

Fort Custer Vegetation and Natural Features Survey

2007-2008 Report



Prepared by:
Joshua G. Cohen, Ryan P. O'Connor, Barbara J. Barton, David L. Cuthrell, Phyllis J.
Higman, and Helen D. Enander

Michigan Natural Features Inventory

P.O. Box 30444

Lansing, MI 48909-7944

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EXECUTIVE SUMMARY

Since 1994, ecological studies have been undertaken at Fort Custer Training Center (FCTC) for the purposes of documenting high quality natural areas, rare, threatened and endangered plant and animal species, and to provide landscape level and selected site management recommendations. Significant management activities have been implemented over the last 15 years to enhance these natural features. The primary objective of this project was to reassess the impact of management activities on known natural features and provide recommendations for management conflicts relating to these features. In addition, findings from other ecological studies conducted at Fort Custer were reviewed, surveys for potential new natural communities and rare species were conducted, and vascular plant taxa not previously recorded during MNFI's 1995 work were collected and vouchered.

Eight occurrences of high-quality natural communities were surveyed in this study, including two dry-mesic southern forests, one mesic sand prairie, three prairie fens (including one new occurrence), one southern hardwood swamp, and one southern wet meadow. Threats and management recommendations were identified for each natural community type. The primary threats included fire suppression, shrub encroachment, and non-native plant invasion.

A total of 31 new plant species were found during the surveys bringing the total known flora for Fort Custer to 835 species. Eighteen rare plant species were located during botanical surveys (36 element occurrences), and of these, seven were newly discovered at FCTC between 2007 and 2008, 24 were updates of previously documented records. Five occurrences could not be relocated during this study. The most significant new occurrences were Virginia flax (*Linum virginianum*), a species not collected in Michigan since 1938 (Voss 1985) and field dodder (*Cuscuta campestris*), which, until collected by Tyler Bassett in 2007, was thought to be potentially extirpated in the state. New occurrences were also found for red mulberry (*Morus rubra*), goldenseal (*Hydrastis canadensis*), leadplant (*Amorpha canescens*), and upland boneset (*Eupatorium sessilifolium*). For each rare plant species found on the base, discussion is provided regarding the distribution of that species within the base, the regional conservation significance of the population, and site-specific and general management recommendations.

The objectives of the animal surveys were to target species that had previously been omitted from survey efforts and to survey additional areas that may contain

rare animal species. Surveys were conducted for several rare lepidopteran species, leafhoppers, and spittlebugs. No state or federally listed species were observed during this effort, however; four species of *Papaipema* moth species were collected during blacklighting. Additionally, a mating pair of pepper and salt skippers (*Amblyscirtes hegon*) was discovered, resulting in a new record for Kalamazoo County. It is recommended that further moth surveys be conducted as suitable habitat is present and the target species are often difficult to detect due to natural population fluctuations.

The report concludes with a discussion of general management issues at Fort Custer, focusing on invasive species management, the prescribed fire program, managing for fire-sensitive species, and the need for implementation of monitoring to facilitate adaptive management. Invasive species control methods currently employed by FCTC include prescribed fire, mechanical removal, herbicide treatment, and biocontrol. We recommend that logging in the immediate vicinity of high-quality natural areas be avoided, and that logging in other parts of the Fort take place during the winter months when soils are frozen. This will minimize soil disturbance, which facilitates the expansion of some invasive plant species. A particular invasive species to focus control efforts on is narrow-leaved cat-tail. This invasive plant has established in Fort Custer within prairie fen habitat and can expand following prescribed fire. It should be immediately controlled through herbicide application.

Numerous recommendations are provided to enhance the use of prescribed fire as a restoration tool. We recommend varying the seasonality of prescribed burning to match the full range of historical variability. Diversifying the timing of fires would increase the success of woody species control in fire-dependent systems such as oak barrens. We encourage the use of seepage areas, vernal pools, and pockets of mesic southern forest and swamp hardwoods as natural firebreaks, however, we discourage the extension of fire lines into or across these sites since they serve as refugia for fire sensitive species. Strategies for minimizing risks to fire-sensitive species (i.e., eastern box turtle) are provided.

We recommend that a monitoring program be implemented at FCTC, concentrated within the high-quality areas, but also throughout the actively managed areas. Monitoring is critical to assess whether prescribed fire is adequately reducing invasive species populations, limiting woody encroachment in open communities such as prairies,

barrens, and prairie fens and in understories of fire-prone forests and woodlands, and fostering regeneration of oak saplings and prairie species in fire-dependent ecosystems.

Finally, assessing the impacts of fire on herptile populations (i.e. eastern box turtle) should be a critical component of the monitoring program.

INTRODUCTION

Fort Custer Training Center (FCTC) is a federally owned military reservation encompassing 7,570 acres and is operated by the Michigan Army National Guard (MIARNG) and the Department of Military and Veterans Affairs (DMVA). Baseline ecological surveys of FCTC were conducted from 1994-1995 (Legge et. al 1995) and resulted in the identification of seven high-quality natural community occurrences, multiple occurrences of nine rare animal species, and 815 vascular plant taxa including multiple occurrences of 16 rare species. Landscape-level and site-specific management recommendations were provided along with information and management profiles for significant natural features discovered during the survey. There has been significant ecological work and management activities since the baseline surveys were conducted, and the specific objectives of this project were to: 1) review findings from the 2004-2005 surveys, 2) review the pertinent ecological work and findings of other parties since 2005, 3) reassess known natural communities and rare plant and animal occurrences, 4) identify potential new targets and conduct surveys, 5) document vascular plant taxa to compare with the baseline species list, and 6) identify specific management conflicts relating to natural features and provide recommendations for resolution.

This report has been organized according to the three main components of the inventory: natural communities, floristic composition with an emphasis on rare plants, and rare animal populations. Rare species and exemplary natural community occurrences are described and specific management recommendations for each are presented within their corresponding sections. A separate section for management recommendations is also provided which integrates site and species-specific recommendations into broad land management concerns. Maps and photographs showing specific sites at FCTC are included in the Natural Community section. Global and state ranking criteria, and plant species lists are provided in the appendices.

Study Area

Fort Custer Training Center is located in the southwest portion of lower Michigan between the cities of Battle Creek and Kalamazoo. Approximately two-thirds of its land area lies in Kalamazoo County, and the remainder

lies to the east in Calhoun County (Figure 1). Fort Custer is important ecologically because it is one of the largest continuous blocks of public land in southwest Lower Michigan, consisting of approximately 7,570 acres of land leased by DMVA from the federal government. The vegetation of Fort Custer circa 1800 is presented in Figure 2 and the major glacial landforms of the base are displayed in Figure 3. For a detailed discussion of the historical and landscape context of the base refer to Legge et al. (1995).

Summary of Previous Investigations

Prairie Vole Monitoring

Prairie voles (*Microtus ochrogaster*) are listed as state endangered in Michigan and were first recorded from FCTC in 1994 (Legge et al. 1995). The population occupied a degraded field that had apparently been heavily used for military training activities up until that year. Previous monitoring also sought to determine the impact of disturbance caused by military vehicles on the prairie vole population. Results were not definitive but provided some evidence that vehicular impacts were not beneficial to the prairie vole (Cooper 2000).

Monitoring studies of prairie vole populations were conducted from 1995 to 1999 and 2002 to 2007 (Cooper 1998, 2000, Legge 2002-2007). During the earlier studies (Cooper 1998, 2000), prairie vole populations went through a natural cycle over the course of the monitoring, declining from 1994 to 1996, then rebounding in 1997 and stabilizing through 1999. The meadow vole population (*M. pennsylvanica*) also declined from 1994 to 1996 but rebounded to extreme abundance in 1997 before once again declining from 1997 to 1999. In the initial years of the study, population levels of prairie voles were lower than meadow vole numbers but appeared to fluctuate in tandem. During the 2002 to 2004 period, prairie vole numbers steadily increased, however; in 2005 population levels dropped dramatically. In 2006, all species of small mammals rebounded and the prairie vole populations peaked at the highest levels since the monitoring efforts began (Legge 2006), but declined slightly in 2007 (Legge 2007).

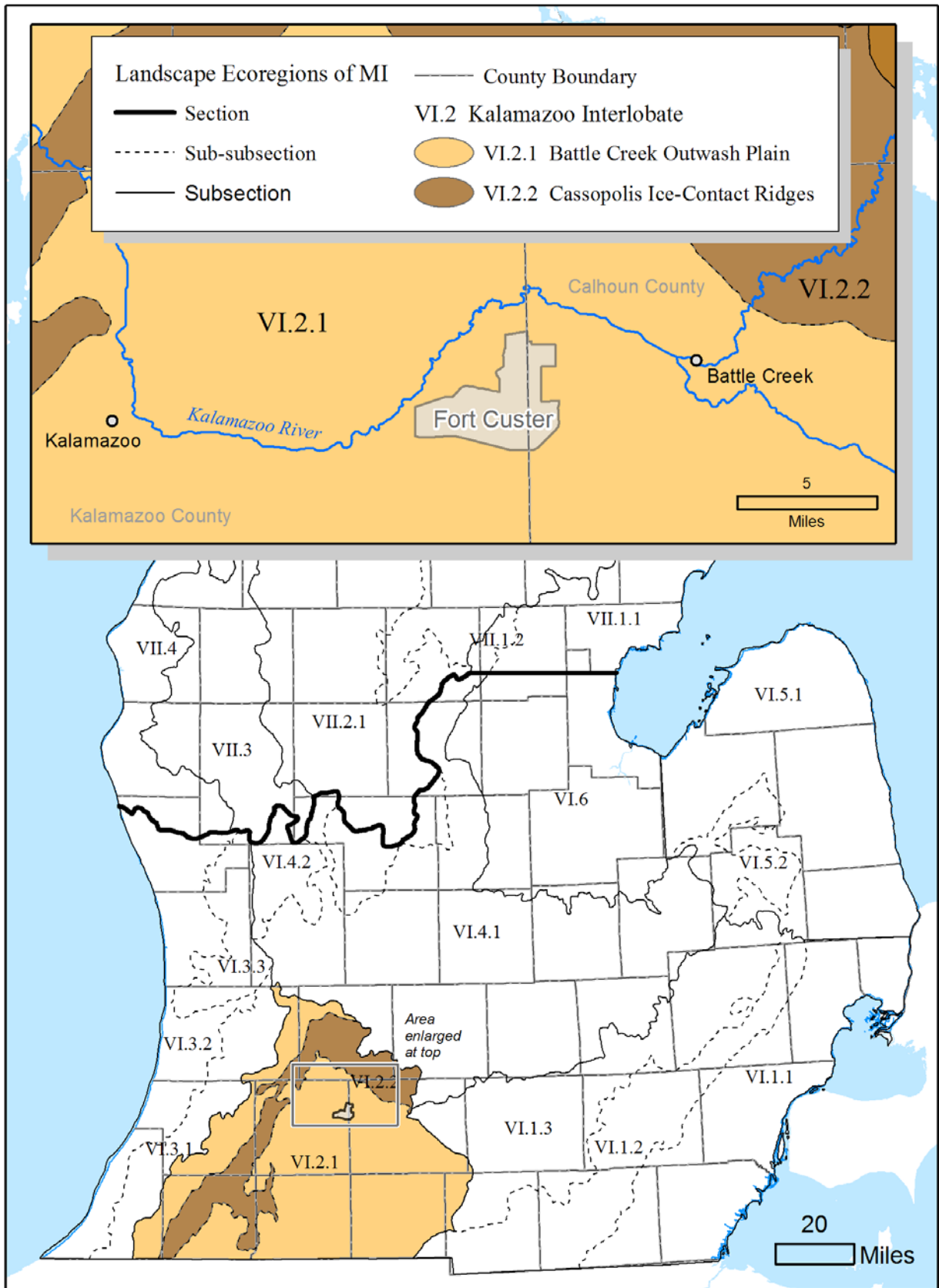


Figure 1. Ecoregions of Southern Lower Michigan (Albert 1995). Fort Custer Training Center occurs within Sub-subsection VI.2.1 (Battle Creek Outwash Plain) of the Kalamazoo Interlobate Subsection (VI.2).

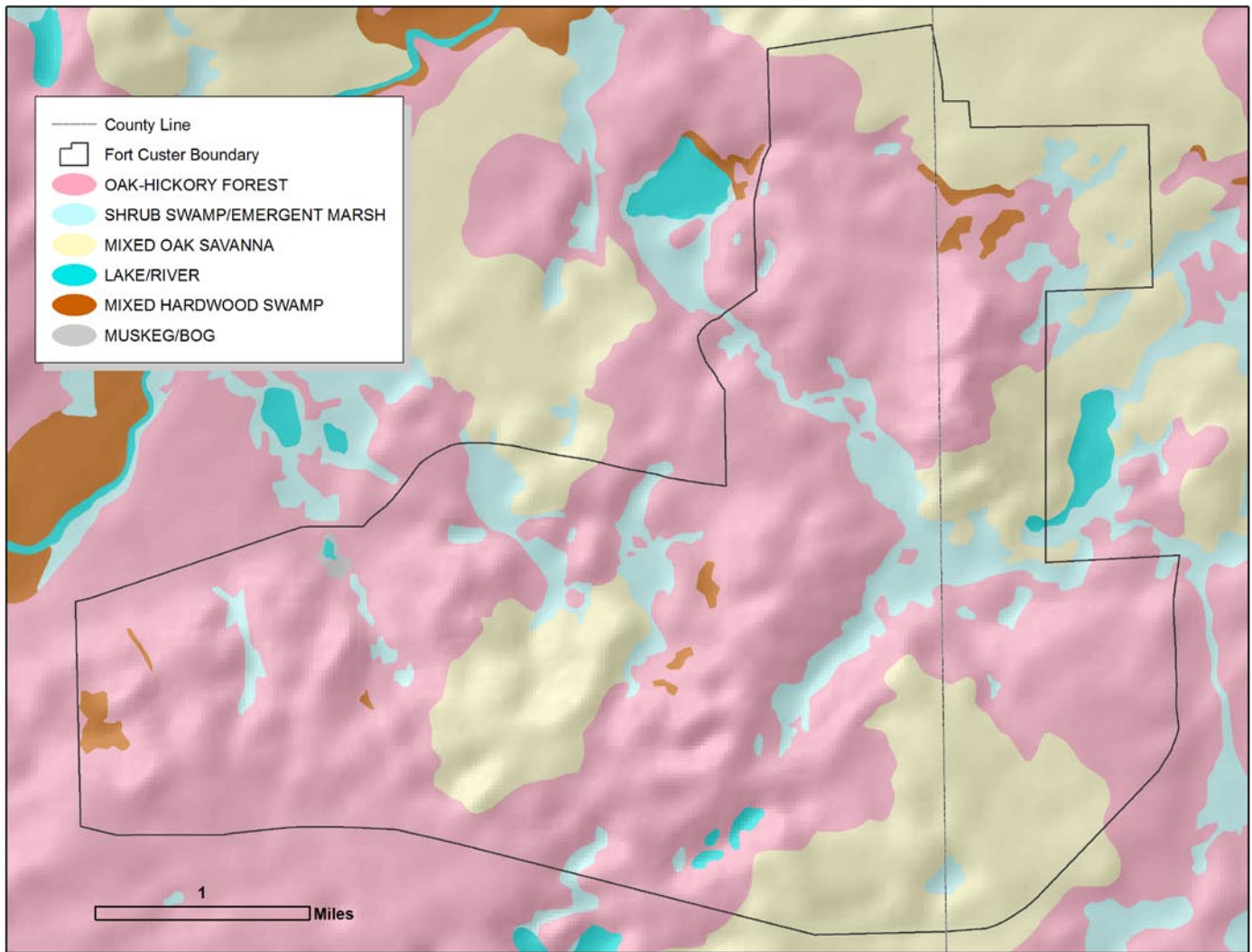


Figure 2. Vegetation circa 1800 of the Fort Custer Training Center and surrounding area (Comer et al. 1995).

Bat Studies

Surveys were conducted for the federally listed Indiana bat (*Myotis sodalis*) in 2005 and none were recorded during these efforts (Kurta and Foster 2005). The state special concern species eastern pipistrelle (*Pipistrellus subflavus*), netted during the 2005 project, was the first to be found in Michigan during the summer maternity season and also the first inland record, as all other records at that time were from the Lower Peninsula near Lake Michigan. The total number of bats (all recorded species) declined substantially at FCTC since the previous bat survey in 1993 (Kurta and Foster 2005). Concern was expressed in the noticeable long-term decline of red bats (*Lasiurus borealis*) in southern Lower Michigan that was not unique to FCTC. Further surveys were recommended for eastern pipistrelles in 2006 and both Indiana and red bats in 2010.

Raptor Inventory

A thorough survey with special emphasis on threatened and endangered species was conducted over a period of four

and a half months in 2005 (Roloff 2005). Twenty species were identified as potentially occurring at FCTC and 11 were documented using various habitats within the Training Center. Two state threatened species of raptors, merlin (*Falco columbarius*) and osprey (*Pandion haliaetus*), were reported utilizing habitat but not nesting. Only three active raptor nests were located during the surveys; two red-tailed hawks (*Buteo jamaicensis*) and one turkey vulture (*Cathartes aura*). Roloff (2005) did not make any specific recommendations due to the lack of threatened or endangered nesting raptors at FCTC.

Herp Surveys

In 2004, 29 species of reptiles and amphibians were recorded throughout the base (Tobin 2005), many new since the 1995 study (Legge et al. 1995). Efforts to locate eastern massasauga rattlesnakes at FCTC were unsuccessful. Additional rare species located during this study were two special concern species, Blanding's turtle (*Emys blandingii*) and Blanchard's cricket frog (*Acris crepitans blanchardi*).

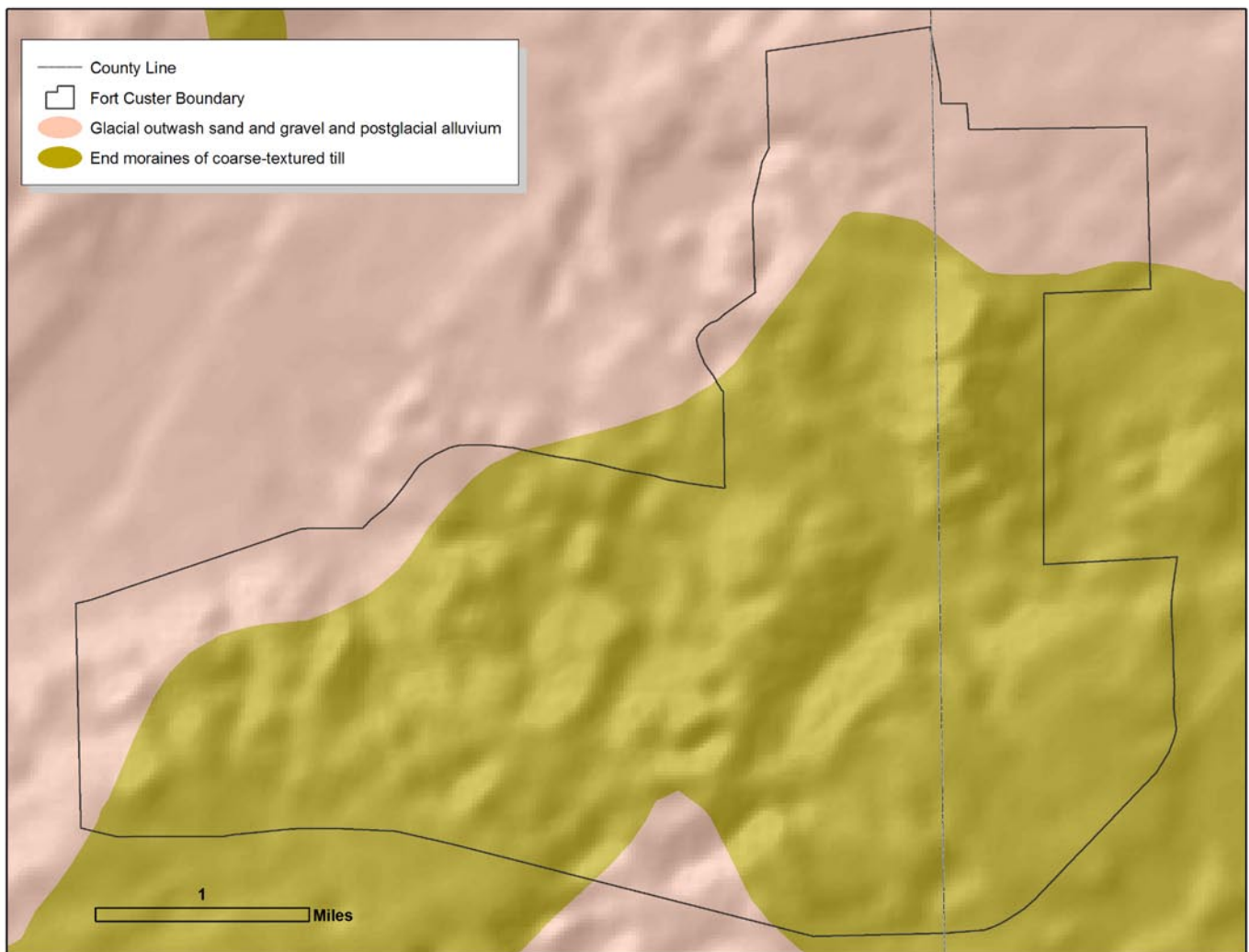


Figure 3. Glacial landforms of the Fort Custer Training Center (Farrand and Bell 1982).

The highlight of this survey was finding 247 state special concern eastern box turtles (*Terrapene carolina*) on the base. Radio telemetry studies began in 2006 by The Center for Reptile and Amphibian Conservation and Management of Purdue University to examine patterns of movement and habitat use by the eastern box turtles, focusing on two areas of FCTC (Training Areas 3 and 7) (Gibson 2007). Researchers found that females made long-distance, directed movements in the spring towards large open-canopy areas. In contrast, no males were observed making similar movements early in the season, but did during fall migration. General life history information, such as home range sizes, mating and nesting periods, habitat use, and migration timing was also collected during this study. Management recommendations for eastern box turtle were provided.

Karner Blue Butterfly Surveys

In 2007, lupine patches in Impact Area 9 and potential nectaring species were mapped and surveys for Karner

blue butterfly (*Lycaeides melissa samuelis*) were conducted during the end of the 1st flight period (Bassett 2007). No Karner blue butterflies were observed during the survey. In 2008, additional lupine patches were located in Impact Area 9 and elsewhere (T. Bassett, personal communication 2008). Surveys were conducted during known first and second flight periods (based on sightings elsewhere in the state) and Bassett documented nectaring species but did not observe the butterfly.

Botanical Surveys

Botanical surveys were conducted from 2007 to 2008 and resulted in the discovery of 17 species new to FCTC (Bassett 2007, T. Bassett personal communication 2008). Annual monitoring of yellow fumewort (*Corydalis flavula*) (per MNFI recommendations), took place from 2007 to 2008. Monitoring involved frequency monitoring in the permanent plot along Harmonia Rd, demographic monitoring in the permanent sub-plots nested within the plot along Harmonia Rd., and Fort-wide qualitative

monitoring of sub-populations and rough estimates of population sizes. In 2007, Bassett mapped each known sub-population and sampled additional transects in areas adjacent to the permanent plot. The effort documented a significant additional population size and, when combined with the permanent plot population, showed that the sub-population is the most significant at FCTC. Bassett (2007) also searched for known and additional populations of 20 listed plant species at FCTC, documented size and numbers in populations and sub-populations, and mapped many of the occurrences. He documented new occurrences of upland boneset (*Eupatorium sessilifolium*, not documented at FCTC since the 1940s) and field dodder (*Cuscuta campestris*).

During 2007 and 2008, seeds were collected from FCTC (and adjacent Fort Custer Recreation Area) to be used in restoring degraded sites and *de novo* restorations. Seed collecting efforts focused primarily on prairie species in 2007 and woodland species in 2008. Approximately 75

species were collected each year (with some overlap) for a total of almost 140 species over the course of two years of collection. The 2007 seeds were raised in plug flats by the USDA-NRCS Plant Materials Center and planted in fields. A small portion of the 2008 seeds will be raised by USDA-NRCS PMC; the rest will be sown in seed plots at FCTC.

Resource Management Plans

Several documents have been written to advise resource management at FCTC, including Michigan Department of Military and Veteran Affairs (2000), Gross and Suding (2002), Gross et al. (2002), and DLZ (2005). Recommendations included prescribed burning, establishing boundaries, control of invasive species, managing woody plant encroachment, protecting threatened and endangered species, and monitoring the effects of management activities (DLZ 2005). Please see references for detailed discussion.

2008 MICHIGAN NATURAL FEATURES INVENTORY SURVEYS NATURAL COMMUNITY SURVEYS

Introduction

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. 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). Prior to this current project, seven high-quality natural communities have been documented within the FCTC (Legge et al. 1995). During the summer of 2008, MNFI scientists conducted surveys of these high-quality natural communities. Surveys assessed the current ranking and classification of these occurrences and detailed the vegetative structure and composition, landscape and abiotic context, threats, ecological boundaries, management needs, and restoration opportunities. The primary goal of this survey effort was to evaluate how restoration practices have impacted the ecological integrity of these natural community occurrences. In addition, these surveys facilitate the assessment of recent management

recommendations proposed for these areas (DLZ 2005). In addition to revisiting the known natural community element occurrences, MNFI ecologists surveyed for new natural community element occurrences. These surveys were focused within the Impact Area, which was not systematically surveyed during the prior survey effort (Legge et al. 1995). These *de novo* natural community surveys assessed the current ecological condition of high-quality areas and detailed the vegetative structure and composition, landscape and abiotic context, threats, management needs, and restoration opportunities. This section of the report summarizes the findings of MNFI's ecological surveys of high-quality natural communities, discusses threats to their ecological integrity, evaluates restoration activities, and provides site-specific management recommendations aimed at protecting biodiversity and abating threats.

Methods

When applying Natural Heritage and MNFI methodologies, three factors are considered when assessing a natural community's ecological integrity or quality; size, landscape context, and condition (Faber-Langendoen et al. 2008). If

a site meets defined requirements (MNFI 1988) for these three criteria it is categorized as a high-quality example of a specific natural community type, entered into MNFI's statewide biodiversity conservation database (MNFI 2009) as an element occurrence, and given a ranking based on the consideration of its size, landscape context, and condition. Growing season surveys were conducted to assess the condition and classification of the sites, while a combination of ground surveys, aerial photographic interpretation, and Geographic Information System (GIS) analysis were employed to determine the size and the landscape context of the sites. Ecological surveys were conducted from 18 June 2008 through 02 September 2008 and each site was visited at least twice. Typically, a minimum of a half day was spent for each site visit. For each site visited, an Ecological Community Field Survey Form was completed. Surveys involved:

- a) compiling comprehensive plant species lists
- 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 anthropogenic disturbances
- f) evaluating potential threats
- g) ground-truthing aerial photographic interpretation and natural community boundary delineation using hand-held GPS units (Global Positioning Systems) (both Garmin and HP iPAQ units were utilized)
- h) taking digital photos and GPS points
- i) surveying adjacent lands to assess landscape context
- j) assessing or assigning a natural community classification
- k) assigning or re-assigning element occurrence ranks
- l) 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 generate or update element occurrence records in MNFI's statewide biodiversity conservation database (MNFI 2009). When necessary, natural community boundaries were re-mapped. Information from the 2008 field surveys and from surveys conducted prior to this project was used to produce site descriptions, threat assessments, and conservation and

management recommendations for each documented high-quality natural community occurrence, which appear within the following Ecological Survey Results and Site Discussion section.

