration, and deer herbivory
Tanager's Demise	Dry-mesic Southern Forest	• Maintain closed canopy • Apply prescribed fire to reduce invasive species and native mesophytic species • Cut and herbicide invasive shrubs (i.e., Morrow honeysuckle) • Monitor following fire and for invasives, oak regeneration, and deer herbivory
Dickerson Floodplain	Floodplain Forest	• Maintain closed canopy and protect hydrology • Retain intact buffer of natural communities surrounding floodplain • Eliminate off-road vehicle activity • Control invasive species through cutting and herbicide • Monitor to evaluate invasives and deer herbivory
Derby Swamp	Hardwood-Conifer Swamp	• Maintain closed canopy • Retain an intact buffer of natural communities surrounding the swamp • Protect hydrology • Monitor to evaluate invasives and deer herbivory
Dickerson Swamp	Hardwood-Conifer Swamp	• Maintain closed canopy • Retain an intact buffer of natural communities surrounding the swamp • Protect hydrology • Control invasive species through cutting and herbicide • Monitor to evaluate invasives and deer herbivory
Grow Swamp	Hardwood-Conifer Swamp	• Maintain closed canopy • Retain an intact buffer of natural communities surrounding the swamp • Protect hydrology • Control invasive species through cutting and herbicide • Monitor to evaluate invasives and deer herbivory
Miller Swamp	Hardwood-Conifer Swamp	• Maintain closed canopy • Retain an intact buffer of natural communities surrounding the swamp • Protect hydrology • Control invasive species through cutting and herbicide • Monitor to evaluate invasives and deer herbivory
Race Lake Swamp	Hardwood-Conifer Swamp	• Maintain closed canopy • Retain an intact buffer of natural communities surrounding the swamp • Protect hydrology (e.g., close Snows Lake Road) • Control invasive species through cutting and herbicide • Monitor to evaluate invasives and deer herbivory
Fenwick Hillside Prairie	Hillside Prairie	• Reduce encroaching woody vegetation through cutting and herbicide • Apply prescribed fire to reduce invasive species, maintain open canopy conditions, and promote prairie flora • Monitor following fire and for invasives
Flat River Meadow	Southern Wet Meadow	• Maintain intact buffer of natural communities surrounding meadow to protect hydrology • Burn meadow with surrounding uplands • Monitor for invasive species and following prescribed fire

Setting Stewardship Priorities

This report provides site-based assessments of thirteen natural community EOs that occur in Flat River 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 Flat River SGA. Because the list of stewardship needs for the game area (Table 14) 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 Flat River 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 examples of the rarest natural community types and the largest sites. 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 Flat River SGA, we recommend that stewardship efforts be focused in natural communities that harbor high levels of biodiversity and provide potential habitat for numerous rare plant and animal species. We also recommend the prioritization of stewardship in sites located along riparian corridors and 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 Fenwick Hillside Prairie* (hillside prairie, EO ID 19983), Dickerson Floodplain* (floodplain forest, EO ID 19964), Race Lake Swamp* (hardwood-conifer swamp, EO ID 19967), Hadicks Lake West (dry-mesic southern forest, EO ID 3327), and Wabasis Forest (dry-mesic northern forest, EO 20103) (Table 15). The highest priority sites within this subset of natural community EOs are indicated by an asterisk.

Monitoring

We recommend that monitoring be implemented at Flat River 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 systems, and fostering regeneration 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.

Table 15. Stewardship priorities for Flat River 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
Wabasis Forest	Dry-mesic Northern Forest	20103	C	2015	2015	G4	S3
Hadicks Lake West	Dry-mesic Southern Forest	3327	C	1989	2014	G4	S3
Dickerson Floodplain*	Floodplain Forest	19964	C	2014	2014	G3?	S3
Race Lake Swamp*	Hardwood-Conifer Swamp	19967	C	2014	2014	G4	S3
Fenwick Hillside Prairie*	Hillside Prairie	19983	BC	2014	2014	G3	S1

Vernal Pools Discussion and Management Recommendations

Despite their small size and temporary nature, vernal pools can be incredibly diverse and productive wetlands, and are important for maintaining healthy forest ecosystems. The mapping and survey of potential and actual vernal pools in the Flat River SGA provide valuable baseline information on the status, distribution, and ecology of vernal pools in the game area. This information will enhance our knowledge of vernal pools and help inform management and protection of these critical wetlands not only in the Flat River SGA but statewide. A total of 172 PVPs were identified and mapped from aerial photo interpretation in the Flat River SGA in 2015 and 24 of these 172 PVPs were evaluated on the ground. Of these 24 PVPs that had been mapped from aerial photos and surveyed in the field in 2015, 21 were verified as actual vernal pools in the field. These results indicate a vernal pool mapping accuracy rate of at least 88% (i.e., 21 of 24 potential vernal pools verified as vernal pools in the field). This rate is comparable to the accuracy rates Lee et al. (2014) obtained for mapping vernal pools/potential vernal pools from aerial photos in their study areas in southeast and northeast Michigan (i.e., 73% and 85%, respectively). Vernal pool mapping and field surveys conducted by MNFI in Middleville SGA and Lost Nation SGA in 2014 resulted in vernal pool mapping accuracy rates of 93% and 100%, respectively (Cohen et al. 2015a and 2015b). Although the numbers of PVPs that were surveyed and verified in the Flat River SGA and in Middleville and Lost Nation SGAs were fairly small, the mapping accuracy rates obtained from these surveys and those reported in Lee et al. (2014) suggest it is likely that a significant number of the PVPs mapped in the Flat River SGA represent actual vernal pools in the field. Given the discovery of additional vernal pools in the field that had not been mapped from aerial photo interpretation, it also is very likely that there are additional vernal pools that were not mapped as PVPs. 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.

The physical and landscape characteristics of the vernal pools verified in the Flat River SGA in 2015 were similar to those of vernal pools found in other parts of Michigan and other states in the glaciated Northeast. For example, most (69%) of the vernal pools verified in the Flat River SGA were classified as open or sparsely vegetated vernal pools with little to no vegetation growing in the pools, and six pools (23%) were classified as forested vernal pools. MNFI's previous vernal pool mapping efforts and other studies in the northeast U.S. also reported open/sparsely vegetated and forested vernal pools being more common than marshy or shrubby vernal pools (Colburn 2004, Lee 2014). Lee (2014) reported about half of the vernal pools verified in the project's study area in the western Upper Peninsula (U.P.) of Michigan in 2014 were open or sparsely vegetated pools, and about one-third of the pools were forested pools. Similarly, Cohen et al. (2015a and 2015b) reported that 79% and 70% of the verified vernal pools in Middleville SGA and Lost Nation SGA, respectively, were classified as open or sparsely vegetated pools.

Additionally, one of the key characteristics for identifying vernal pools is that they are generally isolated basins or depressions, and have no continuous surface-water connections to permanently flooded water bodies (Colburn 2004). Most (75%) of the vernal pools verified in the Flat River SGA in 2015 were isolated basins or depressions, having no inlet or outlet (96%). Similar results were reported for vernal pools that were verified in the western U.P. (Lee 2014) and in Middle and Lost Nation SGAs (Cohen et al. 2015a and 2015b). Although most of the verified vernal pools in the Flat River SGA occurred in isolated basins or depressions, many of the pools occurred in clusters or in the general vicinity of other vernal pools or other wetlands and water bodies.

Another key characteristic of vernal pools is that they are generally small and shallow (Colburn 2004). Verified vernal pools in the Flat River SGA were small and shallow, and were similar in size to those found by Lee (2014) in the western U.P. The vernal pools ranged in size from 58 to 14,761 m^2 (0.01 ac to 3.6 ac), and averaged 1335 m^2 (0.3 ac), based on mapped polygons. The verified vernal pools from the western U.P. ranged from about 4 to 16,187 m^2 (0.001 ac to about 4 ac), with mean vernal pool size about 931 m^2 (0.23 ac) (Lee 2014).

Vernal pools provide critical habitat for wood frogs, blue-spotted salamanders, spotted salamanders, and fairy shrimp, which are considered vernal pool obligate or indicator species in Michigan. About half (i.e., 46%) of the vernal pools verified in the Flat River SGA in 2015 were utilized by wood frogs and/or blue-spotted salamanders for reproduction (i.e., breeding and/or larval development and metamorphosis). These vernal pool occupancy rates are similar to or higher than the rates documented for these species in other studies. Wood frog and/or blue-spotted/spotted salamander adults, larvae, and/or metamorphs were documented in 20% to 55% of vernal pools surveyed in several study areas in southern Michigan (Lee et al. 2014, Cohen et al. 2015a and 2015b). However, higher occupancy rates for wood frogs (70-90%) and blue-spotted salamanders (62%) have been documented in some studies in the northeastern and midwestern U.S. (Calhoun et al. 2003, Egan and Paton 2004, Skidds and Golet 2005, Baldwin et al. 2006, Brodman 2010). Surprisingly, spotted salamanders were not documented in vernal pools that were surveyed in the game area in 2015. This may have been due to small sample size, variability in species' occupancy and breeding among pools and years (i.e., this species may breed in some pools/years and not others), lower occupancy rates or abundance in the game area, and/or missed detection. Some studies have reported lower vernal pool occupancy rates for spotted salamanders compared to those of wood frogs (e.g., 27% compared to 43%, respectively) (Porej et al. 2004) and blue-spotted salamanders (e.g., 22% compared to 62%, respectively) (Brodman 2010), although other studies have reported much higher vernal pool occupancy rates similar to those of wood frogs and blue-spotted salamanders (e.g., 80-90%) (Baldwin et al. 2006).

While wood frogs, blue-spotted salamanders, and spotted salamanders can use a variety of vernal pools, several factors strongly influence occupancy and successful reproduction in vernal pools by these species. These include pool hydroperiod (i.e., length of time a pool holds water), canopy closure, and landscape composition and structure surrounding vernal pools. These species generally require vernal pools that hold water from March or early April to at least early July so that their larvae can complete metamorphosis before the pool dries (Harding 1997, Colburn 2004). Several studies have found that wood frog and spotted salamander breeding populations in vernal pools are positively correlated with longer hydroperiods (e.g., $\geq$16 or 18 weeks) (Calhoun et al. 2003, Babbitt 2005, Baldwin et al. 2006, Green et al. 2013). These species also are more prevalent in densely shaded, closed-canopy pools (Skelly et al. 1999, Colburn 2004, Calhoun and deMaynadier 2008). Because these species spend most of their life cycle outside of the breeding season in forested terrestrial habitats, these species are associated with vernal pools that are primarily surrounded by forests, and are unlikely to utilize vernal pools surrounded by large areas of open habitat (Calhoun and deMaynadier 2008). Wood frog, spotted salamander, and blue-spotted salamander occupancy in vernal pools have been positively associated with forest cover or amount of forest within a 1-km radius around the pools (Guerry and Hunter 2002). Additionally, critical thresholds in forest cover or amount of forest around vernal pools have been documented for these species. Studies have reported spotted salamanders only occurring in vernal pools that had forest cover/forested habitat in at least 20 to 35% of the surrounding area within 100 to 300 m of the pool (Porej et al. 2004, Homan et al. 2004). For wood frogs, thresholds of about 10 to 30% forest cover within 100 to 300 m, and 15% forest cover within 200 m to 1 km of vernal pools have been reported (Porej et al. 2004, Homan et al. 2004). Gibbs (1998) also reported critical thresholds of about 30% forest cover around vernal pools for both these species.

