

The Conservation and Management of
Prairie Fens
and Associated Species

Accomplishments and Lessons from the
MDNR Landowner Incentive Program
2004—2013



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Michigan Natural Features Inventory
October, 2013

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Rebecca A. Norris, MNFI

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Prepared by:

Bradford S. Slaughter, Daria A. Hyde, David L. Cuthrell, Yu Man Lee and
Rebecca A. Norris

Layout and design:

Suzan Campbell

Michigan Natural Features Inventory
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Yu Man Lee, MNFI



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Nate Simons

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David Borneman

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Amy Clark Eagle

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Dick Wolinski

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Executive summary

From 2004–2013, the Michigan Department of Natural Resources, Wildlife Division Landowner Incentive Program (LIP) provided technical assistance and management resources for over 90 private landowners who collectively owned and managed over 20,000 acres of land, including portions of at least 42 high quality prairie fen wetlands totaling approximately 1,800 acres.

Prairie fen is a globally vulnerable groundwater-fed wetland community that supports at least 57 state-listed animal and plant species in Michigan. Collectively, several hundred populations of rare species occupy prairie fen wetlands that were managed with the assistance of LIP over the past decade. In particular, LIP provided crucial resources to land managers working at sites that support several species of federal concern, in particular the federally endangered Mitchell's satyr butterfly (*Neonympha mitchellii mitchellii*), federal candidate eastern massasauga (*Sistrurus catenatus catenatus*), and federal candidate Poweshiek skipperling (*Oarisma poweshiek*).

Over the past 10 years, MNFI staff and partners surveyed and monitored populations of these and other rare species over the course of management activities intended to stabilize or increase their populations. Despite the efforts of the conservation community, many populations of these rare species continue to decline. The results of these surveys and monitoring activities illuminate the variety of deterministic and stochastic processes that act on populations of target species, and illustrate the challenges land managers face when designing and implementing management plans for prairie fens and associated species.

Opposite page:

Baltimore checkerspot

Photo: David L. Cuthrell



Prairie fens in Michigan

Prairie fen is a globally vulnerable wetland type characterized by the accumulation of peat soils where calcium-rich groundwater discharges to the land surface from subsurface soil layers. Prairie fen vegetation is dominated by graminoids, or grasses and grass-like plants, particularly members of the large sedge family (Cyperaceae), and often also by low shrubs such as shrubby cinquefoil (*Dasiphora fruticosa*). Tall shrubs such as dogwoods (*Cornus* spp.) and trees such as tamarack (*Larix laricina*), American elm (*Ulmus americana*), and red maple (*Acer rubrum*) are often scattered within prairie fens, but are not characteristically abundant due to their inability to establish and survive in the waterlogged peat soils. The “prairie” modifier of “prairie fen” refers to the fact that many of these fens occur in or near the “prairie peninsula” that extended from the Great Plains into northwestern Indiana and southwestern Lower Michigan. In these areas, prairie fens support plant species that invaded from the prairies and savannas, such as big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), Indian grass (*Sorghastrum nutans*), and marsh blazing-star (*Liatris spicata*). These species and many others from the prairie and savanna give these fens a unique floristic character that is absent from the more extensive fen systems in the northern United States and Canada that were isolated from the historic prairies and savannas.

Prior to widespread settlement and land conversion in the early 1800s, wet, open grasslands and peatlands such as prairie fens occupied approximately 220,000 acres in the interior of the southern Lower Peninsula (Comer et al. 1995). Today, only approximately 2% of this original “wet prairie” acreage, or approximately 4,000 acres, supports prairie fen of sufficient quality to be tracked and monitored by Michigan Natural Features Inventory (MNFI). This acreage is scattered across approximately 150 sites. Most prairie fens are small, with fewer than 10% of documented sites supporting >40 hectares (100 acres) of fen, and the majority of sites supporting <10 ha (25 ac) of fen (Hyde et al. 2009).

Opposite page:

Prairie fen with marsh blazing star, swamp milkweed and swallowtails

Photo: Michael A. Kost



In addition to common wildlife species such as white-tailed deer and turkeys, prairie fens support at least 43 state-listed species in Michigan, including 22 animals and 21 plants. Many of the rare animal species have been identified as Species of Greatest Conservation Need (SGCN) by the Michigan Department of Natural Resources Wildlife Division (WLD). In particular, prairie fens provide critical habitat for several federally listed animal species, including the endangered Mitchell’s satyr butterfly (*Neonympha mitchellii mitchellii*), federal candidate Poweshiek skipperling (*Oarisma poweshiek*), and federal candidate eastern massasauga (*Sistrurus catenatus catenatus*).



Rare animals

Among the 22 species of state-listed animals that are typical of prairie fens in Michigan, 11 are insects and six are herptiles (reptiles and amphibians) (Table 1). These species were the focus of MNFI survey and monitoring efforts under the WLD Landowner Incentive Program (LIP) from 2004—2013.

Table 1. Rare animals of prairie fen in Michigan.

Common name	Scientific name	Status
Amphibians		
Blanchard's cricket frog	<i>Acris blanchardi</i>	T
Birds		
Northern harrier	<i>Circus cyaneus</i>	SC
Marsh wren	<i>Cistothorus palustris</i>	SC
Red-shouldered hawk	<i>Buteo lineatus</i>	T
Insects: Butterflies and Moths		
Blazing star borer moth	<i>Papaipema beeriana</i>	SC
Mitchell's satyr	<i>Neonympha mitchellii mitchellii</i>	E, FE
Poweshiek skipperling*	<i>Oarisma poweshiek</i>	T, FC
Regal fern borer moth	<i>Papaipema speciosissima</i>	SC
Silphium borer moth	<i>Papaipema silphii</i>	T
Sunflower borer moth	<i>Papaipema maritima</i>	SC
Swamp metalmark	<i>Calephelis mutica</i>	SC
Insects: Dragonflies		
Gray petaltail	<i>Tachopteryx thoreyi</i>	T
Insects: Spittlebugs		
Angular spittlebug*	<i>Lepyronia angulifera</i>	SC
Red-legged spittlebug	<i>Prosapia ignipectus</i>	SC
Insects: Tree Crickets		
Tamarack tree cricket	<i>Oecanthus laricis</i>	SC
Mollusks: Snails (Gastropod)		
Watercress snail	<i>Fontigens nickliniana</i>	SC
Mollusks: Mussels (Unionidae)		
Slippershell mussel	<i>Alasmidonta viridis</i>	T

E= Endangered; T= Threatened; SC= Special Concern; FE= Federally Endangered; FC= Federal Candidate. *= Prairie fen obligate.

Table 1. Rare animals of prairie fen in Michigan. (continued)

Common name	Scientific name	Status
Reptiles		
Blanding's Turtle	<i>Emydoidea blandingii</i>	SC
Eastern Box Turtle	<i>Terrapene carolina carolina</i>	SC
Eastern massasauga	<i>Sistrurus catenatus catenatus</i>	SC, FC
Kirtland's Snake	<i>Clonophis kirtlandii</i>	E
Spotted Turtle	<i>Clemmys guttata</i>	T

E= Endangered; T= Threatened; SC= Special Concern; FE= Federally Endangered; FC= Federal Candidate. *= Prairie fen obligate.

Eastern box turtle



Christopher Hoving, MDNR

Rare insects

A large number of insects utilize or occur in prairie fens in Michigan. These include a total of 11 rare (endangered, threatened, or special concern) insects recognized by the State of Michigan (Table 1). Species which are restricted to prairie fen (i.e., species that do not to our knowledge occur in other habitat types) include the state threatened and federal candidate Poweshiek skipperling (*Oarisma poweshiek*) and the state special concern angular spittlebug (*Lepyronia angulifera*). Four additional insects utilize fens but can also occur in other habitat types including the state and federally endangered Mitchell's satyr (*Neonympha mitchellii mitchellii*), the state special concern swamp metalmark (*Calephelis mutica*), the state threatened gray petaltail (*Tachopteryx thoreyi*), and the state special concern tamarack tree cricket (*Oecanthus laricis*). Surveys and monitoring conducted by MNFI as part of LIP focused primarily on the Mitchell's satyr and Poweshiek skipperling, but we also surveyed for and recorded observations of several other rare insect species.

Swamp metalmark



Barbara J. Barton



Mitchell's satyr

(Global Rank: G1G2T1T2; State Rank: S1)

The Mitchell's satyr (*Neonympha mitchellii mitchellii*) is one of the most endangered butterflies in North America. It is a medium-sized butterfly with a wingspan measuring 4.1 to 4.4 centimeters (1.5 to 1.75 inches). Its color can range from warm tan to dark chocolate brown. The undersides of its wings each have a row of four or five black eyespots that are dotted with silvery markings, ringed in yellow and encircled by two orange bands. The three central eyespots on its hind wing are the largest (Figure 1).



David L. Cuthrell, MNFI

Figure 1. Mitchell's satyr butterfly.