Results and Discussion

Eight occurrences of high-quality natural communities were surveyed including two dry-mesic southern forests, one mesic sand prairie, three prairie fens (including one new occurrence), one southern hardwood swamp, and one southern wet meadow (Figure 4). Information gathered from this survey effort will help Fort Custer's resource managers prioritize restoration management and monitoring needs. The following site summaries contain a detailed discussion for each of these eight natural communities organized alphabetically by community type and then by element occurrence. At the beginning of each grouping of communities there is an overview of the natural community type, which was adapted from MNFI's natural community classification (Kost et al. 2007). For each site summary, the following information is provided:

- a) site name
- b) natural community type
- c) global and state rank (see Appendix 1 for ranking criteria)
- d) current element occurrence rank
- e) size
- f) locational information
- g) digital photographs
- h) detailed site description
- i) threat assessment
- j) management recommendations
- k) discussion of the regional and statewide conservation context

SITE SUMMARIES

Dry-Mesic Southern Forest

Overview: Dry-mesic southern forest is a fire-dependent, oak or oak-hickory forest type on generally dry-mesic sites found south of the climatic tension zone in southern Lower Michigan. Frequent fires maintain semi-open conditions, promoting oak regeneration and ground and shrub layer diversity. This natural community occurs principally on glacial outwash, coarse-textured moraines, sandy glacial

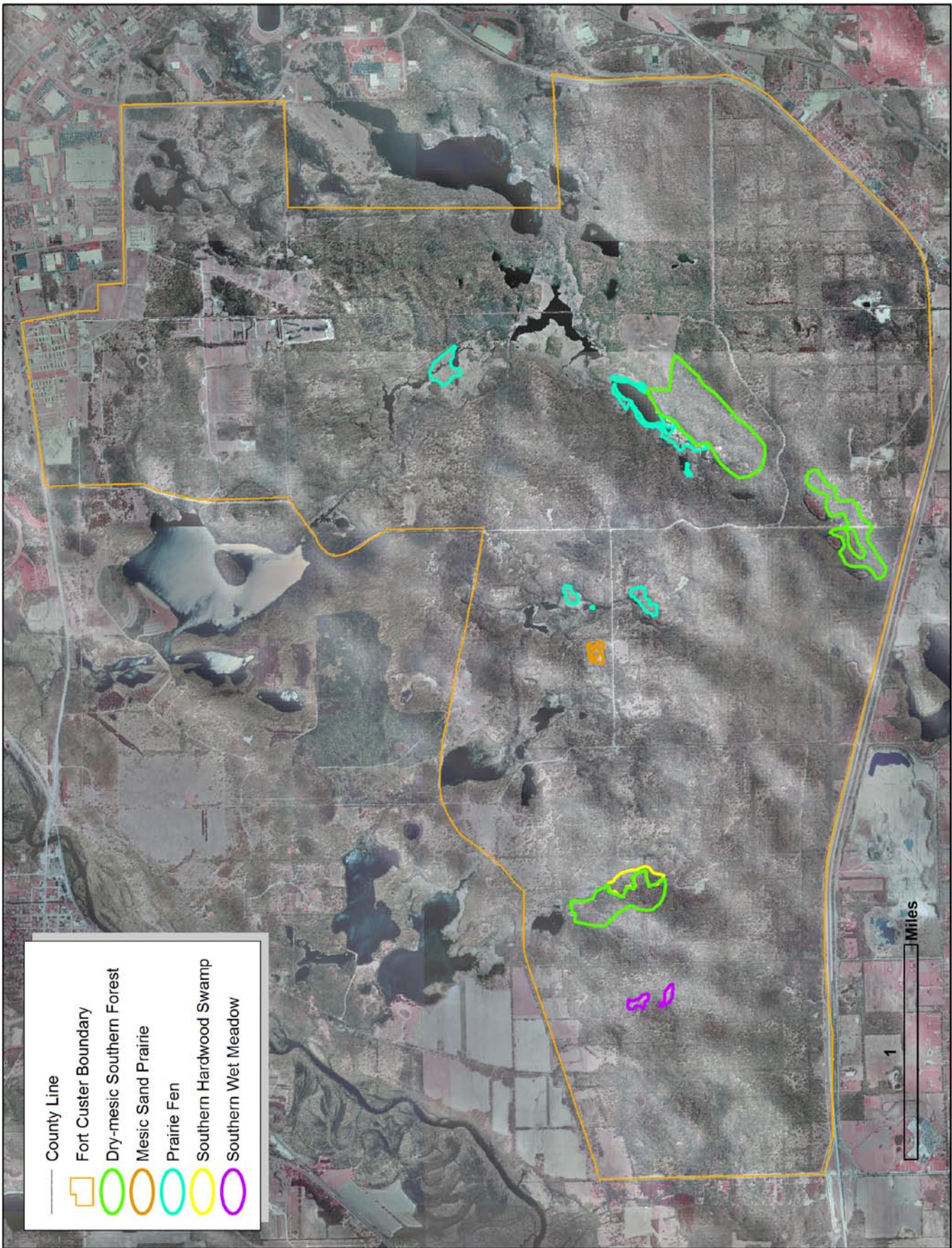


Figure 4. Natural community element occurrences reconfirmed or documented in 2008 in the Fort Custer Training Center.

lakeplains, kettle-kame topography, and sand dunes. Soils are typically sandy loam or loam and slightly acid to neutral in pH (Kost et al. 2007).

1. Cemetery Complex Ridge

Natural Community Type: Dry-mesic southern forest

Rank: G4 S3, apparently secure globally and vulnerable within the state

Element Occurrence Rank: BC

Size: 13 ha (33 ac)

Location: Area 4, T02S R09W Section 15

Site Description: The Cemetery Complex Ridge is an uneven-aged, second-growth oak forest that occurs on moderate to steep slopes of end moraine with fine-textured sandy loam to loamy sands. This forest is adjacent to high-quality southern hardwood swamp (Cemetery Complex Seeps) and contains inclusions of mesic southern forest (Figure 5). Diameters of canopy oak range from 50 to 90 cm and canopy dominants range widely in age with many of the larger trees being over 130 years old. The forest is characterized by large-diameter canopy oaks and moderate volumes of coarse woody debris resulting from windthrows. Occasional canopy oak snags occur throughout the forest. Surface fires were historically an important part of the natural disturbance regime of dry-mesic southern forest and Fort Custer's resource managers have recently re-introduced fire as a critical process influencing species structure and composition (Photo 1). The soils are characterized by shallow, slightly acidic organics (4 to 6 cm deep, pH 6.0) overlying acidic sandy loam, loamy sand, and sands (pH 5.5-6.0). Numerous pebbles and stones of variable size occur on the soil surface and throughout the soil profile. Soils are variable with slope position. At lower slope positions, the soils are finer-textured and loamier and many of these microsites support pockets of mesic southern forest. Areas of seepage at the base of slopes support high-quality southern hardwood swamp (Cemetery Complex Seeps).

The closed canopy (85-95%) is dominated by large-diameter mid-tolerant trees including red oak (*Quercus rubra*), white oak (*Q. alba*), basswood (*Tilia americana*), white ash (*Fraxinus americana*), and tulip tree (*Lireodendron tulipifera*). Pockets of mesic southern forest are dominated by sugar maple (*Acer saccharum*) and tulip tree. Hickories, pignut hickory (*Carya glabra*) and shagbark hickory (*C. ovata*), are common in the subcanopy. The understory ranges from absent to sparse in areas that recently burned to dense in areas that have yet to burn. Prescribed fire has reduced understory stem densities



Photo 1. Fort Custer's resource managers have recently re-introduced fire as a critical process influencing species structure and composition within the Cemetery Complex Ridge dry-mesic southern forest (Photo by Joshua G. Cohen).

and likely contributed to the reduction of invasive shrubs within this forest. Many of the burnt understory species are sprouting from the stump. Characteristic understory species include spicebush (*Lindera benzoin*), flowering dogwood (*Cornus florida*), ironwood (*Ostrya virginiana*), and white ash saplings. Patches of multiflora rose (*Rosa multiflora*) occur in areas that did not burn. The low shrub layer in burnt areas is dominated by stump-sprouting understory species, especially spicebush, white ash, and flowering dogwood. In areas that did not burn, prevalent low shrubs include blackberries (*Rubus* spp.) and gooseberries (*Ribes* spp.). Ground cover is diverse and dense in areas that did not burn. Dominant ground cover plants include May apple (*Podophyllum peltatum*) and sweet cicely (*Osmorhiza claytonii*). Characteristic species of the ground cover include Virginia creeper (*Parthenocissus quinquefolia*), poison ivy (*Toxicodendron radicans*), common trillium (*Trillium grandiflorum*), enchanter's nightshade (*Circaea lutetiana*), yellow violet (*Viola pubescens*), and jumpseed (*Polygonum virginianum*). Local dominants in more mesic pockets include wild ginger (*Asarum canadense*) and wood nettle (*Laportea canadensis*). Goldenseal

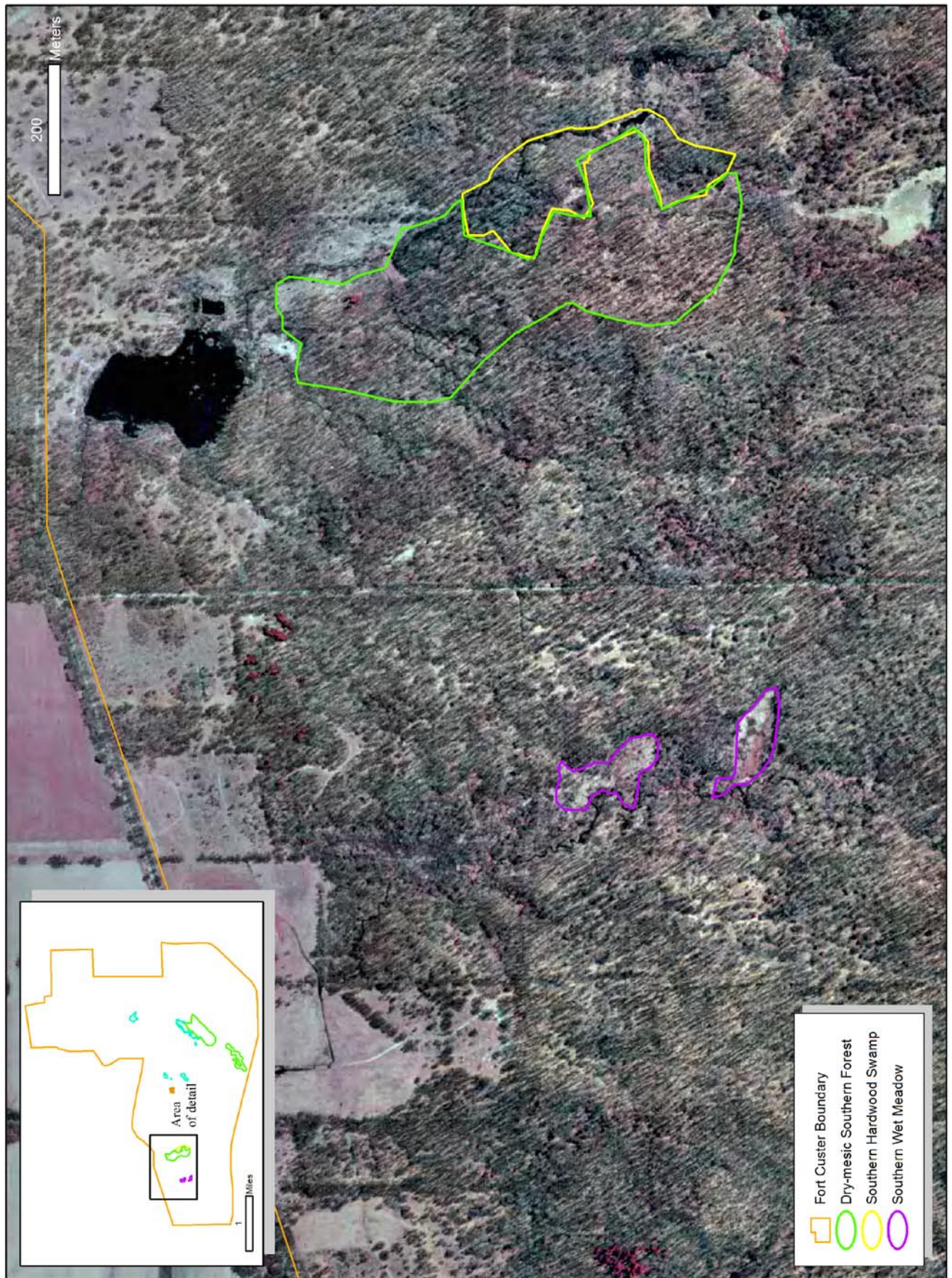


Figure 5. The 42nd Road Seep (southern wet meadow) occurs to the west of the Cemetery Complex Ridge (dry-mesic southern forest), and Cemetery Complex Seeps (southern hardwood swamp).

(*Hydrastis canadensis*, state threatened) and ginseng (*Panax quinquefolius*, state threatened) are common in mesic areas near the headwater streams and small patches of showy orchis (*Galearis spectabilis*, state threatened) were also noted on mesic slopes. The northeastern portion of this occurrence along the stream resembles floodplain forest in terms of species composition and soils. The soils are heterogeneous with sandy loams, sands, and loamy sands, suggesting occasional over-the-bank flooding, likely due to breaking of beaver dams up stream. The canopy is dominated by hackberry (*Celtis occidentalis*) with paw paw (*Asimina triloba*) in the subcanopy and understory and wood nettle dominating the ground cover. Eighty-eight native, vascular plant species were noted within this forest during the 2008 surveys.

The element occurrence polygon of this dry-mesic southern forest was re-mapped to better reflect the current ecological boundaries of this community using recent aerial photographic imagery and GPS and GIS technology.

Threats: The primary threat to this dry-mesic southern forest is posed by invasive species, especially multiflora rose, which is locally common. Patches of Japanese barberry (*Berberis thunbergii*), privet (*Ligustrum vulgare*), and garlic mustard (*Alliaria petiolaris*) occur within this high-quality forest but are prevalent to dominant along with multiflora rose in the surrounding early-successional forest. Glossy buckthorn (*Rhamnus frangula*) was found in trace amounts within this forest and this invasive shrub and common buckthorn (*Rhamnus cathartica*) are less frequent in the adjacent uplands. Non-native earthworms were noted and may be altering the soil and nutrient regimes.

Management Recommendations: The main management recommendations are to continue the use of prescribed surface fire and allow natural processes (i.e., windthrow, flooding, and fire) to operate unhindered (no salvage logging and allow lightning strike fires to burn). Resource managers should continue to use prescribed fire to maintain open understory conditions and reduce invasive species and over the long term, promote oak regeneration. Prescribed fire should be employed in areas of the element occurrence that did not burn in 2008. In addition, the seasonality of burns should be varied to include growing season and fall burns as well as spring burns. Efforts should be continued to reduce invasive species within this site and in the surrounding areas through the use of prescribed fire and where necessary, spot treatment of species like garlic mustard and glossy buckthorn. Reducing invasive species in the surrounding landscape and allowing surrounding early-successional forest to mature will reduce the seed source of invasive species adjacent to this high-quality area. Once invasive species have been controlled within the site, the frequency of burning should be carefully evaluated

and could be reduced to once every 5 to 10 years. Foot traffic should be minimized and vehicular traffic should be excluded from this forest. Permanent monitoring plots should be established to allow for assessment of whether management is reducing invasive species populations and fostering oak regeneration. If oak is not regenerating after ten years, resource managers should evaluate whether additional steps need to be taken such as, planting of acorns or oak saplings, reduction of deer densities, and/or creation of canopy gaps. Monitoring deer densities and deer herbivory will allow for the assessment of whether deer herbivory threatens floristic structure and composition. Little is known about the impacts of prescribed fire on non-native earthworms. The impacts of earthworms on soil properties and the impacts of prescribed fire on earthworm populations should both be monitored.

Discussion: The BC-ranked Cemetery Complex Ridge is one of forty-seven documented dry-mesic southern forests in Michigan. Within the state there are thirty-six dry-mesic southern forest element occurrences that are ranked BC or higher. This dry-mesic southern forest falls within Sub-Subsection VI.2.1 of the regional landscape ecosystems of Michigan hierarchical landscape classification (Albert 1995) (Figure 1). There are 16 dry-mesic southern forests within the Kalamazoo Interlobate (VI.2) and eight within the Battle Creek Outwash Plain (VI.2.1).

2. Whitman Lake Woods

Natural Community Type: Dry-mesic southern forest

Rank: G4 S3, apparently secure globally and vulnerable within the state

Element Occurrence Rank: B

Size: 46 ha (114 ac)

Location: Impact Area, Area 5, and Area 6, T02S R09W Sections 13, 23, and 24

Site Description: The Whitman Lake Woods include two large blocks of uneven-aged, second-growth oak forest on moderate slopes of ice-contact topography with variable aspect and sandy loam to loamy sand soils. The northern polygon occurs just east of Whitman Lake and the associated high-quality prairie fen (Whitman Lake Fen) (Figure 6) and the southern polygon occurs adjacent to kettle depressions that support bog and inundated shrub swamp at the south end of Longman Road (Figure 7). Diameters of canopy oak range from 50 to 100 cm and canopy dominants range widely in age with many of the larger trees being over 120 years old. The forest is characterized by large-diameter canopy oaks and moderate volumes of coarse woody debris resulting from windthrow.

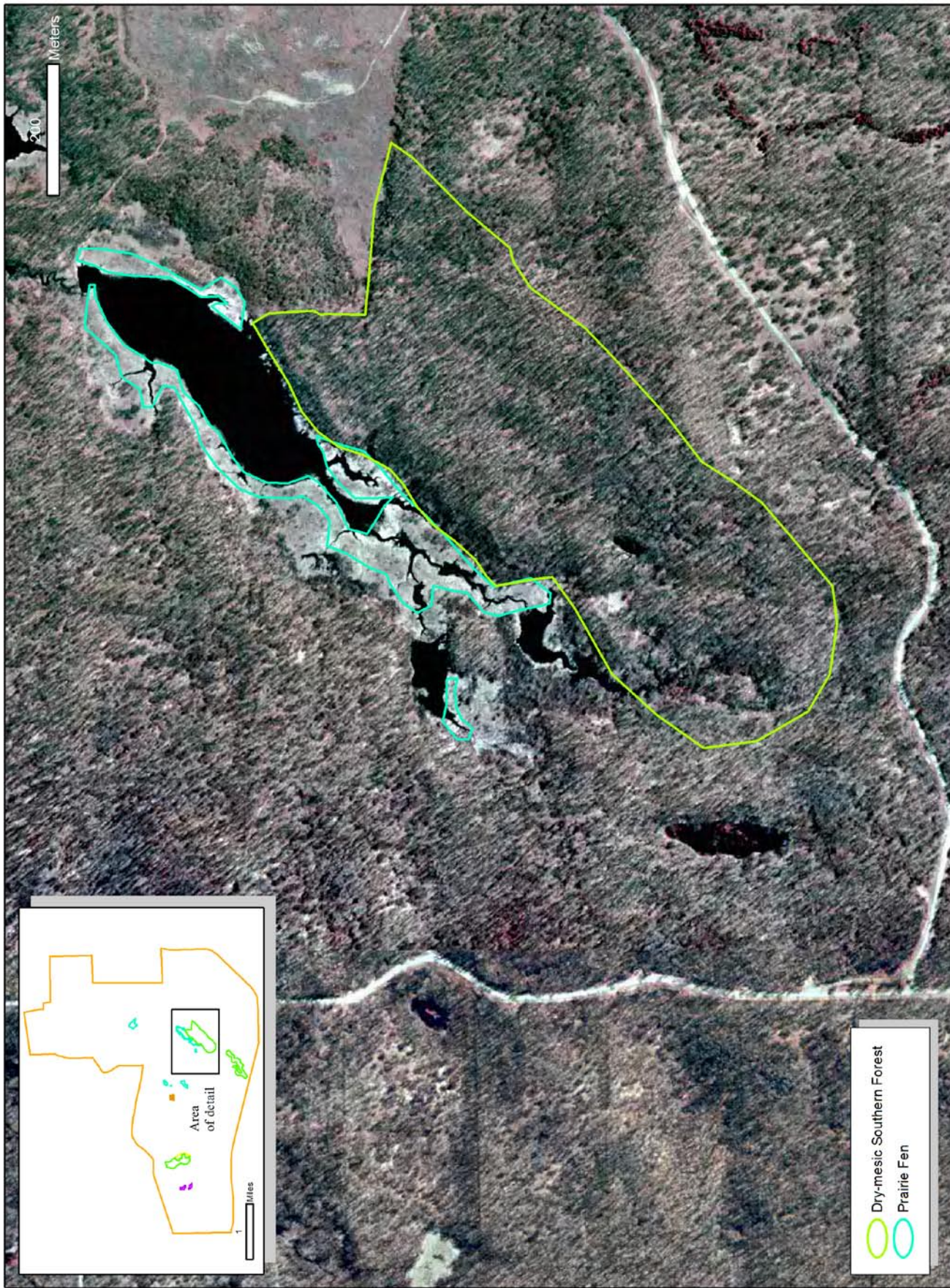


Figure 6. The northern portion of the Whitman Lake Woods (dry-mesic southern forest) and Whitman Lake Fen (prairie fen).

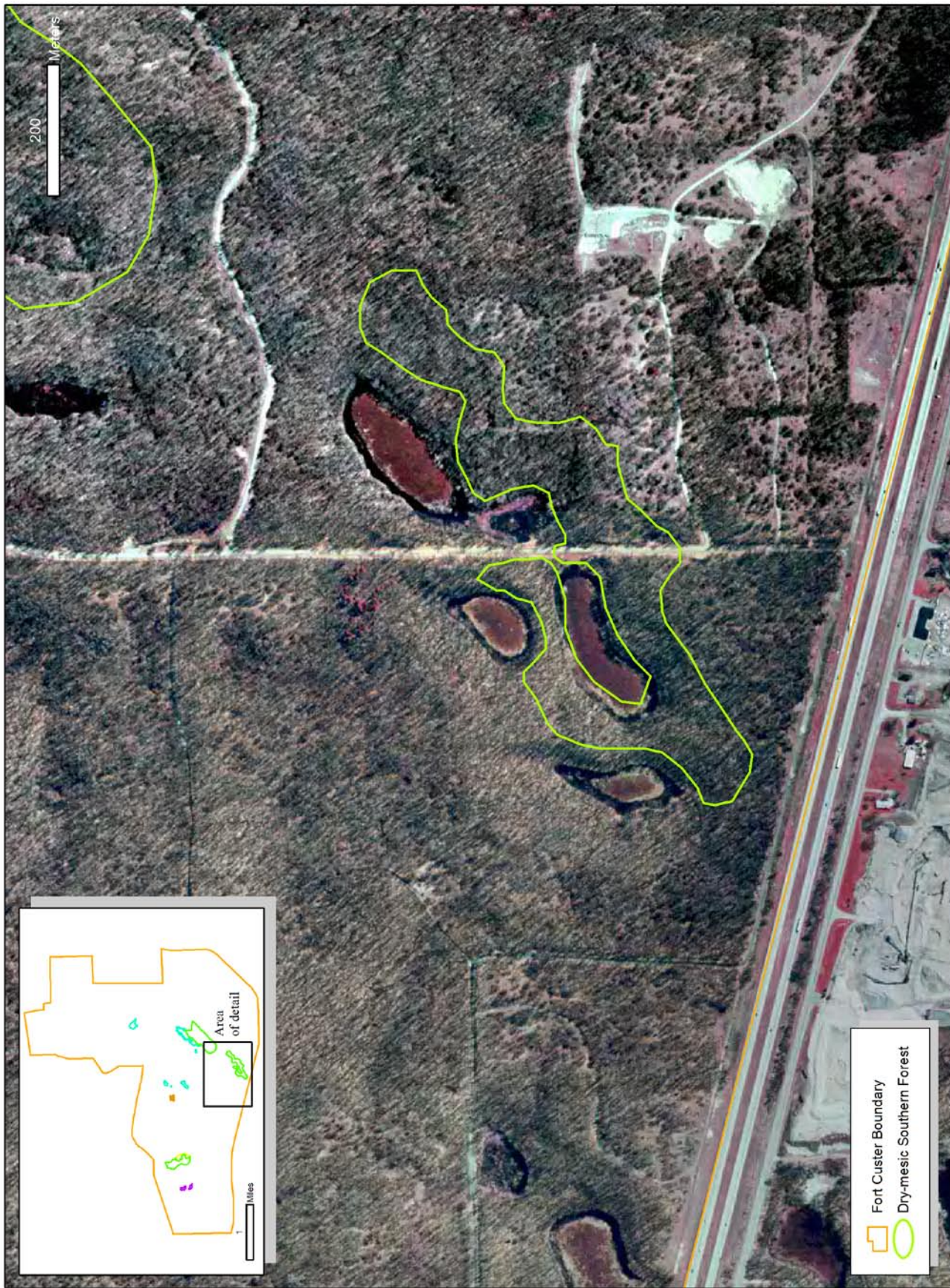


Figure 7. The southern portion of the Whitman Lake Woods (dry-mesic southern forest) occurs adjacent to kettle depressions that support bog and inundated shrub swamp.



Photo 2. Recent prescribed fires have resulted in the overall reduction in density of understory stems within the Whitman Lake Woods dry-mesic southern forest (Photo by Joshua G. Cohen).

Occasional canopy oak snags occur throughout the forest. Surface fires were historically an important part of the natural disturbance regime of dry-mesic southern forest and Fort Custer's resource managers have recently re-introduced fire as a critical process influencing species structure and composition. Recent prescribed fires have resulted in the overall reduction in density of understory stems (Photo 2). In addition, understory trees along the slopes above Whitman Lake have been girdled and killed by beaver. Numerous vernal pools occur throughout the northern polygon and are underlain by clay pan. The soils throughout the dry-mesic southern forest are characterized by shallow, slightly acidic organics (1 to 2 cm deep) overlying acidic sandy loam and loamy sands that are fine-textured and slightly acidic (pH 6.0-6.5) with deeper soils being finer-textured and retaining moisture. Pockets of mesic southern forest occur within the site and are characterized by clay loam soils.

The closed canopy (80-95%) is dominated by large-diameter red oak (*Quercus rubra*). Canopy associates include white oak (*Q. alba*) and black oak (*Q. velutina*). Hickories are also prevalent in the canopy and include pignut hickory (*Carya glabra*) and shagbark hickory (*C. ovata*). In addition to hickories, subcanopy associates include red maple (*Acer rubrum*), basswood (*Tilia americana*), sassafras (*Sassafras albidum*), black cherry (*Prunus serotina*), and ironwood (*Ostrya virginiana*). The understory is sparse to absent. Prescribed fire has reduced understory stem densities and likely contributed to the reduction of invasive shrubs within this forest. Many of the burnt understory species are sprouting from the stump. Characteristic understory species include spicebush (*Lindera benzoin*), which was much more prevalent prior to the fire, red maple, sassafras, black cherry, and flowering

dogwood (*Cornus florida*). The low shrub layer is patchy with many of the understory species prevalent as post-fire stump sprouters. True low shrubs include blackberries (*Rubus* spp.) and huckleberry (*Gaylussacia baccata*). The ground cover is diverse and dense to patchy with clustered-leaved tick trefoil (*Desmodium glutinosum*), May apple (*Podophyllum peltatum*), sweet cicely (*Osmorhiza claytonii*), Virginia creeper (*Parthenocissus quinquefolia*), bedstraw species (*Galium* spp.), enchanter's nightshade (*Circaea lutetiana*), lopseed (*Phryma leptostachya*), long-awned wood grass (*Brachyelytrum erectum*), and jumpseed (*Polygonum virginianum*). Scattered throughout the southern polygon of the Whitman Lake Woods dry-mesic southern forest is a population of the state threatened beaked agrimony (*Agrimonia rostellata*). The areas in the southern polygon adjacent to the bogs and in the northern polygon on the mild slopes of Whitman Lake (Photo 3) are characterized by more open canopy conditions and a wealth of species associated with oak openings including bush clovers (*Lespedeza* spp.), fox gloves (*Digitalis* spp.), and Pennsylvania sedge (*Carex pennsylvanica*). Eighty-seven native, vascular plant species were noted within this dry-mesic southern forest during the 2008 surveys.

The northern polygon of this dry-mesic southern forest element occurrence was re-mapped to better reflect the current ecological boundaries of this community using recent aerial photographic imagery and GPS and GIS technology.

Threats: The primary threat to this dry-mesic southern forest is posed by invasive species, especially multiflora rose (*Rosa multiflora*), Japanese barberry (*Berberis thunbergii*), and garlic mustard (*Alliaria petiolaris*). All of these invasives occur within this forest at low densities but are concentrated in the northern portion of the northern polygon where timber management occurred recently and in the southern polygon near Longman Road. In addition these species are prevalent to dominant in the surrounding early-successional forest. Due to decades of fire suppression, red maple has become common in the understory and also occurs in the subcanopy. Finally, non-native earthworms were noted and may be altering the soil and nutrient regimes.

Management Recommendations: The main management recommendations are to continue the use of prescribed surface fire and allow natural processes (i.e., windthrow and fire) to operate unhindered (no salvage logging and allow lightning strike fires to burn). Resource managers should continue to use prescribed fire to maintain open understory conditions, reduce invasive species and native mesophytic species, especially red maple, and promote oak and hickory regeneration. Prescribed burning of this dry-mesic southern forest should be coordinated with the burning of adjacent high-quality wetlands. The seasonality



Photo 3. Slopes of the Whitman Lake Woods above the Whitman Lake Fen are characterized by open canopy conditions and numerous species associated with oak openings (Photo by Joshua G. Cohen).

of burns should be varied to include growing season and fall burns as well as spring burns. Restricting prescribed fire to early spring can result in understory dominance by fire-tolerant woody species that can sprout following early season burns. If fire fails to kill the understory and subcanopy red maple, resource managers may need to employ girdling and/or herbiciding techniques. Efforts should be continued to reduce invasive species within this site and in the surrounding areas through the use of prescribed fire and where necessary, spot treatment of species like garlic mustard. Reducing invasive species in the surrounding landscape and allowing surrounding early-successional forest to mature will reduce the seed source of invasive species adjacent to this high-quality area. The encroachment of invasive species along the northern margin adjacent to the recent timber harvest suggest that avoiding timber management immediately adjacent to high-quality areas is warranted. Once invasive and mesophytic woody species have been controlled within the site, the frequency of burning should be carefully evaluated and could be reduced to once every 5 to 10 years. Foot traffic should be minimized and vehicular traffic should be excluded from this forest. Permanent monitoring plots should be established to allow for assessment of whether management is reducing invasive and native mesophytic species populations and fostering oak regeneration. If oak is not regenerating after ten years, resource managers should evaluate whether additional steps need to be taken, such as, planting of acorns or oak saplings, reduction of deer densities, and/or creation of canopy gaps. Monitoring deer densities and deer herbivory will allow for the assessment of whether deer herbivory threatens floristic structure and composition. Little is known about the impacts of

prescribed fire on non-native earthworms. The impacts of earthworms on soil properties and the impacts of prescribed fire on earthworm populations should both be monitored.