The number or density of vernal pools and/or other wetlands as well as the diversity of these wetlands (e.g., different hydroperiods) also can impact the presence and abundance of these species (Gibbs 1993, Calhoun and deMaynadier 2008, Brodman 2010). Brodman (2010) found that sites with greater number of wetlands and hydroperiod classes had higher species richness, abundance, and occupancy of pond-breeding salamanders including spotted and blue-spotted salamanders. Wetland clusters with 14 or more wetlands had significantly greater species richness and percentage occupancy than wetland clusters with 2 to 13 wetlands (Brodman 2010). Isolated wetlands had significantly lower species richness, occupancy, and abundance than sites with two or more wetlands (Brodman 2010). Additionally, wetland clusters with three hydroperiod classes had significantly greater species richness, abundance, and occupancy of salamanders than sites with two hydroperiod classes, and sites with one hydroperiod class had significantly lower abundance and occupancy than sites with two hydroperiod classes (Brodman 2010). However, other studies have found that these species may disproportionally use partially isolated pools in some areas because of fewer available options and as stepping stones for dispersal between wetland clusters (Gibbs 2000, Calhoun et al. 2003, Baldwin et al. 2006). These species also have high site fidelity, with all or most adults returning to their natal pools and the same pools to breed in year after year (Colburn 2004).

Fairy shrimp were not documented in any of the vernal pools in the Flat River SGA. This was likely due to timing of the vernal pool surveys in 2015. Fairy shrimp (*Eubranchipus* spp.) are mainly found in flooded vernal pools in early spring until mid to late May, or when water temperatures reach 68°F to 72°F (20°C to 22°C), which can vary in 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). Additional surveys are needed to determine the species composition, status, and distribution of fairy shrimp in the game area to obtain more complete and accurate information on the ecology of vernal pools in the game area, and to increase our knowledge of the statewide status and distribution of fairy shrimp in Michigan since we have so little information on these species.

We provide the following recommendations for the conservation and management of vernal pools and associated species in the Flat River SGA for your consideration. Identifying and mapping vernal pools and understanding their ecological values are critical for effective planning, management, and conservation of these important wetlands. The best time to survey for vernal pools and associated indicator species is in the spring, particularly early spring, when the pools are flooded. However, vernal pools also can be detected during other times of the year as well based on certain signs. These signs include the presence of a small, isolated basin or depression with no permanent inlets/outlets or persistent surface water connections to permanent water; presence of obligate and/or facultative wetland plant species; small depressions or areas with abrupt vegetation change from surrounding forest (e.g., little to no ground vegetation, presence of wetland plants); presence of hydric soils (e.g., saturated or mucky soils); water lines/marks at the base of tree trunks; exposed, lateral tree roots; matted, dark-stained leaves; and/or presence of fingernail clams and freshwater snails under leaf litter when the pool is dry. Ideally, surveys should consist of multiple visits to each pool within a year and across several years to verify pool drying and because vernal pool hydrology and ecology can vary significantly within a year and between years. 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.

In general, management of vernal pools should focus on protecting the vernal pool's physical basin and water quality, and the integrity of the surrounding forest to maintain habitat for associated species, particularly pond-breeding amphibians (Calhoun and deMaynadier 2008). Activities that disturb soils or tree canopies within and immediately adjacent to vernal pools should be avoided or minimized, particularly during critical time periods for most amphibians (i.e., March/April through July/August) (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 within 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 an additional buffer from 31 to 122 m (100-400 ft or 13 ac) with at least 50% canopy cover around vernal pools and providing abundant cover on the forest floor (i.e., leaf litter and coarse woody debris) would protect terrestrial non-breeding habitat for vernal pool–dependent amphibians and invertebrates (Calhoun and deMaynadier 2004 and 2008). Dramatic shifts in forest cover type also may adversely impact forest-dwelling amphibians as they are sensitive to changes in leaf litter composition and chemistry (deMaynadier and Hunter 1995, Waldick et al. 1999). 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). Rutting and scarification of the forest floor also may create barriers and prevent salamanders from travelling to breeding pools (Means et al. 1996). Maintaining or restoring forest cover, wetland density and diversity, and drainage connections between individual vernal pools and clusters of vernal pools across the landscape would facilitate species dispersal among vernal pools and other wetlands (Calhoun and deMaynadier 2008).

Rare Animal Discussion and Management Recommendations

Birds

Management of Flat River SGA has maintained 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 red-shouldered hawk, rare songbird species, and other Neotropical migrant songbirds. Two red-shouldered hawk nests were documented, both of which successfully produced chicks. We also observed two rare songbird species (Louisiana waterthrush 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 rare species, hooded warblers can be locally common breeders in forested landscapes of the southern Lower Peninsula. We documented 71 bird species using forests of the game area (Appendix 8). Recorded bird species included nine MDNR featured species, four SGCN, and four species (red-headed woodpecker, veery, wood thrush, and Louisiana waterthrush) identified as focal species in the Landbird Habitat Conservation Strategy for the Upper Mississippi River and Great Lakes Region Joint Venture (Potter et al. 2007).

Due to the presence of actively nesting red-shouldered hawks within the Flat River Game Area, we suggest the *Management Guidance for Woodland Raptors (Specifically Red-Shouldered Hawks and Northern Goshawk) on State Forest Lands* be followed at these sites (Michigan DNR 2015) (Appendix 11). According to the guidance, active nests should be buffered by a five-chain radius (8 acres) protection area centered on the nest, in which there should be no cutting or new roads constructed. Human disturbance, including loading and skidding, should also be avoided within the protection area. A second zone of five chains, or an area with a 10-chain radius centered on the nest, should also be established in which no management activity should occur between February 15th and July 1st. Within this 10-chain zone, at least one-third of residues should be retained per the Woody Biomass Harvesting Guidance (Michigan DNR 2015). Deviation from these guidelines should be contingent on approval from WLD Field Operations Managers. These guidelines should be implemented at active nests until the nest is determined to be inactive. Inactive nests should be protected by a one-chain no harvest buffer; however, if the nest is found to be in disrepair or unoccupied for multiple years, the nest can be classified as unsuitable and no buffer is required. If DNR personnel find active or inactive nests, they should record these observations as an opportunistic field survey in the enterprise GIS, so the information can be integrated into the MNFI Biotics database and used for monitoring nests, tracking trends, identifying research opportunities, evaluating management guidelines, and developing habitat suitability indices for red-shouldered hawk and northern goshawk (Michigan DNR 2015).

The management guidance for woodland raptors also provides general forest management recommendations to maintain habitat for red-shouldered hawk and northern goshawk. For cover types where uneven-aged management techniques are appropriate, encourage large (>300 acre) contiguous blocks of relatively mature hardwood and mixed hardwood-conifer forest with moderate (about 70%) canopy closure and nearby or interspersed wetlands. Managers should also apply Within-stand Retention Guidance (Michigan DNR 2015) to identify and retain mature trees for future nests, existing stick nests, snags, and coarse woody debris, and where appropriate, retain a minimum of one large-diameter deciduous tree (other than beech and multi-crotched, high-canopy trees preferred) per five acres. For cover types requiring even-aged stand management techniques, apply Within-stand Retention Guidance (Michigan DNR 2015) to retain patches of several large-diameter deciduous trees (multi-crotched, high canopy trees preferred). To maintain adequate prey base for raptors, the management guidelines suggest following Within-stand Retention Guidance for stand diversity to manage for appropriate levels of coarse woody debris (Michigan DNR 2015). We also recommend conducting periodic surveys for red-shouldered hawk to track its breeding status in the game area and identify active nests and nesting territories, so that appropriate management actions can be implemented.

Forest management at Flat River SGA should consider the habitat needs of the rare songbird species we observed. Although we did not reconfirm the presence of cerulean warbler within the game area, the species was documented in 2003 and could still occur in mature riparian forests. Timber harvest occurred since 2003 at or near some of the locations having cerulean warbler observations, so changes to the forest structure may have reduced habitat suitability for the species in some areas. Cerulean warbler, a focal species of the DNR's Wildlife Action Plan, is considered an area-sensitive species. Within the core of its breeding range, cerulean warbler typically occupies forest tracts that are 3,000 ha (7,413 ac) 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 observed them in areas of dense young trees and shrubs. Louisiana waterthrush typically uses mature forest adjacent to small (e.g., first-order) fast-flowing streams within large blocks of deciduous forest (Eaton 1958, Dunn and Garrett 1997). We recommend managing for mature stands of riparian and adjacent upland forest at locations where Louisiana waterthrushes were observed.

The maintenance and expansion of mature forest blocks within the game area would likely benefit cerulean warbler, hooded warbler, Louisiana waterthrush, 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 Flat River SGA to forest-interior nesting songbirds. Furthermore, we observed brown-headed cowbirds (*Molothrus ater*) at 26% 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.

We recommend conducting songbird point counts periodically to monitor use of the game area by rare species and track overall forest bird assemblages over time. 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 and other species of interest. Because rare species are often not detected even when present, additional surveys would help determine if rare songbirds occur at sites where the habitat appeared suitable, but they were not observed in past surveys.

Reptiles and Amphibians

Amphibian and reptile surveys in Flat River SGA in 2015 documented a total of 18 different species (Appendix 3). These include two rare and declining species, three

additional SGCN, and 13 common species. Surveys did not document three listed or rare amphibian and reptile species targeted for surveys in 2015, the eastern massasauga, spotted turtle, and Blanchard's cricket frog.
Suitable habitat for these species is available in Flat River SGA. Additional surveys for these species should be conducted to determine if they occur in the game area

Surveys and reports of the species obtained in 2015 reconfirmed a known EO of Blanding's turtles and documented additional locations of this species in the Flat River SGA. According to MDNR staff, this species has been observed regularly and at multiple locations within and adjacent to the game area (John Niewoonder, personal communication, November 24, 2015). Potential exists for this species to occur throughout the game area given the extent of available suitable habitat. The Blanding's turtle population in the Flat River SGA has been ranked as having excellent to good estimated viability or probability of persisting into the foreseeable future (i.e., at least 20-30 years) (Table 4), if current conditions prevail, based on NatureServe's generic approach or guidelines for ranking species occurrences (Hammerson et al. 2008). Although the size of the Blanding's turtle population in the Flat River SGA is unknown, the population has been ranked as having excellent to good probability of persisting into the foreseeable future because of extensive suitable habitat available within the game area, the species' known and potential extent or occupied area, the species' history of occurrence within the game area (first documented in 2000), and the long-lived nature of this species (i.e., 50-70+ years) (Harding 1997). Additionally, as a state game area, this site has been and will continue to be managed to protect natural and cultural resources (Michigan DNR 2013). However, this population does face some threats or potential threats, including habitat loss and fragmentation, nest predation and lack of population recruitment, illegal collection, and roads, which function as barriers to movement and/or a source of mortality. Continued surveys, research, and monitoring are needed to verify the status and viability of the Blanding's turtle population.