The Mitchell's satyr exists for most of its life as a caterpillar or larva. Adults can be seen from mid-June through mid-July flying low over the vegetation with a slow, rhythmic, bobbing flight in search of mates and suitable locations to lay their eggs. Females deposit their miniscule eggs on the undersides of small plants near the bases of sedge tussocks located near groundwater seeps. When the eggs hatch, tiny caterpillars emerge and feed on the leaves of sedges and other nearby

Opposite page:

Occupied Mitchell's satyr habitat

Photo: Daria A. Hyde

plants. The larvae are lime-green with pale stripes that run the length of their bodies, a camouflaged color scheme that conceals their presence among the sedges and grasses. Under caged conditions larvae have been observed feeding throughout the summer until reaching the fourth instar. They then enter diapause and resume feeding the following spring. In late May to late June the larvae form a chrysalis and the adults emerge 10 to 15 days later (McAlpine et al. 1960).

The Mitchell's satyr is currently confined to 16 sites in southern Michigan and one site in northern Indiana. Historically, this butterfly also occurred in Ohio, New Jersey and possibly Maryland (McAlpine et al. 1960, USFWS 1998) (Figure 2). Genetic analysis of recently discovered populations of *Neonympha mitchellii* in Alabama, Mississippi and Virginia is being conducted to determine if these southern populations are, in fact, also Mitchell's satyr (*Neonympha mitchellii mitchellii*).

The Mitchell's satyr has declined dramatically in the past two decades and has become extirpated in over 20% of known occupied sites despite protection as a federally endangered species since 1992. Only six of the 17 extant populations are considered viable due to habitat degradation and/or critically low numbers. Additionally, 15 of the 17 extant sites in Michigan and Indiana occur partially or entirely on private property where protection of Mitchell's satyr and its habitat is more challenging. Two populations occur on State of Michigan land within the Barry State Game Area and the Yankee Springs State Recreation Area, although it appears that these populations are no longer extant.

Sites that continue to support the Mitchell's satyr contain peat soil with carbonate-rich groundwater seeps and are most often dominated by narrow-leaved sedges, grasses and wildflowers with scattered tamarack, poison sumac and other shrubs. The primary threat to the continued survival of this species is habitat loss and modification. It appears that past and current alterations to the underlying hydrology of fens occupied by Mitchell's satyr have impacted the quality of the habitat and contributed to the reduction of groundwater seeps and proliferation of invasive plants. Although many state and federal agencies have worked collaboratively with non-profit conservation groups and landowners to help this species recover by restoring and protecting its unique habitat, Mitchell's satyr populations at most sites have continued to decline.

In order to reclassify this species from endangered to threatened, 16

geographically distinct, viable populations or metapopulations need to be established or discovered range-wide with at least half of these sites protected and managed. The Mitchell's satyr can be delisted when 25 geographically distinct, viable populations or metapopulations are established or discovered range-wide and remain viable for five consecutive years following reclassification. A minimum of 15 sites must be protected and managed to maintain Mitchell's satyr habitat by state or federal agencies or by private organizations before delisting will be considered. The Mitchell's satyr working group has developed a draft action plan for Mitchell's satyr recovery.

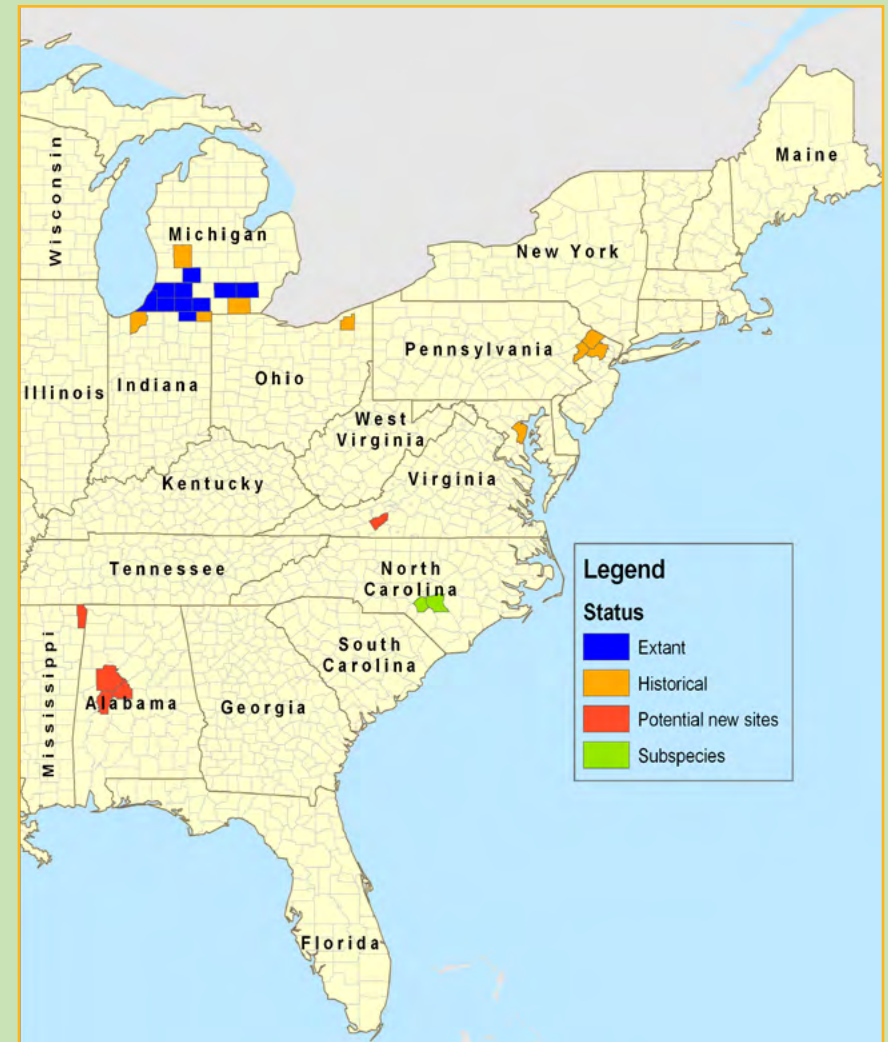


Figure 2. Historic range of *Neonympha mitchellii*.



David L. Cuthrell, MNFI

Figure 3. Poweshiek skipperling.



David L. Cuthrell, MNFI

Poweshiek skipperling habitat at Grand River fen

Poweshiek skipperling

(Global Rank: G1; State Rank: S1)

The Poweshiek skipperling (*Oarisma poweshiek*) has recently been recognized as one of the most imperiled butterflies in North America, and as of fall 2013 is proposed to be listed as a federally endangered species. It is currently known from eight states and the province of Manitoba, Canada, with two of these states, Illinois and Indiana, supporting only historical records. In Michigan, Poweshiek skipperling is extant at six sites, and it is currently listed as a state threatened species.

The Poweshiek skipperling is a small, slender bodied-butterfly (Figure 3). Adult wingspan ranges from 0.9–1.25 in (26–32 mm). The wings are somewhat triangular and pointed at the tips. Upper wing surfaces are dark grayish brown with an orange costal area on the forewing. The undersurface of the hindwing is pale brown and has veins covered with white scales giving an overall whitish appearance to the undersurface (Selby 2005). Basal areas veins are dark brown without white scales. The caterpillar is pale green with a dark green dorsal band outlined by cream lines (Nielsen 1999). Adults can be recognized at a distance by their whirling flight pattern that exhibits a lot of forewing movement with little forward velocity.

A careful study of larval food plants has not been conducted for the Poweshiek skipperling (Selby 2005). Based on very limited observations from McAlpine in 1944 and Holzman in 1970 in Michigan, it was presumed that the larval food plants were spike-rush (*Eleocharis elliptica*) or sedges. Observations of Poweshiek populations in Wisconsin by Borkin (1994, 1995, 1996) suggest that the preferred larval food plants are prairie dropseed (*Sporobolus heterolepis*) and little bluestem (*Schizachyrium scoparium*). Because of the close association in Michigan between Poweshiek adults and prairie dropseed and mat muhly (*Muhlenbergia richardsonis*), it is strongly suspected that one or both of these plants may be a host plant for the larvae (Cuthrell and Slaughter 2012). Additional research is needed in a variety of habitats throughout the Poweshieks' range to determine the preferred host plants of the larvae (Selby 2005).

Based on observations by McAlpine (1972), there are at least seven instar larval stages with the belief that there should be at least one or two additional instars followed by the chrysalis and imago stages (Selby 2005 summarizing McAlpine 1972). Larvae do not construct shelters for overwintering like some skippers, but rest head down on

grass blades or stems between periods of feeding, and overwinter in a similar position (Borkin 1995; R. Dana, Minnesota DNR, pers. comm.). Larval activity and feeding resumes in early spring (around April 1) with adults typically emerging in mid- to late June through late July, depending on weather conditions. Eggs are laid on or very near the host plant and hatch approximately 10 days later (Cuthrell and Slaughter 2012).

In Michigan, adult butterflies readily nectar on black-eyed susan (*Rudbeckia hirta*), pale spike lobelia (*Lobelia spicata*), shrubby cinquefoil (*Dasiphora fruticosa*), and sticky tofieldia (*Triantha glutinosa*). Other documented nectar sources include northern bedstraw (*Galium boreale*), Joe-pye-weed (*Eutrochium maculatum*), Indian hemp (*Apocynum cannabinum*), and white camas (*Anticlea elegans*) (Cuthrell and Slaughter 2012).