Discussion: The B-ranked Whitman Lake Woods is one of forty-seven documented dry-mesic southern forests in Michigan. Within the state there are nineteen dry-mesic southern forest element occurrences that are ranked B or higher. This dry-mesic southern forest falls within Sub-Subsection VI.2.1 of the regional landscape ecosystems of Michigan hierarchical landscape classification (Albert 1995) (Figure 1). There are sixteen dry-mesic southern forests within the Kalamazoo Interlobate (VI.2) and eight within the Battle Creek Outwash Plain (VI.2.1).

Mesic Sand Prairie

Overview: Mesic sand prairie is a native grassland community occurring on sandy loam, loamy sand, or sand soils on nearly level glacial outwash plains and lakeplains in both the northern and southern Lower Peninsula. Sites that support mesic sand prairie experience fluctuating water tables, with relatively high water tables occurring in the spring followed by drought conditions in late summer and fall. Thus, the community contains species from a broad range of moisture classes, but is dominated by species of upland affinity. Dominant grasses include little bluestem (*Andropogon scoparius*), big bluestem (*Andropogon gerardii*), and Indian grass (*Sorghastrum nutans*) (Kost et al. 2007).

3. Mott Road Prairie

Natural Community Type: Mesic sand prairie (formerly dry-mesic sand prairie)

Rank: G2 S1, globally imperiled and critically imperiled in the state

Element Occurrence Rank: C

Size: 1 ha (2.5 ac)

Location: Area 7, T02S R09W Section 14

Site Description: Mott Road Prairie is a small mesic sand prairie that occupies a mild depression within ice-contact topography (Photo 4). This site occurs just west of the Mott Road Fen (Figure 8). Historically this prairie was part of a larger oak opening. In addition, the prairie was likely plowed or at least grazed. Fire was historically a common natural disturbance within prairie ecosystems. This site has been burned several times in the last couple of years resulting in the reduction of woody stems and the increase in area of open prairie. In addition, shrubs have been mechanically removed to reduce woody stem densities and



Photo 4. The Mott Road Prairie mesic sand prairie occurs within a mild depression within ice-contact topography and is characterized by seasonal fluctuations in hydrology (Photo by Joshua G. Cohen).

maintain the open prairie conditions. Fluctuating water levels likely also contribute to the reduction of woody stems and the maintenance of open conditions within portions of this prairie. Mottling in the soils indicate that portions of this prairie experience seasonal inundation or saturation. The soils are characterized as 30 to 40 cm of slightly acidic sandy loam to sandy clay loam (pH 6.0-6.5) over sandy clay loam. Soils were completely dry during the late season survey of this site in early September.

This mesic sand prairie is characterized by high species diversity with numerous forbs and scattered patches of prairie grasses. The prairie openings support dense and tall vegetation (Photo 5). Dominant plants include goldenrods (*Solidago* spp.), especially rough goldenrod (*S. rugosa*), late goldenrod (*S. gigantea*), and Ohio goldenrod (*S. ohioensis*), tick trefoils (*Desmodium* spp.) including clustered-leaved tick trefoil (*Desmodium glutinosum*) and panicked tick trefoil (*D. paniculatum*), and also golden alexanders (*Zizia aurea*), wild bergamot (*Monarda fistulosa*), common boneset (*Eupatorium perfoliatum*), grass-leaved goldenrod (*Euthamia graminifolia*), and little bluestem (*Andropogon scoparius*). Other characteristic species are tall coreopsis (*Coreopsis tripteris*), marsh fern (*Thelypteris palustris*), black-eyed Susan (*Rudbeckia hirta*), Virginia mountain mint (*Pycnanthemum virginianum*), Missouri ironweed (*Vernonia missurica*), hairy bush clover (*Lespedeza hirta*), and milkweeds (*Asclepia* spp.) including swamp milkweed (*A. incarnata*), common milkweed (*A. syriaca*), and butterfly weed (*A. tuberosa*). Graminoids occur in scattered clumps or patches and include little bluestem, big bluestem (*Andropogon gerardii*), bluejoint grass (*Calamagrostis canadensis*), and Indian grass (*Sorghastrum nutans*). Clumps of tall shrubs

occur along the margins of the openings and are dominated by dogwoods (*Cornus* spp), namely gray dogwood (*Cornus foemina*) and silky dogwood (*C. amomum*), sumacs (*Rhus* spp.) including staghorn sumac (*Rhus typhina*) and winged sumac (*R. copallina*), black cherry (*Prunus serotina*), and willows (*Salix* spp). The low shrub layer is dominated by berries (*Rubus* spp.) including black raspberry (*R. occidentalis*), common blackberry (*R. alleghaniensis*), and northern dewberry (*R. flagellaris*) with localized occurrence of shrubby cinquefoil (*Potentilla fruticosa*). Small-diameter trees occur sporadically within the site and include red maple (*Acer rubrum*), American elm (*Ulmus americana*), sassafras (*Sassafras albidum*), and black cherry. Seventy-nine native, vascular plant species were noted within this mesic sand prairie during the 2008 surveys.

This site was formerly classified as a dry-mesic prairie. Following the 2008 survey, Mott Road Prairie was re-classified as mesic sand prairie based on the site's species composition, evidence of seasonal water level fluctuation, and soil properties (sandy loams and sandy clay loam with mottling). This mesic sand prairie was re-mapped to better reflect the current ecological boundaries of this community using recent aerial photographic imagery and GPS and GIS technology.

Threats: The primary threat to this prairie is posed by fire suppression and shrub encroachment of native species as well as non-native invasive species. Multiflora rose (*Rosa multiflora*), glossy buckthorn (*Rhamnus frangula*), and amur honeysuckle (*Lonicera maackii*) are especially pernicious invasives found within shrub-dominated areas along the margins of the prairie and within the understory of the surrounding early-successional forest. In



Photo 5. The Mott Road Prairie is characterized by high species diversity with numerous forbs and scattered patches of prairie grasses (Photo by Joshua G. Cohen).

addition, purple loosestrife (*Lythrum salicaria*) was found sporadically within wet pockets of the prairie. Numerous non-native species characteristic of old fields occur throughout this site. Finally, restricting prescribed fire to early spring can result in the spread of fire-tolerant woody species that can sprout following early season burns. Sassafras and sumac sprouts are abundant within this site, likely because of sprouting following early season burns.

Management Recommendations: Resource managers should continue to use prescribed fire to maintain open prairie conditions and reduce invasive species and native shrub and tree species. The seasonality of burns should be varied to include growing season and fall burns as well as spring burns. Restricting prescribed fire to early spring can result in understory dominance by fire-tolerant woody species, such as sassafras, sumacs, and berries that can sprout following early season burns. Efforts should be continued to reduce invasive species within this site and in the surrounding areas through the use of prescribed fire and where necessary, spot treatment. The small population of purple loosestrife should be treated through spot herbicide treatment, and/or hand-pulling. Reducing invasive species in the surrounding landscape and allowing surrounding early-successional forest to mature will reduce the seed source of invasive species adjacent to this high-quality area. Foot traffic should be minimized and vehicular traffic should be excluded from this prairie. Permanent monitoring plots should be established to allow for assessment of whether management is reducing invasives and native woody species populations and promoting open conditions.

Discussion: The C-ranked Mott Road Prairie is one of only eight documented mesic sand prairies in Michigan. Within the state there are six mesic sand prairie element occurrences that are ranked C or higher. This mesic sand prairie falls within Sub-Subsection VI.2.1 of the regional landscape ecosystems of Michigan hierarchical landscape classification (Albert 1995) (Figure 1). This is the only mesic sand prairie within the Kalamazoo Interlobate (VI.2) and within the Battle Creek Outwash Plain (VI.2.1).

Prairie Fen

Overview: Prairie fen is a wetland community dominated by sedges, grasses, and other graminoids that occurs on moderately alkaline organic soil and marl south of the climatic tension zone in southern Lower Michigan. Prairie fens occur where cold, calcareous, groundwater-fed springs reach the surface. The flow rate and volume of groundwater through a fen strongly influence vegetation patterning; thus, the community typically contains multiple, distinct zones of vegetation, some of which contain prairie grasses and forbs (Kost et al. 2007).



Photo 6. Sphagnum hummock development within the Mott Road Fen generates micro-scale heterogeneity by creating fine-scale gradients of soil moisture and chemistry (Photo by Joshua G. Cohen).

4. Mott Road Fen

Natural Community Type: Prairie fen

Rank: G3 S3, vulnerable globally and within the state

Element Occurrence Rank: B

Size: 2 ha (7 ac)

Location: Areas 5 and 7, T02S R09W Section 14

Site Description: The Mott Road Fen consists of two patches of prairie fen on either side of Mott Road occurring on sloping peat mounds with groundwater-fed streams and numerous seeps (Figure 8). The groundwater, rich in mineral content, generates minerotrophic conditions. Occasional fires were historically an important part of the natural disturbance regime of prairie fen and Fort Custer's resource managers have recently re-introduced fire as a critical process influencing species structure and composition. Prescribed fire has reduced shrubby encroachment and bolstered species diversity. In addition, it appears as though the extent of this prairie fen has been expanded by fire management. Within the fen the organic soils are deep peats with well-developed sphagnum hummocks present, especially in the southern polygon. Sphagnum hummock development generates micro-scale heterogeneity by creating fine-scale gradients of soil moisture and chemistry (Photo 6). In addition, ant mounds occur throughout the site and increase the fen's structural heterogeneity and the ants mix and aerate the soils. The soils are saturated to inundated peats that are alkaline (pH 7.5-8.0) and influenced by cold minerotrophic groundwater.

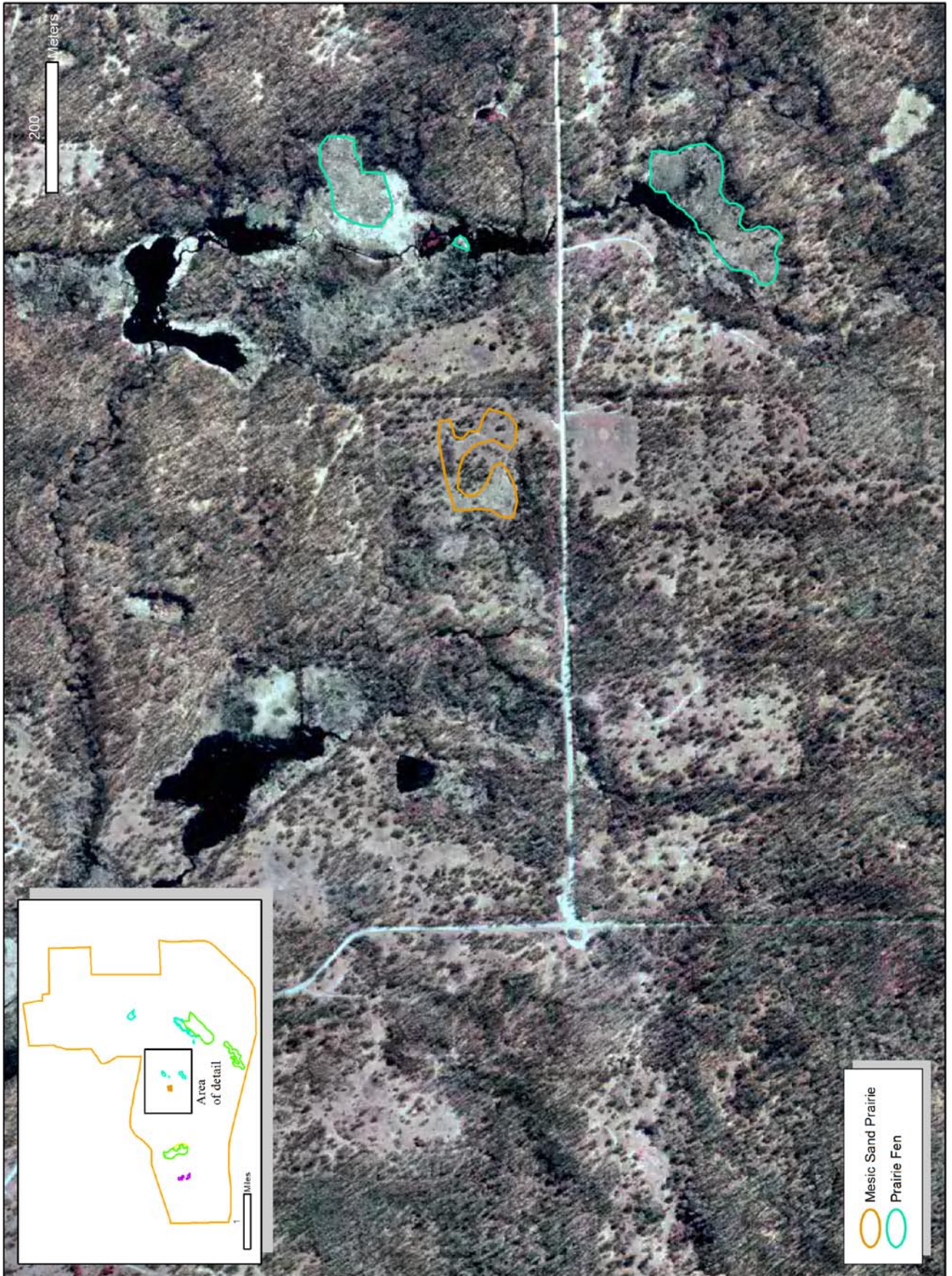


Figure 8. The Mott Road Prairie (mesic sand prairie) and Mott Road Fen (prairie fen).



Photos 7 and 8. The Mott Road Fen is highly diverse due to structural heterogeneity resulting from fine-scale gradients in hydrology and soil chemistry and moisture (Photos by Joshua G. Cohen).

The fen is highly diverse due to structural heterogeneity resulting from fine-scale gradients in hydrology and soil chemistry and moisture (Photos 7 and 8). Zones within the wetland complex include southern shrub-carr along the wetland margins, southern wet meadow, prairie fen in areas of sloping peat, and emergent marsh in areas where water has pooled. The fen is graminoid-dominated with tussock sedge (*Carex stricta*), Indian grass (*Sorghastrum nutans*), bluejoint grass (*Calamagrostis canadensis*), spike-rushes (*Eleocharis* spp.), and broad-leaved cattail (*Typha latifolia*). Characteristic species include asters (*Aster* spp.), goldenrods (*Solidago* spp.) (Photo 9), especially rough goldenrod (*S. rugosa*), swamp goldenrod (*S. patula*), and also marsh fern (*Thelypteris palustris*), black-eyed Susan (*Rudbeckia hirta*), wild bergamot (*Monarda fistulosa*), common boneset (*Eupatorium perfoliatum*), marsh bellflower (*Campanula aparinoides*), jewelweed (*Impatiens capensis*), and swamp milkweed (*Asclepias incarnata*). Scattered within the southern polygon is a small population of the state threatened cut-leaved water-parnsip (*Berula erecta*). Shrubby cinquefoil (*Potentilla fruticosa*) is prevalent in the low shrub layer and poison sumac (*Toxicodendron vernix*) and red maple (*Acer rubrum*) occur sporadically within the sparse understory layer. Patches of shrub-carr are dominated by willows (*Salix* spp.) and dogwoods (*Cornus* spp.). Glossy buckthorn (*Rhamnus frangula*) and purple loosestrife (*Lythrum salicaria*) are locally prevalent. Pockets of southern wet meadow are wetter and dominated by lake sedge (*Carex lacustris*) along with tussock sedge and fewer overall species. Seventy-nine native, vascular plant species were noted within this prairie fen during the 2008 surveys.

This prairie fen was re-mapped to better reflect the current ecological boundaries of this community using recent aerial photographic imagery and GPS and GIS technology.

Threats: The primary threat to this prairie fen is posed by fire suppression and shrub encroachment of native species as well as non-native invasive species, especially glossy buckthorn, which occurs locally within the fen. In addition, purple loosestrife occurs sporadically in the northern polygon where recent biocontrol efforts appear to be effective. One individual black alder (*Alnus glutinosa*) was documented in the southern polygon.

Management Recommendations: Resource managers should continue to use prescribed fire to maintain open prairie fen conditions and reduce invasive species and native shrub and tree species. The seasonality of burns should be varied to include growing season and fall burns as well as spring burns. Historically, prairie fen and adjacent uplands most likely burned during drought



Photo 9. The Mott Road Fen is graminoid-dominated with tussock sedge, Indian grass, bluejoint grass, and spike-rushes, and characteristic forbs including asters and goldenrods (Photo by Joshua G. Cohen).

periods in the late growing season and early fall. Prescribed burning of this prairie fen should be coordinated with the burning of adjacent uplands. Efforts should be continued to reduce invasive species within this site and in the surrounding areas through the use of prescribed fire and where necessary, spot treatment. Clusters of buckthorn should be cut and herbicided. The population of purple loosestrife should continue to be treated through biocontrol and possibly spot herbicide treatment, and/or hand pulling as well. The black alder should be removed immediately before this pernicious species can spread. Reducing invasive species in the surrounding landscape, especially in nearby wetlands, and allowing surrounding early-successional forest to mature will reduce the seed source of invasive species adjacent to this high-quality area. Foot traffic should be minimized and vehicular traffic should be excluded from this forest. Timber harvest within the surrounding uplands should be avoided to prevent alteration to the groundwater-influenced hydrologic regime. Permanent monitoring plots should be established to allow for assessment of whether management is reducing invasives and native woody species populations and maintaining open conditions.

Discussion: The B-ranked Mott Road Fen is one of 148 documented high-quality prairie fens in Michigan. Within the state there are 46 prairie fen element occurrences that are ranked B or higher. This prairie fen falls within Sub-Subsection VI.2.1 of the regional landscape ecosystems of Michigan hierarchical landscape classification (Albert 1995) (Figure 1). Within the Kalamazoo Interlobate (VI.2) there are 49 prairie fen element occurrences and within the Battle Creek Outwash Plain (VI.2.1) there are 37 prairie fen element occurrences, eight of which are ranked B or higher.

5. Territorial Road Fen

Natural Community Type: Prairie fen

Rank: G3 S3, vulnerable globally and within the state

Element Occurrence Rank: B

Size: 3 ha (8 ac)

Location: Impact Area, T02S R09W Section 12

Site Description: The Territorial Road Fen is a newly documented prairie fen that occurs within the Impact Area (Figure 9 and Photo 10). It is characterized by sloping peat mounds with groundwater-fed streams and numerous seeps. The groundwater, rich in mineral content, generates minerotrophic conditions. Within the drainage, beaver damming and ponding have altered the local hydrology, causing pooling and increased water temperatures. Occasional fires were historically an important part of

the natural disturbance regime of prairie fen and Fort Custer's resource managers have recently re-introduced fire as a critical process influencing species structure and composition. Prescribed fire has reduced shrubby encroachment and bolstered species diversity. In addition, it appears as though the extent of this prairie fen has been expanded by fire management. Within the fen the organic soils are deep peats with well-developed sphagnum hummocks present. Sphagnum hummock development generates micro-scale heterogeneity by creating fine-scale gradients of soil moisture and chemistry. The soils are saturated to inundated peats that are deep (> 100 cm), circumneutral to alkaline (pH 7.0-7.5), and influenced by cold minerotrophic groundwater.

The fen is highly diverse due to structural heterogeneity resulting from fine-scale gradients in hydrology and soil chemistry and moisture. Zones within the wetland complex include southern shrub-carr along the wetland margins, southern wet meadow, prairie fen in areas of sloping peat, and emergent marsh in areas along the stream. The fen is dominated by tussock sedge (*Carex stricta*), Virginia mountain mint (*Pycnanthemum virginianum*), joe-pye-weed (*Eupatorium maculatum*), and goldenrods (*Solidago* spp.), especially rough goldenrod (*S. rugosa*), swamp goldenrod (*S. patula*), and tall goldenrod (*S. altissima*). Characteristic species include golden-seeded spike-rush (*Eleocharis elliptica*), prairie dropseed (*Sporobolus heterolepis*, state special concern), marsh fern (*Thelypteris palustris*), black-eyed Susan (*Rudbeckia hirta*), marsh pea (*Lathyrus palustris*), and fringed brome (*Bromus ciliatus*). Shrubby cinquefoil (*Potentilla fruticosa*) is prevalent in the low shrub layer and poison sumac (*Toxicodendron vernix*) occurs sporadically within the sparse understory layer. Patches of shrub-carr are dominated by willows (*Salix* spp.) and dogwoods (*Cornus* spp.). Glossy buckthorn (*Rhamnus frangula*) occurs scattered within the shrub margin of the fen. Eighty-two native, vascular plant species were noted within this prairie fen during the 2008 surveys.

Threats: The primary threat to this prairie fen is posed by fire suppression and shrub encroachment of native species as well as non-native invasive species, especially glossy buckthorn, which occurs locally within the fen. Purple loosestrife (*Lythrum salicaria*) was also documented. Narrow-leaved cat-tail (*Typha angustifolia*) occurs as a local dominant to the south of this wetland complex within the Whitman Lake Fen and use of prescribed has likely facilitated the spread of this species within this wetland.

Management Recommendations: Resource managers should continue to use prescribed fire to maintain open prairie fen conditions and reduce invasive species and native shrub and tree species. The seasonality of burns should be varied to include growing season and fall

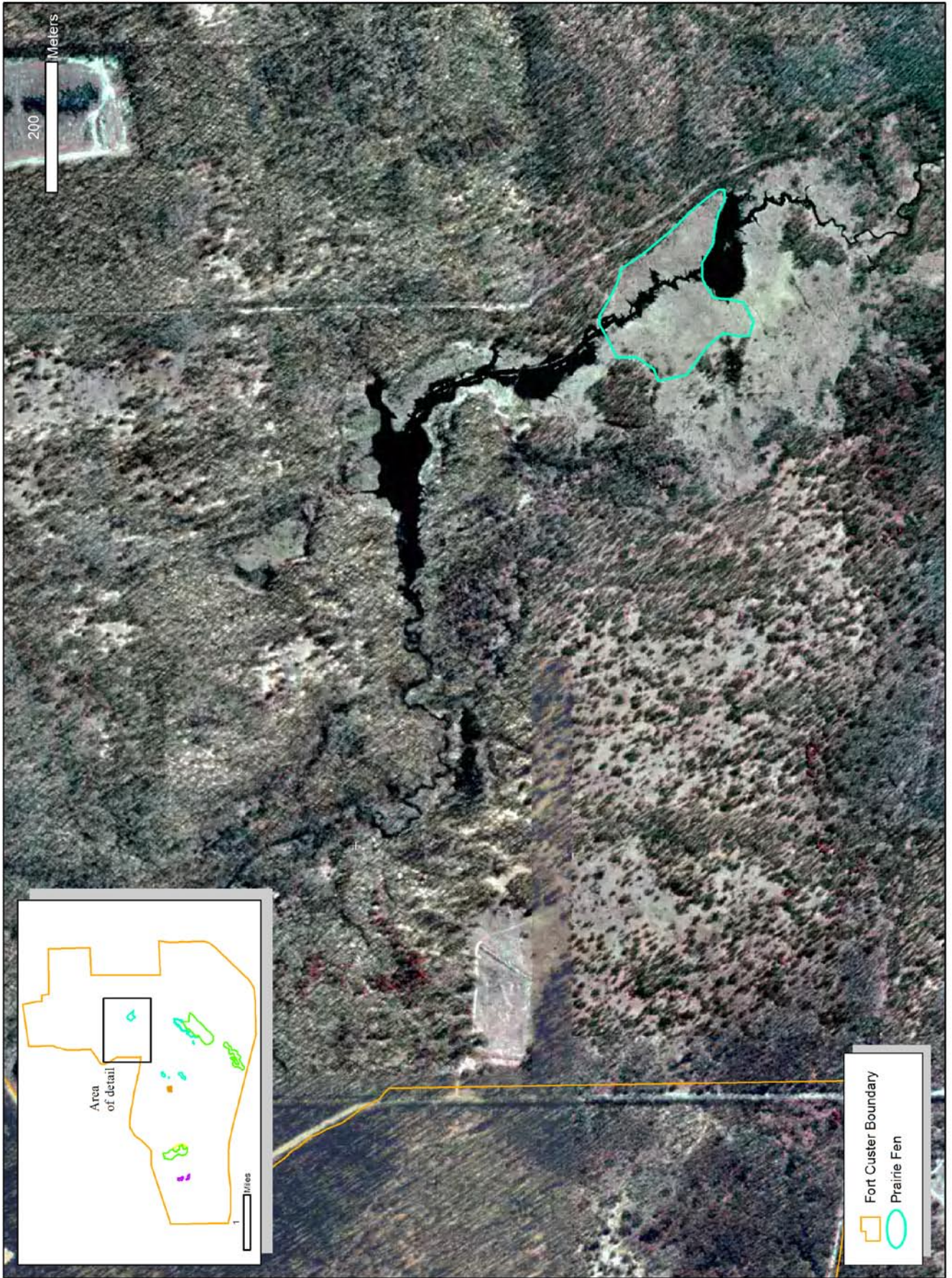


Figure 9. Territorial Road Fen (prairie fen).



Photo 10. The Territorial Road Fen is characterized by sloping peat mounds with groundwater-fed streams and numerous seeps (Photo by Joshua G. Cohen).

burns as well as spring burns. Historically, prairie fen and adjacent uplands most likely burned during drought periods in the late growing season and early fall. Prescribed burning of this prairie fen should be coordinated with the burning of adjacent uplands. Efforts should be continued to reduce invasive species within this site and in the surrounding areas through the use of prescribed fire and where necessary, spot treatment (e.g., for species such as narrow-leaved cat-tail that can spread following fire). Clusters of buckthorn should be cut and herbicided. The population of purple loosestrife should be treated through biocontrol, hand pulling, and/or spot herbicide treatment. Reducing invasive species in the surrounding landscape, especially nearby wetlands, and allowing surrounding early-successional forest to mature will reduce the seed source of invasive species adjacent to this high-quality area. Foot traffic should be minimized and vehicular traffic should be excluded from this forest. Timber harvest within the surrounding uplands should be avoided to prevent alteration to the groundwater-influenced hydrologic regime. Permanent monitoring plots should be established to allow for assessment of whether management is reducing invasives and native woody species populations and maintaining open conditions. Keen attention should be paid to whether or not narrow-leaved cat-tail has infiltrated the fen since this species can spread rapidly following the use of prescribed fire. If populations of narrow-leaved cat-tail are discovered, fire should be restricted from these areas until the cat-tail has been controlled through alternative means (i.e., herbicide treatment).

Discussion: The B-ranked Territorial Road Fen is one of 148 documented high-quality prairie fens in Michigan. Within the state there are 46 prairie fen

element occurrences that are ranked B or higher. This prairie fen falls within Sub-Subsection VI.2.1 of the regional landscape ecosystems of Michigan hierarchical landscape classification (Albert 1995) (Figure 1). Within the Kalamazoo Interlobate (VI.2) there are 49 prairie fen element occurrences and within the Battle Creek Outwash Plain (VI.2.1) there are 37 prairie fen element occurrences, eight of which are ranked B or higher.

6. Whitman Lake Fen

Natural Community Type: Prairie fen

Rank: G3 S3, vulnerable globally and within the state

Element Occurrence Rank: B (formerly C-ranked)

Size: 5 ha (13 ac)

Location: Impact Area, T02S R09W Section 13

Site Description: The Whitman Lake Fen is characterized by several patches of prairie fen on sloping peat mounds with groundwater-fed streams and numerous seeps (Photo 11). High-quality dry-mesic southern forest (the northern polygon of the Whitman Lake Woods) occurs to the east of this prairie fen (Figure 6). The groundwater, rich in mineral content, generates minerotrophic conditions. Beaver damming and ponding have altered the local hydrology, causing pooling and increased water temperatures and promoting marsh and meadow habitat (Photo 12). Occasional fires were historically an important part of the natural disturbance regime of prairie fen and Fort Custer's resource managers have recently re-introduced fire as a critical process influencing species structure and composition. Prescribed fire has reduced shrubby encroachment and bolstered species diversity.



Photo 11. The Whitman Lake Fen is characterized by several patches of prairie fen on sloping peat mounds with groundwater-fed streams and numerous seeps (Photo by Joshua G. Cohen).



Photo 12. Beaver damming and ponding have altered the local hydrology, causing pooling and increased water temperatures and promoting marsh and meadow habitat (Photo by Joshua G. Cohen).



Photo 13. The Whitman Lake Fen is highly diverse due to structural heterogeneity resulting from fine-scale gradients in hydrology and soil chemistry and moisture and the overall influence of prescribed fire and beaver activity (Photo by Joshua G. Cohen).

In addition, it appears as though the extent of this prairie fen has been expanded by fire management. Ant mounds occur throughout the site and increase the fen's structural heterogeneity and the ants mix and aerate the soils. Within the fen the organic soils are deep peats with well-developed sphagnum hummocks present. Sphagnum hummock development generates micro-scale heterogeneity by creating fine-scale gradients of soil moisture and chemistry. The soils are saturated to inundated peats that are alkaline (pH 7.5-8.0), and influenced by cold minerotrophic groundwater.