Surveys and reports of the species from MDNR staff obtained in 2015 also reconfirmed and expanded a known EO of eastern box turtles in the Flat River SGA. Prior to 2015, the species had been known from only two locations in the game area in the vicinity of Wabasis Creek and the Flat River (MNFI 2016a). The species is now known from two additional areas in the game area, including a new area along the Flat River and a new location about two miles northeast of the river (MNFI 2016a, John Niewoonder, personal communication, November 24, 2015). Potential exists for box turtles to occur throughout this portion of the game area and likely other parts of the game area as well given the extent of suitable habitat throughout the game area. The eastern box turtle population in the Flat River SGA has been ranked as having good estimated viability or probability of persisting for the foreseeable future (i.e., at least 20-30 years) (Table 4), if current conditions prevail, based on NatureServe's generic approach or guidelines for ranking species occurrences (Hammerson et al. 2008). Although the size of the box turtle population in the game area is unknown, the population has been ranked as having good probability of persisting for the foreseeable future because of extensive suitable habitat available within the game area, the species' known and potential extent or occupied area, the species' history of occurrence within the game area to date (since 2000), and the long-lived nature of this species (i.e., 40-100+ years) (Harding 1997). The game area also is managed to protect natural and cultural resources (MDNR 2013). The population may even have excellent estimated viability, but the population faces many of the same threats or potential threats as the Blanding's turtle population in the game area. Additional information regarding the potential size, extent, and/or condition of the eastern box turtle population and habitat in the game area as well as threats facing this population would help clarify its potential viability. Continued surveys, research, and monitoring are needed to obtain additional information on the eastern box turtle population in the game area.

Management and protection of the Blanding's turtle and eastern box turtle populations in the Flat River SGA are critical given the rare and declining status and vulnerable life histories of these species, their estimated viability, and the game area's goal of protecting natural resources. In addition to its state status, the Blanding's turtle has been petitioned for federal listing, and the U.S. Fish and Wildlife Service (USFWS) is currently assessing the species' status and threats rangewide and has determined federal listing may be warranted (USFWS 2015). The most critical conservation need for the Blanding's turtle is protection and management of landscape complexes of suitable wetland and adjacent upland habitats (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 move frequently 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 will benefit this species. Maintaining high water quality can be accomplished by keeping natural buffers around wetlands, minimizing roads near wetlands, and restricting use of pesticides in and adjacent to wetlands. If pesticides are used, select only those that are approved for open water use.

Maintaining large, contiguous landscape complexes of forest and wetland habitats is essential for maintaining eastern box turtle populations. 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. Access to open, sunny, sandy nesting areas is critical 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 mesopredators, 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 management strategies that could 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 commercial pet trade, personal collection, 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 the Flat River 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 the Flat River SGA in 2015 (Appendix 3). 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 2015 were found in 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 vernal pools (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. As described earlier, these species also appear to have critical habitat thresholds in which species occupancy or probability of occurrence declines significantly below a certain level of forest cover/forested habitat (Gibbs 1998, Porej et al. 2004, Homan et al. 2005). *Ambystomatid* salamanders, such as the spotted and blue-spotted salamanders, also return to the same ponds to breed (Semlitsch et al. 1993). The main threats to spotted and blue-spotted salamanders are habitat loss, habitat degradation, 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). Mifsud (2014) provides additional best forest management practices for protecting pool-breeding amphibians.

Finally, because many herptile 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 herptile species and other SGCN that have been documented or have potential to occur in the Flat River SGA. These include the eastern massasauga, spotted turtle, and Blanchard's cricket frog. These species have not been documented within or in the immediate vicinity of the state game area, but occurrences of these species have been documented in the region (MNFI 2016a). 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.

Insects

Future surveys are warranted for both the blazingstar borer and the Culver's root borer. Both of these species can be very difficult to detect from certain areas/habitats, especially if their population levels are low. All three of the sites with the host plant would be good places for future surveys. Additional degraded savanna and barren remnants would also be suitable habitat for survey if they contain the moth's host plants. In addition, further surveys for the Great Plains spittlebug are warranted in areas with dry, well-drained soils and the presence of big or little bluestem.

Areas that contain remnant prairie, barrens, or savanna within the game area should be maintained and expanded through prescribed burning. If restoration efforts expand existing remnants of prairie, savanna, or barrens, we recommend future rare insect surveys and continued efforts to monitor for known populations of rare insects.

Aquatic Species and Habitat

Mussel Element Occurrences, Aquatic SGCN, and Fish Species

A new element occurrence for the state endangered eastern pondmussel shell was documented during the course of this project. The eastern pondmussel found at Site 9 in the main stem of the Flat River is the first record of this species in the Flat River watershed. Based on historical (pre-1960) occurrence data from the University of Michigan, Museum of Zoology (UMMZ) Mollusk Collection, eastern pondmussel was present in 15 of Michigan's 58 major watersheds (8-digit HUC). It was documented in the Kalamazoo and St. Joseph River watersheds (Lake Michigan drainage) among others, but not the Grand River watershed. The state conservation rank of eastern pondmussel in Michigan is S2 or "imperiled" (Badra et al. 2014). This occurrence is located several hundred meters upstream of the quarry along the Flat River main stem.

The state threatened slippershell was the only listed mussel documented historically within Flat River SGA. During this project slippershell was recorded at six locations. This data was incorporated into the existing element occurrence for slippersell. As a result, this occurrence includes populations in Dickerson Creek and Wabasis Creek as well as the original location in the Flat River. The state conservation rank for slippershell in Michigan is S2S3 or "imperiled-vulnerable". Although records for slippershell exist throughout Michigan, most records for this species are of empty shells and/or are historical occurrences.

The special concern rainbow was not previously documented in the Flat River SGA. During this survey it was found at six sites, including the Flat River main stem and Dickerson Creek. This data was incorporated into an existing element occurrence for rainbow from nearby the game area. The state conservation rank for rainbow in Michigan is S3 or "vulnerable". Based on historical (pre-1960) occurrence data from the UMMZ Mollusk Collection, rainbow was present in 29 of Michigan's 58 major watersheds (8-digit HUC).

Prior to this project, the special concern ellipse was also not previously documented in the Flat River SGA. Ellipse had been found in the Flat River historically and in recent years. A new element occurrence for ellipse was found within the Flat River SGA during this project. The separation distance between the historical occurrences and those documented in this survey in the SGA is great enough (>10km) that these sites constitute distinct EOs. The special concern round pigtoe had been documented in the Flat River main stem historically (1934) but far enough away from the 2015 occurrence in Flat River SGA that this is also a new EO.

As noted above, two SGCN, creek heelsplitter (*Lasmigona compressa*) and cylindrical papershell (*Anodontoides ferussacianus*) were documented in Flat River SGA. Though it is not state listed or a species of special concern, creek heelsplitter is considered a Regional Forester Sensitive Species by the USDA Forest Service. Its state conservation rank in Michigan is S3 or "vulnerable". Cylindrical papershell is also S3 or "vulnerable", and it is not listed as state endangered or threatened, or as a species of special concern. Cylindrical papershell is being considered for removal from the SGCN list (Amy Derosier, personal communication, March 2015).

An estimate of age can be made by counting the external annular rings of unionid mussels. Young mussels are difficult to detect because of their very small size and often go unseen in field surveys. The presence of a young (2 annular rings) Wabash pigtoe (*Fusconaia flava*) at Site 13 in Wabasis Creek indicates successful reproduction within the past three years.

A historical (1927) record for bigmouth shiner (*Notropis dorsalis*), a species of special concern, is located in Dickerson Creek upstream of Site 5. None were seen during aquatic surveys. All fish species observed during aquatic surveys have a rank of S5 and are considered secure in Michigan. Johnny darter (*Etheostoma nigrum*) is one of the most common fish in Michigan and is tolerant of a wide range of habitat conditions throughout the state. Mottled sculpin (*Cottus bairdii*) is often associated with coldwater streams, and is relatively common in Michigan except for within the Saginaw River watershed. Northern hogsucker (*Hypentelium nigricans*), a species of creeks and small rivers, is common in the southern two-thirds of the Lower Peninsula and an isolated area in the southern portion of the Upper Peninsula. Blackside darter (*Percina maculata*), a species of small to medium rivers, has a range that extends throughout the Lower Peninsula and central Upper Peninsula (Bailey et al. 2004).

Unionid Mussel/Host Fish Relationship and Implications for Management

Unionid mussels rely on fish hosts to reproduce. Eggs are fertilized within the female in the summer months and develop into larvae, called glochidia. These glochidia are brooded within marsupial gills of female mussels until they are ready to be released. In some species, the glochidia overwinter within the parent mussel (bradytictic), while in other species they are released in the fall (tachytictic). When they are released, glochidia must attach to the gills or fins of a fish host in order to survive and develop into the adult mussel form. The fish host provides a stable environment for the glochidia to grow. Glochidia do not harm fish hosts. Some species of mussel are specialists and have only a few species of fish known to act as hosts, others are generalists and are known to utilize a dozen or more different host species. Without the proper species of fish co-occurring with the unionid mussel population, glochidia do not survive and reproduction cannot occur. Glochidia are transported with their host fish until they transform into the adult form and drop off the fish. This allows unionid mussels, which are otherwise mostly sedentary, to migrate to new habitats and exchange genes among populations.

Some species of unionid mussels have lures that attract fish hosts when glochidia are ready to be released. The lures of species in the *Lampsilis* genus (e.g., fatmucket, *Lampsilis siliquoidea*) resemble minnows, complete with an eye spot and fringes that look like fins. The female mussel extends and moves the lure in an undulating motion. When the potential host fish bites the lure, glochidia are released and have a much better chance of attaching to their fish host. Dr. Chris Barnhart's website at http://unionid.missouristate.edu/ provides video footage of mussel lures in action (Barnhart 2008).

Fish hosts for eastern pondmussel are not currently known. Eastern pondmussels are most commonly found in ponds and lakes, but occasionally inhabit rivers. Maximum lifespan is around 10 years. Eastern pondmussel are bradytictic, that is, glochidia overwinter in the female mussel before being released the following spring or summer.

Known hosts for slippershell are mottled sculpin, Johnny darter, and banded sculpin (*Cottus carolinae*), though banded sculpin does not occur in Michigan. Maximum lifespan of slippershell is around 10 years. The slippershell is found almost exclusively in small streams and creeks, and has one of the strongest associations to headwater habitats of any freshwater mussel species. No fish host lure has been documented for slippershell. They are suspected to be bradytictic (Watters et al. 2009).

Rainbow are known to utilize fifteen different host fish species including the common and widespread mottled sculpin, green sunfish (*Lepomis* cyanellus), bluegill (*Lepomis macrochirus*), and smallmouth bass (*Micropterus dolomieu*). Rainbow are most common in creeks and small rivers, occasionally in larger rivers. Female rainbow display one of the most remarkable lures of the unionid mussels. The lure resembles a crayfish with legs, tail, and eyespots, and the mussel can move the lure with very convincing motion (http://unionid.missouristate.edu/gallery/Villosa_iris/villosa_iris_movie.htm).
Maximum lifespan for the rainbow is around 15 years, and they are bradyticitc.

Ellipse are known to use 14 fish species as hosts, including Johnny darter, blackside darter, and mottled sculpin. They are most often found in headwater streams and small rivers. Maximum lifespan is around 10 years and they are bradytictic.

Round pigtoe have been reported from creeks, rivers, and lakes. They have been shown to successfully use central stoneroller (*Campostoma anomalum*), spotfin shiner (*Cyprinella spiloptera*), bluegill (*Lepomis macrochirus*), southern redbelly dace (*Phoxinus erythrogaster*), northern redbelly dace (*Phoxinus eos*), and bluntnose minnow (*Pimephales notatus*). Round pigtoe has two shell morphologies, a small stream form and a larger river form. Individuals from large rivers tend to have more pronounced umbos (the oldest part/peak of the shell). Round pigtoe can live up to 30 years of age. They have a tachytictic breeding strategy, with eggs appearing in May and glochidia developing from May to July.