Poweshiek skipperling nectaring on black-eyed susan



David L. Cuthrell, MNFI

Small colony sizes and isolation, due to past habitat loss, are the primary threats facing the Poweshiek skipperling in Michigan. Current stressors include habitat destruction for residential and commercial development, incompatible agricultural practices, and the rapid spread of invasive species. These disturbances and potentially others have reduced the distribution of this species to a few remaining high quality prairie fen systems. Although many state and federal agencies have worked collaboratively with non-profit conservation groups and landowners to help this species recover by restoring and protecting its unique habitat, Poweshiek skipperling populations at several sites have declined sharply in the past year.

Eastern hog-nosed snake



Barbara J. Barton

Rare amphibians and reptiles

Eleven of the 28 amphibian and reptile species currently identified as SGCN in Michigan's Wildlife Action Plan utilize prairie fens for habitat. These include several state-listed or rare and declining species such as the state threatened Blanchard's cricket frog (*Acris blanchardi*), state threatened spotted turtle (*Clemmys guttata*), state special concern eastern box turtle (*Terrapene carolina carolina*), and state endangered Kirtland's snake (*Clonophis kirtlandii*). These also include amphibian and reptile species that are more common but are still of conservation concern in the state such as the northern leopard frog (*Rana pipiens*), pickerel frog (*Rana palustris*), blue racer (*Coluber constrictor foxii*), and eastern hog-nosed snake (*Heterodon platirhinos*). Surveys and monitoring conducted by MNFI as part of the LIP and Competitive SWG Prairie Fen projects focused primarily on the eastern massasauga, but we also surveyed for and recorded observations of the Blanchard's cricket frog, spotted turtle, Blanding's turtle, and eastern box turtle.



Eastern massasauga

(Global Rank: G3G4T3Q; State Rank: S3S4)

The Eastern massasauga is Michigan's only rattlesnake, and is a SGCN that inhabits prairie fens and other wetlands in the state. The eastern massasauga is a medium-sized, thick-bodied snake, with adults averaging about 60–80 cm (2 to 2.5 feet) long, and reaching a maximum length of about 91 cm (3 feet) (Harding 1997) (Figure 4). It has a distinctive body pattern with dark brown, saddle- or hourglass-shaped blotches along the top of the body and smaller, dark brown spots along the sides. The background color is grayish or light brown, although some individuals can be solid black in color. The "rattle" at the end of its tail is comprised of loosely attached, interlocking, hard segments made of keratin, which is the same material found in hair, nails, and reptile scales and claws. When a massasauga vibrates or rattles its tail, it makes a buzzing sound like an insect. Eastern massasaugas rattle their tails when they feel threatened, although their first defense



Figure 4. Eastern massasauga.

Opposite page:

Eastern massasauga rattlesnake habitat

Photo: Yu Man Lee



is to stay still and hide or blend in with their surroundings. Eastern massasaugas are well-camouflaged and difficult to find in their natural habitats. They are generally non-aggressive but may bite if threatened, picked up or stepped on. The eastern massasauga is Michigan's only venomous snake.

Michigan is considered to be the last stronghold for the eastern massasauga with more sites documented in the state than any other state or province in the species' range (USFWS 1998). Massasaugas have been reported from over 200 sites throughout Michigan's Lower Peninsula, with over 90 sites confirmed within the last 20-30 years (MNFI 2013). However, the eastern massasauga has declined in Michigan and throughout its range (USFWS 1998). The species has been listed as endangered or threatened in every state or province within its range, except in Michigan where it is currently a species of special concern. Due to its rangewide decline, the U.S. Fish and Wildlife Service designated the eastern massasauga as a candidate for federal listing in 1999.

One of the main threats facing the eastern massasauga is habitat loss and degradation. Eastern massasaugas inhabit prairie fens and other open, early to mid-successional wetlands such as wet meadows and emergent marshes, as well as forested wetlands. Massasaugas also utilize drier, upland sites, ranging from prairies, savannas, and old fields to upland forests and forest openings. Massasaugas require open wetland

and upland habitats for basking, foraging, reproducing, and dispersing. They also need some cover or refugia within open habitats (e.g., thicker or taller vegetation, dead vegetation on the ground, woody debris, and/or burrows) to provide shelter for regulating body temperature, protection from predators, and other aspects of the species' biology. However, disruption of natural disturbance processes (e.g., fire suppression), hydrological alterations, vegetative succession, invasive species, and lack of active management have changed the composition and structure of the plant communities in some prairie fens, and have resulted in some prairie fens becoming unsuitable or less suitable habitat for massasaugas. Efforts to protect and restore prairie fens are needed to maintain and enhance habitat for massasaugas.

Additional factors that impact conservation of eastern massasaugas in Michigan include lack of knowledge and information about massasauga populations and human persecution. Limited information is available on the size, status, viability, and ecology of massasauga populations in Michigan, including if and how populations respond to management efforts. This information is critical for developing and implementing effective conservation strategies for the eastern massasauga and their populations in the state. Additionally, because of a lack of understanding and misconceptions about the species, massasaugas have often been purposely killed when encountered. Efforts to increase knowledge and understanding about the massasauga and how people can safely co-exist with this species are needed to help reduce mortality and promote conservation of this species.





Barbara J. Barton

Edible valerian



Christopher Hoving, MDNR

Prairie Indian plantain



Barbara J. Barton

Small white lady-slipper



Christopher Hoving, MDNR

Queen-of-the-prairie

Rare plants

Prairie fens support at least 21 state-listed plant species, including at least eight species that are modal, or have their maximum presence in this community type (Table 2). Most of these species are listed because of their localized presence on the landscape and their dependence on open conditions that are compromised by changes in hydrology, lack of fire, and other anthropogenic disturbances. Several of the listed plant species are range-restricted components of the prairie flora that barely enter the southwestern part of the state, where they now find refugia in prairie fens.

Table 2. Rare plants of prairie fen in Michigan.

Common Name	Scientific Name	Status
Prairie Indian plantain*	<i>Arnoglossum plantagineum</i>	SC
Purple milkweed	<i>Asclepias purpurascens</i>	T
Cut-leaved water parsnip	<i>Berula erecta</i>	T
Hairy-fruited sedge	<i>Carex trichocarpa</i>	SC
Small white lady-slipper*	<i>Cypripedium candidum</i>	T
English sundew	<i>Drosera anglica</i>	SC
Flattened spike-rush	<i>Eleocharis compressa</i>	T
Spike-rush	<i>Eleocharis geniculata</i>	X
Rattlesnake master	<i>Eryngium yuccifolium</i>	T
Queen-of-the-prairie*	<i>Filipendula rubra</i>	T
Mat muhly*	<i>Muhlenbergia richardsonis</i>	T
Northern bayberry*	<i>Myrica pensylvanica</i>	T
Wild sweet William*	<i>Phlox maculata</i>	T
Jacob's ladder	<i>Polemonium reptans</i>	T
Shooting-star	<i>Primula meadia</i>	E
Broad-leaved mountain mint	<i>Pycnanthemum muticum</i>	T
Canadian burnet*	<i>Sanguisorba canadensis</i>	T
Rosinweed	<i>Silphium integrifolium</i>	T
Prairie dropseed	<i>Sporobolus heterolepis</i>	SC
Edible valerian*	<i>Valeriana edulis var. ciliata</i>	T
southern wild-rice	<i>Zizania aquatica</i>	T

E= Endangered; T= Threatened; SC= Special Concern; X= Extirpated.

*= Modal in prairie fen.



A decade of stewardship:

A summary of LIP work in fen habitats, 2004—2013

Over the course of the last decade (2004–2013), the MDNR Wildlife Division Landowner Incentive Program has provided technical assistance and land management resources to landowners and land managers of prairie fens across the southern Lower Peninsula. Table 3 is derived from a synthesis of LIP field forms, management plans, maps, shapefiles, and MNFI natural community and rare species element occurrences (EOs). The numbers provided are estimates, but indicate the scale of private lands work on prairie fens and associated ecosystems and species over the past decade.

Table 3. Summary Statistics on LIP Prairie Fen Work, 2004–2013.

Variable	Number
# Properties	69
# Landowners (Public and Private)	90
# Management or Treatment Units	182
# Acres Potentially Impacted	20,127
# Prairie Fen EOs Impacted	42
# Prairie Fen EO Acres Impacted	1,808
% Known Prairie Fen EOs Impacted	27
% Known Prairie Fen Acreage Impacted	45
# Overall Rare Plant and Animal EOs	400

Scientific discovery

Private lands funding has provided scientists and land managers with the resources to make important contributions to our understanding of the distribution and conservation status of rare plant and animal species in Michigan. Of note is the discovery during this period of two previously undocumented populations of the federal candidate Poweshiek skipperling (*Oarisma poweshiek*). This species is known from

Opposite page:

Tameka Dandridge, USFWS, and Barbara Barton, MNFI, working in fen

Photo: Daria A. Hyde

fewer than eight sites in Michigan, which may be the global stronghold for this species (Cuthrell and Slaughter 2012). Several new records for the federal candidate eastern massasauga (*Sistrurus catenatus catenatus*) were also documented during LIP surveys. In addition, over 30 new EOs of state-listed rare animal species were documented from LIP sites over the past decade. A special emphasis on rare insects yielded several important findings, including new sites for the state threatened and recently described species Huron River leafhopper (*Flexamia huroni*) and its hostplant, the state threatened mat muhly (*Muhlenbergia richardsonis*), and numerous new sites for several other rare insects, including the state special concern Kansan leafhopper (*Dorydiella kansana*), angular spittlebug (*Lepyronia angulifera*), red-legged spittlebug (*Prosapia ignipectus*), and tamarack tree cricket (*Oecanthus laricis*). The documentation of additional populations of rare insects has important implications for conservation, as the new data collected as a result of LIP surveys may justify modifying the state listing status for several species.