The fen is highly diverse due to structural heterogeneity resulting from fine-scale gradients in hydrology and

soil chemistry and moisture and the overall influence of prescribed fire and beaver activity (Photo 13). Zones within the wetland complex include southern shrub-carr along the wetland margins, southern wet meadow, prairie fen in areas of sloping peat, and emergent marsh in beaver ponds, streams, and along the lake margin. The fen is graminoid-dominated with tussock sedge (*Carex stricta*), wiregrass sedge (*C. lasiocarpa*), bulrush (*Scirpus atrovirens*), and cat-tails (*Typha* spp.). Characteristic species include marsh fern (*Thelypteris palustris*), black-eyed Susan (*Rudbeckia hirta*), prairie dropseed (*Sporobolus heterolepis*, state special concern), Virginia mountain mint (*Pycnanthemum virginianum*), twig-rush (*Cladium mariscoides*), common boneset (*Eupatorium perfoliatum*), and swamp goldenrod (*Solidago patula*). A small colony of queen-of-the-prairie (*Filipendula rubra*, state threatened) occurs within the prairie fen on the northwestern shore of Whitman Lake. Scattered within the southern portion of the site in tiny rivulets and seeps is a small population of the state threatened cut-leaved water-parsnip (*Berula erecta*). Shrubby cinquefoil (*Potentilla fruticosa*) is prevalent in the low shrub layer and poison sumac (*Toxicodendron vernix*) and red maple (*Acer rubrum*) occur sporadically within the sparse understory layer. Patches of shrub-carr are dominated by willows (*Salix* spp.) and dogwoods (*Cornus* spp.). Glossy buckthorn (*Rhamnus frangula*) locally dominates portions of the shrub margin of the fen, especially along the western side of the Whitman Lake. In addition, narrow-leaved cat-tail (*Typha angustifolia*), a non-native invasive, locally dominates the northeastern portion of the fen (Photo 14). Ninety-nine native, vascular plant species were noted within this prairie fen during the 2008 surveys.

This prairie fen was re-mapped to better reflect the current ecological boundaries of this community using recent aerial photographic imagery and GPS and GIS technology.

Threats: The primary threat to this prairie fen is posed by fire suppression and shrub encroachment of native species as well as expansion of non-native invasive species, especially glossy buckthorn and narrow-leaved cat-tail, which both occur as local dominants. Dense thickets of glossy buckthorn occur throughout the fen, especially along the northwestern shore of Whitman Lake. As noted above, narrow-leaved cat-tail is a dominant along the northeastern shore of Whitman Lake and the spread of this species was likely facilitated by prescribed fire. In addition, scattered patches of purple loosestrife (*Lythrum salicaria*) were observed throughout the fen at low densities. Beaver have dramatically altered the site's hydrology and community structure and composition, increasing the extent of wet meadow and emergent marsh and decreasing the total acreage of prairie fen.



Photo 14. Narrow-leaved cat-tail, a non-native invasive, locally dominates the northeastern portion of the Whitman Lake Fen. It is imperative that controlled burning be restricted from areas where narrow-leaved cat-tails occurs to prevent the further spread of this fire-tolerant species (Photo by Joshua G. Cohen).

Management Recommendations: Resource managers should continue to use prescribed fire to maintain open prairie fen conditions and reduce invasive species and native shrub and tree species. The seasonality of burns should be varied to include growing season and fall burns as well as spring burns. Historically, prairie fen and adjacent uplands most likely burned during drought periods in the late growing season and early fall. Prescribed burning of this prairie fen should be coordinated with the burning of the adjacent high-quality dry-mesic southern forest. It is imperative that controlled burning be restricted from areas where narrow-leaved cat-tails occurs to prevent the further spread of this fire-tolerant species. Efforts should be continued to reduce invasive species within this site and in the surrounding areas through the use of prescribed fire and where necessary, herbicide spot treatment (e.g., for species such as narrow-leaved cat-tail that can spread following fire). Clusters of glossy buckthorn should continue to be cut and herbicided. The population of purple loosestrife should be treated through biocontrol, hand pulling, and/or spot herbicide treatment. Reducing invasive species in the surrounding landscape, especially in nearby wetlands, and allowing surrounding early-successional forest to mature will reduce the seed source of invasive species adjacent to this high-quality area. Foot traffic should be minimized and vehicular traffic should be excluded from this forest. Timber harvest within the surrounding uplands should be avoided to prevent alteration to the groundwater-influenced hydrologic regime. The impacts of beaver should be monitored and if large acreage of prairie fen is threatened by beaver activity, control of beaver should be considered. Permanent monitoring plots should be established to

allow for assessment of whether management is reducing invasives and native woody species populations and maintaining open conditions. Keen attention should be paid to whether or not narrow-leaved cat-tail has infiltrated other portions of this fen since this species can spread rapidly following the use of prescribed fire. If additional populations of narrow-leaved cat-tail are discovered, fire should be restricted from these areas until the cat-tail has been controlled through alternative means (i.e., herbicide treatment).

Discussion: The B-ranked Whitman Lake Fen is one of 148 documented high-quality prairie fens in Michigan. Within the state there are 46 prairie fen element occurrences that are ranked B or higher. This prairie fen falls within Sub-Subsection VI.2.1 of the regional landscape ecosystems of Michigan hierarchical landscape classification (Albert 1995) (Figure 1). Within the Kalamazoo Interlobate (VI.2) there are 49 prairie fen element occurrences and within the Battle Creek Outwash Plain (VI.2.1) there are 37 prairie fen element occurrences, eight of which are ranked B or higher.

Southern Hardwood Swamp

Overview: Southern hardwood swamp is a minerotrophic forested wetland occurring in southern Lower Michigan on mineral or occasionally organic soils dominated by a mixture of lowland hardwoods. Conifers are absent or local. The community occupies shallow depressions and high-order stream drainages on a variety of landforms (Kost et al. 2007).

7. Cemetery Complex Seeps

Natural Community Type: Southern hardwood swamp

Rank: G3 S3, vulnerable globally and within the state

Element Occurrence Rank: B

Size: 3 ha (9 ac)

Location: Area 4, T02S R09W Section 15

Site Description: The Cemetery Complex Seeps is an uneven-aged seepage swamp dominated by relatively young hardwoods ranging in age from 20 to 80 years. This swamp is adjacent to high-quality dry-mesic southern forest (Cemetery Complex Seeps), which contains inclusions of mesic southern forest (Figure 5). Diameters of canopy trees range from 10 to 40 cm. Cool groundwater seepage along the end moraine slopes generates minerotrophic growing conditions and saturated mucky soils. The organic soils are deep saturated mucks (20 to 80 cm deep) overlying circumneutral to alkaline (pH 7.0-8.0) wet sand, sandy clay, or clay. Numerous braided headwater streams occur within



Photo 15. The Cemetery Complex Seeps is a unique southern hardwood swamp with areas of dense understory (Photo by Joshua G. Cohen).

the site and feed into a larger creek at the base of the slopes. The drainages contain concentrations of tufa, calcium carbonate deposits formed following precipitation. In addition, beaver flooding, following the breaking of beaver dams up stream have locally influenced portions of the swamp adjacent to the creek. Finally, portions of the swamp recently burned following prescribed fire in the spring of 2008. Southern hardwood swamp historically burned very infrequently and would have burned only during years of extreme drought and during the late growing season or fall.

The closed to scattered canopy (60-85%) is dominated by small- to medium-diameter hardwoods with canopy associates including black ash (*Fraxinus nigra*), American elm (*Ulmus americana*), basswood (*Tilia americana*), red maple (*Acer rubrum*), and tulip tree (*Liriodendron tulipifera*). Musclewood (*Carpinus caroliniana*) is dominant in the subcanopy and understory layer along with spicebush (*Lindera benzoin*) (Photo 15). One red mulberry (*Morus rubra*, state threatened) sapling was encountered re-sprouting after haven been top-killed by the spring 2008 prescribed fire. Multiflora rose (*Rosa multiflora*) occurs as a local dominant, especially in areas with open to

partial canopy. Prevalent low shrubs include blackberries (*Rubus* spp.) and gooseberries (*Ribes* spp.). The ground cover is diverse and dense with local dominants including jewelweed (*Impatiens capensis*), wood nettle (*Laportea canadensis*), and skunk cabbage (*Symplocarpus foetidus*) (Photo 16). Characteristic species of the ground cover include sensitive fern (*Onoclea sensibilis*), poison ivy (*Toxicodendron radicans*), black snakeroot (*Sanicula marilandica*), golden ragwort (*Senecio aureus*), honewort (*Cryptotaenia canadensis*), joe-pye-weed (*Eupatorium maculatum*), Jack-in-the-pulpit (*Arisaema triphyllum*), marsh marigold (*Caltha palustris*), and river grape (*Vitis riparia*). Scattered within seeps and stream channels is a metapopulation of the state threatened cut-leaved water-parsnip (*Berula erecta*). Stiff gentian (*Gentianella quinquefolia*, state threatened) was documented in open meadow habitat in seepages associated within the southern hardwood swamp. Goldenseal (*Hydrastis canadensis*, state threatened) and ginseng (*Panax quinquefolius*, state threatened) occur in mesic pockets along the headwater streams. Wahoo (*Euonymus atropurpurea*, state special concern) was documented within this site in 1994 but has not been observed since then. Seventy-four native, vascular plant species were noted within this swamp during the 2008 surveys.

This southern hardwood swamp was re-mapped to better reflect the current ecological boundaries of this community using recent aerial photographic imagery and GPS and GIS technology.

Threats: The primary threat to this southern hardwood swamp is posed by invasive species, especially multiflora rose, which is locally dominant. Patches of Japanese barberry (*Berberis thunbergii*), privet (*Ligustrum vulgare*), and garlic mustard (*Alliaria petiolaris*) occur within the adjacent high-quality dry-mesic southern forest but are prevalent to dominant along with multiflora rose in the surrounding early-successional forest. Glossy buckthorn (*Rhamnus frangula*) was found in trace amounts in the adjacent dry-mesic southern forest and common buckthorn (*R. cathartica*) was observed near the site. Finally, prescribed burning could detrimentally impact the swamp's native species composition and structure and alter the soils.

Management Recommendations: The main management recommendation is to allow natural processes (i.e., windthrow, flooding, and fire) to operate unhindered (no salvage logging and allow lightning strike fires to burn). Prescribed fire should be avoided within this site, although the seepage can be used as a natural fire break and surface fires can be allowed to creep into the margins. Fire lines should not be extended into the swamp. Within "Resource Management in High Quality Natural Areas" (DLZ 2005), it is stated that the most critical management



Photo 16. Ground cover of the Cemetery Complex Seeps is diverse and dense with local dominants including skunk cabbage (*Symplocarpus foetidus*) (pictured here), jewelweed (*Impatiens capensis*), and wood nettle (*Laportea canadensis*) (Photo by

issue is brush encroachment and that brush-cutting and periodic prescribed fire should be employed. We strongly disagree with these recommendations since fire was an infrequent disturbance factor within southern hardwood swamp and subsequently, native shrub understory was often dense (Photos 15 and 16). However, reduction of the non-native component of the understory is warranted. Efforts should be continued to reduce invasive species within this site and in the surrounding areas. Within this swamp, invasives should be controlled using cutting and/or herbicide application. Reducing invasive species in the surrounding landscape and allowing surrounding early-successional forest to mature will reduce the seed source of invasive species adjacent to this high-quality area. Permanent monitoring plots should be established to allow for assessment of whether management is reducing invasive species populations. Monitoring deer densities and deer herbivory will allow for the assessment of whether deer herbivory threatens floristic structure and composition. Foot traffic should be minimized within seepage areas and vehicular traffic should be excluded. Timber harvest within

the surrounding uplands should be avoided to prevent alteration to the groundwater-influenced hydrologic regime.

Discussion: The B-ranked Cemetery Complex Seeps is one of fourteen documented southern hardwood swamp in Michigan. Within the state there are five southern hardwood swamp element occurrences that are ranked B or higher. This southern hardwood swamp falls within Sub-Subsection VI.2.1 of the regional landscape ecosystems of Michigan hierarchical landscape classification (Albert 1995) (Figure 1). There are four southern hardwood swamp within the Kalamazoo Interlobate (VI.2) and the Battle Creek Outwash Plain (VI.2.1) and three of these swamps are B-ranked or higher.

Southern Wet Meadow

Overview: Southern wet meadow is an open, groundwater-influenced (minerotrophic), sedge-dominated wetland that occurs in central and southern Lower Michigan. Open conditions are maintained by seasonal flooding, beaver-induced flooding, and fire. Sedges in the genus *Carex*, in particular tussock sedge (*Carex stricta*), dominate the community (Kost et al. 2007).

8. 42nd Road Seep

Natural Community Type: Southern wet meadow

Rank: G4? S3, apparently secure globally and vulnerable within the state

Element Occurrence Rank: BC

Size: 1 ha (4 ac)

Location: Area 3, T02S R09W Section 16

Site Description: The 42nd Road Seep is a narrow drainage channel in coarse textured end moraine that supports southern wet meadow intermixed with southern shrub-carr and southern hardwood swamp (Figure 5). Groundwater seepage, rich in mineral content, generates minerotrophic conditions. The organics soils are circumneutral (pH 7.0-7.5) mucks overlying clay and sandy gravel. The mucks are saturated to inundated and of variable depth (30-70 cm but >100 cm in places).

This southern wet meadow is floristically diverse and is dominated by graminoids and forbs (Photos 17 and 18). Prevalent species include tussock sedge (*Carex stricta*), lake sedge (*Carex lacustris*), goldenrods (*Solidago* spp.), sensitive fern (*Onoclea sensibilis*), joe-pye-weed (*Eupatorium maculatum*), common boneset (*E. perfoliatum*), and skunk cabbage (*Symplocarpus foetidus*). Other characteristic species include jewelweed (*Impatiens*



Photos 17 and 18. The 42nd Road Seep is a diverse southern wet meadow (Photos by Joshua G. Cohen).

capensis), wood nettle (*Laportea canadensis*), black-eyed Susan (*Rudbeckia hirta*), cut-leaved coneflower (*R. laciniata*), Missouri ironweed (*Vernonia missurica*), and cut grass (*Leersia oryzoides*). Patches of shrub-carr are dominated by willows (*Salix* spp.) and dogwoods (*Cornus* spp.) including gray dogwood (*Cornus foemina*), silky dogwood (*C. amomum*), red-osier dogwood (*C. stolonifera*), Bebb's willow (*Salix bebbiana*), pussy willow (*S. discolor*), and sandbar willow (*S. exigua*). Glossy buckthorn (*Rhamnus frangula*) and multiflora rose (*Rosa multiflora*) locally occur within these patches of shrub-carr. Within the open southern wet meadow are scattered purple loosestrife (*Lythrum salicaria*) and bittersweet nightshade (*Solanum dulcamara*).

This site was formerly classified as a prairie fen. Following the 2008 survey, 42nd Road Seep was re-classified as southern wet meadow based on the site's species composition, landscape context (seepage), and soils (muck over mineral soil). This southern wet meadow was re-mapped to better reflect the current ecological boundaries of this community using recent aerial photographic imagery and GPS and GIS technology.

Threats: The primary threat to this prairie fen is posed by shrub encroachment of non-native invasive species, especially glossy buckthorn and multiflora rose, which both occur within the wetland. In addition, scattered purple loosestrife was observed at low densities. Deer have been using this wetland as indicated by bedding sites and numerous trails and deer herbivory may be impacting the meadow's floristic composition and structure.

Management Recommendations: Resource managers should consider using prescribed fire to maintain open conditions and reduce invasive species and native shrub and tree species. The seasonality of burns should be varied to include growing season and fall burns as well as spring

burns. Historically, southern wet meadow and adjacent uplands most likely burned during drought periods in the late growing season and early fall. Prescribed burning of this wet meadow should be coordinated with the burning of the adjacent uplands. Reduction of invasive species within this site and in the surrounding areas should be implemented through the use of prescribed fire and where necessary, herbicide spot treatment. Clusters of glossy buckthorn should be cut and herbicided. The population of purple loosestrife should be treated through biocontrol, spot herbicide treatment, and/or hand pulling. Reducing invasive species in the surrounding landscape, especially in nearby wetlands, and allowing surrounding early-successional forest to mature will reduce the seed source of invasive species adjacent to this high-quality area. Foot traffic should be minimized and vehicular traffic should be excluded from this drainage. Timber harvest within the surrounding uplands should be avoided to prevent alteration to the groundwater-influenced hydrologic regime. Permanent monitoring plots should be established to allow for assessment of whether management is reducing invasives and native woody species populations and maintaining open conditions. Monitoring deer densities and deer herbivory will allow for the assessment of whether deer herbivory threatens floristic structure and composition.

Discussion: The BC-ranked 42nd Road Seep is one of twenty-one documented high-quality southern wet meadows in Michigan. Within the state there are thirteen southern wet meadow element occurrences that are ranked BC or higher. This southern wet meadow falls within Sub-Subsection VI.2.1 of the regional landscape ecosystems of Michigan hierarchical landscape classification (Albert 1995) (Figure 1). Within the Kalamazoo Interlobate (VI.2) there are seven southern wet meadow element occurrences and within the Battle Creek Outwash Plain (VI.2.1) there are six southern wet meadow element occurrences, five of

FLORISTIC INVENTORY

Introduction

A review of existing ecological, floristic, and land management data was undertaken in preparation for initial surveys. The 1995 Fort Custer report by MNFI (Legge et al. 1995) served as the primary reference and was supplemented by information gathered from local experts such as Tyler Bassett of Native Connections. In addition, information on recent land management activity such as prescribed burns was gathered and was used to target field surveys (DLZ 2005).

Botanical surveys focused on three goals: 1) reconfirming previously documented rare species, 2) documenting new rare species not found in previous studies, and 3) documenting new non-listed species to add to the comprehensive flora of Fort Custer.

Methods

Rare plant species were targeted for survey based on the natural communities determined to be present at Fort Custer and known historical and current rare plant distribution patterns within the region. Rare plant inventories were performed by meander survey of appropriate habitat during periods when the targeted plants were most recognizable (usually flowering or fruiting periods).

Whenever rare species were found, locational information was collected using hand-held GPS units, local abundance was estimated, and habitat quality was evaluated. For new rare species occurrences, a voucher specimen was also collected. Species were collected in a manner that did not significantly reduce the size of the local population or harm the remaining population. In the case of one rare species, red mulberry (*Morus rubra*), only one very small individual was found and a specimen could not have been collected without severely compromising the viability of the plant. For all rare species, MNFI Special Plant Forms were completed and the updated information was added to the MNFI Biotics Database (MNFI 2009).

A copy of a list of plant species previously collected at Fort Custer was carried on all botanical surveys, and when a new non-listed species was encountered, a voucher specimen was collected and preserved in a standard plant press. While in the field, relevant data on the local abundance, natural community type, habitat, and plant associates were also recorded. Labels were prepared, and specimens were verified by Tony Reznicek at the University of Michigan Herbarium (MICH) and added to the herbarium's collection.

Results

Eighteen rare plant species listed as endangered, threatened, or special concern by the state of Michigan have been documented on FCTC lands (Table 1) between 1993 and 2008 (MNFI 2009). This includes two new species that were found during 2008, Virginia flax (*Linum virginianum*) and red mulberry. In 2007, Tyler Bassett collected field dodder (*Cuscuta campestris*), a species previously thought to be potentially extirpated in the state. In addition, Bassett relocated upland boneset (*Eupatorium sessilifolium*), which had been documented from the vicinity of Fort Custer by C.R. Hanes (1947). Two previously documented species, lesser ladies-tresses (*Spiranthes ovalis*) and wahoo (*Euonymus atropurpurea*) were searched for but could not be relocated.

The 18 rare species accounted for 36 element occurrences (EOs). Of these, seven were new occurrences found in 2008, 24 were updates of previously documented records, and five were occurrences that could not be relocated (Tables 1 and 2). The most significant new occurrences were Virginia flax, a species not collected in Michigan since 1938 (Voss 1985) and field dodder (noted above). New occurrences were also found for red mulberry, goldenseal, leadplant, and upland boneset (Table 1 and 2).

Unfortunately, voucher specimens were not collected for all new species found. This was due to a variety of factors including a lack of suitable material for collection, missing collection windows, failure to locate species verbally reported by experts, and miscommunication between field surveyors. We anticipate that by working with partners, vouchers of all species found will be collected over time. The list of new species found and those still needing voucher specimens is presented in Table 2. A complete list of species found at the Fort is available in Appendix 2.

Several changes to the listing status of the rare plants have occurred since the previous MNFI report. Wahoo was added as a special concern species, and two other previously tracked species, Sullivan's black-eyed-Susan (*Rudbeckia sullivantii*) and yellow ladies-tresses (*Spiranthes ochroleuca*) were delisted after it was determined that these species were more common than previously thought. In addition, several species have been upgraded from special concern to threatened, including beaked agrimony (*Agrimonia rostellata*) and showy orchis (*Galearis spectabilis*), and prairie dropseed (*Sporobolus heterolepis*) has been downgraded from threatened to special concern.

Table 1. Rare plant species known to occur at Fort Custer Training Center.

Scientific Name	Common Name	Global Rank	State Rank	State Status	EO Updates	New EOs	EOs Not Located**
<i>Agrimonia rostellata</i>	beaked agrimony	G5	S1S2	T	2		
<i>Amorpha canescens</i>	leadplant	G5	S3	SC	1	1	
<i>Berula erecta</i>	cut-leaved water parsnip	G4G5	S2	T	4		
<i>Castanea dentata</i>	American chestnut	G4	S1S2	E	1		
<i>Corydalis flavula</i>	yellow fumewort	G5	S2	T	6		
<i>Cuscuta campestris</i>	field dodder	G5T5	S1*	SC		1	
<i>Euonymus atropurpurea</i>	wahoo	G5	S3	SC			1
<i>Eupatorium sessilifolium</i>	upland boneset	G5	S1	T		1	
<i>Filipendula rubra</i>	Queen-of-the-prairie	G4G5	S2	T	1		1
<i>Galearis spectabilis</i>	showy orchis	G5	S2	T	1		1
<i>Gentianella quinquefolia</i>	stiff gentian	G5	S2	T	2		
<i>Hydrastis canadensis</i>	goldenseal	G4	S2	T	1	2	
<i>Linum virginianum</i>	Virginia flax	G4G5	S2	T		1	
<i>Liparis lilifolia</i>	purple twayblade	G5	S3	SC	2		1
<i>Morus rubra</i>	red mulberry	G5	S2	T		1	
<i>Panax quinquefolius</i>	ginseng	G4	S2S3	T	1		
<i>Spiranthes ovalis</i>	lesser ladies-tresses	G5	S1	T			1
<i>Sporobolus heterolepis</i>	prairie dropseed	G5	S3	SC	1		
Total					24	7	5

* Prior to this survey the species was listed as SH

** Efforts to relocate these known element occurrences were unsuccessful

Discussion

General

The 31 new species that were found bring the total known flora for Fort Custer to 835 species. Most of these species can be placed in at least one of three general categories: species that are expanding as a result of ongoing management, species that may have been overlooked, and non-native species that may have established at the Fort since the last survey. The majority of the new species appear to be those that benefit from ongoing management, such as prescribed burning. Despite not being collected during previous extensive surveys, several of these species such as porcupine grass (*Stipa avenacea*), sky-blue aster (*Aster oolentangiensis*), and northern blazing star (*Liatris scariosa*) are locally common in areas managed with fire. It is likely that they were previously present in small numbers or in a vegetative state and difficult to find. In addition, many species also were discovered by seeking out species in particular types of habitat, such as prairie fens, in which the following four new species were found: slender wheat grass (*Agropyron repens*), a sedge (*Carex cryptolepis*), green-keeled cotton grass (*Eriophorum viridicarinatum*), and balsam ragwort (*Senecio pauperculus*). In addition, small but highly unique habitats were likely overlooked previously, such as the small intermittent wetland southwest of the intersection of Territorial Road

and Longman Road where the following three new species were found: puccinellia grass (*Puccinellia pallida*), lance-leaved violet (*Viola lanceolata*), and smooth white violet (*Viola macloskeyi*). Finally, four new species were non-native, including Norway maple (*Acer platanoides*), black alder (*Alnus glutinosa*), a sedge (*Carex spicata*), and storksbill (*Erodium cicutarium*). Of these, Norway maple and black alder are highly invasive, and should be removed immediately. Norway maple was found along a treeline just south of a newly constructed training facility in the northeast portion of Area 3. Black alder was found in an open portion of Mott Road Fen south in area 5. Only single individuals were found of each species, but managers should remain vigilant for additional individuals and remove them before they become widely established.

The finding of new species was greatly aided by noting potential gaps in the previous list (Legge et al. 1995), and targeting surveys for additional species during their blooming periods in unique habitats. In addition, we benefited greatly from individuals like Tyler Bassett of Native Connections who had spent extensive time at the Fort in previous years, and had noted potentially new species during his field work.

It is highly likely that additional species will continue to be found. The area is extensive, and it was impossible to

Table 2. New plant species found at Fort Custer Training Center in 2007-2008. Non-native species are bolded.

Scientific name	Common name	Status	Vouchered?
<i>Acer platanoides</i>	Norway maple		Yes
<i>Agropyron trachycaulum</i>	slender wheat grass		Yes
<i>Aletris farinosa</i>	colic root		No
<i>Alnus glutinosa</i>	black alder		Yes
<i>Aster oolentangiensis (A. azureus)</i>	prairie heart-leaved aster		Yes
<i>Aureolaria pedicularia</i>	annual false foxglove		No
<i>Carex aggregata</i>	sedge		No
<i>Carex cryptolepis</i>	sedge		Yes
<i>Carex frankii</i>	sedge		Yes
<i>Carex spicata</i>	sedge		No
<i>Cuscuta campestris</i>	field dodder	SC	Yes
<i>Deschampsia flexuosa</i>	hair grass		Yes
<i>Desmodium sessilifolium</i>	sessile-leaved tick-trefoil		Yes
<i>Eriophorum viridi-carinatum</i>	green-keeled cotton-grass		Yes
<i>Erodium cicutarium</i>	storksbill; alfileria		Yes
<i>Eupatorium sessilifolium</i>	upland boneset	T	Yes
<i>Frasera caroliniensis (Swertia c.)</i>	American columbo		No
<i>Heuchera americana</i>	alum root		Yes
<i>Juncus torreyi</i>	Torrey's rush		No
<i>Liatris scariosa (L. novae-angliae)</i>	northern blazing star		Yes
<i>Linum virginianum</i>	Virginia flax	T	Yes
<i>Lysimachia lanceolata</i>	lance-leaved loosestrife		Yes
<i>Morus rubra</i>	red mulberry	T	No
<i>Panicum dichotomum</i>	panic grass		Yes
<i>Puccinellia pallida</i>	Puccinellia		Yes
<i>Senecio pauperculus</i>	balsam ragwort		Yes
<i>Solidago ulmifolia</i>	elm-leaved goldenrod		No
<i>Stipa avenacea</i>	black oatgrass		Yes
<i>Tephrosia virginiana</i>	goat's-rue		No
<i>Viola lanceolata</i>	lance-leaved violet		Yes
<i>Viola macloskeyi (V. pallens)</i>	smooth white violet		Yes

search all large habitat blocks in all seasons thoroughly. In addition, ongoing management may bring out new species from the seedbank or allow small populations to expand, increasing their likelihood of being found. An additional 50 species have been reported by the consultant firm DLZ and are potentially new, but need confirmation and voucher specimens collected. It is very likely that the total flora of the Fort could exceed 900 species, over one-third of all the species known in Michigan.

Listed Plants

The 18 listed plants documented at Fort Custer (Table 1) are a testament to the habitat quality and extensive ongoing management at the Training Center. For many species, Fort Custer contains the best populations in Kalamazoo and Calhoun Counties, and for a handful of species, it contains the best populations in the entire state. In particular, populations of beaked agrimony (*Agrimonia rostellata*),

yellow fumewort (*Corydalis flavula*), stiff gentian (*Gentianella quinquefolia*), and Virginia flax (*Linum virginianum*) reach their greatest abundance and long-term viability at Fort Custer out of all populations known statewide. In addition, FCTC contains the only known extant population in the state of field dodder (*Cuscuta campestris*). The extensive habitat and permanent protection offered by the Training Center makes Fort Custer a unique opportunity for significant conservation for many of these species.

Many species have expanded due to ongoing management, such as prescribed burning. This includes species like leadplant (*Amorpha canescens*), which was noted in small numbers before, but is evidently rapidly increasing in abundance and distribution following several years of prescribed fire. Other species that appear to be benefiting from prescribed burns include those found in dry-mesic southern forest, oak barrens, and prairies fen, such as



Photo 19. Beaked agrimony (*Agrimonia rostellata*)
(Photo by Ryan P. O'Connor).

upland boneset (*Eupatorium sessilifolium*), cut-leaved water parsnip (*Berula erecta*), Virginia flax, purple twayblade (*Liparis lilifolia*), prairie dropseed (*Sporobolus heterolepis*), and queen-of-the-prairie (*Filipendula rubra*). Queen-of-the-prairie has also greatly benefited from the removal of glossy buckthorn, which was threatening to take over the only portion of Whitman Lake Fen where this rare plant was found. Other more mesic species may have been adversely impacted by prescribed burns. Rare shrubs and small trees like red mulberry and wahoo can be top-killed by burns, and resprouts are more susceptible to deer browse. Other rich mesic species like showy orchis flourish in sites with thick mats of leaf litter and a mature forest canopy, and shallow root systems may be highly sensitive to heat damage and desiccation. While mesic sites and streams likely served as natural burn breaks historically, and can continue to be used as such, they should not be burned intentionally.