The creek heelsplitter is a generalist when it comes to utilizing host fish. At least 20 fish species have been found to be acceptable hosts, including common species that occur in southern Michigan. Host fish in southern Michigan include smallmouth bass, black bullhead (*Ameiurus melas*), yellow bullhead (*Ameiurus natalis*), spotfin shiner (*Cyprinella spiloptera*), green sunfish (*Lepomis cyanellus*), bluegill (*Lepomis macrochirus*), and creek chub (*Semotilus atromaculatus*) (Bailey et al. 2004, Watters et al. 2009). Maximum lifespan for creek heelsplitter is 13 years. It is typically found in creeks and small streams with high water quality, and in sand and cobble substrate. This species is bradytictic, with glochidia overwintering in the gills of the female. Creek heelsplitter is one of a few unionid mussels reported to be hermaphroditic (Ortman 1912, Watters et al. 2009).

Cylindrical papershell is a short-lived unionid known to utilize 14 different hosts to complete its life cycle, including some of the most common fish species in Michigan. Fish hosts include white sucker (*Catostomus commersoni*), spotfin shiner (*Cyprinella spiloptera*), bluegill, common shiner (*Luxilus cornutus*), largemouth bass (*Micropterus salmoides*), bluntnose minnow (*Pimephales notatus*), and black crappie (*Pomoxis nigromaculatus*). Maximum lifespan of cylindrical papershell is seven to eight years. It is a bradytictic species that is found in headwater streams in a variety of substrates from cobble and pebble to mud and clay (Watters et al. 2009).

The Grand River, which the Flat River flows into, is the second largest river in Michigan and supports diverse fish and unionid mussel communities. The Grand River is a potential source for fish and mussel species to colonize habitats and exchange genes among populations in the Flat River watershed. Historically the lower Grand supported 31 native mussel species, making it the second most species rich river in Michigan behind only the Detroit River (pre-1960 occurrence data from the UMMZ Mollusk Collection). Twenty-three species have been recorded in recent surveys (1989-2009 occurrence data from the Natural Heritage Database and MNFI surveys) including the state and federally endangered snuffbox mussel (*Epioblasma triquetra*). Snuffbox has been proposed as a Focal SGCN (Derosier et al. 2015). A population of snuffbox is located near the confluence of the Flat and Grand Rivers below the Lowell Dam. Two known host fish species for snuffbox, mottled sculpin and blackside darter, were observed in Flat River SGA during these surveys.

There are four dams on the Flat River between Flat River SGA and the confluence with the Grand. These are the Belding, Whites Bridge, Burroughs, and Lowell dams. These dams restrict fish passage, and since unionid mussels rely on fish hosts for transportation to new locations, they in turn restrict the passage of mussels (Watters 1996). Removing these dams would improve the viability of mussel populations within the Flat River SGA by improving the connectivity of mussel populations within the watershed. Removing dams will allow for mussel migration to new habitats, the transportation of mussels between populations, and improved gene flow among populations, which prevents inbreeding and genetic isolation of populations.

<u>Water Quality, Stream Habitat, and Aquatic Invasive Mollusks</u>

Conductivity measures taken at the time of surveys were within normal expected ranges (455-567µS) (Table 13). Conductivity of rivers in the United States ranges between 50 and 1500µS. Streams supporting good fisheries typically measure between 150 and 500µS. Conductivity, a measure of the ability of water to carry an electrical current, is determined by the amount of inorganic dissolved substances including chloride, nitrate, sulfate, and phosphate (negatively charged ions), and sodium, magnesium, calcium, iron, and aluminum (positively charged ions). The geology of a given watershed is normally a strong factor in determining the amount of these substances present in river water. Streams that run through clay soils pick up materials in the clay that ionize in water resulting in higher conductivity, while streams that run through areas dominated by granite have lower conductivity because granite has an abundance of materials that do not ionize in water. Conductivity can be affected by point and non-point discharges into streams as well. Input of chlorides, phosphate, and nitrates can raise conductivity in rivers and lakes. Unusually high conductivity measures can be indicative of impacts such as excessive input of fertilizer or sewage overflows.

Alkalinity and hardness measures at Sites 4-10 in Dickerson Creek and Flat River main stem were within normal ranges, indicating enough buffering capacity to help protect aquatic life from normal fluctuations in pH (180-216mg/l CaCO3) (Table 13). Sites 1-3 in the south branch of Dickerson Creek, and Sites 11-13 in the Flat River main stem and Wabasis Creek had low measures of alkalinity and hardness (52-76mg/l) relative to the other sites in this study. These values are low compared to typical values of southwest Michigan streams as well (USGS http://water.usgs.gov/owq/hardness-alkalinity.html). These low values came from samples collected on September 30, 2015, while the other samples were collected between August 20th and September 24th, 2015. No precipitation was documented in Greenville, MI on September 29th or 30th (https://www.wunderground.com/history). Repeat measures should be done to rule out inaccuracy in the pH meter or other sources of error, or to identify and investigate any changes in stream water chemistry that may have been caused by unusual inputs into the stream.

The toxicity of some pollutants can depend in part on alkalinity. For example, the toxicity of copper to fish increases when alkalinity is < 50mg/l. Alkalinity is a measure of how much carbonate (mg/liter of CaCO3) is present in water and is one factor in determining how much acid can be added to water without causing a change in pH. In this way alkalinity buffers against rapid changes in pH. Hardness is a similar measure that accounts for other minerals such as magnesium and iron, in addition to calcium carbonate. Alkalinity is influenced by the surficial geology of the watershed. Streams flowing through areas with limestone tend to have high alkalinity.

Low numbers of zebra mussels were found at Sites 8-10. Zebra mussels have had dramatic negative effects on native unionid mussels and aquatic ecosystems in Michigan (Gillis and Mackie 1994, Schloesser et al. 1998). Zebra mussel larvae do not require a fish host to complete their life cycle. They are free swimming and are not normally able to migrate upstream in lotic habitats. The most common pathway for zebra mussel introduction is inadvertent transportation on boats and trailers. Both larvae and adults can be introduced in this way. Zebra mussel larvae are microscopic and can exist in small amounts of water that can be found in boats, boat trailers, and live wells. Bait buckets and waders are other possible pathways for introduction. For waterways like Dickerson Creek and Wabasis Creek, which have no or low boat traffic, bait buckets, and waders may be the most likely pathways for zebra mussel introduction. The risk of introduction can be reduced by promoting the washing and drying of boats, canoes, kayaks, waders and any other gear that could transport zebra mussel larvae or adults before such equipment is used in the watershed. Commonly used fishing sites are the most likely points of zebra mussel introduction. Signage describing the threat of zebra mussels and how to limit their spread could help minimize impacts.

The Flat River main stem had notably high abundance (100s/m2) of the banded mysterysnail (*Viviparus georgianus*), a non-native species in Michigan. Banded mysterysnail is native to the Mississippi River drainage and southern U.S., and is thought to have invaded Michigan, Wisconsin, Quebec, and other northern areas sometime since 1867 (Clench and Fuller 1965). This species was introduced purposefully into the Hudson River drainage by an amateur conchologist and has likely been introduced repeatedly via releases from aquaria (Jokinen 1992, Mills et al. 1993). Densities have been measured up to 864/m^2 in Michigan (Pace and Szuch 1985). Negative impacts have not been well documented.

Flat River Watershed Planning

The Flat River is a relatively high-quality waterway that contributes to maintaining the quality of downstream habitats like the lower Grand River. Due to cumulative downstream effects of non-point source impacts including erosion/siltation, impervious surface, and pollutants, the quality of large river habitats is dependent upon the quality of headwater habitats. Excessive siltation does not appear to be a large problem within the Flat River SGA. The benefit that Flat River SGA provides through relatively wide intact riparian buffers, low levels of impervious surface (large amount of natural land cover), and low levels of other non-point and point source impacts extends into the lower Grand River watershed. Flat River SGA contributes to the habitat quality of the Grand River and the species that system supports, including the state and federally endangered snuffbox mussel.

A nation-wide assessment of threats to imperiled freshwater fauna identified three leading threats: 1) altered sediment loads and nutrient inputs from agricultural nonpoint pollution; 2) non-native species, and 3) altered hydrologic regimes associated with impoundments (Richter et al. 1997). The rivers within Flat River SGA are somewhat buffered from agricultural impacts by relatively wide riparian zones of natural vegetation cover. Though zebra mussels are present within the Flat River main stem, they do not appear to be currently having a large negative impact on native mussels. However, impacts from zebra mussel may have already occurred in the past. There is opportunity to return some of the hydrologic characteristics of the Flat River to a more natural state by removing remnant dam structures and releasing water in ways that more closely mimic natural flow patterns. The banks of the South Branch of Dickerson Creek at Site 3 (Long Lake Rd.) were eroded, presumably due to water releases from the dam approximately 50 m upstream of the survey site. Three other sites had banks that were moderately eroded with no apparent direct cause nearby. As noted above, a potential management action that could improve the viability of populations of eastern pondmussel, slippershell, and other mussels within the Flat River SGA and watershed is to improve connectivity of mussel populations by removing barriers and improving fish passage within the Flat River watershed. Monitoring potential impacts from the quarry on the Flat River main stem may provide opportunities to improve water quality.

A wide range of values has been attributed to the Flat River and its tributaries, including historical, ecological, scenic, and recreational features. The Flat River was an important waterway for Native American travel between villages and between major foot trails. Examples of the historical/cultural features of the Flat River include two covered bridges, the Fallasburg Bridge and, until it was destroyed by fire in 2013, Whites Bridge. Historical industries that took place on the Flat River included a fur trading post in the early 1800s, a sawmill circa 1870-1890, and a button factory near Lowell, Michigan that was in operation until the use of plastics became widespread in the 1930s and 1940s. Before plastics, buttons were often made out of unionid mussel shells. Live mussels were harvested, cleaned, and sold to button factories where circular discs were drilled out of the shells and fashioned into buttons. Overharvest of native mussels also contributed to the decline of the shell button industry, and the Grand River was one of the most utilized rivers for mussel harvest in Michigan (Van der Schalie 1948). The Michigan Department of Conservation (now the Michigan DNR), eventually ceased legal harvest of native mussels in Michigan due to declines in the resource. The Flat River is considered one of the best smallmouth bass fisheries in southern Michigan. Dickerson Creek has in the past been chemically treated to reduce native fish populations and allow for restocking with brown trout, a popular species for recreational fishing (Michigan DNR 1979). Other recreational uses include camping and canoeing. The Flat River is featured in the folk ballad "Jack Haggerty (The Flat River Girl)", a song about a heartbroken raftsman from Greenville, Michigan written by Dan McGinnis in 1872 (https://www.youtube.com/watch?v=AaL89mGzltQ and http://www.fresnostate.edu/folklore/ballads/LC25.html).

In 1979 the Natural Resources Commission designated the Flat River as a county-scenic river and adopted the Flat River Natural River Plan under Act 231 of the Public Acts of 1970. Guidelines for management of the Flat River system in the plan include minimum setbacks for new construction (25 ft from the 50-year floodplain or 100 ft from the ordinary high-water mark, whichever is greater), vegetated buffers along the river's edge (25-50ft), no commercial, industrial, or mining operations within 300ft of the river, and other guidelines (Michigan DNR 1979).