Conservation impacts

Properties managed under LIP between 2004 and 2013 support approximately 400 element occurrences of natural communities, rare plants, and rare animals (see Tables 1 and 2 for lists of rare species associated with prairie fen in Michigan). Although many of these populations are associated with habitats other than fen on these properties, it is likely that land management activities impacted hundreds of populations of state-listed plants and animals within fen communities on these sites, in addition to the fen communities as a whole. Some of these impacts are clear following a single treatment. For example, several fire-adapted plant species of fens, such as the state special concern prairie dropseed (*Sporobolus heterolepis*), state threatened purple milkweed (*Asclepias purpurascens*), and state threatened small white lady-slipper (*Cypripedium candidum*), demonstrated significant year-to-year increases following application of prescribed fire at several sites. In many cases, the impacts of management were difficult to discern from natural population fluctuations, or due to the difficulty in sampling an adequate portion of the target population (particularly for animals). Beginning in 2010, WLD and MNFI selected several target species to monitor over the duration of a three-year grant focused on improving habitat quality for these and other species. Results of these findings are summarized later in this report, and provide direction for future long-term monitoring efforts.

Collaboration

Technical assistance, management assistance or resources, and/or biological surveys and monitoring have been conducted on lands owned and managed by over 90 individuals or entities (Table 3). This includes work on public lands administered by the Michigan Department of Natural Resources WLD, MDNR Parks and Recreation Division, and Michigan Department of Transportation, and lands owned or administered by four units of local government, three conservation organizations, six land trusts, 14 private organizations (including youth camps and corporations), and 63 private individuals or families. Work with private landowners is especially important in southern Lower Michigan, where public land comprises only a small percentage (approximately 4%) of the landscape and prairie fens predominantly occur on lands not owned or managed by the state or federal government.

In addition to landowners and land managers, private lands funds allowed MNFI and MDNR staff to interact with a variety of other stakeholders, including the land trust community, private organizations dedicated to conservation, such as The Stewardship Network, and academics. Several useful presentations and publications were created with the assistance of information and expertise derived from LIP-funded projects. A selection of these works is provided in the References section of this report.

Habitat monitoring

The placement of permanent photographic monitoring points is an efficient, cost-effective method to assess qualitative (and sometimes quantitative) changes in ecological community structure and plant species composition over time. Photographs are taken at a specified frequency, often annually, to document changes associated with natural succession or habitat management objectives. These photographs can assist with the assessment of ecological management, and can provide evidence for the efficacy of specific management activities within the context of an adaptive management framework.

From 2009 to 2013, MNFI biologists established permanent photographic monitoring points at nine prairie fen or wet meadow sites in southern Lower Michigan to assess changes in vegetation associated with natural processes and management activities, which typically consisted of mechanical or herbicidal invasive species removal, mechanical removal of woody vegetation, or prescribed fire. A total of 22 permanent photo monitoring points were placed in these nine sites.

Overall, monitoring photographs taken at the majority (13 of 22) of photo points did not demonstrate significant changes in vegetative structure or composition (Table 4). Photos taken at three of the remaining nine photo points showed positive management impacts, whereas photos taken at the remaining six points demonstrated negative changes in habitat. There are a variety of potential explanations for these findings (Table 4). These explanations can be broken down by the change category:

Negative change

- Woody encroachment or invasive species encroachment; no evidence of management
- Woody encroachment or invasive species encroachment; evidence of management

No change

- No apparent change; no evidence of management
- No apparent change; evidence of management

Positive change

- Reduced woody cover or invasive species cover; no evidence of management
- Reduced woody cover or invasive species cover; evidence of management

Photo point monitoring was most effective where significant mechanical treatments (e.g., mechanical woody stem removal, release of purple loosestrife beetles) occurred. Where minor changes occurred, between-year differences were much more difficult to visualize, if they were at all distinguishable. Because photo points were only visited once a year, seasonal variations were responsible for some of the differences between photos. Photographs taken earlier in the year show less dense vegetation than photographs taken later in the summer. Some of the apparent increase or decrease in herbaceous species such as cattails (*Typha* spp.) may be the result of photographs taken during different seasons. Difference in rainfall, temperature, and other climatic factors are likely also responsible for some of the changes in vegetation between and among years. Last, differences in cloud cover and direction and intensity of sunlight can alter the impression of some of the images and suggest false changes in cover or composition.

Table 4. Photographic monitoring point interpretation for 9 fen sites. Photographs were taken annually, and the overall impressions for each photo point were summed for all six photos (360°)

Site	PP	Years	Change	Details	Mgmt Evidence
Camp Dainava	73	2011-2012	0		N
	74	2011-2012	0		N
Camp Friedenswald	72	2010-2013	0		N
Dahlem Center	51	2010-2012	-	↑ <i>Typha</i>	N
	52	2010-2012	0		N
	53	2010-2012	0		N
Deep Lake	58	2010-2012	0		Y
	59	2010-2013	-	↑ shrubs ↑ <i>Typha</i>	Y
	60	2010-2013	-	↑ <i>Typha</i>	Y
	61	2010-2013	-	↑ <i>Typha</i>	N
Long Lake	77	2011-2013	0		N
			0		N
Mill Creek East	66	2010-2013	+	↓ <i>Typha</i>	Y
	67	2010-2013	+	↓ <i>Elaeagnus</i>	Y
	68	2010-2013	-	↑ shrubs ↑ <i>Typha</i>	N
	69	2010-2013	0	↓ <i>Elaeagnus</i> ↑ <i>Typha</i>	Y
Onsted SGA	56	2010-2012	+	↓ <i>Lythrum</i>	Y
	57	2010-2012	-	↑ <i>Typha</i>	Y
Park Lyndon North	70	2010-2013	0		N
	71	2010-2013	0		N
Turner Creek	75	2011-2013	0		N
	76	2011-2013	0		N

PP= photo point tag number. Change: += positive change; 0= no discernible change; -= negative change. Mgmt evidence: Y= clear photographic evidence of management activities; N= no clear photographic evidence of management activities.



Mitchell's satyr monitoring

Over the past ten years (2004–2013), most Mitchell's satyr sites were visited annually if permission was granted by the landowner to conduct a survey (Table 5). In addition, sites with uncertain status were surveyed to determine if they were still occupied. A minimum of two trained observers worked together to conduct timed-meander surveys at least once during the flight. Typically, more than one visit was made to ensure that the survey was conducted near the peak of the flight. Staff or volunteers from partnering conservation organizations often assisted with the counts and landowners occasionally participated as well. Surveyors used a GPS device to track the path followed and to record the locations of satyrs. In addition, surveyors recorded the date, site name, landowner name, weather conditions, the number of surveyors, the amount of time spent searching for the satyr in suitable habitat, the number of satyrs counted, the sex of the satyrs observed (if distinguishable), other rare species seen, and any threats to the satyr and its habitat. Data were entered into the statewide database of rare and declining plants, animals and natural communities. During surveys, additional potential habitat was noted and surveyed for Mitchell's satyr if time allowed.



Opposite page:

Daria Hyde, MNFI

Photo: Ryan O'Connor

Table 5. Annual Monitoring of Mitchell's satyr sites 2004 - 2013.

Yellow highlighted sites are considered likely viable.