Finally, a handful of species appear to be in decline or of uncertain status. The only chestnut found in 1994 was relocated but the tree was dead. In addition, lesser ladies-tresses was only found once, in 1993, and has not been found since, despite numerous searches. It may still be present, and should continue to be sought. Lastly, a species of dodder (*Cuscuta pentagona*) was last collected in 1945 by Clarence and Florence Hanes (Hanes 1947). This plant

belongs to a group of species that are difficult to tell apart. A recent collection by Tyler Bassett from the vicinity of Hanes' record in the northern portion of the Impact Area was determined to be field dodder (*Cuscuta campestris*) (J. McNeal, University of Georgia, personal communication 2008). The status of *C. pentagona* remains uncertain. It is possible that both species occur, at least historically, or is possible that the original *C. pentagona* specimen was misidentified, and only *C. campestris* occurs at FCTC. This matter deserves additional study in consultation with botanical experts at herbaria at the University of Michigan, Western Michigan University, and the University of Georgia. In addition, the collection site should continue to be searched during the appropriate time of year to better document the species of dodder that are present.

In the following section, for each of the 18 listed plant species found at FCTC, a brief discussion is provided that includes information on the distribution of the species within the Fort, the conservation significance of the occurrence, and species-specific management recommendations

Agrimonia rostellata

(beaked agrimony, G5 S1S2, state threatened)

FCTC Distribution: Two occurrences of beaked agrimony were reconfirmed at FCTC, both of which were in relatively mature and rich dry-mesic woods (Photo 19). One of these occurrences was on the west side of Little Hart's Lake, the other in the south portion of Area 5, where it was found scattered in the Whitman Lake Woods dry-mesic southern forest in an area where the forest surrounds a series of depressional wetlands dominated by southern shrub-carrs.

Significance: The two occurrences at FCTC occur in relatively high-quality habitat and represent two of the best occurrences for the species in the state.

Management Recommendations: This species is likely vulnerable to canopy removal and protection of its habitat is essential. Invasive species are also a major concern for this species, in particular non-native shrubs such as Japanese barberry and multiflora rose could outcompete this species. Prescribed burns at the Whitman Lake Woods dry-mesic southern forest appear to have had a very beneficial impact, while those at Hart Lake have been less effective at reducing invasive shrubs. In addition, garlic mustard is a major concern, and a few scattered rosettes were found at the Whitman Lake Woods site on the crest of a hill just west of the road. Garlic mustard control should be a top priority at this site due to the presence of beaked agrimony and many other unique and conservative species that occur there.

Amorpha canescens

(leadplant, G5 S3, state special concern)

FCTC Distribution: Two occurrences of leadplant were found, both in the Impact Area north of Territorial Road. The first was just east of an area used for exercises such as tear gas training within recovering oak barrens. Many new colonies were added to this existing occurrence, which appears to be benefiting greatly from prescribed burn management. The second site was a new occurrence, and is located immediately south of the ranges east of Armstrong Road, on the edge of an open area. At both sites, flowering and fruiting plants were restricted to open areas receiving sufficient light, while many vegetative plants were found in the adjacent black oak-dominated dry southern forests.

Significance: Although a large number of records exist in southern Michigan for leadplant, very few are being actively managed and occur in such a large intact landscape as Fort Custer. This highly conservative species is an excellent indicator of the improving habitat quality of oak barrens at the Fort.

Management Recommendations: As with most legumes, leadplant responds very positively to fire, regardless of the seasonality of the burn. It also requires at least a moderately open canopy, and appears to be most abundant in areas with widely scattered trees forming open oak barrens. Prescribed burn management at both sites appears to be greatly benefiting the leadplant populations. However, the timing of the burns being conducted in early spring also appears to be stimulating intense sprouting of woody species like sassafras and shining sumac. These clonal species could easily take over openings if left unmanaged, which would be detrimental to leadplant and other flora and fauna of prairies and savannas. For further discussion on the seasonality of burns, please refer to General Management Section.

Berula erecta

(cut-leaved water-parsnip, G4G5 S2, state threatened)

FCTC Distribution: Four occurrences of cut-leaved water parsnip were documented at FCTC, all in streams or small seeps associated with southern wet meadow and prairie fen. One particularly significant metapopulation is associated with the Cemetery Complex Seeps southern hardwood swamp (Photo 20) and adjacent wet meadows in Area 4, where it was found both in seeps surrounding beaver ponds at the extreme headwaters of the site, as well as in the main stream channels that run through the upper portion of the southern hardwood swamp. Other sites include the several small colonies found along the margins of lakes, streams, and southern wet meadow in Area 7 and northeast corner of Area 4 and a small population in the southern portion of

the Mott Road prairie fen in Area 5. The occurrence in the Whitman Lake Fen was also relocated, and was primarily found in the southern portion of the site in tiny rivulets and seeps feeding the wetland.

Significance: Although several dozen occurrences for cut-leaved water parsnip exist in southwest Michigan, the Cemetery Complex Seeps population is relatively large. Due to the numerous colonies present both above and below active beaver dams, as well as in the main channel of the stream, the site represents an opportunity to study the ecology of this species and the impact beaver and forest canopy have on populations.

Management Recommendations: Cut-leaved water-parsnip is vulnerable to changes in hydrology and possibly to changes in canopy conditions. Invasive species are also a concern, and glossy buckthorn found in and around the beaver ponds near the source of the Cemetery Complex Seeps, as well as in areas in Whitman Lake Fen should be a high priority for control. In addition, narrow-leaved cat-tail is rapidly taking over areas of Whitman Lake Fen. Although currently limited in extent, especially along the northeastern shore, this species is highly aggressive, forms monotypic stands, and invades high-quality marl seeps, the primary habitat for cut-leaved water parsnip. In addition, narrow-leaved cat-tail is stimulated by fire. Thus, prescribed burns in areas containing narrow-leaved cat-tail should be postponed until adequate control can be enacted. Foliar application of herbicides using a wick applicator have been used by other conservation organizations to control narrow-leaved cat-tail (Steve Woods, The Nature Conservancy, personal communication 2008).

Castanea dentata

(American chestnut, G4 S1S2, state endangered)

FCTC Distribution: A single American chestnut was found during the 1994 survey along Territorial Road, just under a mile west of Longman Road in Area 7. It was described as being just a few feet south of the road. The tree was relocated but was dead, likely having finally succumbed to chestnut blight. No sprouts were present at the base of the tree, and despite extensive surveys, no additional live trees or saplings were found.

Significance: Although chestnut was never common in Michigan, the chestnut blight has decimated this species in Michigan and very few live specimens remain. This was the only occurrence for chestnut in Kalamazoo County, but several other occurrences are known in southwest Michigan.

Management recommendations: The previous documentation of a mature chestnut suggests that Fort

Custer once supported at least a small population of this species, although the tree may have been planted by early settlers. The combination of extensive habitat restoration and relatively intact landscape at the Fort may present a unique opportunity to plant blight-resistance chestnut at this site or other sites with similar soils. Any efforts to replant chestnut should be accompanied by regular monitoring and careful habitat management.

Corydalis flavula

(yellow fumewort, G5 S2, state threatened)

FCTC distribution: Significant populations of this species occur at FCTC and are represented by six element occurrence records. These include the northeast corner of Area 2, the northeast corner of Area 1, southwest of the intersection of Longman Road and Territorial Road on the border with Fort Custer Recreation Area, along Augusta-Climax Road southeast of Territorial Road as well as southwest of Mott Road in Areas 7 and 4, south of Reese Road in the Impact Area, and northeast of the intersection of Armstrong Road and Territorial Road in the Impact Area.

Significance: The FCTC populations of yellow fumewort represent a significant portion of its stronghold in Michigan; the Fort contains nearly half of the occurrences in the state. Additional populations of this species are likely present in the area.

Management Recommendations: Many sites occupied by this species are dominated by black locust (*Robinia pseudoacacia*), a tree considered invasive in Michigan. Garlic mustard and invasive shrubs are also abundant near many colonies. Fort Custer has stated three management goals for these sites: controlling invasive species, maintaining or improving populations of yellow fumewort, and restoring habitat towards oak openings where



Photo 20. Stream within Cemetery Complex Seeps (Photo by Ryan P. O'Connor).

appropriate. The sequence and timing of management activities will be critical in accomplishing these goals.

We recommend conducting management in the following order:

- 1) Remove garlic mustard** by hand-pulling in the areas occupied by *Corydalis*, and by using a foliar herbicide outside of occupied areas. Herbicide applications should be conducted in late fall or early spring, targeting garlic mustard rosettes while most other plants are dormant. Because *Corydalis* is a winter annual (plants germinate from seed in the fall, overwinter as a green rosette, and flower the following spring) it is also susceptible to herbicide in fall and spring and it is therefore critical to avoid using foliar herbicides where it occurs. Controlling garlic mustard will likely take several years, but is critical before removing the canopy and exposing the site to more light. Annual monitoring and continued pulling of plants that emerge from the seed bank should also be conducted. Concurrently, invasive shrubs should be controlled by cutting stems and treating the stumps with a concentrated herbicide.
- 2) Remove black locust** after garlic mustard is adequately controlled. “Drill-and-fill” is a low-impact technique used by some conservation organizations to control black locust. This highly effective technique involves drilling a number of holes at a downward angle into the trunk of the tree, and filling the holes with a concentrated herbicide (Steve Woods, The Nature Conservancy, personal communication). It is crucial to treat all stems in a given clone to avoid resprouting. Girdling or cutting trees and treating stumps with herbicides is often less effective and induces sprouting from the clonal root system. After black locust has died, standing stems can either be left in place or removed. Preferably, removal should be conducted in the winter when the ground is frozen and snow-covered to minimize soil disturbance.
- 3) Allow desirable native tree species to recolonize the site.** In some locations, native trees may already be present in the understory, while at other sites, planting may be necessary. If a site is dominated exclusively by black locust, underplanting of native species should take place prior to removal of black locust if possible. This will provide at least some canopy cover to *Corydalis* after the locust is removed. Finally, it should be noted that while restoration of sites to an oak openings natural community is a noteworthy

goal, management should be approached on a site by site basis, with the recognition that it may not be appropriate or feasible at all sites. An overstory of native hardwood species would also provide appropriate cover and habitat for *Corydalis*. Ultimately, restoration of oak openings may be more easily achieved at sites elsewhere at the Fort with fewer complicating factors.

Cuscuta campestris

(field dodder, G5 SH, state special concern)

FCTC Distribution: Field dodder was collected by Tyler Bassett in late summer 2007 in the northern portion of the Impact Area. The area was searched extensively in 2008, but no plants were found. As an annual, this species may not occur every year, and the lack of additional plants in 2008 should not be interpreted as the species no longer being present.

Significance: Previously thought to be possibly extirpated, this occurrence is the only known extant population in the state for field dodder, and thus is highly significant. Three other occurrences for field dodder are historically known from the state. Two were last observed in 1937 in Kalamazoo and St. Joseph Counties, and one was last observed in 1973 in Berrien County.

Management recommendations: Field dodder likely requires open, sandy habitat for survival. As a parasitic annual, it is dependent both on appropriate environmental conditions for germination, as well as other host plants. However, little is known about these specific requirements. In general, the area should be managed in the context of the remnant natural communities present, and should include periodic use of prescribed fire and, if necessary, additional control of woody shrubs and trees invading existing openings.

Euonymus atropurpurea

(wahoo, G5 S3, state special concern)

FCTC Distribution: Wahoo was found during the 1994 MNFI survey of Fort Custer in the Cemetery Complex Seeps southern hardwood swamp near a stream in Area 4 (Photo 20), but at the time, the species was not tracked. It was added to the list as a special concern species in 1999. Despite efforts to relocate the species, it was not found during this study. There is excellent potential for wahoo to persist, and future surveys should continue to target the species.

Significance: This is the 20th occurrence of this species in the state, and the only one currently known from Kalamazoo County. Most other occurrences are known

from southeast Michigan, making this a significant site for this rare species.

Management recommendations: Maintaining a mature forest canopy and stream hydrology is likely important for this species of mature floodplain forests. Fires were likely an infrequent part of the disturbance regime in floodplain forest habitat, and would likely top-kill wahoo shrubs. It is recommended that the rich, streamside sites should not be intentionally burned on a regular basis. However, streams and mesic sites that border drier upland habitat likely would have functioned as natural fire breaks historically and it would be appropriate to continue to use these features as such for landscape-level prescribed burns.

Eupatorium sessilifolium

(Upland boneset, G5 S1, state threatened)

FCTC Distribution: A new occurrence of this species was found by Tyler Bassett in 2007 and is comprised of two primary colonies. The larger colony consisted of hundreds of plants and was located on a ridge in a dry-mesic southern forest just east of Longman Road north of the intersection with Mott Road on the fringe of the Impact Area. The second smaller colony was located just south of a trail in an opening along a ridge on the west side of Whitman Lake Fen.

Significance: This represents the 11th occurrence of upland boneset in Michigan, and only the 2nd in Kalamazoo County. The only other record in the county has not been documented since 1947, making the Fort Custer site highly significant.

Management recommendations: Upland boneset is associated with dry-mesic southern forests with a partially open canopy. Prescribed burn management appears to be very beneficial for this species, which dramatically increased in abundance following the 2008 prescribed burn based on anecdotal observations. Continued management of invasive species like garlic mustard and multiflora rose will be important for conservation of this species. In addition, a stand of tree-of-heaven (*Ailanthus altissima*) occurs near the second colony, and should be aggressively controlled. Tree-of-heaven can be successfully controlled with herbicides by conducting basal bark application of triclopyr (Garlon 4) mixed with bark-penetrating oil (Swearingen and Pannill 2005). This method is most successful during early spring (February or March), but the ground must be free of snow, and the method works best on stems less than 6 inches in diameter. Control of larger stems can be achieved with the “hack and squirt” method, in which a hand-ax is used to make downward-angled cuts in the tree and the wound is filled with a highly concentrated water soluble herbicide such as Garlon 3A (Swearingen and Pannill 2005). Other techniques such as cut-stump

treatment and girdling have been shown to be ineffective because they stimulate aggressive sprouting.

Filipendula rubra

(queen-of-the-prairie, G4G5 S2, state threatened)

FCTC Distribution: Two occurrences of this species were previously documented at Fort Custer in prairie fens, but only one was relocated during this study. The population in Whitman Lake Fen near the dam in the Impact Area was reconfirmed and although concentrated in a relatively small area, it appeared vigorous. The other occurrence had previously been reported in a wetland south of Territorial Road in Area 7. The wetland was altered and the water level raised since the previous MNFI study, likely to the detriment of queen-of-the-prairie, which is thought to be sensitive to hydrologic changes. The species was not seen at the Territorial Road site despite several extensive searches.

Significance: Only 19 occurrences of queen-of-the-prairie are currently known in Michigan, with two-thirds found in Kalamazoo and Calhoun Counties. Like most colonies in the state, the Whitman Lake Fen population is limited in extent, but because it occurs in a high-quality fen in a largely intact landscape, it represents a unique opportunity for active protection and management of the species.

Management Recommendations: In Michigan, queen-of-the-prairie occurs exclusively in prairie fens and it requires adequate open conditions for flowering and fruiting. The Whitman Lake Fen population had been threatened by an infestation of glossy buckthorn, but the buckthorn was in the process of being removed during this study. Continued monitoring and removal of invasive species like buckthorn as well as narrow-leaved cat-tail should remain a priority at the site. Maintenance of hydrology is also important for the viability of queen-of-the-prairie, and prescribed burns will also benefit this clonal species. However, as noted above, prescribed burns in areas containing narrow-leaved cat-tail should be postponed until adequate control of cat-tail through herbicide treatment can be enacted.

Galearis spectabilis

(showy orchis, G5 S2, state threatened)

FCTC distribution: Two occurrences of showy orchis were documented at FCTC. One was relocated in sloping habitat and along steep mesic ravines in the Cemetery Complex Ridge dry-mesic southern forest in Area 4. The second colony occurs on level topography of a rich mesic forest just east of the Mott Road Fen in Area 7. This occurrence was not relocated in 2008 despite several searches, but it is very likely that it still persists given the high-quality habitat and variable nature of orchid flowering.

Significance: Although numerous occurrences for this species have been documented within the state, many are on the decline and the Cemetery Complex Ridge population at Fort Custer is robust and healthy, and presents an opportunity for active protection.

Management Recommendations: Maintenance of hydrology and maturity of its woodland habitat are likely important. Prescribed burns in mesic areas may be very detrimental to showy orchis, which flowers early in the spring and is likely susceptible to heat damage to leaves and shallow corms. It is recommended that mesic sites should not be intentionally burned on a regular basis. However, streams and mesic sites that border drier upland habitat likely would have functioned as natural fire breaks historically and it would be appropriate to continue to use these features as such for landscape-level prescribed burns.

Gentianella quinquefolia

(stiff gentian, G5 S1, state threatened)

FCTC Distribution: Two populations of stiff gentian (Photo 21) were reconfirmed at FCTC. Both of these populations occurred in relatively open sites with moist soils. One occurrence was located in Area 7 in the Mott Road mesic sand prairie, just north of the road. Additional colonies were previously found in a small opening in southern hardwood swamp near a streamlet that feeds into the nearby Mott Road Fen. The second occurrence was found in Area 4 in the Cemetery Complex Seeps, both near the top of the seeps in an early-successional forest just upland from the main branch of the stream and in a moist open meadow near the bottom of the seeps.

Significance: Although 17 occurrences of stiff gentian have been documented for Michigan, nearly half are historical collections dating back to the 1920s or before. The populations at Fort Custer are moderately large, consisting of several hundred individuals each, and are significant in that they present an excellent opportunity for conservation at a landscape scale.

Management Recommendations: Stiff gentian appears to prefer relatively open sites with a water table close to the surface, though little is known about its exact habitat requirements. Protection of hydrology is likely critical and maintaining sufficiently open light conditions may be important. In addition, control of invasive species will also help stiff gentian. The effect of encroaching overstory is unclear, but it may have a negative effect on the long-term viability of populations by reducing flowering and seedset. The FCTC populations present an opportunity for more in-depth study of this species. In particular, the relative importance of hydrology and the effect of canopy closure on flowering rate should be examined.



Photo 21. Stiff gentian (*Gentianella quinquefolia*) (Photo by Ryan P. O'Connor).

Hydrastis canadensis

(goldenseal, G4 S2, state threatened)

FCTC Distribution: One large occurrence of goldenseal was reconfirmed at Fort Custer, and two new smaller occurrences were also documented. The occurrence in Area 4 in the Cemetery Complex Seeps southern hardwood swamp and Cemetery Complex Ridge dry-mesic southern forest is very large, consisting of numerous colonies making up a large metapopulation of several thousand stems. The species is abundant along the stream banks near the head of the seeps and is found in exceptionally high-quality habitat. A new occurrence was found in Area 3, alongside a small headwater stream that feeds the 42nd Road Seeps southern wet meadow. A new occurrence was also found in Area 5 in a mesic forest just south of the southern portion of the Mott Road Fen.

Significance: The occurrence in the Cemetery Complex Seeps and Cemetery Complex Ridge likely represents one of the largest known extant populations in the state and should be actively protected and managed.

Management Recommendations: Goldenseal is most commonly found in rich, deeply shaded, mesic forests, and often occurs in high moisture regime microhabitats along streams and floodplains. Protection of the hydrology and

forest habitat, as well as protection from exploitation, is critical for the survival of this species. Much of its decline in the state and elsewhere in its range is attributed to the harvesting of the species for its knotty rhizome, considered to have medicinal value. Although prescribed burns do not appear to be detrimental to this clonal species, fires were likely a minor component of the natural disturbance regime in its floodplain forest and southern hardwood swamp habitat. Therefore, it is recommended that the rich, streamside sites should not be intentionally burned on a regular basis. However, streams and mesic sites that border drier upland habitat likely would have functioned as natural fire breaks historically and it would be appropriate to continue to use these features as such for landscape-level prescribed burns. Invasive species at goldenseal sites should be controlled and monitored. In particular, one large common buckthorn was found in an area near the head of the Cemetery Complex Seeps, and multiflora rose was common near the colony in Area 3.

Linum virginianum

(Virginia flax, G4G5 S2, state threatened)

FCTC Distribution: A new occurrence of Virginia flax (Photo 22) was found in a narrow band of dry-mesic southern forest on a west-facing slope above the Territorial Road Fen in the Impact Area. Only 19 plants were found, but there is excellent potential for additional colonies to be found.

Significance: This find is highly significant since it is the first collection of this state-threatened species since 1938 (Voss 1985). In addition, it is one of three new rare species found at Fort Custer during this survey. As one of the only recently verified populations of Virginia flax in the state, it should be a very high conservation priority.

Management recommendations: The exact habitat and management requirements for this species are unknown, but it is usually found in dry woods and hillsides, often near lakes or streams. Historically, these sites would have been dominated by oaks and would have experienced periodic fires, likely creating a semi-open oak woodland. The occurrence at Fort Custer has likely benefited from recent prescribed burns. However, these burns have also stimulated a nearby black locust clone that is threatening to expand and take over the occurrence. The site should be carefully assessed, and a plan developed to control the black locust while protecting the Virginia flax (Photo 23).

Liparis liliifolia

(purple twayblade, G5 S3, state special concern)

FCTC Distribution: Purple twayblade was found scattered widely throughout FCTC, mostly in small numbers. The



Photo 22. Virginia flax (*Linum virginianum*)
(Photo by Ryan P. O'Connor).

individual populations have been collapsed into three separate occurrences based upon proximity. These include a single population in Area 1, four populations near Sand Trail, and four populations in the central part of the training area in Areas 4, 5, and 7. Most of the populations were found in disturbed dry-mesic southern forest habitat.

Significance: Although nearly 25 occurrences of purple twayblade have been documented in the state, there are few that occur as metapopulations with numerous smaller colonies across a large, relatively intact landscape. As with other species, purple twayblade could be conserved at a landscape scale at Fort Custer.

Management: Purple twayblade primarily occurs in dry to dry-mesic early-successional communities with partial canopy cover. It likely benefits from management such as prescribed burning. Invasive shrubs apparently have little impact on this species, but they should still be controlled as part of an overall restoration strategy.

Morus rubra

(red mulberry, G5 S2, state threatened)

FCTC Distribution: A new occurrence of red mulberry was found in the Cemetery Complex Seeps southern

hardwood swamp in Area 4, in a mesic to wet-mesic area with moderate canopy cover. Typically a species of floodplain forests, only a single specimen was found in an area between two branches of the stream, resprouting after apparently being top-killed by a prescribed burn.

Significance: Of the 28 occurrences of red mulberry that have been found in Michigan, all are in southern Lower Michigan, and this represents only the second occurrence in Kalamazoo County. Because only a single young tree was found (less than 10 years old), it is extremely probable that additional trees are located in the vicinity. However, this species is rarely found in large colonies, and more often has been documented as widely scattered single mature individuals. A collection of this species was not made because young sprouts are often not representative of mature trees, and collection would have threatened the viability of the individual. It is highly recommended that a voucher specimen be collected when the sprout matures into a sapling.

Management Recommendations: The only plant found was an individual that was resprouting after having been top-killed by a prescribed burn in the spring of 2008. Fires were likely an infrequent component of the natural disturbance regime in this species floodplain forest and southern hardwood swamp habitat. Therefore, it is recommended that the rich, streamside sites should not be intentionally burned on a regular basis. However, streams and mesic sites that border drier upland habitat likely would have functioned as natural fire breaks historically and it would be appropriate to continue to use these features as such for landscape-level prescribed burns. Invasive species in the Cemetery Complex Seeps should be controlled using other methods. In particular, one large common buckthorn was found in an area near the head of the Cemetery



Photo 23. Virginia flax (*Linum virginianum*) occurs in a semi-open dry-mesic southern forest that is being encroached on by the invasive tree black locust (upper right of photo) (Photo by Ryan P. O'Connor).

Complex Seeps, and should be removed and the area monitored for other encroaching invasive species.

Panax quinquefolius

(ginseng, G4 S2S3, state threatened)

FCTC Distribution: One occurrence of ginseng was documented in the Cemetery Complex Ridge dry-mesic southern forest overlooking the Cemetery Complex Seeps southern hardwood swamp in Area 4. Although the population was not extensive, it appeared to be persisting well.

Significance: The ginseng population at Fort Custer is relatively small, but occurs in an intact landscape. By virtue of being protected at the Fort, it also represents an excellent opportunity for conservation of a species that is frequently poached for the medicinal value of its root.

Management Recommendations: The primary management needs of ginseng are protection from poaching, maintenance of the forest canopy, and monitoring and removal of invasive species. It is recommended that mesic sites should not be intentionally burned on a regular basis. However, streams and mesic sites that border drier upland habitat likely would have functioned as natural fire breaks historically and it would be appropriate to continue to use these features as such for landscape-level prescribed burns.

Spiranthes ovalis

(lesser ladies'-tresses, G5 S1, state threatened)

FCTC Distribution: One occurrence of this orchid was documented at FCTC in September of 1993. It was discovered approximately 25 feet from the northern

shoreline of a small pond in the northwest corner of Area 4 and consisted of only six plants. It was not relocated in 1994 or in 2008.

Significance: This is one of only four occurrences of the species in Michigan.

Management Recommendations: Attempts to reconfirm the FCTC population should be made in future years and a suitable well buffered area should be designated off-limits surrounding the site of the original collection. If found, management of invasive plants would also be a high priority.

Sporobolus heterolepis

(prairie dropseed, G5 S3, state special concern)

FCTC Distribution: One occurrence of prairie dropseed was reconfirmed at FCTC in the Whitman Lake Fen in the Impact Area. Additional new colonies were also found in the Territorial Road Fen and added to the existing occurrence.

Significance: Although 28 occurrences for prairie dropseed are currently known in Michigan, few occur in such a large intact landscape. The Whitman Lake Fen population presents a unique opportunity for active protection, study, and monitoring due to its location in a restricted access area.

Management Recommendations: In southern Michigan, prairie dropseed primarily occurs in open high-quality prairie fens, often on large peat domes. The species should be managed within the context of Whitman Lake Fen and Territorial Road Fen and will benefit from invasive species control, woody shrub removal, and periodic fire.

ANIMAL SURVEYS

Introduction

There have been numerous faunal surveys at FCTC (see general introduction) and 14 rare animal species listed as endangered, threatened, or special concern by the state of Michigan have been documented (Table 3) between 1993 and 2008 (Legge et al. 1995, MNFI 2009). The objective of this survey was to target species that have previously been omitted from survey efforts or to survey additional sites which may contain rare animal species. These included;

- Butterflies – Karner blue (*Lycaeides melissa samuelis*, federal endangered and state threatened),

frosted elfin (*Incisalia iris*, state threatened), and persius duskywing (*Erynnis persius persius*, state threatened)

- Moths – blazing star borer moth (*Papaipema beeriana*, state special concern) and Culver's root borer moth (*P. sciata*, state special concern)
- Leafhoppers – state special concern leafhopper species *Flexamia delongi* and *F. reflexus*
- Spittlebugs – Great Plains spittlebug (*Lepyronia gibbosa*, state threatened) and red-legged spittlebug (*Prosapia ignipectus*, state threatened)

Table 3. Rare animal species known to occur at Fort Custer Training Center.

Scientific Name	Common Name	Global Rank	State Rank	State Status
<i>Microtus ochrogaster</i>	Prairie vole	G5	S1	E
<i>Cygnus buccinator</i>	Trumpeter swan	G4	S3	T
<i>Accipiter cooperii</i>	Cooper's hawk	G5	S3S4	SC
<i>Circus cyaneus</i>	Northern harrier	G5	S3	SC
<i>Dendroica cerulea</i>	Cerulean warbler	G4	S3	SC
<i>Wilsonia citrina</i>	Hooded warbler	G5	S3	SC
<i>Emys blandingii</i>	Blanding's turtle	G4	S3	SC
<i>Terrapene carolina carolina</i>	Eastern box turtle	G5T5	S2S3	SC
<i>Acris crepitans blanchardi</i>	Blanchard's cricket frog	G5T5	S2S3	SC
<i>Notropis anogenus</i>	Pugnose shiner	G3	S3	SC
<i>Flexamia delongi*</i>	Leaf hopper	GNR	S1S2	SC
<i>Flexamia reflexus*</i>	Leaf hopper	GNR	S1	SC
<i>Pygarctia spraguei</i>	Sprague's pygarctia	G5	S2S3	SC
<i>Fontigens nickliniana</i>	Watercress snail	G5	SU	SC

* Efforts to relocate these known element occurrences were unsuccessful although suitable habitat still exists at the site.

Methods

Rare animal species were targeted for survey based on the natural communities determined to be present at Fort Custer and known historical and current rare animal distributions within the region. Rare animal inventories were performed in appropriate habitat during periods when the targeted animals were most active (or when adults would be expected to occur).