The Flat River was designated a natural river under the Michigan Natural River Act in 1994. In 2011, the Flat River Watershed Council was formed with the purpose "to protect, enhance, and maintain land and water quality and other natural resources in the Flat River Watershed". In 2013, the council was awarded a grant from MDEQ to write a Watershed Management Plan (WMP). An approved WMP is a prerequisite for receiving certain state and federal funding to cover restoration activities in the watershed. The WMP will provide guidelines for assessing the health of the watershed and approved methods of solving identified problems. A Watershed Planning Project began in 2014 as a first step toward the creation of the Flat River WMP. Four main issues of concern have been identified, these are: 1) Increased levels of *E. coli* bacteria throughout the watershed; 2) Increased water temperatures within the watershed's traditionally cold water tributaries (e.g., Dickerson Creek); 3) Potential violations of the Natural Rivers Act throughout the watershed; and 4) Adherence to run-of-river requirement by dam operators within the watershed. This planning project defines specific goals and objectives for the development of the WMP (Flat River Watershed Planning Project 2014).

Maintaining a buffer of natural cover along the Flat River is recommended. Photo by Peter J. Badra

CONCLUSION

During the Integrated Inventory Project at Flat River SGA, MNFI documented 16 new element occurrences (EOs) and updated an additional ten EOs (Tables 1-6). In total, 16 SGCN were documented during the project including ten rare animal species (Table 8). Surveys for exemplary natural communities resulted in eleven new high-quality natural communities and two known high-quality community were updated (Table 1). Seven different natural community types are represented in the thirteen element occurrences surveyed including: bog (2 EOs), dry-mesic northern forest (1 EO), dry-mesic southern forest (2 EOs), floodplain forest (1 EO), hardwood-conifer swamp (5 EOs), hillside prairie (1 EO), and southern wet meadow (1 EO). 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, three rare plant EOs were opportunistically documented (Table 2). Records for prairie buttercup (*Ranunculus rhomboideus*, state threatened) were updated and a new record for ginseng (*Panax quinquefolius*, state threatened) was documented.

Employing aerial photo interpretation, MNFI scientists identified and mapped 172 potential vernal pools in the Flat River SGA. During the 2015 field season, 26 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 three rare bird species were recorded during the 2015 breeding season (Table 3). We updated EOs for Louisiana waterthrush and hooded warbler and documented a new EO for red-shouldered hawk. A total of four avian SGCN were documented in Flat River SGA during the 2015 breeding season (Appendix 8).

During the course of the project, two reptile EOs were updated, a Blanding's turtle EO and an eastern box turtle EO. A total of five amphibian and reptile SGCN have been documented in the Flat River SGA, with all five being recorded during this project (Table 4 and Appendix 3).

Seven rare insect species have been documented in the game area (Table 5). No rare insects were documented during targeted surveys for this project. However, Karner blue were documented in 2015 during a concurrent project focused on Karner blue (Monfils and Cuthrell 2015).

Surveys for unionid mussels resulted in three new element occurrences and two updated element occurrences. New records for eastern pondshell, ellipse, and round pigtoe were documented and records for slippershell and rainbow were updated. All of these species are SGCN. Two additional SGCN mussels, cylindrical papershell and creek heelsplitter were also documented in Flat River SGA (Table 6 and Appendix 6).

Primary management recommendations for the Flat River SGA include 1) invasive species control focused in high-quality ecosystems, 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 riparian corridors, 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, barrens, and prairie 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 Flat River 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 Japanese barberry (*Berberis thunbergii*), autumn olive (*Elaeagnus umbellata*), Morrow honeysuckle (*Lonicera morrowii*), multiflora rose (*Rosa multiflora*), narrow-leaved cat-tail (*Typha angustifolia*), glossy buckthorn (*Frangula alnus*), reed canary grass (*Phalaris arundinacea*), purple loosestrife (*Lythrum salicarea*), and reed (*Phragmites australis*). Invasive species management at Flat River 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 Flat River SGA historically supported fire-dependent ecosystems, such as oak barrens, oak-pine barrens, oak openings, dry-mesic southern forest, and dry-mesic northern forest. 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 savanna, barrens, and prairies have converted to closed-canopy forests dominated by shade-tolerant native and invasive species. This conversion of fire-dependent open 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 Flat River SGA and in the surrounding area depend on these fire-dependent habitats. In addition, due to fire suppression, closed-canopy forests within Flat River SGA are experiencing strong regeneration of thin-barked, shade-tolerant mesophytic trees and invasive shrubs.

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 prairie, barrens, and oak savanna within Flat River SGA will depend on the implementation of frequent prescribed fire. Pursuing restoration of savanna, barrens, and prairie 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., hillside prairie and dry-mesic southern forest) and immediately adjacent systems. Where rare herptiles and insects 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 Flat River SGA supports over 8,865 acres of forest and over 582 acres of high-quality forest, primarily lowland forest (hardwood-conifer swamp and floodplain forest). The large area of upland forest and lowland 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 closing redundant forest roads, limiting the creation of new roads, halting the creation of new wildlife openings within forested landscapes, and decreasing forest harvest levels. 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 riparian corridors, wetlands, and existing high-quality natural communities.

In general, prioritization of stewardship within Flat River SGA should focus on the highest quality examples of the rarest natural community types and the largest sites. Biodiversity is most easily and effectively protected by preventing high-quality sites from degrading. Within Flat River SGA, we recommend the following 1) that stewardship efforts be focused in natural communities that harbor high levels of biodiversity and provide habitat for numerous rare plant and animal species; 2) that management efforts focus on riparian corridors and 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.

Miller Swamp hardwood-conifer swamp. 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 #:

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

Township/Range/Section/1/4 info: Latitude: Longitude:

County:

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

Method for locating pool? Latitude: Longitude:

☐ GPS ☐ Topo Map ☐ Google Earth ☐ Air Photo 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 **Disturbances:** ☐ Powerline right-of-way ☐ Other:

☐ Upland Coniferous Forest ☐ Lowland Coniferous Forest ☐ Agriculture ☐ Light development (<25%) ☐ No disturbances

☐ Upland Mixed Forest ☐ Lowland Mixed Forest ☐ Road/driveway ☐ Intensive development (>25%)

☐ Floodplain ☐ Grassland or open ☐ paved ☐ Minor logging (> or = 70% canopy remaining)

☐ Emergent Wetland (marsh, bog) ☐ dirt/gravel ☐ Major logging (< or = 70% canopy remaining)

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

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

Width: feet

Length: feet

Size determined by: ☐ Pacing ☐ Measuring ☐ Using GPS

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):

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

Page 1 of 2

Appendix 1 (continued). Vernal Pool Monitoring Form.

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%

Tree canopy over pool basin (when leaves are fully out): ☐ 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

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

Appendix 2. Vernal Pool Types.

1) **Open Pool** – "Classic" vernal pool with trees, shrubs, and herbaceous (non-woody) plants covering less than 10% of the ground within the pool when the pool is flooded or wet. Herbaceous plants are plants whose stems and leaves die at the end of the growing season and have no woody stems above ground.

2) **Sparsely Vegetated Pool** – Trees, shrubs, and non-woody herbaceous plants covering 10% to less than 30% of the ground within the pool when the pool is flooded or wet.

3) **Shrubby Pool** – Pool is dominated by shrubs, with shrubs covering 30% or more of the ground within the pool when it is flooded or wet, and representing the tallest vegetation layer within the pool.

Appendix 2 (continued). Vernal Pool Types.

4) **Forested Pool –** Pool is dominated by trees with rooted, live trees covering 30% or more of the ground within the pool when it is flooded or wet, and representing the tallest vegetation layer within the pool. For example, a forested swamp pool, pool within a larger forested swamp, and a floodplain pool.

5) **Marsh Pool –** Pool dominated by non-woody herbaceous plants, including emergent plants which are plants that grow in water and stick up out of the water. Non-woody herbaceous and emergent plants cover 30% or more of the ground within the pool when it is flooded or wet, and represent the uppermost vegetation layer within the pool. Trees and shrubs may be present but cover less than 30% of the pool.

Appendix 3. List of amphibian and reptile species known to occur or with potential to occur in Flat River 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 Targeted for 2015 Surveys	Species Found During 2015 Surveys	Species Found Prior to 2015	General Habitats[3,4]
Amphibian	Eastern Newt	*Notophthalmus viridescens*							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		Deciduous and coniferous forests from moist bottomlands to dry uplands; ponds that retain water into midsummer essential
Amphibian	Spotted Salamander **	*Ambystoma maculatum*							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*							Forests, marshes, and grasslands; breeding - permanent and semi-permanent ponds
Amphibian	Eastern Red-backed Salamander	*Plethodon cinereus*					X		Deciduous, coniferous, and mixed forests
Amphibian	Four-toed Salamander **	*Hemidactylium scutatum*							Moist deciduous, coniferous, or mixed forests, usually in vicinity of spring-fed creeks, sphagnum seepages, bogs, or boggy ponds
Amphibian	Mudpuppy *	*Necturus maculosus maculosus*			X				Permanent waters, including rivers, reservoirs, inland lakes, and Great Lakes bays and shallows
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*							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	X	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*			X	X			Permanent waterbodies - ponds, lakes, marshes, sloughs, rivers; highly aquatic
Reptile	Spotted Turtle	*Clemmys guttata*		T	X	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

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 2015 due to low likelihood or probability of detecting the species given available methods and resources for surveys.

** - Species was a SGCN prior to 2015 but was removed as a SGCN by the Michigan DNR in 2015.

Listed/rare amphibian and reptile species and/or SGCN targeted for surveys and documented in Flat River SGA in 2015.

Additional amphibian and reptile species that have been documented in Flat River SGA during MNFI or other surveys in 2015 and/or prior to 2015.

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

[3]Harding, J.H. 1997. Amphibians and Reptiles of the Great Lakes Region. The University of Michigan Press, Ann Arbor, MI. 378 pp.

Appendix 3 (continued). List of amphibian and reptile species known to occur or with potential to occur in Flat River 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 Targeted for 2015 Surveys	Species Found During 2015 Surveys	Species Found Prior to 2015	General Habitats[3,4]
Reptile	Blanding's Turtle	*Emydoidea blandingii*		SC	X	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*					X		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	Eastern Spiny Softshell	*Apalone spinifera spinifera*					X		Rivers and larger streams, inland lakes, reservoirs, protected bays and river mouths; can tolerate fairly swift currents; prefer sandy or muddy substrates and open habitats with little aquatic vegetation; rarely leave vicinity of water
Reptile	Common 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 Watersnake	*Nerodia sipedon sipedon*							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	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	Dekay's Brownsnake	*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 Gartersnake	*Thamnophis sirtalis sirtalis*							Almost any natural habitats - open and forested habitats and moist grassy places - edges of ponds, lakes, streams ditches,
Reptile	Northern Ribbonsnake	*Thamnophis sauritus septentrionalis*			X	X	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	X			Moist, shady forests and adjacent open habitats including old fields, grassy dunes; often found under leaf litter or cover or in burrows
Reptile	Eastern Hog-nosed Snake **	*Heterodon platirhinos*							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	X	X	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 Milksnake	*Lampropeltis triangulum triangulum*							Open forests, bogs, swamps, forest edges, marshes, lakeshores, old fields, and pastures
Reptile	Smooth Greensnake	*Opheodrys vernalis*			X	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*	Proposed LT (09/2015)	SC	X	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 2015 due to low likelihood or probability of detecting the species given available methods and resources for surveys.
** - Species was a SGCN prior to 2015 but was removed as a SGCN by the Michigan DNR in 2015.