Site name	No. of satyrs/No. of surveyors/No. of hours				No. of satyrs/No. of surveyors/No. of hours						
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	
Cedar Creek/Lime Lake Fen	42/3/3.5	121/5/3.5	71/2/2.15	78/4/2	35/2/2.15*	35/2/2.5	0/1/1 survey late	106/2/3	no survey	no survey	
Coldwater Lake Fen	74/2/2	160/3/6	*382 marked pop est. 700 (2/3 habitat)	*143/4/3 no survey on NW prop.	142/3/3/ no survey swmlc/ NW prop	49/3/5.5 (late in flight)	*27/2/3.25 Survey late, not all surveyed	305/7/4	8 - just flight check- no survey	30/5/3	
Cook Lake/Rudy Rd.	90/2/4	75/3/2.75	58/2/3	*24/2/?	56/3/2.75	no survey	16/2/2 Survey late	47/2/3	no survey	5/?/1	
Grand River Fen	MRR est 1106	MRR est 1200	*29/1/1.25 on Weaver prop. only	MRR est- ~3000 v 1/2/3 : Melling	*39/3/1 Weaver and County only.	E.Lib- 8/2/? West side of creek 80/2/? E. side ?/3/?	440/4/4 (both sides of creek)	103/1/3	* ~58 seen at 8 sites in or near GR fen	150/3/3 during Poweshiek surveys	
Shavehead Lake-Camp F.		10/3/1.5	*26/2/3.25	13/2/1	32/3/4	35/2/?	52/2/1	*7/2/0.5	35/5/1.5	no survey	
Skiff Lake Fen	10/2/2	18/2/3	38/4/1.5	31/2/1	16/2/1	8/2/?	32/2/0.75	34/2/1.75	5-Clifford*	4-Clifford*	
Blue Creek Fen	15/2/2	7/3/?	*35/3/5	8/3/1	no survey	no survey	no survey	0/4/? No survey on Sirk site	no survey	no survey	
Butternut Creek	15/2/2	10/5/5	19/2/1.2	16/2/5	13/3/1.25	6/2/?	4/2/1	0/2/0.5	no survey	0/4/1.5	
Deep Lake Fen/Yankee Springs SGA	3/2/2	16/2/1	7/6/1.5	8/3/2.15	13/4/2	1/3/?	0/4/1	0/5/2.5	no survey	0/3/2	
Lower Paw Paw R.-Sarrett	10/2/2	19/6/4.5	31/2/1.5	39/2/1	40/1/0.5	16/2/1	12/2/1.25	12/2/0.75	several seen	4/4/1	
Mill Creek-East/Irwin's Farm	MRR-32 captured	39/6/3	*81 marked in study area; approx. 2/3 of habitat	47/3/2	*58 marked in study area: approx 2/3 of habitat	48/2/ (40/60 split M and F)	12/2/2	11/3/1	9/3/1.5	2/3/1.75	
Paw Paw Lake	4/2/1.5	5/1/2	*8/4/.25	1/2/2	12/2/4	6/2/?	no survey	*0/3/2	0/2/1	0/1/1.5	
Swains Lake Drain/ Concord Fen	no survey	11/4/2	2/4/1.3	1/5/5	2/2/1.5	1/2/?	0/2/1	no survey	no survey	no survey	
Tamarack Swamp-Wakelee Fen	11/2/3	8/2/2	*12/2/1.5- Skidmore. No survey TNC pres.	34/2/3 on Skidmore prop(6-26) 15/3/1.5 on TNC (7-3)	10/2/1.5: Skidmore prop (7/4) 20/3/1 on TNC (7/3)	19/2/? TNC 3/2/? Skidmore	no survey	19/2/? TNC and 10/2/? On Skidmore	3/3/4	1/3/3.75	
Thompson Lake Fen	8/3/3	1/2/4.5	3/2/2.25	6/4/3	3/2/1.15	0/2/1 Bothamley no survey-Frohriep	0/2/1 Bothamely	no survey	no survey	no survey	
Turner Creek	19/2/2	69/4/1	24/3/.65	37/3/1.5	18/4/1	8/2/?	0/4/1.25	5/3/1	2/3/2	0/2/1.5	

Survey results indicate that of the 16 extant Mitchell's satyr sites, six populations are considered likely viable, three populations are thought to be potentially viable and the remaining seven sites are considered non-viable due to low numbers of butterflies or degradation of the habitat (Table 6). All of the non-viable sites received this designation within the past ten years.

One goal of monitoring Mitchell's satyr is to provide land managers with feedback on whether habitat management is having a positive influence on the population. Unfortunately, it is extremely difficult, if not impossible, to directly tie the results of habitat management to an increase or decrease in Mitchell's satyr populations due to variables that affect detectability of Mitchell's satyr and other factors which influence population viability. The number of Mitchell's satyr observed during timed-meander surveys is a subset of the actual number of satyrs present on a specific day and of the entire adult population in a given year. Variations in weather, time of day, area and amount of time surveyed, number of surveyors and surveyor experience all influence the number of Mitchell's satyrs recorded during surveys.

Although the primary threat to the continued survival of Mitchell's satyr is loss and disruption of suitable fen habitat, there are a number of other variables which influence the viability of Mitchell's satyr populations: 1) Mitchell's satyr populations are isolated from each other and habitat is extremely fragmented; this has likely led to increased inbreeding and decreased population viability; 2) intracellular bacteria in the genus *Wolbachia* have been documented in Mitchell's satyr from several populations in Michigan. *Wolbachia* can disrupt reproductive compatibility and fitness and is estimated to have the potential to reduce Mitchell's satyr populations by half; 3) Reduced winter snow cover during some years may result in the exposure of overwintering larvae to freezing as they may not be adapted to repeated freeze-thaw cycles; 4) Severe storms can result in mortality to adults and/or larvae; 5) Predation of adults by birds, dragonflies and other insects is likely a common occurrence and severe mortality of eggs and larvae due to spiders has been documented during captive rearing experiments.

Table 6. Mitchell's satyr site history and viability.

Site Name	First Obs.	Last Obs.
Cedar Creek Fen/Lime Lake	1999	2011
Coldwater Lake Fen	1965	2013
Cook Lake/Rudy Rd. Fen	1987	2013
Grand River Fen/Liberty Fen	1974	2013
Shavehead Lk/Camp Friedenswald	2005	2012
Skiff Lake Fen	1996	2013
Lower Paw Paw River Fen/Sarrett NC	1986	2013
Mill Creek-East/Irwin's Farm	1952	2013
Wakelee Fen/Tamarack Swamp	1889	2013
Blue Creek Fen	1987	2007
Butternut Creek	2002	2010
Deep Lake Fen/Yankee Springs	1965	2009
Paw Paw Lake Fen	1974	2009
Swains Lake Drain Fen/Concord Fen	1980	2009
Thompson Lake	1996	2008
Turner Creek-North Fen	1974	2012
Bear Creek	1978	1978
Cleveland Lake	1965	1980
Kellogg Biological Station	1956	1956
Mill Creek-West	1952	2007
Priest Lake	1979	1993
Springbrook Fen	1973	2003
Upper Paw Paw River Fen/Paw Paw CC.	1984	1993
Willis Road	1931	1931
	Likely viable	
	Potentially viable	
	Non-viable	
	Historical	

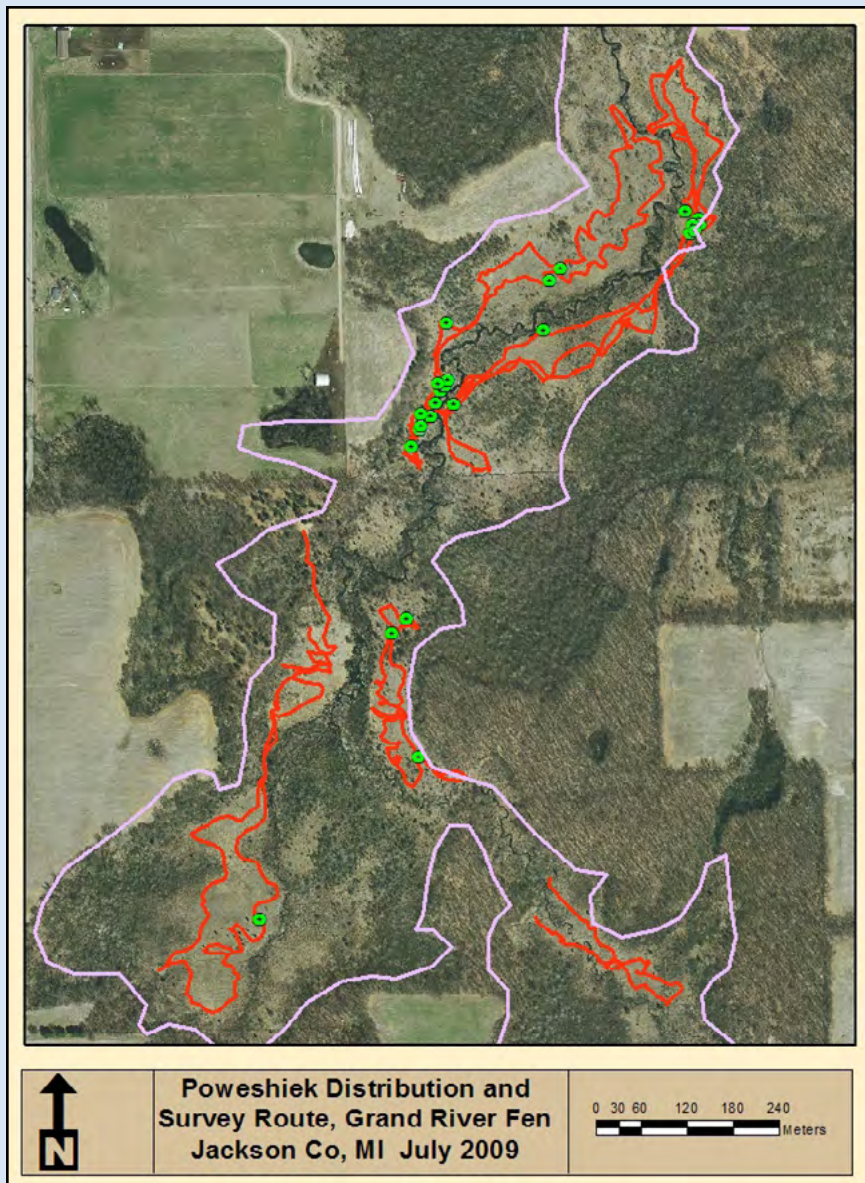


Figure 5. Example of survey routes and GPS points for locations of Poweshiek skipperling individuals, Grand River Fen, Jackson County, Michigan.