Butterflies

We searched several known lupine patches in the Impact Zone and Range 4 for associated lepidopteran species including Karner blue butterfly, frosted elfin, and persius duskywing (Figure 10). Surveys were conducted by thoroughly searching lupine patches for butterflies during appropriate flight periods. All butterfly species encountered during the search were recorded and habitat was evaluated for the target species.

Moths

Blacklighting consisted of a standard mercury-vapor and UV lights powered by a portable generator. A 2 x 2 meter metal conduit frame supporting a large white sheet was used as a collecting surface. This frame was placed in the field in a central location with larval host plants on all sides to maximize the likelihood of collecting *Papaipema* adults. These locations were recorded using a hand-held GPS unit and *Papaipema* moth survey forms were completed. Blacklighting occurred at two sites within FCTC. The first site was located in Area 2 in a degraded barrens/prairie site which contained a large population of blazing star (*Liatris aspera*) (Figure 11). Sampling occurred from 2200 hrs to

0130 hrs on 17-18 September. A second site was located on the western edge of Mott Road Fen, which contained a small population of Culver's root (*Veronicastrum virginicum*) (Figure 11). Sampling occurred here on 18 September from 2045 hrs through midnight.

Leafhoppers and Spittlebugs

Sweepnet samples were taken in prairie and fen habitats which contained appropriate hostplants for the leafhoppers *F. reflexus* and *F. delongi*, and the Great Plains and red-legged spittlebugs (Figure 11). At each location, vegetation was sampled while meandering through appropriate habitat. A standard sample consisted of approximately sixty swings of a sweepnet, with one swing taken with each step. The contents of the net were emptied into a large killing jar charged with ethyl acetate. When the specimens had stopped moving they were transferred to a zip-lock plastic bag and placed into a cooler. Bagged samples were then frozen until they could be processed later in the fall. Processing consisted of sorting all insects from the vegetation, pinning larger specimens and pointing smaller ones. Those specimens that were similar to the targets were labeled and keyed or directly compared to specimens contained in the Michigan Natural Features Inventory Reference Collection.

Results and Discussion

No rare species of butterflies were discovered during field surveys. We did locate a mating pair of pepper and salt skippers (*Amblyscirtes hegon*) which was a new record for Kalamazoo County (Photo 24). Four species of *Papaipema*

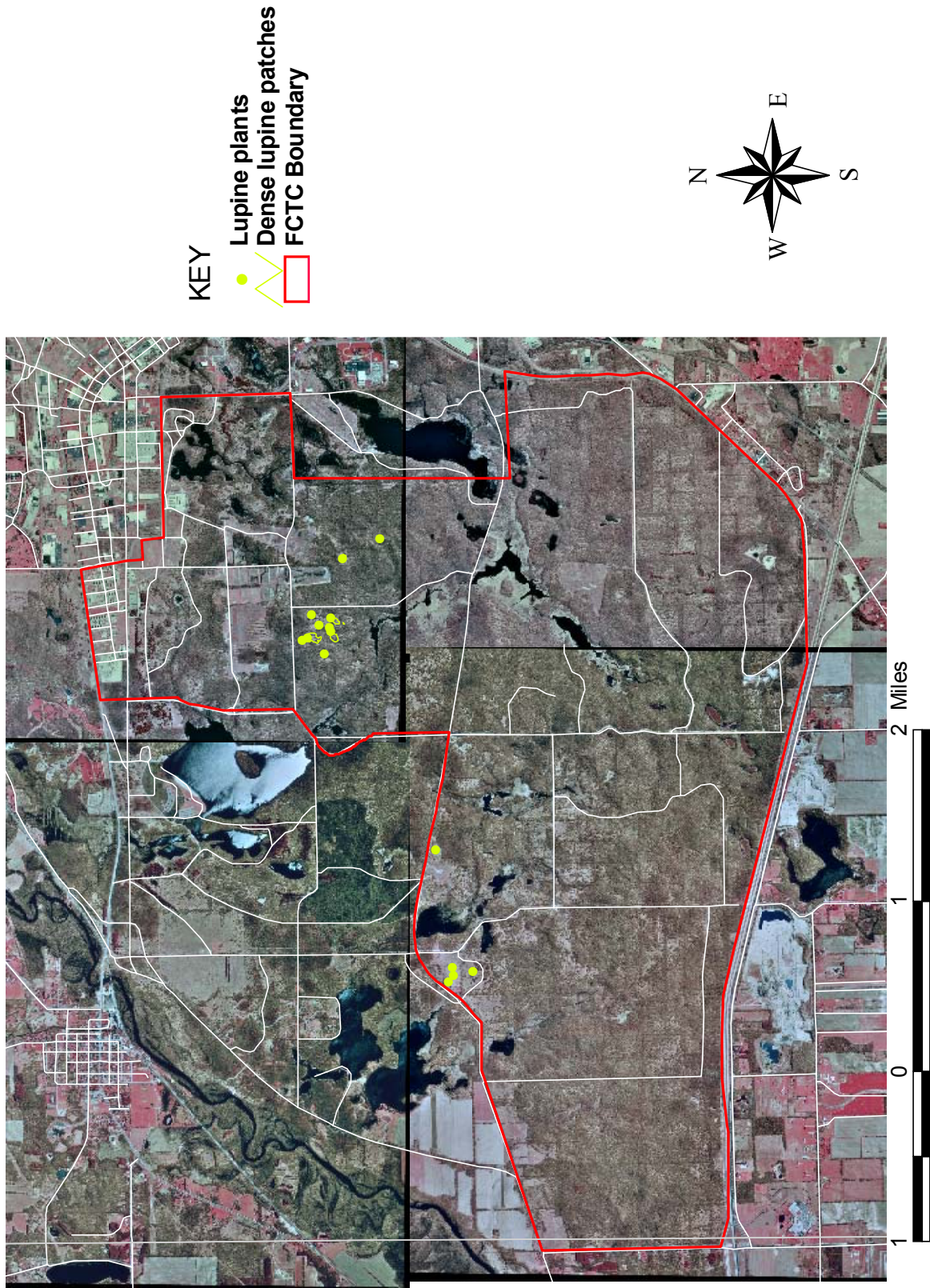


Figure 10. Lupine patches within the Fort Custer Training Center.

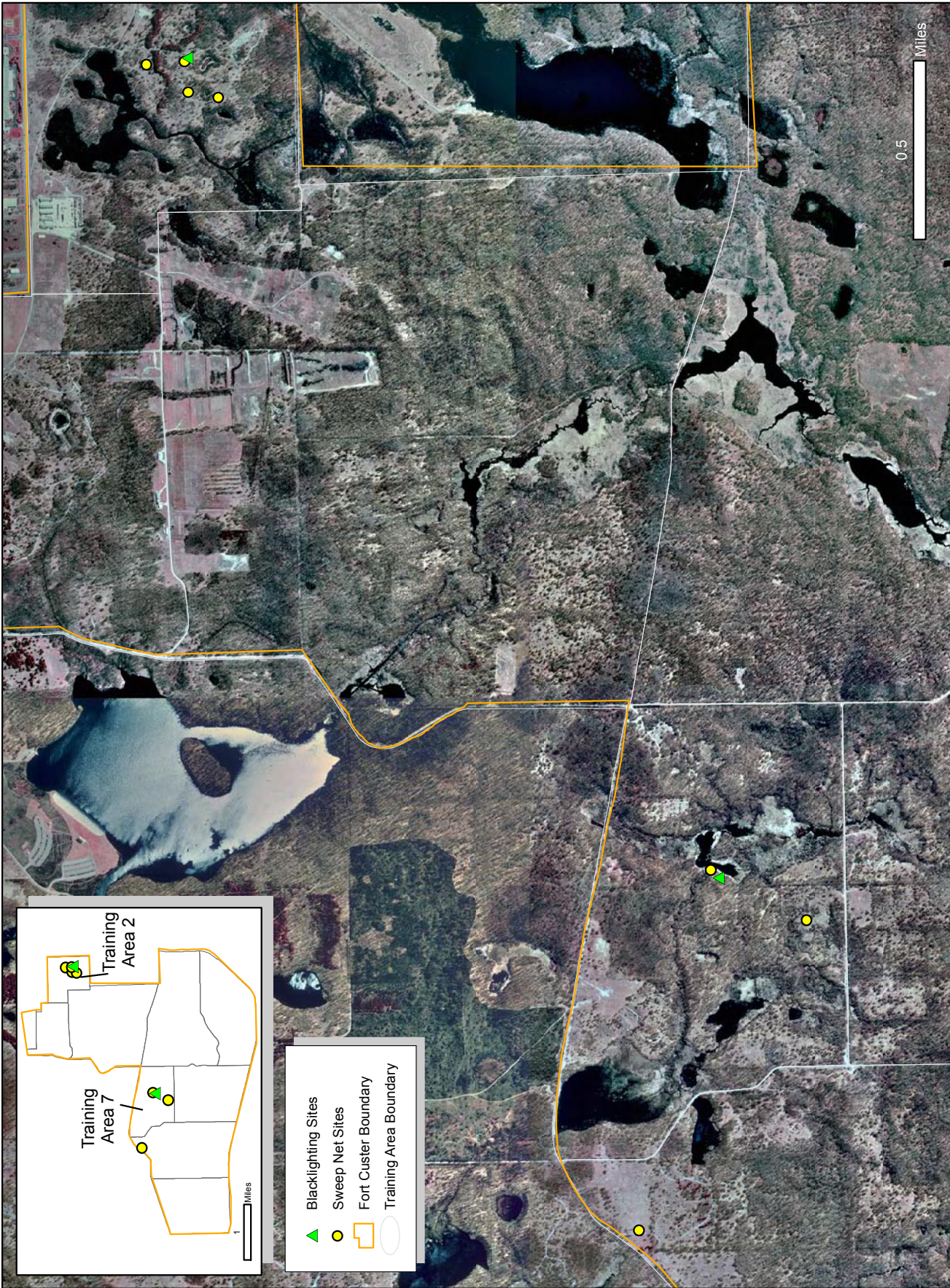


Figure 11. Blacklighting locations for *Papaipema* species. The site in Area 2 contains a large population of blazing star (*Liatis aspera*) and the second site on the western edge of Mott Road Fen contains a small population of Culver's root (*Veronicastrum virginicum*).

moths were recorded from the two nights of blacklighting, none of which are state listed. Species recorded included *P. arctivorens*, *P. cataphracta*, *P. inquaesita*, and an unidentified species. Currently the Culver's root borer moth is not likely to occur on FCTC due to the overall lack of larval host plants. However, Culver's root is becoming more common due to prescribed burning, and in time, the moth may find its way into the area from adjacent occupied sites. The blazing star borer moth has the potential to occur on the FCTC as there is a significant population of its larval host plant blazing star (*Liatriis aspera*). Within five meters of the blacklighting sheet, 70-75 flowering blazing star plants were counted. Blazing star borer moth, like many invertebrates, can be difficult to detect due to fluctuations in population. At one well known blazing star borer moth site in southern Michigan it took five years of blacklighting (one night of blacklighting each year) before the moth was detected. Further blacklighting would be important to monitor for the presence of these species.

In addition, we failed to locate *F. delongi* at the Lawler Cemetery site and *F. reflexus* in the oak openings adjacent to the Industrial park in Area 2. However, at both of these sites the habitat appears to be in excellent condition with an abundance of little bluestem and Indian grass throughout

the respective sites. It is very likely that the leafhoppers still occur within FCTC. The only *Flexamia* species we recorded during 2008 surveys was *F. aerolata*, a specialist on love grass (*Eragrostis spectabilis*).



Photo 24. A mating pair of pepper and salt skippers (*Amblyscirtes hegon*), a new record for Kalamazoo County, were found in a lupine meadow within the Impact Area (Photo by Barbara J. Barton).

GENERAL MANAGEMENT DISCUSSION

Fort Custer is at the forefront of landscape-scale restoration management in southern Michigan and within the lower Great Lakes. The core of this effort revolves around large-scale prescribed fires and invasive species control focused in high-quality natural areas. We encourage the continued use of fire and focus on invasive species control and provide the following discussion to help improve this excellent restoration program.

Invasive Species Control

Invasive species management at Fort Custer focuses on controlling populations of pernicious invasive species within high-quality natural areas and in the surrounding landscape. Prescribed fire is employed as the primary mechanism for reducing invasive species at the landscape scale and spot treatment through cutting and/or herbicide application and biocontrol are employed locally. We encourage this multi-faceted approach and emphasize that improving the landscape context surrounding the high-quality natural areas is critical. Reducing background levels of invasive species surrounding high-quality sites will reduce the seed source for these invaders. Logging in the immediate vicinity of high-quality natural areas

should be avoided. As noted above, logging adjacent to the Whitman Lake Woods has increased invasive species populations locally and throughout the base. Also areas of recent logging are associated with local dominance of garlic mustard. Restricting future logging operations to winter months when the soils are frozen will help limit the establishment and expansion of invasive species that benefit from soil disturbance, such as garlic mustard. Minimizing soil disturbance can also reduce detrimental impacts to plant and animal species. We strongly encourage the implementation of monitoring within the high-quality natural areas and throughout actively managed areas to gauge the success of restoration activities intended to reduce invasive species populations.

Periodic early detection surveys should be implemented to allow for the identification of invasive species that have yet to establish a stronghold on the base. Because Fort Custer Training Center is such an ecologically important region in southwest Michigan, adding an aggressive prevention and early detection-rapid response effort is recommended (Higman and Campbell 2009). As infestations grow, ecological and economic costs escalate and likelihood of successful control declines. Invasive plants not yet recorded

or not yet widespread at Fort Custer that are particularly important to monitor for and quickly treat include pale and black swallow-wort (*Vincetoxicum rossicum*, *V. nigrum*) Japanese knotweed (*Polygonum cuspidatum*), giant knotweed (*P. sachalinensis*), leafy spurge (*Euphorbia esula*), black jetbed (*Rhodotypos scandens*), Oriental bittersweet (*Celastrus orbiculata*), Tartarian honeysuckle (*Lonicera tatarica*), Japanese honeysuckle (*L. japonica*), Amur cork-tree (*Phellodendron amurense*), black alder (*Alnus glutinosa*), tree-of-heaven (*Ailanthus altissima*), Scotch pine (*Pinus sylvestris*), phragmites (*Phragmites australis*), curly pondweed (*Potamogeton crispus*), Eurasian water milfoil (*Myriophyllum spicatum*), water-hyacinth (*Eichhornia crassipes*), reed mannagrass (*Glyceria maxima*), Japanese stilt grass (*Microstegium vimineum*), and narrow-leaved cat-tail (*Typha angustifolia*). Narrow-leaved cat-tail is of particular concern since it has been observed as a local dominant within the Whitman Lake Fen. As noted within the above discussion of the prairie fen sites, it is critical that prescribed fire should be avoided in areas where narrow-leaved cat-tail occurs since this species tends to increase following fire. We recommend controlling populations of narrow-leaved cat-tail immediately through foliar application of herbicide using a wick applicator. Pictures and information on narrow-leaved cat-tail and many of the above invasive species can be viewed on the MNFI Web site: <http://web4.msue.msu.edu/mfni/education/invasives/cfm>.

Prescribed Fire Program

In approximately 2006, the Fort Custer Training Center embarked on a large-scale prescribed burn program with the goal of maintaining high-quality areas in pristine condition, restoring degraded habitats, and controlling invasive species. Numerous aspects of the burn program are exemplary, including prioritizing management and focusing on existing high-quality areas; creating large burn units several hundred to one thousand acres in size, facilitating landscape-scale fires to promote underrepresented fire-dependent natural communities such as prairie, oak barrens and prairie fen; and using an initially aggressive fire return interval to repeatedly burn areas that have been fire suppressed.

However, two aspects of the burn program have generated ecological concern. Within "Resource Management in High Quality Natural Areas" (DLZ 2005), it is recommended that the high-quality southern hardwood swamp be burned. During 2008 surveys it was noted that prescribed fire had been employed within this southern hardwood swamp and nearby within pockets of mesic southern forest. Fire was noted to have detrimentally impacted a rare plant (red mulberry). Mesic to wet forested sites within Fort Custer

where fire was an infrequent disturbance factor should not be intentionally burned. We recommend using these areas as natural fire breaks where surface fires can be allowed to creep into the margins but discourage the extension of fire lines into or across seepage areas, vernal pools, and pockets of mesic southern forest. These microsites serve as important refugia for fire-sensitive species.

The second area of concern is the restriction of burn seasonality to spring time. To date, the majority of prescribed burning has occurred in early 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 impacts 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). Many of the natural communities that are found at Fort Custer including prairie fen, dry-mesic southern forest, oak barrens, and prairie likely historically 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 oak barrens and dry-mesic southern forest 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 during surveys of Fort Custer (Photo 25). However, if burns are conducted later in the spring after leafout, or during the growing season or fall, 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 (i.e., eastern box turtle). While these are all legitimate reasons, we feel that the long-term benefits of diversifying burn seasonality outweigh the costs and that ultimately, successful restoration of oak savanna ecosystems at Fort Custer will depend on expansion of the burn season beyond early spring.

Management Considerations for Fire-Sensitive Species

In spring and fall, eastern box turtles spend the daylight hours foraging; during hot summer months they tend to forage in the mornings and evenings, rest during the heat of the day under rotting logs, decaying leaves, or in the mud, and are thus susceptible to fire. To minimize potential impacts, techniques should be employed during burns throughout the year for reducing risks to eastern box turtles and other fire-sensitive species. These should include the avoidance of burning within and around rotted logs, vernal pools, and seepage areas, and establishing rotating refugia within large burn units. Slow backburns may have less impact on snakes and possibly turtles, since they might give the animals time to escape or find refugia. There is evidence that hot, fast headfires (especially those that encircle animals) have caused turtle mortality and/or injury (Y. Lee, personal communication 2009). In areas where herptile populations are concentrated, we recommend minimizing headfires as much as possible for burns that occur post-emergence. We also recommend that the burn units are surveyed immediately prior to and during the burn when possible to look for any turtles that may be in the area, so that turtles can be temporarily removed during the fire and returned to the area after the burn to minimize injury or mortality.

Radio telemetry data on eastern box turtles at Fort Custer provided locational information on hibernaculum and other high-use areas (Gibson 2007). Hibernaculum areas in Training Areas 3 and 7 (see Gibson 2007 for maps) should only be burned during the hibernation period between late October and late March to avoid negative impacts to the turtles.

Monitoring

We recommend that monitoring be implemented at Fort Custer, concentrated within the high-quality areas but also throughout actively managed areas. Monitoring can help inform adaptive management by gauging the success of restoration at meeting the management goals of reducing

invasive species populations, limiting woody encroachment in open communities such as prairies, barrens, and prairie fens and in understories of fire-prone forests and woodlands, and fostering regeneration of oak saplings and prairie species in fire-dependent ecosystems.

Assessing the impacts of prescribed fire on herptile populations (i.e., eastern box turtle) should be a critical component of the burning program, especially following potential burns in the summer and fall, and can help direct adaptive management. Because of the high concentration of eastern box turtles at FCTC, there is an excellent opportunity to study the long-term effects of prescribed burning on the population. Part of this monitoring study could include an eastern box turtle conservation area, where management is directed toward the species. Eastern box turtles are known to utilize three distinct habitat types (upland forest, wetlands, and open grassland/prairie) at FCTC (Gibson 2007) and the data from this and subsequent studies should be used to inform management decisions.

The adaptive management of unique ecosystems and the responses of their component species (both native and non-native) within Fort Custer offer diverse research opportunities. For example, the interaction of beaver activity and fire management within prairie fen should be studied. In addition, the impacts of non-native earthworms on soil properties and the impacts of prescribed fire on earthworm populations should be assessed. Finally, monitoring deer densities and deer herbivory will allow for the assessment of whether deer browsing threatens floristic structure and composition.



Photo 25. Repeated prescribed burning in early spring has stimulated sprouting of clonal species like shining sumac, which threaten to take over small openings (Photo by Ryan P. O'Connor).

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Appendix 1

Global and State 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 2
Flora of Fort Custer Training Center

Family	Scientific name	Common name	Status	Native/Aventive
Aceraceae	<i>Acer negundo</i> L.	box elder		N
	<i>Acer nigrum</i> Michaux f.	black maple		N
	<i>Acer platanoides</i> L.	Norway maple		A
	<i>Acer rubrum</i> L.	red maple		N
	<i>Acer saccharinum</i> L.	silver maple		N
	<i>Acer saccharum</i> Marsh.	sugar maple		N
Alismataceae				
	<i>Alisma plantago-aquatica</i> L.	water-plantain		N
	<i>Sagittaria latifolia</i> Willd.	common arrowhead		N
Amaranthaceae				
	<i>Amaranthus albus</i> L.	tumbleweed		N
Amaryllidaceae				
	<i>Hypoxis hirsuta</i> (L.) Cov.	star-grass		N
Anacardiaceae				
	<i>Rhus copallina</i> L.	winged sumac		N
	<i>Rhus glabra</i> L.	smooth sumac		N
	<i>Rhus typhina</i> L.	staghorn sumac		N
	<i>Toxicodendron radicans</i> (L.) Kuntze	poison-ivy		N
	<i>Toxicodendron vernix</i> (L.) Kuntze	poison sumac		N
Annonaceae				
	<i>Asimina triloba</i> (L.) Dunal	pawpaw		N
Apiaceae				
	<i>Angelica atropurpurea</i> L.	angelica		N
	<i>Berula erecta</i> (B. pusilla) (Hudson) Cov.	water-parsnip	T	N
	<i>Cicuta bulbifera</i> L.	water hemlock		N
	<i>Cicuta maculata</i> L.	water hemlock		N
	<i>Cryptotaenia canadensis</i> (L.) DC.	honewort		N
	<i>Daucus carota</i> L.	Queen-Anne's-lace		A
	<i>Erigenia bulbosa</i> (Michaux) Nutt	harbinger-of-spring		N
	<i>Osmorhiza claytonii</i> (Michaux) C. B.			
	Clarke	hairy sweet-cicely		N
	<i>Osmorhiza longistylis</i> (Torrey) DC.	smooth sweet-cicely		N
	<i>Oxypolis rigidior</i> (L.) Raf.	cowbane		N
	<i>Sanicula canadensis</i> L.	black snakeroot		N
	<i>Sanicula gregaria</i> Bickn.	black snakeroot		N
	<i>Sanicula trifoliata</i> Bickn.	black snakeroot		N

Apiaceae cont...	<i>Taenidia integerrima</i> (L.) Drude	yellow-pimpernel	N
	<i>Torilis japonica</i> (Houtt.) DC.	hedge-parsley	A
	<i>Zizia aurea</i> (L.) Koch	golden Alexanders	N
Apocynaceae	<i>Apocynum cannabinum</i> L.	Indian hemp	N
	<i>Vinca minor</i> L.	periwinkle	A
Aquifoliaceae	<i>Ilex opaca</i> Aiton	American holly	A
	<i>Ilex verticillata</i> (L.) A. Gray	Michigan holly	N
Araceae	<i>Arisaema dracontium</i> (L.) Schott	green dragon	N
	<i>Arisaema triphyllum</i> (L.) Schott	jack-in-the-pulpit	N
	<i>Peltandra virginica</i> (L.) Schott & Endl.	arrow-arum	N
	<i>Symplocarpus foetidus</i> (L.) Nutt.	skunk-cabbage	N
Araliaceae	<i>Aralia nudicaulis</i> L.	wild sarsaparilla	N
	<i>Aralia racemosa</i> L.	spikenard	N
	<i>Panax quinquefolius</i> L.	ginseng	T
	<i>Panax trifolius</i> L.	dwarf ginseng	N
Aristolochiaceae	<i>Asarum canadense</i> L.	wild-ginger	N
Asclepiadaceae	<i>Asclepias amplexicaulis</i> Sm.	clasping milkweed	N
	<i>Asclepias exaltata</i> L.	poke milkweed	N
Asclepiadaceae cont...	<i>Asclepias incarnata</i> L.	swamp milkweed	N
	<i>Asclepias syriaca</i> L.	common milkweed	N
	<i>Asclepias tuberosa</i> L.	butterfly-weed	N
	<i>Asclepias viridiflora</i> Raf.	green milkweed	N
Aspleniaceae	<i>Asplenium platyneuron</i> (L.) Oakes ex D. C. Eaton	ebony spleenwort	N
Asteraceae	<i>Achillea millefolium</i> L.	yarrow	N
	<i>Ambrosia artemisiifolia</i> L.	common ragweed	N
	<i>Ambrosia trifida</i> L.	giant ragweed	N
	<i>Antennaria neglecta</i> Greene	cat's foot	N
	<i>Antennaria parvifolia</i> (A. plantaginifolia) Fern.	smooth pussytoes	N
	<i>Arctium minus</i> Schk.	common burdock	A
	<i>Artemisia campestris</i> L.	wormwood	N
	<i>Aster ciliolatus</i> Lindl.	northern heart-leaved aster	N

Asteraceae cont...	<i>Aster laevis</i> L.	smooth aster	N
	<i>Aster lanceolatus</i> Willd.	eastern lined aster	N
	<i>Aster lateriflorus</i> (L.) Britton	side-flowering aster	N
	<i>Aster macrophyllus</i> L.	big-leaved aster	N
	<i>Aster novae-angliae</i> (<i>Virgulus n.</i>) L.	New England aster	N
	<i>Aster oolentangensis</i> (<i>A. azureus</i>) Riddell	prairie heart-leaved aster	N
	<i>Aster pilosus</i> Willd.	hairy aster	N
	<i>Aster puniceus</i> (<i>A. lucidulus</i>) L.	swamp aster	N
	<i>Aster sagittifolius</i> Willd.	arrow-leaved aster	N
	<i>Aster umbellatus</i> Miller	tall flat-top white aster	N
	<i>Bidens cernuus</i> L.	nodding bur-marigold	N
	<i>Bidens connatus</i> Muhl.	purple-stemmed tickseed	N
	<i>Bidens coronatus</i> (L.) Britton	tall swamp-marigold	N
	<i>Bidens frondosus</i> L.	common beggar-ticks	N
	<i>Bidens polylepis</i> S. F. Blake	Ozark tickseed sunflower	A
	<i>Centaurea jacea</i> L.	brown knapweed	A
	<i>Centaurea maculosa</i> Lam.	spotted knapweed	A
	<i>Chondrilla juncea</i> L.	skeleton-weed	A
	<i>Chrysanthemum leucanthemum</i> L.	ox-eye daisy	A
	<i>Cichorium intybus</i> L.	chicory	A
	<i>Cirsium arvense</i> (L.) Scop.	Canadian-thistle	A
	<i>Cirsium discolor</i> (Muhl.) Spreng.	pasture-thistle	N
	<i>Cirsium muticum</i> Michaux	swamp-thistle	N
	<i>Cirsium vulgare</i> (Savi) Tenore	bull-thistle	A
	<i>Conyza canadensis</i> (<i>Erigeron c.</i>) (L.) Cronq.	horseweed	N
	<i>Coreopsis tripteris</i> L.	tall coreopsis	N
	<i>Crepis capillaris</i> (L.) Wallr.	hawk's beard	A
	<i>Erechtites hieracifolia</i> (L.) Raf.	fireweed	N
	<i>Erigeron annuus</i> (L.) Pers.	annual fleabane	N
	<i>Erigeron philadelphicus</i> L.	marsh fleabane	N
	<i>Erigeron strigosus</i> Muhl.	daisy fleabane	N
	<i>Eupatorium maculatum</i> L.	Joe-pye weed	N
	<i>Eupatorium perfoliatum</i> L.	common boneset	N
	<i>Eupatorium purpureum</i> L.	purple Joe-pye weed	N
	<i>Eupatorium rugosum</i> Houtt.	white snakeroot	N
	<i>Eupatorium sessilifolium</i> L.	upland boneset	N
	<i>Euthamia graminifolia</i> (<i>Solidago g.</i>) (L.) Nutt.	grass-leaved goldenrod	N
	<i>Gnaphalium macounii</i> Greene	clammy cudweed	N