Listed/rare amphibian and reptile species and/or SGCN targeted for surveys and documented in Flat River SGA in 2015.
Additional amphibian and reptile species that have been documented in Flat River SGA during MNFI or other surveys in 2015 and/or prior to 2015.

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.
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[3]Harding, J.H. 1997. Amphibians and Reptiles of the Great Lakes Region. The University of Michigan Press, Ann Arbor, MI. 378 pp.

Appendix 4. Rare Herptile Survey Form.

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 ____

____

01/05/2016

Appendix 4 (continued). Rare Herptile Survey Form.

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

01/05/2016

Appendix 5. Papaipema Moth Survey Form.

* Remember to find ETOH for tomorrow to help chase killjar.

Michigan Natural Features Inventory Papaipema Moth Survey Form

Survey Site: FRSGA Miller Road S. of Fenwick	Date 2015 -09 -15	Managed Area: Flat River SGA
Surveyors: David Cuthrell	overall start time 8 : 00	
	overall end time :	
GPS coordinates of blacklight setup 43.13816 -85.17603		Waypoint or file name: 2015 BL 2

-Based out 7:10 pm to ESE
-RSHA to WNW 7:15 pm

Start time of the period	Scientific Name: Papaipema pterisii	TOTALS	temperature [C] [F]	relative humidity - %	wind speed - max [km/h] [mph]	wind speed - avg [km/h] [mph]	cloud cover - %	precipitation level	moon visibility	barometric pressure [kPa] [inHg]
1st hour 8:00	0		66.5	70.0	0	0	2	0	0	30.26
2nd hour 9:00	0		59.8	80.5	0	0	0	0	0	30.26
3rd hour 10:00	1		57.6	89.2	0	0	0	0	0	30.26
4th hour 11:00	0		55.0	87.7	0	0	0	0	0	30.26
5th hour 12:00	0		53.5	91.3	0	0	0	0	0	30.26
6th hour :										
7th hour :										
TOTALS	1	1								

Dominant Plant Species	
Lespedeza capitata	Black-eyed Susan
Solidago canadensis	Euphorbia corollata
Ragweed	Big Bluestem
Little bluestem	Penn Sedge
unknown grass	Porcupine grass
Butterfly milkweed	White Aster sp. - Flowering
Spotted Knapweed	Bastard toadflax
Dewberry	Liatris aspera - 50-75 fruiting stalks

Notes/Comments/Diagrams

8-9 - No Papaipema - few moths
9-10 - " "
10:06 - ~~eight?~~ ptersii

H:\2012 Proposal\TNC Oak Openings Insects\papaipema_forms2.xls

Appendix 5 (continued). Papaipema Moth Survey Form.

Michigan Natural Features Inventory Papaipema Moth Survey Form

Survey Site: FRSGA Bluebird Lane - E. of Berreedge	Date 2015 - 09 - ~~18~~ 16	Managed Area: Flat River State Game Area	
Surveyors: David Cuthrell	overall start time 8 : 00		
	overall end time 12 : 00		
GPS coordinates of blacklight setup 43.13150 -85.20916		Waypoint or file name: 2015BL3	

8:07pm Whippoorwill – 8:27pm
Milky E. Screech owl
3 Woodcock @ dusk

Start time of the period		Scientific Name: Papaipema pterisii	Papaipema arctivorens	TOTALS	temperature [C] [F]	relative humidity - %	wind speed - max [km/h] [mph]	wind speed - avg [km/h] [mph]	cloud cover - %	precipitation level	moon visibility	barometric pressure [kPa] [inHg]
1st hour	8 : 00			0	61.8	71.8	0	0	0	0	1	30.16
2nd hour	9 : 00		1	1	58.2	80.5	0	0	0	0	2	30.16
3rd hour	10 : 00	II	1	3	54.5	81.8	0	0	0	0	0	30.16
4th hour	11 : 00	III		3	53.5	84.2	0	0	0	0	0	30.15
5th hour	12 : 00			0	51.9	82.9	0	0	0	0	0	30.14
6th hour	:											
7th hour	:											
TOTALS		5	2	7								

Dominant Plant Species	
Unknown grass	Dewberry
Little bluestem	Penn Sedge
Spotted Knapweed	Jack Pine
St. Johns Wort	Red Pine
Black-eyed Susan	Black Cherry
Red Oak Saplings	Autumn Olive
Mullein	Liatris aspera ≈ 75-100 flowering plants
Equisetum near road	Smooth brome
Common milkweed	Solidago canadensis

Notes/Comments/Diagrams

9:25 - yellow-spotted
10:38 - " "
10:43 - yellow-yellow spotted - pterisii?
10:59 - small yellow
11:05 - orange w/spots
11:38 - damaged Papaipema
11:52 - yellow spotted

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Appendix 5 (continued). Papaipema Moth Survey Form.

Michigan Natural Features Inventory Papaipema Moth Survey Form

Survey Site: Flat River SGA - Karner Trail	Date 2015 - 09 - 14	Managed Area: Karner Trail	
Surveyors: David Cuthrell	overall start time :	Flat River SGA - Powerline ROW	
	overall end time :		
GPS coordinates of blacklight setup WGS84 43.13652 -85.23808		Waypoint or file name: 2015 BL1	

Photos #
4718 → 4700

-Whip-poorwill } at dusk
- Barred owl

Start time of the period	P. limpida	P. ignaucsita	P. pterisii	P. rigida											TOTALS	temperature [C] [F]	relative humidity - %	wind speed - max [km/h] [mph]	wind speed - avg [km/h] [mph]	cloud cover - %	precipitation level	moon visibility	barometric pressure [kPa] [inHg]
1st hour 8:00	0															63.3	68.7	0.9	0	0	0	0	
2nd hour 9:00	1			𝍸 ||										7		58.2	78.7	0	0	0	0	0	
3rd hour 10:00	0	|	|	|||										5		55.8	87.0	0	0	0	0	0	
4th hour 11:00	0		𝍸 𝍸 ||||											14		56.1	86	0	0	0	0	0	
5th hour 12:00	0															55.3	87.2	0	0	0	0	0	
6th hour 12:15	0															55.5	87.8	0	0	0	0	0	
7th hour :																							
TOTALS	1	1	15	9										25									

Dominant Plant Species	
Little bluestem	Purple love grass
Brome	Black-eyed Susan
Big Bluestem	Daisy Fleabane
Spotted knapweed	Butterfly weed
Aster spp.	Solidago canadensis
Cacalia	Autumn Olive
Indian Grass	Dewberry
Lupine	Liatris aspera? - 200+

see photos

flowering plants

Notes/Comments/Diagrams

9:08 - ~~[illegible]~~ - 56.8, 82.8 RH
- 56.9, 85
~~[illegible]~~
9:22 - yellow - rigida
9:26 - rigida
9:28 - rigida
9:55 - rigida
9:56 - rigida
10:10 - rigida
10:20 - rigida
10:24 - bracken fern borer ?
10:52 - rigida
10:56 - ~~[illegible]~~ cutyphraeta
11:00 - yellow-spotted
11:07 - yellow-spotted
11:11 - " "
11:12 - yellow spotted-like
11:15 - yellow spotted
11:20 - " "
11:24 " "
11:27 " "
11:33 " "
11:34 " "
11:37 " "
11:41 " "
11:47 " "
11:54 " "

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Appendix 6. A checklist of Michigan's unionid mussel species found at sites surveyed in Flat River State Game Area in 2015. "S" denotes that surveys found shells of dead mussels and "L" denotes that surveys found living mussels. In addition, species with historical (pre-1960) records from the Flat River Watershed are indicated with an "X". Historical records are from the University of Michigan Museum of Zoology Mollusk Collection. State and federal status abbreviations are as follows: E, state or federally endangered; T, state threatened; and SC, state special concern.

		Historical records in Flat River	Historical records in Wabasis Creek	Flat River 2015	Wabasis Creek 2015	Dickerson Creek 2015	State status	Federal status
Actinonaias ligamentina	Mucket							
Alasmidonta marginata	Elktoe	X	X				SC	
Alasmidonta viridis	Slippershell	X	X	S	S	S	T	
Amblema plicata	Threeridge							
Anodontoides ferussacianus	Cylindrical papershell	X	X	S	L	L		
Cyclonaias tuberculata	Purple wartyback						T	
Elliptio complanata	Eastern elliptio							
Elliptio crassidens	Elephant-ear							
Elliptio dilatata	Spike	X		L	L	L		
Epioblasma obliquata perobliqua	White catspaw						E	E
Epioblasma torulosa rangiana	Northern riffleshell						E	E
Epioblasma triquetra	Snuffbox						E	E
Fusconaia flava	Wabash pigtoe		X	L	S	L		
Lampsilis fasciola	Wavy-rayed lampmussel						T	
Lampsilis siliquoidea	Fatmucket					S		
Lampsilis ventricosa	Pocketbook	X	X	S	L			
Lasmigona complanata	White heelsplitter							
Lasmigona compressa	Creek heelsplitter	X	X	S	L			
Lasmigona costata	Fluted-shell	X	X	S	L	S		
Leptodea fragilis	Fragile papershell							
Leptodea leptodon	Scaleshell						SC	E
Ligumia nasuta	Eastern pondmussel			S			E	
Ligumia recta	Black sandshell						E	
Obliquaria reflexa	Three-horned wartyback						E	
Obovaria olivaria	Hickorynut						E	
Obovaria subrotunda	Round hickorynut						E	
Pleurobema clava	Clubshell						E	E
Pleurobema sintoxia	Round pigtoe	X				S	SC	
Potamilus alatus	Pink heelsplitter							
Potamilus ohiensis	Pink papershell						T	
Ptychobranchus fasciolaris	Kidney-shell						SC	
Pyganodon grandis	Giant floater	X						
Pyganodon lacustris	Lake floater						SC	
Pyganodon subgibbosa	Lake floater						T	
Quadrula pustulosa	Pimpleback							
Quadrula quadrula	Mapleleaf							
Simpsonaias ambigua	Salamander mussel						E	
Strophitus undulatus	Strange floater	X	X	S	L			
Toxolasma lividus	Purple lilliput						E	
Toxolasma parvum	Lilliput						E	
Truncilla donaciformis	Fawnsfoot						T	
Truncilla truncata	Deertoe						SC	
Utterbackia imbecillis	Paper pondshell						SC	
Venustaconcha ellipsiformis	Ellipse	X		L	L	L	SC	
Villosa fabalis	Rayed bean						E	E
Villosa iris	Rainbow	X	X	S		S	SC	