Poweshiek skipperling monitoring

The goal of this effort was to determine the total Poweshiek skipperling population size and spatial location of each individual butterfly at occupied sites and monitor population trends over time. The purpose was not to make any statistically valid assumptions about the effects of management on Poweshiek skipperlings. The method for conducting Poweshiek counts consisted of a hybrid between visual encounter surveys and Pollard-Yates, both of which are described by O'Connor (2007). First, however, we conducted reconnaissance surveys at all known sites during 2005–2007 to establish GPS points and to identify general spatial locations of occupied habitat within these larger fen complexes, and to determine if all known sites still contained Poweshiek skipperlings. These occupied locations were also communicated to the various land managers to help them determine placement and number of burn/management units which subsequently helped us determine the placement of our meander transects.

From 2008 to 2013, MNFI biologists conducted timed meander surveys for adult Poweshiek skipperlings at seven prairie fen sites. Each site was visited at least once during the flight period with a goal of visiting each site during peak flight. Surveys were conducted by walking through suitable habitat during appropriate weather conditions and visually observing adults in flight, perched on vegetation, or nectaring on flowers within 3–4 meters on each side of the transect lines. These observations were tallied on data sheets and GPS points for each butterfly were recorded. An example of the GPS data points (adult butterfly observations) and transect lines (survey route taken) at a site is included in Figure 5.

Unlike the western states in the Poweshiek skipperling's core range (Iowa, Minnesota, North Dakota, and South Dakota), Michigan was believed to have stable populations and the count years 2008–2012 seemed to corroborate this assumption. After a high count year of 2012 at all Michigan sites except Grand River Fen, it was even thought that the populations were actually increasing. However, 2013 counts across all sites were at all-time lows. Zero individuals were counted at the Grand River Fen site, and only one Poweshiek skipperling was observed at Park Lyndon. This rapid, steep decline in numbers following several "good" years is very similar to what occurred in the core of the Poweshiek skipperling's range (Selby 2005, 2010). Future surveys will determine if the declines were temporary or if the species is now critically imperiled in Michigan. The individual site results are presented below.

Poweshiek skipper, Brandt Road Fen



Brandt Road Fen

This fen in Oakland County, Michigan contains one of the largest populations of Poweshiek skipperlings in the world. Counts during 2007–2013 ranged from a high count of 138 in 2011 to a low count of 35 in 2013 (Figure 6). This is probably the most important site in terms of reliable sightings of Poweshiek skipperlings over the past several years. It appears that the population at this site is still within the recent natural range of population fluctuations, but we have a limited data set and future monitoring will be required to monitor trends.

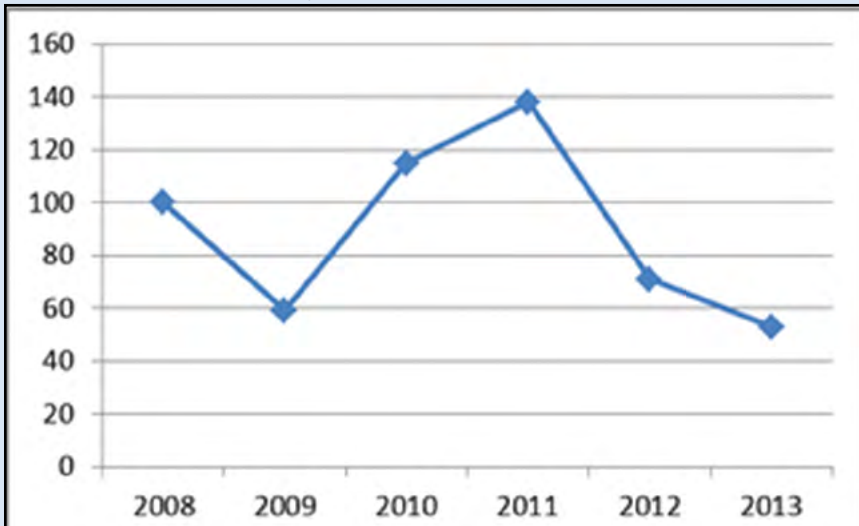


Figure 6. Number of adult Poweshiek skipperlings recorded in meander surveys at Brandt Road Fen Complex, Oakland County, Michigan, 2008–2013.

Park Lyndon Fen

Park Lyndon Fen has recently supported low but apparently stable numbers of Poweshiek skipperlings (Figure 7). After a high count year in 2012 at 22, it was hoped that the upward trend in adults would continue. However, the population crashed in 2013, with only one adult observed despite multiple visits during the flight.

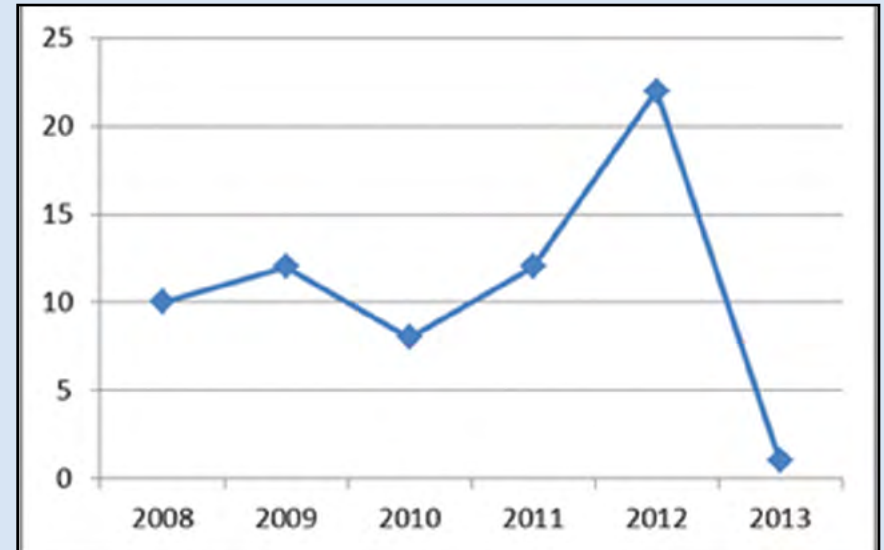


Figure 7. Number of adult Poweshiek skipperlings recorded in meander surveys at Park Lyndon, Washtenaw County, Michigan, 2008–2013.

Park Lyndon Fen



Big Valley Nature Sanctuary

Numbers at this nature sanctuary in Oakland County ranged from a high of 84 individuals in both 2010 and 2012 to a low of two individuals in 2013 (Figure 8). Adult count numbers at this site appeared to be increasing after burns in 2008, 2009, and 2011, but two visits in 2013 revealed a plummet to only two individuals.

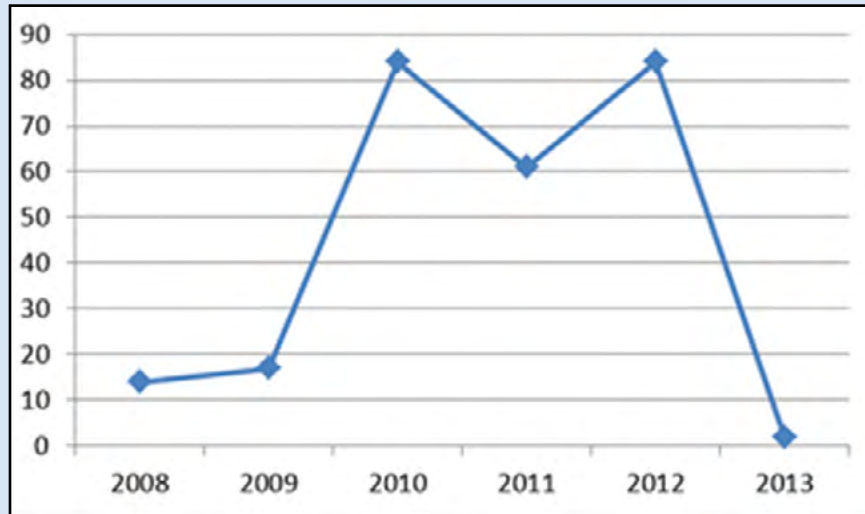


Figure 8. Number of adult Poweshiek skipperlings recorded in meander surveys at Big Valley Nature Sanctuary, Oakland County, Michigan, 2008–2013.

Big Valley Fen, Oakland County, Michigan,



Poweshiek skipperling habitat at Clifford R. and Calla C. Burr Memorial Plant Preserve, Oakland County, Michigan



Clifford R. and Calla C. Burr Memorial Plant Preserve

This site, about one mile downstream from Long Lake Fen, has always had very low counts (Figure 9). It has not been determined if the observations might just reflect dispersing adults from much larger populations near Long Lake. Surveys were not conducted here during 2013, and individuals were last observed here in 2009.