Asteraceae cont...	<i>Gnaphalium obtusifolium</i> L.	old-field balsam	N
	<i>Helonium flexuosum</i> Raf.	sneezeweed	A
	<i>Helianthus decapetalus</i> L.	pale sunflower	N
	<i>Helianthus divaricatus</i> L.	woodland sunflower	N
	<i>Helianthus giganteus</i> L.	tall sunflower	N
	<i>Helianthus strumosus</i> L.	pale-leaved sunflower	N
	<i>Hieracium aurantiacum</i> L.	orange hawkweed	A
	<i>Hieracium caespitosum</i> (<i>H. pratense</i>) Dumort	king-devil	A
	<i>Hieracium gronovii</i> L.	hairy hawkweed	N
	<i>Hieracium longipilum</i> Torrey	long-bearded hawkweed	N
	<i>Hieracium piloselloides</i> Villars	glaucous king-devil	A
	<i>Hieracium scabrum</i> Michaux	rough hawkweed	N
	<i>Hypochaeris radicata</i> L.	spotted cat's-ear	A
	<i>Krigia biflora</i> (Walter) Blake	false dandelion	N
	<i>Krigia virginica</i> (L.) Willd.	dwarf dandelion	N
	<i>Lactuca biennis</i> (Moench) Fern.	tall blue lettuce	N
	<i>Lactuca canadensis</i> L.	tall lettuce	N
	<i>Lactuca saligna</i> L.	willow lettuce	A
	<i>Liatris aspera</i> Michaux	rough blazing star	N
	<i>Liatris scariosa</i> (<i>L. novae-angliae</i>) (L.) Willd.	northern blazing star	N
	<i>Matricaria discoidea</i> D.C.	pineapple-weed	A
	<i>Polygonum canadensis</i> L.	leafcup	N
	<i>Prenanthes altissima</i> L.	tall white lettuce	N
	<i>Ratibida pinnata</i> (Vent.) Barmh.	yellow coneflower	N
	<i>Rudbeckia fulgida</i> (<i>R. sullivantii</i>) Aiton	black-eyed Susan	N
	<i>Rudbeckia hiirta</i> L.	black-eyed Susan	N
	<i>Rudbeckia laciniata</i> L.	cut-leaved coneflower	N
	<i>Rudbeckia triloba</i> L.	three-lobed coneflower	N
	<i>Senecio aureus</i> L.	golden ragwort	N
	<i>Senecio pauperulus</i> Michaux	balsam ragwort	N
	<i>Solidago altissima</i> L.	tall goldenrod	N
	<i>Solidago caesia</i> L.	blue-stemmed goldenrod	N
	<i>Solidago canadensis</i> L.	Canada goldenrod	N
	<i>Solidago gigantea</i> Ait.	late goldenrod	N
	<i>Solidago hispida</i> Muhl.	white goldenrod	N
	<i>Solidago juncea</i> Ait.	early goldenrod	N
	<i>Solidago nemoralis</i> Ait.	old-field goldenrod	N
	<i>Solidago ohioensis</i> Riddell	Ohio goldenrod	N
	<i>Solidago patula</i> Muhl.	swamp goldenrod	N

Asteraceae cont...	<i>Solidago riddellii</i> Frank	Riddell's goldenrod	N
	<i>Solidago rugosa</i> Miller	rough goldenrod	N
	<i>Solidago speciosa</i> Nutt.	showy goldenrod	N
	<i>Solidago uliginosa</i> Nutt.	bog goldenrod	N
	<i>Solidago ulmifolia</i> Muhl.	elm-leaved goldenrod	N
	<i>Sonchus arvensis</i> (S. <i>uliginosus</i>) L.	perennial sow thistle	A
	<i>Sonchus asper</i> (L.) Hill	prickly sow thistle	A
	<i>Taraxacum officinale</i> L.	common dandelion	A
	<i>Tragopogon dubius</i> Scop.	goat's-beard	A
	<i>Tragopogon pratensis</i> L.	common goat's-beard	A
	<i>Vernonia missurica</i> Raf.	Missouri ironweed	N
Balsaminaceae			
	<i>Impatiens capensis</i> Meerb.	spotted touch-me-not	N
Berberidaceae			
	<i>Berberis thunbergii</i> DC.	Japanese barberry	A
	<i>Caulophyllum thalictroides</i> (L.) Michaux	blue cohosh	N
	<i>Podophyllum peltatum</i> L.	may-apple	N
Betulaceae			
	<i>Alnus glutinosa</i> (L.) Gaertner	black alder	A
	<i>Betula pendula</i> Roth	European white birch	A
	<i>Betula pumila</i> L.	bog birch	N
	<i>Carpinus caroliniana</i> Walter	blue-beech	N
	<i>Corylus americana</i> Walter	hazelnut	N
	<i>Ostrya virginiana</i> (Miller) K. Koch	ironwood; hop-hornbeam	N
Bignoniaceae			
	<i>Campsis radicans</i> (L.) Bureau	trumpet vine	A
Bignoniaceae cont...	<i>Catalpa speciosa</i> Warder	northern catalpa	A
Blechnaceae			
	<i>Woodwardia virginica</i> (L.) Smith	Virginia chain-fern	N
Boraginaceae			
	<i>Hackelia virginiana</i> (L.) Johnst.	beggar's lice	N
	<i>Myosotis scorpioides</i> L.	forget-me-not	A
Brassicaceae			
	<i>Alliaria petiolata</i> (Bieb.) Cavara & Grande	garlic mustard	A
	<i>Alyssum alyssoides</i> (L.) L.	pale alyssum	A
	<i>Arabisopsis thaliana</i> (L.) Heynh.	mouse-ear cress	A
	<i>Arabis canadensis</i> L.	sickle-pod	N
	<i>Arabis glabra</i> (L.) Benth.	tower mustard	N
	<i>Barbarea vulgaris</i> R. Br.	yellow rocket	A
	<i>Berteroa incana</i> (L.) DC.	hoary alyssum	A
	<i>Capsella bursa-pastoris</i> (L.) Medicus	shepherd's purse	A
	<i>Cardamine bulbosa</i> (Muhl.) BSP.	spring cress	N

Brassicaceae cont...	<i>Cardamine douglassii</i> Britton	pink spring cress	N
	<i>Cardamine hirsuta</i> L.	hoary bitter cress	A
	<i>Cardamine pennsylvanica</i> Willd.	Pennsylvania bitter cress	N
	<i>Cardamine pratensis</i> L.	cuckoo-flower	N
	<i>Dentaria diphylla</i> (<i>Cardamine d.</i>) Michaux	two-leaved toothwort	N
	<i>Dentaria laciniata</i> Willd.	cut-leaved toothwort	N
	<i>Hesperis matronalis</i> L.	dame's rocket	A
	<i>Lepidium campestre</i> (L.) R. Br.	field cress	A
	<i>Lepidium densiflorum</i> Schrader	small peppergrass	A
	<i>Lepidium virginicum</i> L.	common peppergrass	N
	<i>Nasturtium officinale</i> R. Br.	watercress	A
	<i>Rorippa palustris</i> L. Besser var. <i>hispidula</i> (Desv.) Rydb.	yellow cress	N
	<i>Rorippa palustris</i> L. Besser var. <i>fernaldiana</i> (Butters & Abbe)	yellow cress	N
	<i>Sisymbrium altissimum</i> L.	tumble mustard	A
	<i>Sisymbrium officinale</i> L.	hedge mustard	A
Campanulaceae			
	<i>Campanula americana</i> L.	tall bellflower	N
	<i>Campanula aparinooides</i> Pursh	marsh bellflower	N
	<i>Campanula rotundifolia</i> L.	harebell	N
	<i>Lobelia inflata</i> L.	Indian tobacco	N
	<i>Lobelia kalmii</i> L.	bog lobelia	N
	<i>Lobelia siphilitica</i> L.	great blue lobelia	N
	<i>Lobelia spicata</i> Lam.	pale spiked lobelia	N
	<i>Specularia perfoliata</i> (<i>Triodanis p.</i>) (L.) A. DC.	Venus's looking glass	N
Cannabaceae			
	<i>Humulus lupulus</i> L.	common hop	N
Capparaceae			
	<i>Polanisia dodecandra</i> (<i>P. graveolens</i>) (L.) DC.	clammy-weed	N
Caprifoliaceae			
	<i>Lonicera dioica</i> L.	red honeysuckle	N
	<i>Lonicera maackii</i> Maxim.	Amur honeysuckle	A
	<i>Lonicera morrowii</i> A. Gray	Morrow honeysuckle	A
	<i>Lonicera xbella</i> Zabel	hybrid honeysuckle	A
	<i>Sambucus canadensis</i> L.	elderberry	N
	<i>Viburnum acerifolium</i> L.	maple-leaved arrow-wood	N
	<i>Viburnum lentago</i> L.	nannyberry European	N
	<i>Viburnum opulus</i> L.	highbush cranberry	A

	<i>Viburnum opulus</i> var. <i>americanum</i> (V.		
Caprifoliaceae cont...	<i>trilobum</i>) Aiton	highbush cranberry	N
	<i>Viburnum rafinesquianum</i> Schult.	downy arrow-wood	N
Caryophyllaceae			
	<i>Arenaria serpyllifolia</i> L.	thyme-leaved sandwort	A
	<i>Dianthus armeria</i> L.	deftford pink	A
	<i>Saponaria officinalis</i> L.	bouncing bet	A
	<i>Scleranthus annuus</i> L.	knawel	A
	<i>Silene antirrhina</i> L.	sleepy catchfly	N
	<i>Silene pratensis</i> (<i>Lynchnis alba</i>) (Rafn.)		
	Godron & Gren.	white catchfly	A
	<i>Silene vulgaris</i> (<i>S. cucubalus</i>) (Moench)		
	Garcke	bladder campion	A
	<i>Stellaria longifolia</i> Willd.	long-leaved chickweed	N
	<i>Stellaria media</i> (L.) Vill.	common chickweed	A
Celastraceae			
	<i>Celastrus orbiculata</i> Thunb.	Oriental bittersweet	A
	<i>Celastrus scandens</i> L.	American bittersweet	N
	<i>Euonymus alata</i> (Thunb.) Siebold	winged wahoo	A
	<i>Euonymus atropurpurea</i> Jacq.	wahoo, burning-bush	N
	<i>Euonymus obovata</i> Nutt.	running strawberry-bush	N
Ceratophyllaceae			
	<i>Ceratophyllum demersum</i> L.	coontail	N
	<i>Ceratophyllum echinatum</i> A. Gray	spiny hornwort	N
Chenopodiaceae			
	<i>Chenopodium album</i> L.	lamb's quarters	A
	<i>Chenopodium hybridum</i> L.	maple-leaved goosefoot	N
	<i>Cyclopoma atriplicifolium</i> (Sprengel)		
	Coulter	winged pigweed	A
Cistaceae			
	<i>Helianthemum canadense</i> (L.) Michaux	common rockrose	N
	<i>Lechea villosa</i> Ell.	hairy pinweed	N
Commelinaceae			
	<i>Tradescantia ohiensis</i> Raf.	common spiderwort	N
Convolvulaceae			
	<i>Calystegia sepium</i> (L.) R. Br.	hedge bindweed	N
Cornaceae			
	<i>Cornus alternifolia</i> L. f.	alternate-leaved dogwood	N
	<i>Cornus amomum</i> Miller	silky dogwood	N
	<i>Cornus florida</i> L.	flowering dogwood	N
	<i>Cornus foemina</i> (<i>C. racemosa</i>) Miller	gray dogwood	N
	<i>Cornus stolonifera</i> Michaux	red-osier dogwood	N

Crassulaceae	<i>Sedum telephium</i> L.	live forever	A
Cucurbitaceae	<i>Sicyos angulatus</i> L.	bur-cucumber	N
Cupressaceae	<i>Juniperus virginiana</i> L.	red-cedar northern	N
	<i>Thuja occidentalis</i> L.	white-cedar; arborvitae	N
Cuscutaceae	<i>Cuscuta campestris</i> Yunk	field dodder	N
	<i>Cuscuta cephalanthi</i> Engelm.	buttonbush dodder	N
	<i>Cuscuta gronovii</i> Willd.	common dodder	N
Cyperaceae	<i>Carex aggregata</i> Mack.	sedge	N
	<i>Carex alburquina</i> Sheldon	sedge	N
	<i>Carex amphibola</i> Steudel	sedge	N
	<i>Carex annectens</i> (Bickn.) Bickn.	sedge	N
	<i>Carex aquatilis</i> Wahl.	sedge	N
	<i>Carex bebbii</i> (Bailey) Fern.	sedge	N
	<i>Carex bicknellii</i> Britton	sedge	N
	<i>Carex blanda</i> Dewey	sedge	N
	<i>Carex brevior</i> (Dewey) Mack.	sedge	N
	<i>Carex bromoides</i> Willd.	sedge	N
	<i>Carex buxbaumii</i> Wahl.	sedge	N
	<i>Carex cephalophora</i> Willd.	sedge	N
	<i>Carex comosa</i> Boott	sedge	N
	<i>Carex crinita</i> Lam.	sedge	N
	<i>Carex cristatella</i> Britton	sedge	N
	<i>Carex cryptolepis</i> Mack.	sedge	N
	<i>Carex diandra</i> Schrank	sedge	N
	<i>Carex flava</i> L.	sedge	N
	<i>Carex frankii</i>	sedge	N
	<i>Carex gracillima</i> Schw.	sedge	N
	<i>Carex granularis</i> Willd.	sedge	N
	<i>Carex grisea</i> Wahlenb.	sedge	N
	<i>Carex hirtifolia</i> Mack.	sedge	N
	<i>Carex hitchcockiana</i> Dewey	sedge	N
	<i>Carex hystericina</i> Willd.	sedge	N
	<i>Carex interior</i> Bailey	sedge	N
	<i>Carex jamesii</i> Schw.	James' sedge	N
	<i>Carex lacustris</i> Willd.	sedge	N
	<i>Carex laevivaginata</i> (Kuk.) Mack.	sedge	N
	<i>Carex laxiculmis</i> Schw.	sedge	N

Cyperaceae cont...			
<i>Carex leptalea</i> Wahl.	sedge		N
<i>Carex lupulina</i> Willd.	sedge		N
<i>Carex muhlenbergii</i> Willd.	sedge		N
<i>Carex pellita</i> (<i>C. lanuginosa</i>) Willd.	sedge		N
<i>Carex pensylvanica</i> Lam.	sedge		N
<i>Carex prairea</i> Dewey	sedge		N
<i>Carex pseudo-cyperus</i> L.	sedge		N
<i>Carex radiata</i> (Wahlenb.) Small	straight-styled wood sedge		N
<i>Carex rosea</i> (<i>C. convoluta</i>) Schkuhr ex. Willd.	curly-styled wood sedge		N
<i>Carex sartwellii</i> Dewey	sedge		N
<i>Carex scoparia</i> Willd.	sedge		N
<i>Carex sparganioides</i> Willd.	sedge		N
<i>Carex spicata</i> Hudson	sedge		A
<i>Carex sterilis</i> Willd.	sedge		N
<i>Carex stipata</i> Willd.	sedge		N
<i>Carex stricta</i> Lam.	sedge		N
<i>Carex swanii</i> (Fern.) Mack.	sedge		N
<i>Carex tetanica</i> Schk.	sedge		N
<i>Carex tribuloides</i> Wahl.	sedge		N
<i>Carex utriculata</i> F. Boott	sedge		N
<i>Carex vulpinoidea</i> Michaux	sedge		N
<i>Cladium mariscoides</i> (Muhl.) Torrey	twig-rush		N
<i>Cyperus dianthus</i> Steudel	umbrella sedge		N
<i>Cyperus filiculmis</i> Vahl.	slender sand sedge		N
<i>Cyperus rivularis</i> Kunth	brook nut sedge		N
<i>Cyperus strigosus</i> L.	long scaled nut sedge		N
<i>Dulichium arundinaceum</i> (L.) Britton	three-way sedge		N
<i>Eleocharis elliptica</i> Kunth	golden-seeded spike rush		N
<i>Eleocharis erythropoda</i> Steudel	spike-rush		N
<i>Eleocharis intermedia</i> Schultes	spike-rush		N
<i>Eleocharis obtusa</i> (Willd.) Schultes	spike-rush		N
<i>Eleocharis rostellata</i> Torrey	spike-rush		N
<i>Eriophorum viridicarinatum</i> (Engelm.) Fern.	green-keeled cotton-grass		N
<i>Rhynchospora capillacea</i> Torrey	beak-rush		N
<i>Schoenoplectus acutus</i> (<i>Scirpus a.</i>) (Muhl. Ex Bigelow) A. & D. Love	hardstem bulrush		N
<i>Schoenoplectus pungens</i> (<i>Scirpus americanus</i>) (Vahl) Palla	three-square		N
<i>Schoenoplectus tabernaemontani</i> (<i>Scirpus validus</i>) (K.C. Gmel.) Palla	softstem bulrush		N
<i>Scirpus atrovirens</i> Willd.	bulrush		N
<i>Scirpus cyperinus</i> (L.) Kunth	wool-grass		N

Cyperaceae cont...	<i>Scirpus pendulus</i> Muhl.	bulrush	N
	<i>Scleria verticillata</i> Willd.	nut-rush	N
Dioscoreaceae			
	<i>Dioscorea villosa</i> L.	wild yam	N
Droseraceae			
	<i>Drosera rotundifolia</i> L.	round-leaved sundew	N
Elaeagnaceae			
	<i>Elaeagnus umbellata</i> Thunb.	autumn-olive	A
Equisetaceae			
	<i>Equisetum arvense</i> L.	common horsetail	N
	<i>Equisetum fluviatile</i> L.	water horsetail	N
	<i>Equisetum laevigatum</i> A. Br.	smooth scouring rush	N
	<i>Equisetum variegatum</i> Schleich.	variegated scouring rush	N
Ericaceae			
	<i>Chamaedaphne calyculata</i> (L.) Moench	leatherleaf	N
	<i>Gaylussacia baccata</i> (Wang) K. Koch	huckleberry	N
	<i>Vaccinium corymbosum</i> L.	smooth highbush blueberry	N
	<i>Vaccinium myrtilloides</i> Michaux	Canada blueberry	N
Euphorbiaceae			
	<i>Acalypha rhomboidea</i> Raf.	three-seeded mercury	N
	<i>Euphorbia corollata</i> L.	flowering spurge	N
	<i>Euphorbia cyparissias</i> L.	Cypress spurge	A
	<i>Euphorbia maculata</i> L.	nodding spurge	N
	<i>Euphorbia nutans</i> Lag.	eyebane	N
	<i>Euphorbia vermiculata</i> Raf.	hairy spurge	A
Fabaceae			
	<i>Amorpha canescens</i> Pursh	lead plant	N
	<i>Amphicarpea bracteata</i> (L.) Fern.	hog-peanut	N
	<i>Apios americana</i> Medicus	groundnut	N
	<i>Cercis canadensis</i> L.	redbud	N
	<i>Coronilla varia</i> L.	crown-vetch	A
	<i>Desmodium canadense</i> (L.) DC.	showy tick-trefoil	N
	<i>Desmodium ciliare</i> (Willd.) DC.	hairy tick-trefoil	N
	<i>Desmodium glutinosum</i> (Willd.) Wood	clustered-leaved tick-trefoil	N
	<i>Desmodium illinoense</i> A. Gray	prairie tick-trefoil	N
	<i>Desmodium marilandicum</i> (L.) DC.	small-leaved tick trefoil	N
	<i>Desmodium nudiflorum</i> (L.) DC.	naked tick-trefoil	N
	<i>Desmodium paniculatum</i> (L.) DC. var.	panicled tick-trefoil	N
	<i>Desmodium paniculatum</i> (L.) DC. var.	panicled tick-trefoil	N
	<i>dillenii</i> (Darl.) Isley	round-leaved tick-trefoil	N
	<i>Desmodium rotundifolium</i> DC.	round-leaved tick-trefoil	N
	<i>Desmodium sessilifolium</i> (Torrey) T. & G.	sessile-leaved tick-trefoil	N

Family	Scientific name	Common name	Status	Native/Aventive
Fabaceae cont...	<i>Gleditsia triacanthos</i> L.	honey locust		N
	<i>Lathyrus latifolius</i> L.	everlasting pea		A
	<i>Lathyrus palustris</i> L.	marsh pea		N
	<i>Lathyrus venosus</i> Willd.	veiny pea		N
	<i>Lespedeza capitata</i> Michaux	round-headed bush-clover		N
	<i>Lespedeza hirta</i> (L.) Hornem.	hairy bush-clover		N
	<i>Lespedeza intermedia</i> (Watson) Britton	bush-clover		N
	<i>Lespedeza virginica</i> (L.) Britton	slender bush-clover		N
	<i>Lupinus perennis</i> L.	wild lupine		N
	<i>Medicago lupulina</i> L.	black medick		A
	<i>Robinia hispida</i> L.	bristly locust		A
	<i>Robinia pseudoacacia</i> L.	black locust		A
	<i>Tephrosia virginiana</i> (L.) Pers.	goat's-rue		N
	<i>Trifolium arvense</i> L.	rabbitfoot clover		A
	<i>Trifolium campestre</i> Schreber	low hop clover		A
	<i>Trifolium dubium</i> Sibth.	little hop clover		A
	<i>Trifolium hybridum</i> L.	alsike clover		A
	<i>Trifolium pratense</i> L.	red clover		A
	<i>Trifolium repens</i> L.	white clover		A
	<i>Vicia americana</i> Willd.	American vetch		N
	<i>Vicia caroliniana</i> Walter	pale or wood vetch		N
	<i>Vicia villosa</i> Roth	hairy vetch		A
	Fagaceae			
	<i>Castanea dentata</i> (Marsh.) Borkh.	American chestnut	E	N
	<i>Fagus grandifolia</i> Ehrh.	American beech		N
	<i>Quercus alba</i> L.	white oak		N
	<i>Quercus macrocarpa</i> Michaux	bur oak		N
	<i>Quercus rubra</i> L.	red oak		N
	<i>Quercus velutina</i> Lam.	black oak		N
Fumariaceae				
	<i>Corydalis flavula</i> (Raf.) DC.	yellow harlequin	T	N
	<i>Dicentra canadensis</i> (Goldie) Walp.	squirrel-corn		N
	<i>Dicentra cucullaria</i> (L.) Bernh.	Dutchman's breeches		N
Gentianaceae				
	<i>Frasera carolinensis</i> (Swertia c.) (Walter)	American columbo		N
	<i>Gentiana andrewsii</i> Griseb.	bottle gentian		N
	<i>Gentianella quinquefolia</i> (L.) Small	stiff gentian	T	N
	<i>Gentianopsis crinita</i> (Gentiana c.) (Froel.) Ma	fringed gentian		N

	<i>Gentianopsis procera</i> (<i>Gentiana p.</i>)	small fringed gentian	N
	(Holm.) Ma	storksbill; alfileria	A
Geraniaceae			
	<i>Geranium maculatum</i> L.	wild geranium	N
Grossulariaceae			
	<i>Ribes americanum</i> Miller	wild black currant	N
	<i>Ribes cynosbati</i> L.	prickly or wild gooseberry	N
	<i>Ribes hirtellum</i> Michaux	swamp gooseberry	N
Guttiferaceae (Clusiaceae)			
	<i>Hypericum ascyron</i> (<i>H. pyramidatum</i>) L.	giant St. John's-wort larger Canada St. John's- wort	N
	<i>Hypericum majus</i> (A. Gray) Britton	weak St. John's-wort	N
	<i>Hypericum mutilum</i> L.	common St. John's-wort	A
	<i>Hypericum punctatum</i> Lam.	spotted St. John's-wort	N
	<i>Iridium fraseri</i> (<i>Hypericum f.</i>) (Spach)	marsh St. John's-wort	N
	Gl.		
Haloragaceae			
	<i>Myriophyllum verticillatum</i> L.	water-milfoil	N
Hamamelidaceae			
	<i>Hamamelis virginiana</i> L.	witch-hazel	N
Hydrocharitaceae			
	<i>Elodea canadensis</i> Michaux	common waterweed	N
	<i>Hydrophyllum appendiculatum</i> Michaux	great waterleaf	N
Iridaceae			
	<i>Iris virginica</i> L.	southern blue flag	N
Juglandaceae			
	<i>Carya cordiformis</i> (Wang.) K. Koch	bitternut hickory	N
	<i>Carya glabra</i> (<i>C. Ovalis</i>) (Miller) Sweet	pignut hickory	N
	<i>Carya ovata</i> (Miller) K. Koch	shagbark hickory	N
Juglandaceae cont...	<i>Juglans cinerea</i> L.	butternut	N
	<i>Juglans nigra</i> L.	black walnut	N
Juncaceae			
	<i>Juncus acuminatus</i> Michaux	sharp-fruited rush	N
	<i>Juncus brachycephalus</i> (Engelm.) Buch.	rush	N
	<i>Juncus dudleyi</i> Wieg.	Dudley's rush	N
	<i>Juncus effusus</i> L.	soft-stemmed rush	N
	<i>Juncus nodosus</i> L.	joint rush	N
	<i>Juncus tenuis</i> Willd.	path rush	N
	<i>Juncus torreyi</i> Cov.	Torrey's rush	N
	<i>Luzula multiflora</i> (Retz.) Lej.	common wood rush	N

Family	Scientific name	Common name	Status	Native/Aventive
Juncaginaceae	<i>Triglochin palustre</i> L.	slender bog arrow-grass		N
Lamiaceae	<i>Clinopodium vulgare</i> (Satureja vulgaris) (L.) Fritsch	wild basil		N
	<i>Collinsonia canadensis</i> L.	richweed		N
	<i>Glechoma hederacea</i> L.	ground ivy		A
	<i>Lamium purpureum</i> L.	purple dead-nettle		A
	<i>Leonurus cardiaca</i> L.	motherwort		A
	<i>Lycopus americanus</i> Muhl.	common water horehound		N
	<i>Lycopus uniflorus</i> Michaux	northern bugle weed		N
	<i>Mentha arvensis</i> L.	wild mint		N
	<i>Mentha spicata</i> L.	spearmint		A
	<i>Monarda fistulosa</i> L.	wild bergamot		N
	<i>Monarda punctata</i> L.	horsemint		N
	<i>Nepeta cataria</i> L.	catnip		A
	<i>Prunella vulgaris</i> L.	lawn prunella		N
	<i>Pycnanthemum virginianum</i> (L.) Durand & Jackson	common mountain mint		N
	<i>Satureja hortensis</i> L.	savory		A
	<i>Scutellaria galericulata</i> L.	common skullcap		N
	<i>Scutellaria lateriflora</i> L.	mad-dog skullcap		N
Lamiaceae cont...	<i>Stachys hyssopifolia</i> Michaux	hyssop hedge nettle		N
	<i>Teucrium canadense</i> L.	wood sage		N
Lauraceae	<i>Lindera benzoin</i> (L.) Blume	spicebush		N
	<i>Sassafras albidum</i> (Nutt.) Nees	sassafras		N
Lemnaceae	<i>Lemna minor</i> L.	small duckweed		N
	<i>Lemna trisulca</i> L.	star duckweed		N
	<i>Spirodela polyrhiza</i> (L.) Schleiden	great duckweed		N
	<i>Wolffia columbiana</i> Karsten	common water meal		N
	<i>Wolffia punctata</i> Griseb.	dotted water meal		N
Lentibulariaceae	<i>Utricularia gibba</i> L.	humped bladderwort		N
	<i>Utricularia intermedia</i> Hayne	flat-leaved bladderwort		N
	<i>Utricularia minor</i> L.	small bladderwort		N
	<i>Utricularia vulgaris</i> L.	great bladderwort		N
Liliaceae	<i>Alettris farinosa</i> L.	colic root		N
	<i>Allium tricoccum</i> Aiton	wild leek		N
	<i>Allium vineale</i> L.	field garlic		A

<i>Asparagus officinalis</i> L.	asparagus	A
<i>Convallaria majalis</i> L.	lily-of-the-valley	A
<i>Hemerocallis fulva</i> (L.) L.	orange day-lily	A
<i>Lilium michiganense</i> Farw.	Michigan lily	N
<i>Maianthemum canadense</i> Desf.	Canada mayflower	N
<i>Muscari botryoides</i> (L.) Miller	grape-hyacinth	A
<i>Ornithogalum umbellatum</i> L.	star-of-Bethlehem	A
<i>Polygonatum biflorum</i> (Walter) Ell.	Solomon-seal	N
<i>Polygonatum pubescens</i> (Willd.) Pursh	downy Solomon-seal	N
<i>Smilacina racemosa</i> (L.) Desf.	false spikenard	N
<i>Smilacina stellata</i> (L.) Desf.	starry false Solomon-seal	N
<i>Smilax lasioneura</i> Hooker	carrión-flower	N
<i>Smilax tannoides</i> (<i>S. hispida</i>) L.	bristly green-brier	N
<i>Trillium cernuum</i> L.	nodding trillium	N
<i>Trillium grandiflorum</i> (Michaux) Salisb.	common trillium	N
<i>Uvularia grandiflora</i> Sm.	bellwort	N
<i>Yucca filamentosa</i> L.	yucca	A
Limnanthaceae		
<i>Floerkea proserpinacoides</i> Willd.	false mermaid	N
Linaceae		
<i>Linum virginianum</i> L.	Virginia flax	T
Lycopodiaceae		
<i>Diphasiastrum digitatum</i> (<i>Lycopodium d.</i>) (Dillenius ex A. Braun) Holub	ground-cedar	N
Lythraceae		
<i>Decodon verticillatus</i> (L.) Ell.	whorled or swamp loosestrife	N
<i>Lythrum salicaria</i> L.	purple loosestrife	A
Magnoliaceae		
<i>Liriodendron tulipifera</i> L.	tulip tree	N
Malvaceae		
<i>Abutilon theophrasti</i> Medicus	velvetleaf	A
<i>Mahya neglecta</i> Wallr.	cheeses	A
Menispermaceae		
<i>Menispermum canadense</i> L.	moonseed	N
Molluginaceae		
<i>Mollugo verticillata</i> L.	carpet-weed	A
Monotropaceae		
<i>Monotropa hypopithys</i> L.	pinemap	N
<i>Monotropa uniflora</i> L.	Indian pipe	N
Moraceae		
<i>Maclura pomifera</i> (Raf.) Schneider	osage orange	A
<i>Morus alba</i> L.	white mulberry	A
<i>Morus rubra</i> L.	red mulberry	T