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 8. List of bird species detected during 103 point counts conducted in forested areas of Flat River State Game Area during 2015. State status (T = threatened, SC = special concern) and the proportion of points having detections are provided for each species. Bird species considered as Michigan Department of Natural Resources featured 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[1]	Featured Species[2]	SGCN[3]	JV Focal Species[4]	Prop. of Points
Acadian flycatcher	*Empidonax virescens*					0.41
American crow	*Corvus brachyrhynchos*					0.44
American goldfinch	*Spinus tristis*					0.19
American redstart	*Setophaga ruticilla*					0.22
American robin	*Turdus migratorius*					0.64
Baltimore oriole	*Icterus galbula*					0.02
Barred owl	*Strix varia*					0.01
Belted kingfisher	*Megaceryle alcyon*					0.01
Black-and-white warbler	*Mniotilta varia*					0.03
Black-capped chickadee	*Poecile atricapillus*					0.50
Blue jay	*Cyanocitta cristata*					0.41
Blue-gray gnatcatcher	*Polioptila caerulea*					0.18
Blue-headed vireo	*Vireo solitarius*					0.01
Blue-winged warbler	*Vermivora cyanoptera*				X	0.07
Brown creeper	*Certhia americana*					0.05
Brown thrasher	*Toxostoma rufum*					0.01
Brown-headed cowbird	*Molothrus ater*					0.26
Cedar waxwing	*Bombycilla cedrorum*					0.42
Chestnut-sided warbler	*Setophaga pensylvanica*					0.02
Chipping sparrow	*Spizella passerina*					0.08
Common grackle	*Quiscalus quiscula*					0.04
Common yellowthroat	*Geothlypis trichas*					0.32
Downy woodpecker	*Picoides pubescens*					0.22
Eastern bluebird	*Sialia sialis*		X			0.01
Eastern phoebe	*Sayornis phoebe*					0.02
Eastern kingbird	*Tyrannus tyrannus*					0.01
Eastern towhee	*Pipilo erythrophthalmus*					0.11
Eastern wood-pewee	*Contopus virens*					0.62
Field sparrow	*Spizella pusilla*					0.05
Gray catbird	*Dumetella carolinensis*					0.17
Great blue heron	*Ardea herodias*					0.01
Great crested flycatcher	*Myiarchus crinitus*					0.41
Hairy woodpecker	*Picoides villosus*					0.18
Hooded warbler	*Setophaga citrina*	SC		X		0.03
House wren	*Troglodytes aedon*					0.04
Indigo bunting	*Passerina cyanea*					0.09
Killdeer	*Charadrius vociferus*					0.01
Louisiana waterthrush	*Seiurus motacilla*	T		X	X	0.02
Mallard	*Anas platyrhynchos*		X			0.01
Mourning dove	*Zenaida macroura*					0.40
Mourning warbler	*Geothlypis philadelphia*					0.01
Northern cardinal	*Cardinalis cardinalis*					0.36
Northern flicker	*Colaptes auratus*					0.13
Northern waterthrush	*Parkesia noveboracensis*					0.08

[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 (Derosier et al. 2015).
[4]Focal species in the Upper Mississippi River and Great Lakes Region Joint Venture Landbird Habitat Conservation Strategy (Potter et al. 2007).

Appendix 8 (continued). List of bird species detected during 103 point counts conducted in forested areas of Flat River State Game Area during 2015. State status (T = threatened, SC = special concern) and the proportion of points having detections are provided for each species. Bird species considered as Michigan Department of Natural Resources featured 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[1]	Featured Species[2]	SGCN[3]	JV Focal Species[4]	Prop. of Points
Ovenbird	*Seiurus aurocapilla*					0.54
Pileated woodpecker	*Dryocopus pileatus*		X			0.14
Pine warbler	*Setophaga pinus*					0.13
Purple martin	*Progne subis*					0.01
Rose-breasted grosbeak	*Pheucticus ludovicianus*					0.34
Red-bellied woodpecker	*Melanerpes carolinus*					0.28
Red-eyed vireo	*Vireo olivaceus*					0.82
Red-headed woodpecker	*Melanerpes erythrocephalus*		X	X	X	0.01
Red-shouldered hawk	*Buteo lineatus*	T	X	X		0.08
Red-winged blackbird	*Agelaius phoeniceus*					0.07
Ring-necked pheasant	*Phasianus colchicus*		X			0.01
Ruby-throated hummingbird	*Archilochus colubris*					0.04
Sandhill crane	*Grus canadensis*					0.04
Scarlet tanager	*Piranga olivacea*					0.47
Song sparrow	*Melospiza melodia*					0.22
Swamp sparrow	*Melospiza georgiana*					0.03
Tree swallow	*Tachycineta bicolor*					0.01
Tufted titmouse	*Baeolophus bicolor*					0.37
Veery	*Catharus fuscescens*				X	0.33
White-breasted nuthatch	*Sitta carolinensis*					0.39
Wild turkey	*Meleagris gallopavo*		X			0.01
Winter wren	*Troglodytes hiemalis*					0.02
Wood duck	*Aix sponsa*		X			0.12
Wood thrush	*Hylocichla mustelina*		X		X	0.49
Yellow warbler	*Setophaga petechia*					0.10
Yellow-billed cuckoo	*Coccyzus americanus*					0.10
Yellow-throated vireo	*Vireo flavifrons*					0.09

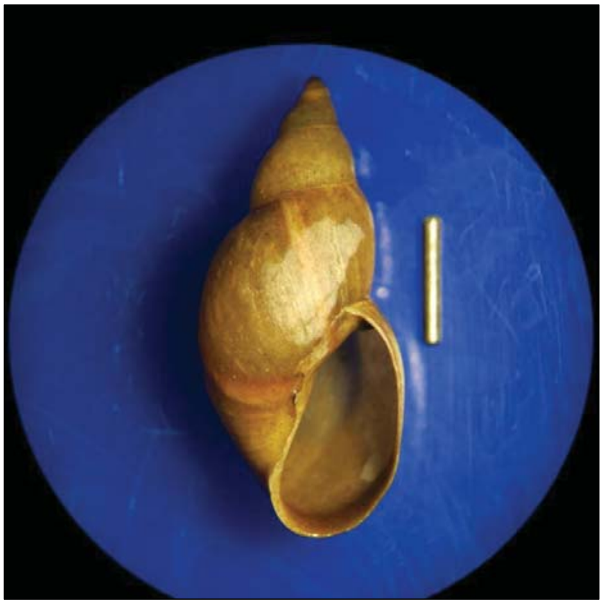
[1]Michigan listing status (T = state threatened, SC = state special concern).
[2]Identified as featured species for habitat management by MDNR Wildlife Division.
[3]Species of greatest conservation need in the Michigan Wildlife Action Plan (Derosier et al. 2015).
[4]Focal species in the Upper Mississippi River and Great Lakes Region Joint Venture Landbird Habitat Conservation Strategy (Potter et al. 2007).

Appendix 9. List of bird species having special status that were detected at Flat River State Game Area during 2015 surveys and general habitat requirements.

Species	General Habitat Requirements	State Status[1]	Featured Species[2]	WAP SGCN[3]	JV Focal Species[4]
Blue-winged warbler	Open shrublands, woodland openings, stream edges, willow swamps, and old fields with shrubs and small deciduous trees.				X
Eastern bluebird	Open oak and pine woodlands, residential and roadside hedges, old fields, pastures, and hayfields.		X		
Hooded warbler	Mature mesic or wet deciduous forest with dense understories of shrubs/small trees.	SC		X	
Louisiana waterthrush	Fast-flowing streams within large blocks of mature deciduous forest with moderate to sparse understory.	T		X	X
Mallard	Shallow marshes and ponds, lakes, rivers, and streams. Nests in grasslands, wetlands, hayfields, and shrublands.		X		
Pileated woodpecker	Mature mesic deciduous, lowland, and mixed hardwood-conifer forests with dead or dying trees.		X		
Red-headed woodpecker	Farmlands, old burns, prairie edges, or partially cleared areas where dead trees are standing.		X	X	X
Red-shouldered hawk	Mature swamp and upland forest, interspersed with marshy openings, oxbows, bayous, and grasslands.	T	X	X	
Ring-necked pheasant	Row crops, old fields, hay fields, grassy and shrubby fence rows, and marshes.		X		
Veery	Large tracts of moist forest, dense understory of deciduous trees/shrubs				X
Wild turkey	Variety of forest types that provide mast-producing trees, herbaceous openings, and protection from disturbance.		X		
Wood thrush	Large tracts of wet and mesic deciduous forest and sometimes dry forest.		X	X	X
Wood Duck	Variety of swamps, marshes, streams, beaver ponds, and lakes. Nests in tree cavities of mature forests near wetlands or water bodies.		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 (Derosier et al. 2015).
[4]Focal species in the Upper Mississippi River and Great Lakes Region Joint Venture Landbird Habitat Conservation Strategy (Potter et al. 2007).

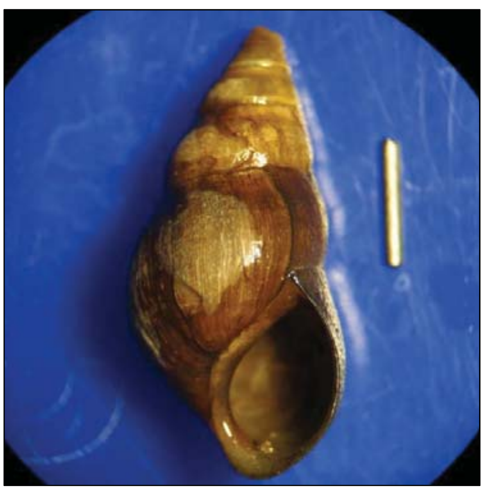
Appendix 10. Photos of snail species observed during aquatics surveys at Flat River State Game Area in 2015. Photos by Peter J. Badra.



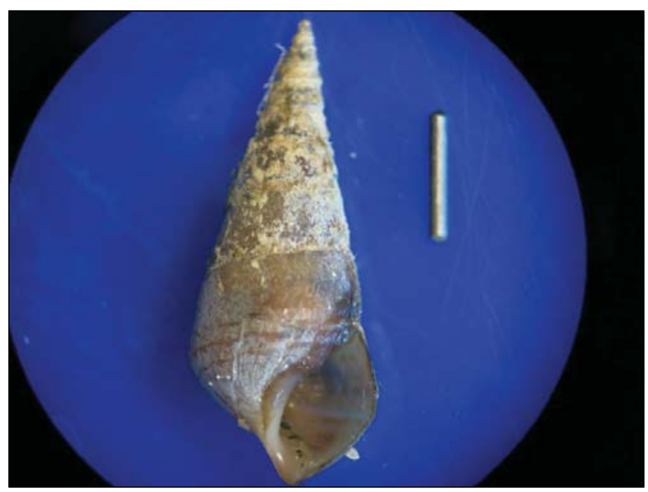
Marsh pondsnail (*Stagnicola elodes*), Flat River, Site 8

Tadpole physa (*Physella gyrina*), Flat River, Site 8

Golden fossaria (*Fossaria obrussa*), S. Branch Dickerson Creek, Site 2



Liver elimia (*Elimia livescens*), Flat River, Site 8



Sharp hornsnail (*Pleurocera acuta*), Wabasis Creek, Site 12

(Bar is 5mm in length in all photos)