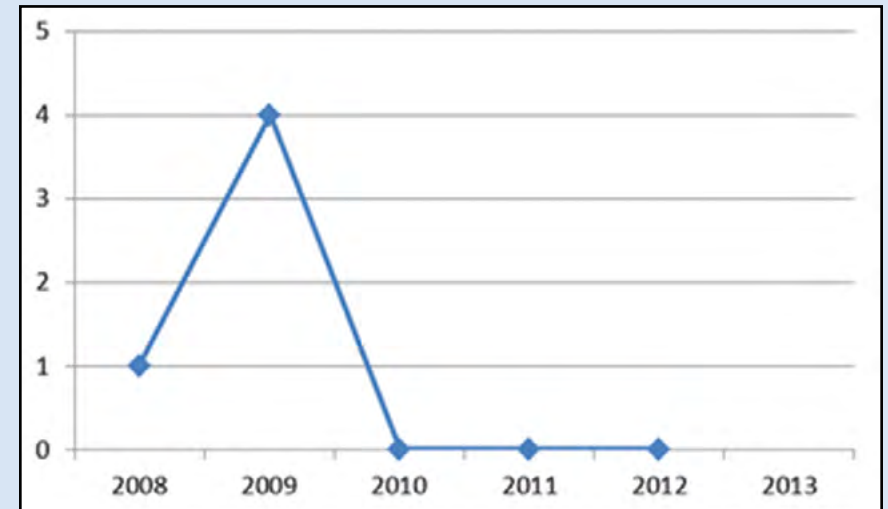


Figure 9. Number of adult Poweshiek skipperlings recorded in meander surveys at Calla Burr Memorial Plant Preserve, Oakland County, Michigan, 2008–2013.

Katherine Hollins

Goose Creek Grasslands Nature Sanctuary

The numbers at Goose Creek Grasslands Nature Sanctuary (Lenawee County) during our study period have always been low, and with limited data, changes in numbers are impossible to interpret (Figure 10). However, historically, the site apparently supported a much larger population. Past surveyors recorded notes such as “large number of adults observed.” Surveys were not conducted here in 2012 or 2013.

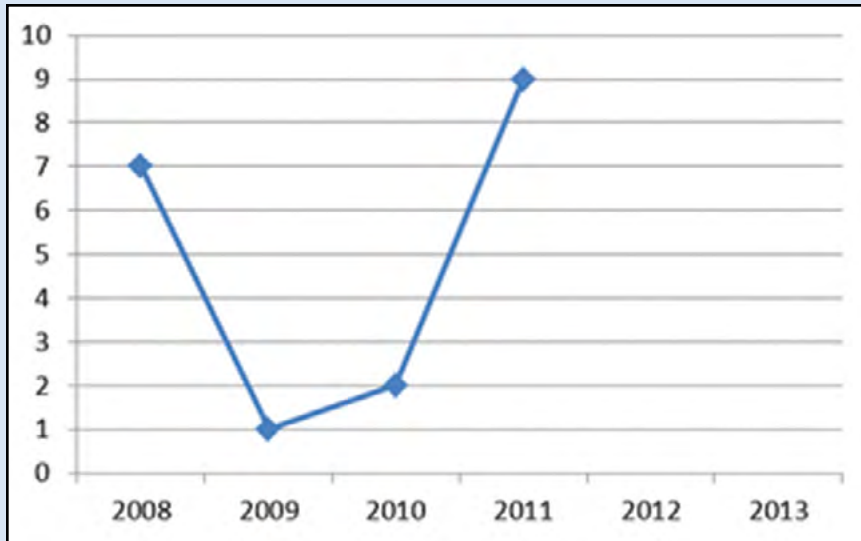


Figure 10. Number of adult Poweshiek skipperlings recorded in meander surveys at Goose Creek Grasslands Nature Sanctuary, Lenawee County, Michigan, 2008–2013.

Little Goose Lake Fen



Grand River Fen



Grand River Fen Preserve

The population at this site in Jackson County increased between 2008 and 2011, when a high count of 114 individuals was documented. The population declined dramatically after 2011, and zero individuals were counted in 2013 despite two six-hour surveys (Figure 11). The reasons for the collapse of the formerly healthy Poweshiek skipperling population at this protected site are unclear.

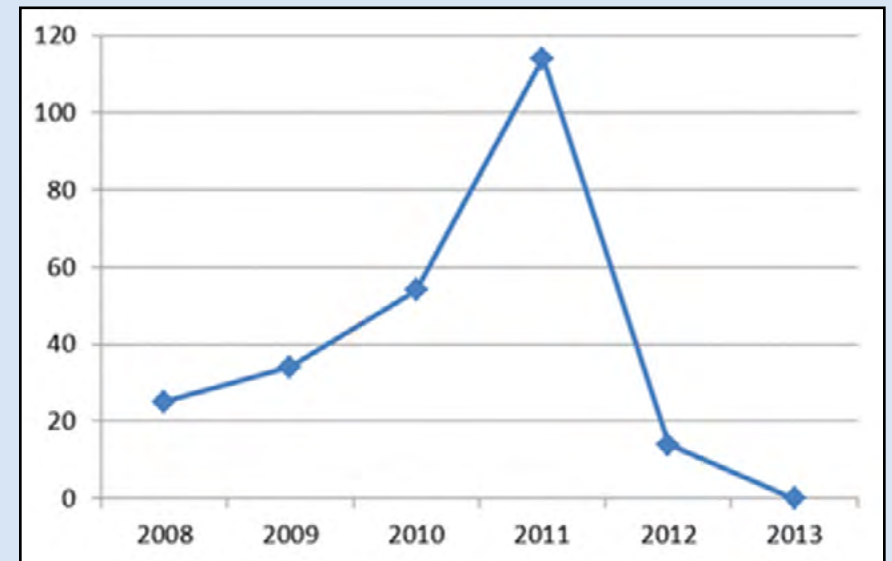


Figure 11. Number of adult Poweshiek skipperlings recorded in meander surveys at Grand River Fen, Jackson County, Michigan, 2008–2013.

Long Lake Fen

See Long Lake Fen case study.



Eastern massasauga monitoring

Although Eastern massasauga populations have been documented at a large number of sites in Michigan, little is known about the size, status, and long-term viability of these populations. Limited population demographic data (e.g., population size/abundance, age structure, growth rates, survival, litter size, and/or sex ratio) have been compiled from only about five sites in Michigan (Bissell 2006, Bailey 2010, Bailey et al. 2011, Jones et al. 2012, King and Hileman pers. comm.), and only a small number of sites across the species' range (e.g., Reinert 1981, Seigel 1986, Johnson 1995, King 1999, Middleton and Chu 2004, Dreslik 2005, Miller 2005, Harvey and Weatherhead 2006, Jones et al. 2012). Population demographic information is critical for understanding the status and behavior of massasauga populations, and for developing and implementing effective management and recovery efforts for these populations and the species in Michigan. Baseline data will help managers assess how populations respond to management activities over time, and adjust efforts as needed based on management goals and objectives.

To obtain additional information on massasauga populations in Michigan, we developed and initiated more intensive monitoring of two known populations. Our specific objectives for the intensive monitoring efforts at these sites were to: 1) obtain initial abundance estimates and data on the spatial distribution of massasaugas to help managers assess the current status and distribution of the population and impacts of management activities; and 2) develop an approach, methods, and baseline data for implementing long-term monitoring efforts to assess massasauga population demographics, viability, and impacts of management activities over time. Long-term monitoring is essential for producing valid estimates of demographic rates (USFWS 1998). These monitoring efforts will provide information that can help guide conservation and management efforts at these two sites, but will also provide insights that could potentially be applied to other massasauga populations in Michigan.

Opposite page:

Eastern massasauga habitat

Photo: Andrea Feldpausch/Ryne Rutherford

The two massasauga populations that were intensively monitored are located at the Pierce Cedar Creek Institute (PCCI) in Barry County in southwest Michigan, and The Nature Conservancy's (TNC) Ives Road Fen Preserve in Lenawee County in southeast Michigan. PCCI is a 267-ha (661-ac) nature preserve, environmental education center, and biological field station. Open and forested wetlands comprise about half the site, including prairie fen, southern wet meadow, rich tamarack swamp, and southern hardwood swamp (Slaughter and Slean 2003). The remaining half consists of open and forested uplands including prairie grass and forb plantings, old fields, and dry to mesic southern forests (Slaughter and Slean 2003). The Nature Conservancy's Ives Road Fen Preserve is a 283-ha (700-ac) nature preserve. This site contains approximately 40 ha (100 ac) of restored prairie fen, as well as southern floodplain forest, dry-mesic southern forest, prairie grass and forb plantings, old fields, and agricultural fields. Prior to our recent monitoring efforts, some massasauga research had been conducted at PCCI and Ives Road Fen, and the massasauga populations at both sites had been presumed to be large, healthy and/or viable based on previous studies and frequent observations of massasaugas (Woods 2003, Bissell 2006, Bailey 2010, Faust et al. 2011). However, only limited population demographic information (i.e., survival estimates) has been available for these sites (Bissell 2006, Bailey 2010, Bailey et al. 2011, Jones et al. 2012). Additionally, PCCI and TNC have conducted management efforts to maintain and restore prairie fen and surrounding habitats for massasaugas and other rare species, and they are continuing such efforts. Bailey et al. (2012) found that massasauga movement did not appear to be impaired by management activities such as burning or shrub removal at PCCI during 2004–2005 and 2008–2009. But it is unknown if and how management activities may be impacting the massasauga population in terms of population size or abundance, survival, and population growth and viability at PCCI and Ives Road Fen. Mark-recapture surveys for the Eastern massasauga were conducted at PCCI and Ives Road Fen by MNFI staff and numerous volunteers from 2011 to 2013. Surveys consisted of teams of observers slowly and systematically walking through suitable habitat, looking for massasaugas. Observed snakes were captured and processed, which included marking and collecting biological information about them. Snakes were released at their initial capture sites after processing. New snakes and previously marked snakes were documented and/or captured during subsequent surveys. Surveys focused on a subset of the areas

with suitable habitat for massasaugas at PCCI and Ives Road Fen, particularly areas in which massasaugas had been found during previous studies (Figures 12 and 13). These areas included prairie fen and other open wetland and upland habitats totaling 22.2 ha (55 ac) at PCCI and about 20 ha (50 ac) at Ives. Some habitat management (i.e., prescribed