Family	Scientific name	Common name	Status	Native/Aventive
Najadaceae	<i>Najas flexilis</i> (Willd.) Rostk. & Schmidt	slender naiad		N
	<i>Najas guadalupensis</i> (Sprengel) Magnus	southern naiad		N
	<i>Najas marina</i> L.	spiny naiad		A
Nymphaeaceae	<i>Nuphar advena</i> (Aiton) Aiton f.	yellow pond-lily		N
	<i>Nymphaea odorata</i> (<i>N. tuberosa</i>) Aiton	sweet-scented waterlily		N
Oleaceae	<i>Fraxinus americana</i> L.	white ash		N
	<i>Fraxinus nigra</i> Marsh.	black ash		N
	<i>Fraxinus pennsylvanica</i> Marsh.	red ash		N
	<i>Fraxinus quadrangulata</i> Michaux	blue ash		N
	<i>Syringa vulgaris</i> L.	common lilac		A
Onagraceae	<i>Circaea lutetiana</i> L.	enchanter's-nightshade		N
	<i>Epilobium coloratum</i> Biehler	cinnamon willow-herb		N
	<i>Epilobium hirsutum</i> L.	great hairy willow-herb		A
	<i>Epilobium leptophyllum</i> Raf.	fen willow-herb		N
	<i>Epilobium strictum</i> Sprengel	downy willow-herb		N
	<i>Ludwigia palustris</i> (L.) Ell.	water-purslane		N
	<i>Oenothera biennis</i> L.	common evening-primrose		N
Ophioglossaceae	<i>Botrychium dissectum</i> Sprengel f.			
	<i>dissectum</i>	cut-leaved grape-fern		N
	<i>Botrychium dissectum</i> Sprengel f.			
	<i>obliquum</i>	cut-leaved grape-fern		N
	<i>Botrychium multifidum</i> (Gmel.) Rupr.	leather grape-fern		N
<i>Botrychium virginianum</i> (L.) Sw.	rattlesnake fern		N	
Orchidaceae	<i>Aplectrum hyemale</i> (Willd.) Torrey	putty root		N
	<i>Corallorhiza maculata</i> Raf.	spotted coral-root		N
	<i>Corallorhiza odontorhiza</i> (Willd.) Nutt.	fall coral-root		N
	<i>Cypripedium calceolus</i> var. <i>parviflorum</i> (Salisb.) Fern.	small yellow lady-slipper		N
	<i>Cypripedium calceolus</i> var. <i>pubescens</i> (Willd.) Correll	large yellow lady-slipper showy or queen's lady-		N
	<i>Cypripedium reginae</i> Walter	slipper		N
	<i>Galearis spectabilis</i> (<i>Orchis s.</i>) (L.) Raf.	showy orchis	T	N
	<i>Liparis liliifolia</i> (L.) Rich. ex Lindl.	lily-leaved twayblade	SC	N
	<i>Liparis loeselii</i> (L.) Rich.	Loesel's twayblade		N

<i>Platanthera hyperborea</i> (<i>Habenaria h.</i>) (L.) Lindl.	tall northern bog orchid	N
<i>Platanthera lacera</i> (<i>Habenaria l.</i>) (Michaux) G. Donn in Sweet	green-fringed orchid	N
<i>Platanthera psycodes</i> (<i>Habenaria p.</i>) (L.) Lindl.	small purple-fringed orchid	N
<i>Spiranthes cernua</i> (L.) Rich.	nodding ladies'-tresses	N
<i>Spiranthes lacera</i> (Raf.) Raf.	slender ladies'-tresses	N
<i>Spiranthes ochroleuca</i> (Rydb.) Rydb.	yellow ladies'-tresses	N
<i>Spiranthes ovalis</i> Lindley	oval ladies'-tresses	N
T		
Orobanchaceae		
<i>Conopholis americana</i> (L.) Wallr.	squawroot	N
<i>Epifagus virginiana</i> (L.) Bart.	beechnut	N
Osmundaceae		
<i>Osmunda cinnamomea</i> L.	cinnamon fern	N
<i>Osmunda claytoniana</i> L.	interrupted fern	N
<i>Osmunda regalis</i> L.	royal fern	N
Oxalidaceae		
<i>Oxalis fontana</i> (<i>O. Europaea</i>) Bunge	yellow wood-sorrel	N
<i>Oxalis stricta</i> L.	common yellow wood-sorrel	N
Papaveraceae		
<i>Sanguinaria canadensis</i> L.	bloodroot	N
Phytolaccaceae		
<i>Phytolacca americana</i> L.	pokeweed	N
Pinaceae		
<i>Abies balsamea</i> (L.) Mill.	balsam fir	N
<i>Larix laricina</i> (DuRoi) K. Koch	tamarack	N
<i>Picea abies</i> (L.) Karsten	Norway spruce	A
<i>Picea glauca</i> (Moench) A. Voss	white spruce	N
<i>Pinus banksiana</i> Lamb.	jack pine	N
<i>Pinus resinosa</i> Aiton	red pine	N
<i>Pinus strobus</i> L.	white pine	N
<i>Pinus sylvestris</i> L.	scotch pine	A
Plantaginaceae		
<i>Plantago aristata</i> Michaux	buckhorn	A
<i>Plantago lanceolata</i> L.	English plantain	A
<i>Plantago rugelii</i> Dene.	red-stalked plantain	N
Platanaceae		
<i>Platanus occidentalis</i> L.	sycamore	N
Poaceae		
<i>Agropyron repens</i> (L.) Beauv.	quack grass	A
<i>Agropyron smithii</i> Rydb.	Smith's wheat grass	A

Family	Scientific name	Common name	Status	Native/Aventive
	<i>Agropyron trachycaulum</i> (Link) Malte	slender wheat grass		N
	<i>Agrostis gigantea</i> Roth	redtop		A
	<i>Agrostis hyemalis</i> (Walter) BSP.	ticklegass		N
	<i>Agrostis perennans</i> (Walter) Tuckerman	autumn bent grass		N
	<i>Andropogon gerardii</i> Vitman	big bluestem		N
	<i>Andropogon scoparius</i> (<i>Schizachyrium s.</i>) Michaux	little bluestem grass		N
	<i>Andropogon virginicus</i> L.	broom-sedge		N
	<i>Anthoxanthum odoratum</i> L.	sweet vernal grass fork-tipped three-awned grass		A
	<i>Aristida basiramea</i> Vasey	grass		N
	<i>Aristida purpurascens</i> Poiret	three-awned grass		N
	<i>Arrhenatherum elatius</i> (L.) Presl	tall oatgrass		A
	<i>Brachelytrum erectum</i> (Roth) Beauv.	long-awned wood grass		N
	<i>Bromus ciliatus</i> L.	fringed brome		N
	<i>Bromus inermis</i> Leysser	smooth brome		A
	<i>Bromus japonicus</i> Murray	Japanese brome		A
	<i>Bromus latiglumis</i> (Shear) Hitchc.	ear-leaved brome		N
	<i>Bromus mollis</i> L.	soft chess		A
	<i>Bromus pubescens</i> Willd.	Canada brome		N
	<i>Bromus racemosus</i> L.	smooth chess		A
	<i>Bromus squarrosus</i> L.	brome		A
	<i>Bromus tectorum</i> L.	cheat grass		A
	<i>Calamagrostis canadensis</i> (Michaux) Beauv.	blue-joint grass		N
	<i>Calamagrostis inexpansa</i> A. Gray	bog reedgrass		N
	<i>Cenchrus longispinus</i> (Hackel) Fern.	sandbur		N
	<i>Coelorachis cylindrica</i> (Michx.) Nash	joint grass		A
	<i>Dactylis glomerata</i> L.	orchard grass		A
	<i>Danthonia spicata</i> (L.) R. & S.	poverty grass; oatgrass		N
	<i>Deschampsia cespitosa</i> (L.) Beauv.	hair grass		N
	<i>Deschampsia flexuosa</i> (L.) Beauv.	hair grass		N
	<i>Digitaria ischaemum</i> (Schreber) Muhl.	smooth crab grass		A
	<i>Digitaria sanguinalis</i> (L.) Scop.	hairy crab grass		A
	<i>Echinochloa crusgalli</i> (L.) Beauv.	barnyard grass		A
	<i>Echinochloa muricata</i> (Beauv.) Fern.	barnyard grass		N
	<i>Echinochloa walteri</i> (Pursh) Heller	salt-marsh cockspear grass		N
	<i>Eleusine indica</i> (L.) Gaertner	goose grass		A
	<i>Elymus riparius</i> Wieg.	riverbank wild-rye		N
	<i>Elymus villosus</i> Willd.	silky wild-rye		N
	<i>Elymus virginicus</i> L.	Virginia wild-rye		N
	<i>Eragrostis ciliaris</i> (All.) Mosher	stink grass		A

<i>Eragrostis minor</i> Host	low love grass	A
<i>Eragrostis pectinacea</i> (Michaux) Nees	love grass	N
<i>Eragrostis spectabilis</i> (Pursh) Steudel	purple love grass	N
<i>Festuca arundinacea</i> Schreber	fall fescue	A
<i>Festuca octoflora</i> Walter	six-weeks fescue	N
<i>Festuca ovina</i> L.	sheep fescue	A
<i>Festuca pratensis</i> Hudson	meadow fescue	A
<i>Festuca rubra</i> L.	red fescue	A
<i>Festuca subverticillata</i> (<i>F. obtusa</i>) (Persh.) E. Alexeev.	nodding fescue	N
<i>Glyceria canadensis</i> (Michaux) Trin.	rattlesnake grass	N
<i>Glyceria striata</i> (Lam.) Hitchc.	fowl manna grass	N
<i>Hystrix patula</i> Moench	bottlebrush grass	N
<i>Leersia oryzoides</i> (L.) Sw.	cut grass	N
<i>Leersia virginica</i> Willd.	white grass	N
<i>Leptoloma cognatum</i> (Schultes) Chase	fall witch grass	N
<i>Lolium perenne</i> L.	perennial rye grass	A
<i>Muhlenbergia frondosa</i> (Poirét) Fern.	common satin grass	N
<i>Muhlenbergia glomerata</i> (Willd.) Trin.	marsh wild-timothy	N
<i>Muhlenbergia mexicana</i> (L.) Trin.	leafy satin grass	N
<i>Muhlenbergia schreberi</i> J. F. Gmelin	nimblewill	N
<i>Panicum capillare</i> L.	witch grass	N
<i>Panicum clandestinum</i> L.	panic grass	N
<i>Panicum depauperatum</i> Muhl.	panic grass	N
<i>Panicum dichotomiflorum</i> Michaux	panic grass	N
<i>Panicum dichotomum</i> L.	panic grass	N
<i>Panicum implicatum</i> Britton	panic grass	N
<i>Panicum latifolium</i> L.	broad-leaved panic grass	N
<i>Panicum oligosanthes</i> Schultes	panic grass	N
<i>Panicum praecocius</i> Hitchc. & Chase	panic grass	N
<i>Panicum sphaerocarpon</i> Ell.	round-fruited panic grass	N
<i>Panicum virgatum</i> L.	switch grass	N
<i>Paspalum ciliatifolium</i> Michaux	hairy lens grass	N
<i>Phalaris arundinacea</i> L.	reed canary grass	N
<i>Phleum pratense</i> L.	timothy	A
<i>Phragmites australis</i> (Cav.) Steudel	reed	N
<i>Poa annua</i> L.	annual bluegrass	A
<i>Poa compressa</i> L.	Canada bluegrass	A
<i>Poa pratensis</i> L.	Kentucky bluegrass	A
<i>Poa trivialis</i> L.	bluegrass	A
<i>Puccinellia pallida</i> (Torrey) Clausen	puccinellia	N
<i>Setaria glauca</i> (L.) Beauv.	yellow foxtail	A
<i>Setaria viridis</i> (L.) Beauv.	green foxtail	A

Family	Scientific name	Common name	Status	Native/Aventive
	<i>Sorghastrum nutans</i> (L.) Nash	Indian grass		N
	<i>Spartina pectinata</i> Link	cordgrass		N
	<i>Sphenopholis intermedia</i> (Rydb.) Rydb.	slender wedgrass		N
	<i>Sporobolus cryptandrus</i> (Torrey) A. Gray	sand dropseed		N
	<i>Sporobolus heterolepis</i> (A. Gray) A. Gray	prairie dropseed	SC	N
	<i>Sporobolus neglectus</i> Nash	small rush grass		N
	<i>Stipa avenacea</i> L.	black oatgrass		N
	<i>Tridens flavus</i> (L.) Hitchc.	purpletop		N
Polemoniaceae				
	<i>Phlox divaricata</i> L.	woodland phlox		N
	<i>Phlox paniculata</i> L.	garden phlox		A
	<i>Phlox pilosa</i> L.	prairie phlox		N
Polygalaceae				
	<i>Polygala polygama</i> Walter	racemed milkwort		N
	<i>Polygala sanguinea</i> L.	field milkwort		N
Polygonaceae				
	<i>Polygonum amphibium</i> L. var. <i>stipulaceum</i>			
	Coleman	water smartweed		N
	<i>Polygonum amphibium</i> L. var. <i>emersum</i> Michx.	water smartweed		N
	<i>Polygonum aviculare</i> L.	knotweed		A
	<i>Polygonum convolvulus</i> L.	false buckwheat		A
	<i>Polygonum hydropiper</i> L.	water-pepper		N
	<i>Polygonum hydropiperoides</i> Michaux	water-pepper		N
	<i>Polygonum lapathifolium</i> L.	nodding smartweed		N
	<i>Polygonum pensylvanicum</i> L.	bigseed smartweed		N
	<i>Polygonum persicaria</i> L.	lady's-thumb		A
	<i>Polygonum punctatum</i> Ell.	smartweed		N
	<i>Polygonum sagittatum</i> L.	arrow-leaved tear-thumb		N
	<i>Polygonum scandens</i> L.	false buckwheat		N
	<i>Polygonum tenue</i> Michaux	slender knotweed		N
	<i>Polygonum virginianum</i> (Tovara v.) L.	jumpseed		N
	<i>Rumex acetosella</i> L.	sheep sorrel		A
	<i>Rumex crispus</i> L.	curly dock		A
	<i>Rumex obtusifolius</i> L.	bitter dock		A
	<i>Rumex orbiculatus</i> A. Gray	great water dock		N
Polypodiaceae				
	<i>Adiantum pedatum</i> L.	maidenhair fern		N
	<i>Athyrium filix-femina</i> (L.) Roth	lady fern		N
	<i>Athyrium pycnocarpon</i> (Sprengel) Tidest.	narrow-leaved spleenwort		N
	<i>Athyrium thelypteroides</i> (Michaux) Desv.	silvery spleenwort		N

<i>Cystopteris bulbifera</i> (L.) Bemb.	bulblet fern	N
<i>Dryopteris carthusiana</i> (<i>D. spinulosa</i>) (Vill.) H. P. Fuchs	spinulose woodfern	N
<i>Dryopteris cristata</i> (L.) A. Gray	crested shield fern	N
<i>Dryopteris goldiana</i> (Hooker) A. Gray	Goldie's woodfern	N
<i>Dryopteris intermedia</i> (Muhl. ex Willd.) A. Gray	evergreen woodfern	N
<i>Matteuccia struthiopteris</i> (L.) Todaro	ostrich fern	N
<i>Onoclea sensibilis</i> L.	sensitive fern	N
<i>Polystichum acrostichoides</i> (Michaux) Schott.	Christmas fern	N
<i>Thelypteris hexagonoptera</i> (Michaux) Weatherby	broad beech-fern	N
<i>Thelypteris palustris</i> Schott	marsh fern	N
Pontederiaceae		
<i>Pontederia cordata</i> L.	pickereel weed	N
Portulacaceae		
<i>Claytonia caroliniana</i> Michaux	spring-beauty	N
Potamogetonaceae		
<i>Potamogeton foliosus</i> Raf.	leafy pondweed	N
<i>Potamogeton friesii</i> Rupr.	Fries's pondweed	N
<i>Potamogeton gramineus</i> L.	pondweed	N
<i>Potamogeton illinoensis</i> Morong	Illinois pondweed	N
<i>Potamogeton natans</i> L.	pondweed	N
<i>Potamogeton pectinatus</i> L.	sago pondweed	N
<i>Potamogeton pusillus</i> L.	small pondweed	N
<i>Potamogeton zosteriformis</i> Fern.	flat-stemmed pondweed	N
Primulaceae		
<i>Lysimachia ciliata</i> L.	fringed loosestrife	N
<i>Lysimachia lanceolata</i> Walter	lance-leaved loosestrife	N
<i>Lysimachia quadriflora</i> Sims	whorled loosestrife	N
<i>Lysimachia quadrifolia</i> L.	four-leaved loosestrife	N
<i>Lysimachia terrestris</i> (L.) BSP.	swamp candles	N
<i>Lysimachia thyrsoflora</i> L.	tufted loosestrife	N
Pteridaceae		
<i>Pteridium aquilinum</i> (L.) Kuhn	bracken fern	N
Pyrolaceae		
<i>Chimaphila maculata</i> (L.) Pursh	spotted wintergreen	N
<i>Pyrola elliptica</i> Nutt.	large-leaved shinleaf	N
Ranunculaceae		
<i>Actaea pachypoda</i> Ell.	doll's-eyes	N
<i>Actaea rubra</i> (Aiton) Willd.	red baneberry	N
<i>Anemone cylindrica</i> A. Gray	thimbleweed	N

Family	Scientific name	Common name	Status	Native/Aventive
	<i>Anemone quinquefolia</i> L.	wood anemone		N
	<i>Anemone virginiana</i> L.	thimbleweed		N
	<i>Anemone thalictroides</i> (L.) Spach	rue anemone		N
	<i>Aquilegia canadensis</i> L.	wild columbine		N
	<i>Caltha palustris</i> L.	marsh-marigold		N
	<i>Clematis virginiana</i> L.	virgin's bower		N
	<i>Hepatica americana</i> (DC.) Ker	round-lobed hepatica		N
	<i>Hydrastis canadensis</i> L.	goldenseal	T	N
	<i>Isopyrum biternatum</i> (Raf.) T. & G.	false rue anemone		N
	<i>Ranunculus abortivus</i> L.	small-flowered buttercup		N
	<i>Ranunculus hispidus</i> Michaux	swamp buttercup		N
	<i>Ranunculus pensylvanicus</i> L. f.	bristly crowfoot		N
	<i>Ranunculus recurvatus</i> Poiret	hooked crowfoot		N
	<i>Ranunculus sceleratus</i> L.	cursed crowfoot		N
	<i>Thalictrum dasycarpum</i> Fisch. & Ave- Lall.	purple meadow-rue		N
	<i>Thalictrum dioicum</i> L.	early meadow-rue		N
Rhamnaceae				
	<i>Ceanothus americanus</i> L.	New Jersey-tea		N
	<i>Rhamnus alnifolia</i> L'Her.	alder-leaved buckthorn		N
	<i>Rhamnus cathartica</i> L.	common buckthorn		A
	<i>Rhamnus frangula</i> L.	glossy buckthorn		A
Rosaceae				
	<i>Agrimonia gryposepala</i> Wallr.	tall agrimony		N
	<i>Agrimonia parviflora</i> Aiton	swamp agrimony		N
	<i>Agrimonia pubescens</i> Wallr.	soft agrimony		N
	<i>Agrimonia rostellata</i> Wallr.	beaked agrimony	SC	N
	<i>Amelanchier arborea</i> (Michaux f.) Fern.	juneberry		N
	<i>Amelanchier laevis</i> Wieg.	smooth shadbush		N
	<i>Amelanchier spicata</i> (Lam.) K. Koch	shadbush serviceberry		N
	<i>Crataegus calpodendron</i> (Ehrh.) Medicus	hawthorn		N
	<i>Crataegus cris-galli</i> L.	cockspur thorn		N
	<i>Crataegus holmesiana</i> Ashe	hawthorn		N
	<i>Crataegus margaretta</i> Ashe	hawthorn		N
	<i>C. monogyna</i> X <i>punctata</i>	hybrid hawthorn		I
	<i>Filipendula rubra</i> (Hill) Robinson	queen-of-the-prairie	T	N
	<i>Fragaria virginiana</i> Miller	wild strawberry		N
	<i>Geum aleppicum</i> Jacq.	yellow avens		N
	<i>Geum canadense</i> Jacq.	white avens		N
	<i>Malus coronaria</i> (L.) Miller	American crab		N
	<i>Malus pumila</i> Miller	apple		A
	<i>Malus sieboldi</i> Regel	toringo crab		A

<i>Potentilla argentea</i> L.	silvery cinquefoil	A
<i>Potentilla arguta</i> Pursh	tall or prairie cinquefoil	N
<i>Potentilla fruticosa</i> L.	shrubby cinquefoil	N
<i>Potentilla norvegica</i> L.	rough cinquefoil	N
<i>Potentilla palustris</i> (L.) Scop.	marsh cinquefoil	N
<i>Potentilla recta</i> L.	rough-fruited cinquefoil	A
<i>Potentilla simplex</i> Michaux	old-field cinquefoil	N
<i>Prunus avium</i> (L.) L.	sweet cherry	A
<i>Prunus mahaleb</i> L.	perfumed cherry	A
<i>Prunus serotina</i> Ehrh.	wild black cherry	N
<i>Prunus virginiana</i> L.	choke cherry	N
<i>Rosa carolina</i> L.	pasture rose	N
<i>Rosa multiflora</i> Murray	multiflora rose	A
<i>Rosa palustris</i> Marsh.	swamp rose	N
<i>Rubus allegheniensis</i> Porter	common blackberry	N
<i>Rubus flagellaris</i> Willd.	northern dewberry	N
<i>Rubus hispidus</i> L.	swamp dewberry	N
<i>Rubus occidentalis</i> L.	black raspberry	N
<i>Rubus pensylvanicus</i> Poiret	dewberry	N
<i>Rubus pubescens</i> Raf.	dwarf raspberry	N
<i>Rubus strigosus</i> (<i>R. idaeus</i>) Michaux	wild red raspberry	N
<i>Sorbus decora</i> (Sarg.) C. K. Schneid.	mountain-ash	N
<i>Spiraea alba</i> Du Roi	meadowsweet	N
<i>Spiraea tomentosa</i> L.	steplebush	N
<i>Spiraea xvanhouttei</i> (Briot) Carr.	bridal-wreath	A
Rubiaceae		
<i>Cephalanthus occidentalis</i> L.	buttonbush	N
<i>Galium aparine</i> L.	annual bedstraw	N
<i>Galium asprellum</i> Michaux	rough bedstraw	N
<i>Galium boreale</i> L.	northern bedstraw	N
<i>Galium circaeazans</i> Michaux	white wild licorice	N
<i>Galium lanceolatum</i> Torrey	yellow wild licorice	N
<i>Galium obtusum</i> Bigel.	wild madder	N
<i>Galium pilosum</i> Ait.	hairy bedstraw	N
<i>Galium tinctorium</i> L.	stiff bedstraw	N
<i>Galium trifidum</i> L.	small bedstraw	N
<i>Galium triflorum</i> Michaux	fragrant bedstraw	N
<i>Mitchella repens</i> L.	partridge berry	N
Rutaceae		
<i>Zanthoxylum americanum</i> Miller	prickly-ash	N
Salicaceae		
<i>Populus deltoides</i> Marsh.	cottonwood	N
<i>Populus grandidentata</i> Michaux	big-toothed aspen	N

Family	Scientific name	Common name	Status	Native/Aventive
	<i>Populus tremuloides</i> Michaux	quaking aspen		N
	<i>Salix bebbiana</i> Sarg.	Bebb's willow		N
	<i>Salix candida</i> Willd.	hoary willow		N
	<i>Salix discolor</i> Muhl.	pussy willow		N
	<i>Salix eriocephala</i> Michaux	willow		N
	<i>Salix exigua</i> (<i>S. Interior</i>) Nutt.	sandbar willow		N
	<i>S. Xrubens</i> Shrank	hybrid willow		N
	<i>Salix sericea</i> Marsh.	silky willow		N
	<i>Salix serissima</i> (Bailey) Fern.	autumn willow		N
Santalaceae				
	<i>Comandra umbellata</i> (L.) Nutt.	bastard-toadflax		N
Saxifragaceae				
	<i>Heuchera americana</i> L.	alum root		N
	<i>Mitella diphylla</i> L.	bishop's cap		N
	<i>Parnassia glauca</i> Raf.	grass-of-Parnassus		N
	<i>Saxifraga pensylvanica</i> L.	swamp saxifrage		N
Scrophulariaceae				
	<i>Agalinis purpurea</i> (<i>Gerardia p.</i>) (L.) Pennell	purple gerardia		N
	<i>Aureolaria flava</i> (L.) Farw.	smooth false foxglove		N
	<i>Aureolaria pedicularia</i> (L.) Raf.	annual false foxglove		N
	<i>Chelone glabra</i> L.	turtlehead		N
	<i>Linaria canadensis</i> (L.) Dum.	blue toadflax		N
	<i>Lindernia dubia</i> (L.) Pennell	false pimpernel		N
	<i>Mimulus ringens</i> L.	monkey-flower		N
	<i>Pedicularis canadensis</i> L.	wood-betony		N
	<i>Pedicularis lanceolata</i> Michaux	swamp-betony		N
	<i>Penstemon digitalis</i> Nutt.	foxglove beard-tongue		N
	<i>Penstemon hirsutus</i> (L.) Willd.	hairy beard-tongue		N
	<i>Penthorum sedoides</i> L.	ditch stoncrop		N
	<i>Scrophularia lanceolata</i> Small	early figwort		N
	<i>Scrophularia marilandica</i> L.	late figwort		N
	<i>Verbascum blattaria</i> L.	moth mullein		A
	<i>Verbascum thapsus</i> L.	common mullein		A
	<i>Veronica anagallis-aquatica</i> L.	water speedwell		N
	<i>Veronica arvensis</i> L.	corn speedwell		A
	<i>Veronica officinalis</i> L.	common speedwell purslane speedwell or neckweed		A
	<i>Veronica peregrina</i> L.			N
	<i>Veronicastrum virginicum</i> (L.) Farw.	Culver's root		N
Selaginellaceae				
	<i>Selaginella eclipes</i> Buck.	selaginella		N

Simaroubaceae	<i>Ailanthus altissima</i> (Miller) Swingle	tree-of-heaven	A
Solanaceae	<i>Physalis heterophylla</i> Nees	clammy ground-cherry	N
	<i>Solanum carolinense</i> L.	horse nettle	A
	<i>Solanum dulcamara</i> L.	bittersweet nightshade	A
	<i>Solanum physalifolium</i> (<i>S. sarachoides</i>) Rusby	hairy nightshade	A
	<i>Solanum ptychanthum</i> (<i>S. nigrum</i>) Dunal	black nightshade	N
Sparganiaceae	<i>Sparganium americanum</i> Nutt.	American bur-reed	N
	<i>Sparganium chlorocarpum</i> Rydb.	green-fruited bur-reed	N
	<i>Staphylea trifolia</i> L.	bladdernut	N
Tiliaceae	<i>Tilia americana</i> L.	basswood	N
Typhaceae	<i>Typha angustifolia</i> L.	narrow-leaved cat-tail	A
	<i>Typha latifolia</i> L.	broad-leaved cat-tail	N
Ulmaceae	<i>Celtis occidentalis</i> L.	hackberry	N
	<i>Ulmus americana</i> L.	American elm	N
	<i>Ulmus glabra</i> Huds.	wych elm	A
	<i>Ulmus rubra</i> Muhl.	slippery elm	N
Urticaceae	<i>Boehmeria cylindrica</i> (L.) Sw.	false nettle	N
	<i>Laportea canadensis</i> (L.) Wedd.	wood nettle	N
	<i>Parietaria pensylvanica</i> Willd.	pellitory	N
	<i>Pilea fontana</i> (Lunell) Rydb.	bog clearweed	N
	<i>Urtica dioica</i> L.	nettle	N
Valerianaceae	<i>Valeriana uliginosa</i> (T. & G.) Rydb.	bog valerian	N
Verbenaceae	<i>Phryma leptostachya</i> L.	looseseed	N
	<i>Verbena bracteata</i> Lag. & Rodr.	creeping vervain	A
	<i>Verbena hastata</i> L.	blue vervain	N
	<i>Verbena stricta</i> Vent.	hoary vervain	N
	<i>Verbena urticifolia</i> L.	white vervain	N
Violaceae	<i>Viola arvensis</i> Murray	field pansy	A
	<i>Viola canadensis</i> L.	Canada violet	N
	<i>Viola cucullata</i> Aiton	marsh violet	N
	<i>Viola lanceolata</i> L.	lance-leaved violet	N

Family	Scientific name	Common name	Status	Native/Aventive
Violaceae cont...	<i>Viola macloskeyi</i> (<i>V. pallens</i>) F. E. Lloyd	smooth white violet		N
	<i>Viola pubescens</i> Aiton	yellow violet		N
	<i>Viola rostrata</i> Pursh	long-spurred violet		N
	<i>Viola sagittata</i> Aiton	arrow-leaved violet		N
	<i>Viola sororia</i> Willd.	common blue violet		N
	<i>Viola striata</i> Aiton	cream violet		N
Vitaceae	<i>Parthenocissus inserta</i> (A. Kerner)			
	Eritsch	thicket creeper		N
	<i>Parthenocissus quinquefolia</i> (L.)			
	Planchon	Virginia creeper		N
	<i>Vitis aestivalis</i> Michaux	summer grape		N
<i>Vitis riparia</i> Michaux	riverbank grape		N	