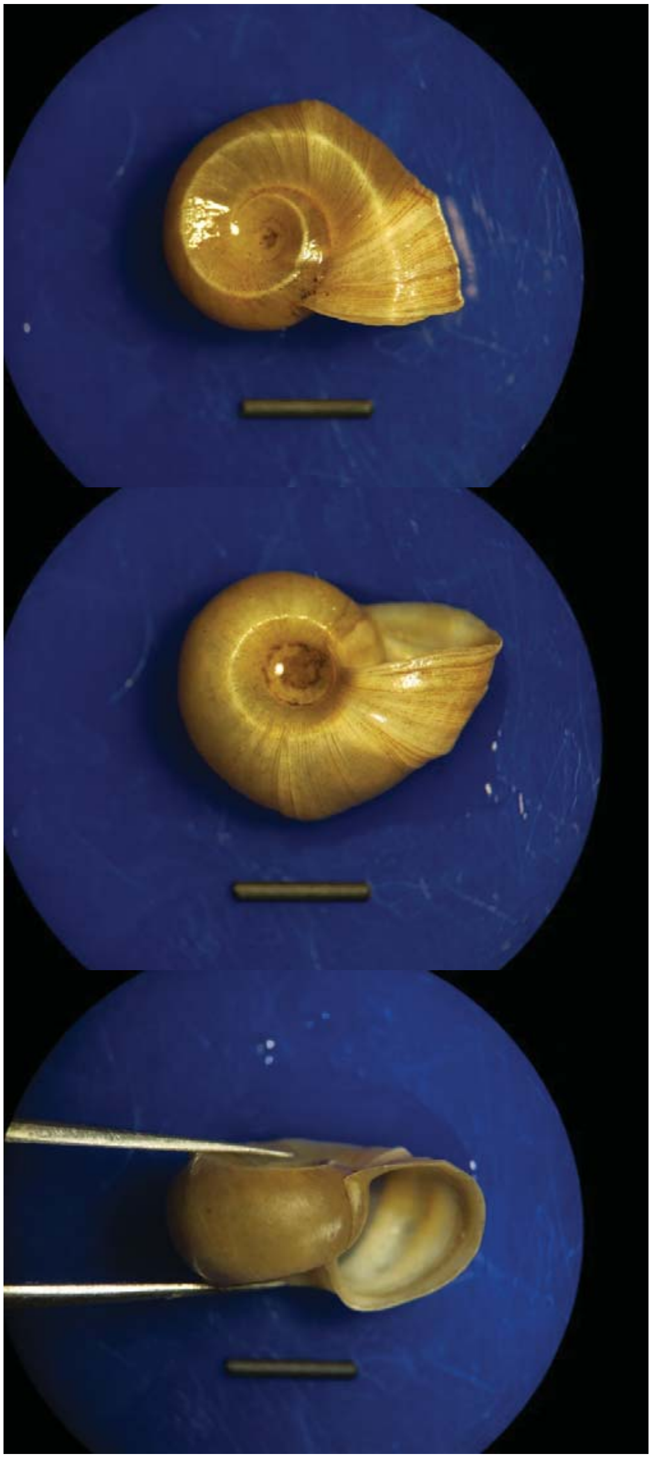
Appendix 10 (continued). Photos of snail species observed during aquatics surveys at Flat River State Game Area in 2015. Photos by Peter J. Badra.

Banded mysterysnail (*Viviparus georgianus*), Flat River, Site 8

Pointed campeloma (*Campeloma decisum*), Wabasis Creek, Site 12

(Bar is 5mm in length in all photos)

Appendix 10 (continued). Photos of snail species observed during aquatics surveys at Flat River State Game Area in 2015. Photos by Peter J. Badra.

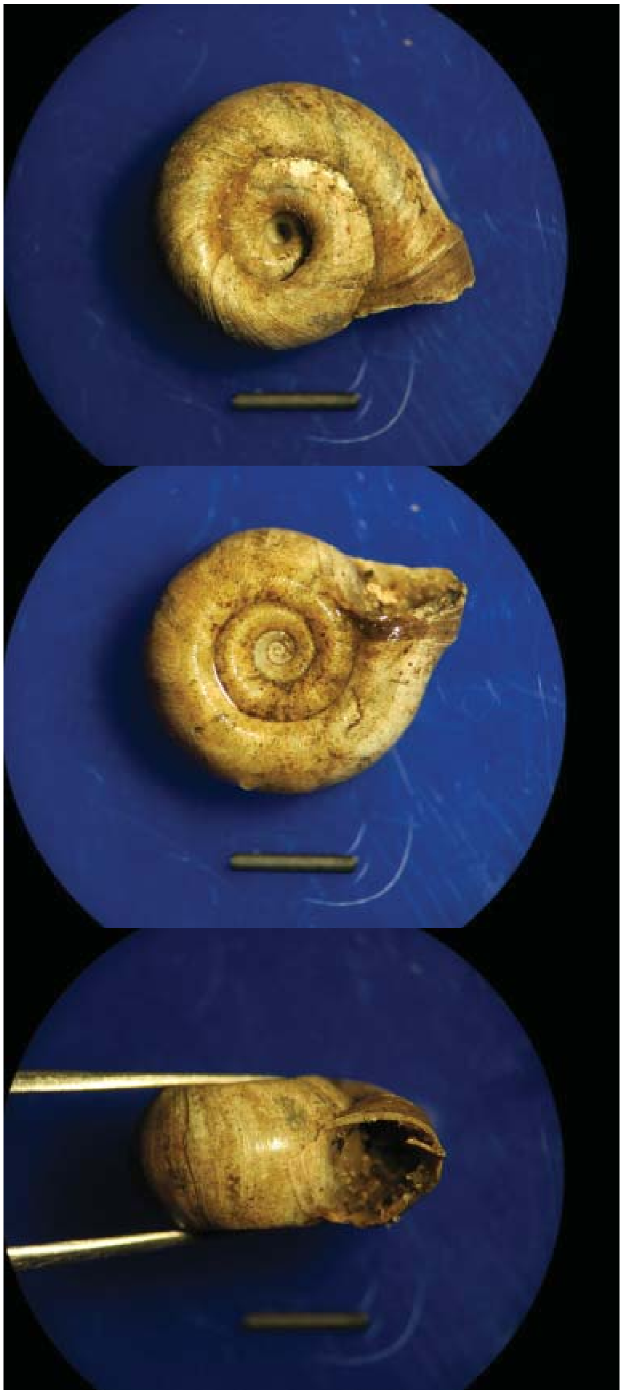


Two-ridge rams-horn (*Helisoma anceps*), Flat River, Site 8

Marsh rams-horn (*Planorbella trivolvis*), Flat River, Site 10

(Bar is 5mm in length in all photos)

Appendix 10 (continued). Photos of snail species observed during aquatics surveys at Flat River State Game Area in 2015. Photos by Peter J. Badra.



Bellmouth rams-horn (*Planorbella campanulata*), Dickerson Creek, Site 4

Creeping ancylid (*Ferrissia rivularis*), Flat River, Sites 8 and 11

(Bar is 5mm in length in all photos)

Appendix 10 (continued). Photos of snail species observed during aquatics surveys at Flat River State Game Area in 2015. Photos by Peter J. Badra.

Aquatic snails with penny for scale. Bar is 5mm in length.

Appendix 11. Management Guidance for Woodland Raptors (Specifically Red-Shouldered Hawks and Northern Goshawk) on State Forest Lands.

MICHIGAN DEPARTMENT OF NATURAL RESOURCES

INTEROFFICE COMMUNICATION

Management Guidance for Woodland Raptors (specifically Red-Shouldered Hawks and Northern Goshawk) on State Forest Lands

June 11, 2015

Background

Draft management guidelines for Red-shouldered hawk (RSH) were developed for the northern Lower Peninsula ecoregion by a Woodland Raptor Working Group in 1999. Those draft guidelines were never formally adopted by the Department. Survey information on RSH populations helped inform a decision to re-assess and update the draft guidelines and additional information also helped inform the decision to include the Northern goshawk (NG) in these guidelines and identified them as interim guidance in 2012. These interim management guidelines served to inform actions on state land as part of the State Forest Management Plan. The Field Coordinators from Wildlife Division (WLD) and Forest Resources Division (FRD) were tasked with finalizing guidance materials for woodland raptors (including RSH and NG) in 2014.

Objectives

These guidelines will focus on the following main objectives for woodland raptors:

1. Protect woodland raptors.
2. Establish raptor guidelines that recognize and compliment timber cover type management objectives to the extent possible.
3. Continue to evaluate methods and determine if management changes are necessary (adaptive management strategies).
4. Develop a special data layer within the MiFi system for tracking woodland raptor nests (specifically Red-shouldered hawks and Northern goshawks).

Management Guidelines

These new guidelines, approved by the joint management team of Wildlife and Forest Resources Divisions shall be used by the two divisions' field staff for woodland raptors, including Red-shouldered hawks and Northern goshawks on all state forest lands. These guidelines supersede guidelines contained in the draft 1999 "*Management Guidelines for Red-shouldered Hawks on State-owned Lands in Michigan*" and the 2012 "*Interim Guidance for Red-shouldered Hawks and Northern goshawk on State Forest Lands.*" The current guidelines were developed from multiple sources but primarily from recommendations in Szuba and Bell (1991), Naylor (2009), and Naylor et al. (2004).

Nest Site Guidelines

1. If an active red-shouldered hawk or goshawk nest is found, the following guidelines will be put into place until such time as the nest is determined to be inactive.

    a. Active RSH and NG nests will be buffered with a 5-chain radius (8 acre) protection area, centered on the nest tree, in which there will be no cutting or new roads constructed. Avoid human disturbance, including loading and skidding, in this protection area.

b. An additional zone of 5 chains (total of 10 chains centered on the active nest trees) will be established in which there is no management activity during the following activity times: Southern Lower Peninsula from February 15 to July 1; Northern Lower Peninsula from March 15 to July 15; Upper Peninsula from April 1 to July 30.
c. Within this 10 chain zone, retain at least one-third of residues per the Woody Biomass Harvesting Guidance (Michigan DNR 2010).
d. Deviation from these guidelines is contingent on compartment review agreement and/or approval from WLD Field Operations Managers and FRD District Managers (or their supervisors if agreement cannot be reached).

2. Red-shouldered and goshawk nests determined to be inactive by joint decision involving local WLD and FRD staff will be protected with a 1-chain no-harvest buffer. If the nest is found to be in disrepair or un-occupied for multiple years, it can be classified as an unsuitable nest in which case no buffer is required.

3. Record observations of active and inactive nests as an opportunistic field survey in the enterprise GIS. This will involve developing and jointly (FRD and WLD staff) populating a separate layer in MiFi specific to raptor nests. This layer will be used for determining baseline information for use in long-term nest monitoring. It will also be used to identify trends, research opportunities, and eventual feedback/evaluation for management guidelines and development of a Habitat Suitability Index for RSH and NG.

Management Area Guidelines

1. In cover types where uneven-aged management techniques are used:

    a. When possible, and considering forest health conditions, encourage large contiguous blocks (usually >300 acres) of relatively mature, northern hardwood and mixed hardwood-conifer forest cover types, with moderate (about 70%) canopy closure and nearby or interspersed wetland habitats (blocks can be comprised of multiple stands in different Years of Entry).
    b. Apply Within-Stand Retention Guidance (Michigan DNR 2012), to identify and retain mature trees for future nests, existing stick nests, snags, and coarse woody debris. Where possible, retain a minimum of one large diameter deciduous (other than beech) tree per 5 acres, and with a preference for multi-crotched trees high in the canopy.

2. In cover types where even-aged management techniques are used:
    a. Apply Within-Stand Retention Guidance (Michigan 2012), retaining patches of several large diameter deciduous trees (especially multi-crotched trees high in the canopy).

3. Maintain adequate prey base by managing for appropriate levels of coarse woody debris:

    a. Follow Within-Stand Retention Guidance (Michigan 2012) for stand diversity.

Appendix 11 (continued). Management Guidance for Woodland Raptors (Specifically Red-Shouldered Hawks and Northern Goshawk) on State Forest Lands.

Citations

Michigan Department of Natural Resources. 2012. Within-Stand Retention Guidance. IC4119. Michigan Department of Natural Resources, Lansing, MI. 39 pp.

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Naylor, B.J., J.A. Baker and K.J. Szuba, 2005. Effects of forest management practices on Red-shouldered Hawks in Ontario. The Forestry Chronicle 80: 54-60.

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Szuba, K. J., and P. Bell. 1991. Hawk guide for Ministry of Natural Resources field personnel. OMNR, Wildlife Policy Branch, Toronto.