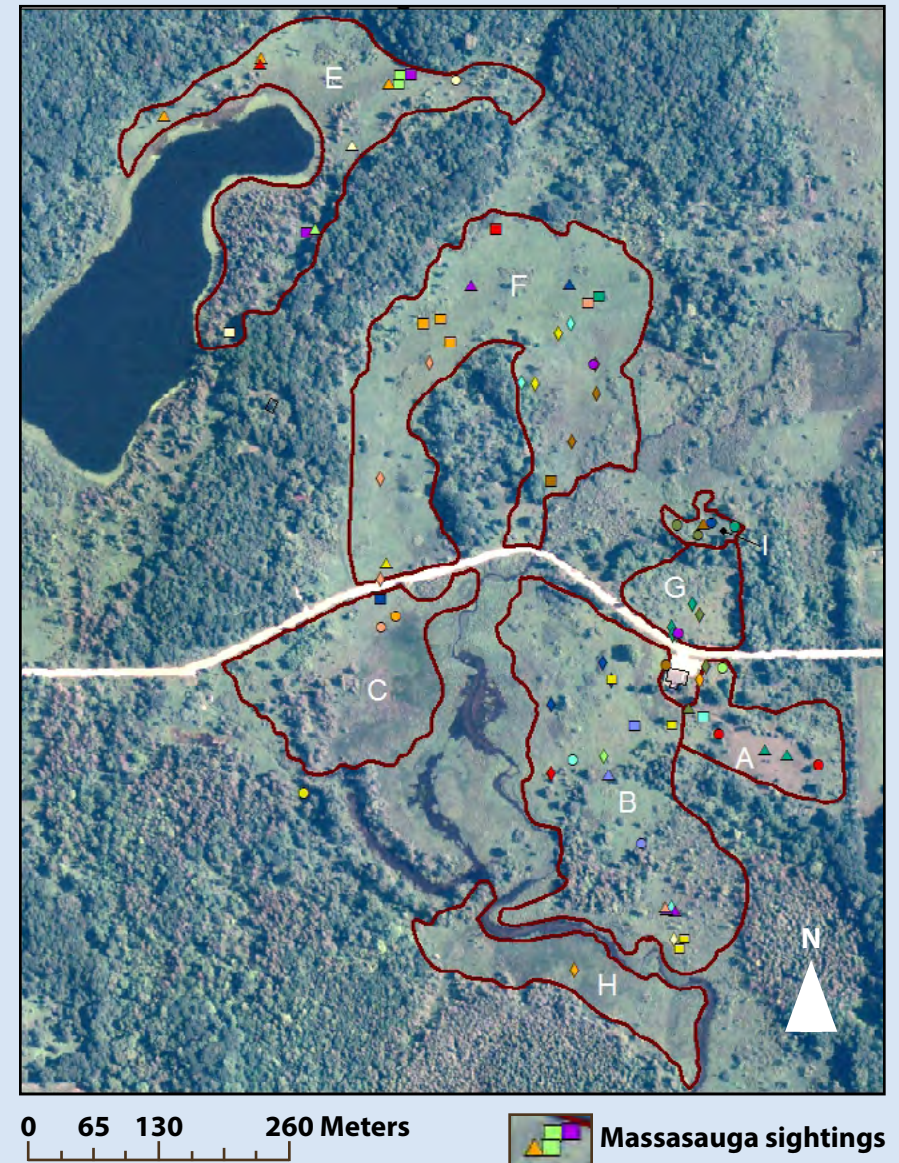


Figure 12. Distribution of Eastern massasaugas at Pierce Cedar Creek Institute, Barry County, Michigan, 2013 (Bradke & Kiel, 2013).

burning, mechanical and/or chemical control of invasive plants, and/or planting of native grasses and wildflowers) has occurred or will occur in these areas. Surveys were conducted during one week (5 days total) in June 2011, and during one week in May, one week in June, and two days in August (12 days total) in 2012 at both sites. In 2013, surveys were conducted during one week in May and one week in June (10 days total) at Ives Road Fen. At PCCI, in addition to these surveys, we worked with PCCI and Dr. Jennifer Moore from Grand Valley State University (GVSU) to recruit and train two undergraduate students from GVSU who conducted additional mark-recapture surveys from May through early August (48 days total) to increase data for population modeling.

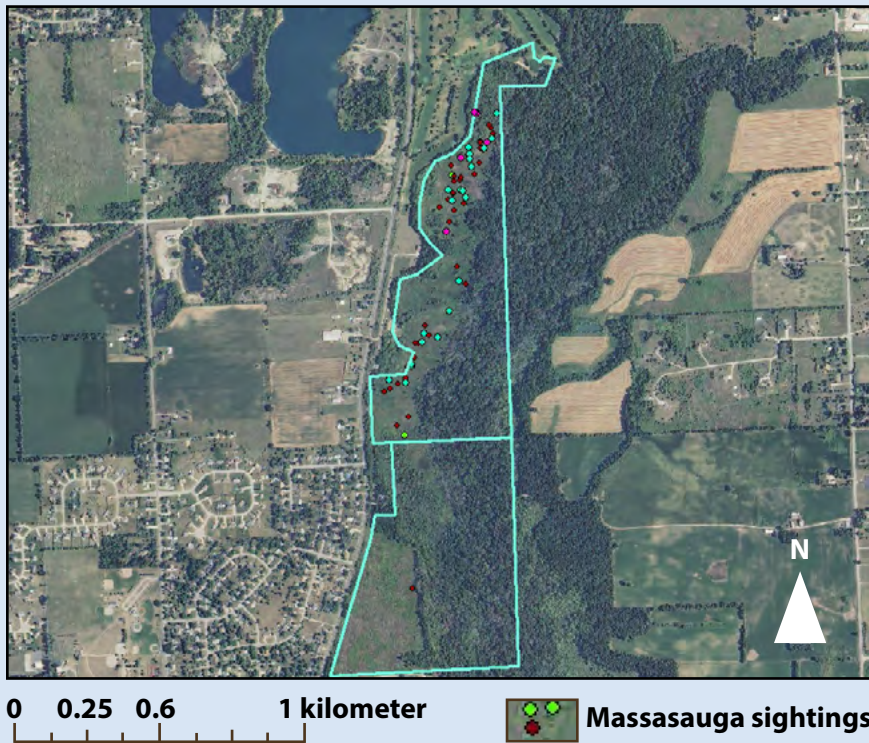


Figure 13. Distribution of Eastern massasaugas at Ives Road Fen Preserve, Lenawee County, Michigan 2011—2013.

We used closed population capture-recapture models and Program MARK software (White and Burnham 1999) to estimate abundance of adult massasaugas, where abundance refers to the number of adult individuals occurring within the surveyed areas. The population modeling focused only on adults because they are the only individuals

capable of contributing to population growth. We used closed population capture-mark-recapture models to estimate abundance because these models account for detection probability and are thus a much more effective means of achieving a reliable population estimate than just using count data (e.g., minimum number known alive) (Mazerolle et al. 2007, Bradke and Kiel 2013). We also examined massasauga spatial distribution in relation to managed areas at both sites.

The mark-recapture surveys at PCCI from 2011–2013 documented a total of 122 observations of Eastern massasaugas (i.e., 16 in 2011, 23 in 2012, and 83 in 2013; Table 7). These observations consisted of at least 75 unique individuals, of which 53 were adults and 22 were sub-adults or juveniles. These included 35 adult females (at least 23 were gravid or carrying young), 17 adult males, 9 juvenile females, and 10 juvenile males. Overall survey effort across all three years was 774 person-hours, and the overall catch per unit effort was 0.15 snakes/person-hour, although this varied slightly from year to year (Table 7).

Table 7. Results from Eastern massasauga (EMR) population monitoring effort at Pierce Cedar Creek Institute (PCCI) in Barry County in southwest Michigan from 2011–2013.

	2011	2012	2013	Total ¹
Total EMR Observations*	16	23	83	122
Individual/Unique EMRs	11	19	51	75
New/Initial EMR Captures	11	19	47 ²	75
EMR Recaptures/Resightings	4	1	29	40
Adult Males	0	4	13	17
Adult Females	8	4	26	35
Juvenile Males	0	5	5	10
Juvenile Females	0	4	7	9
Unknown Adults/Juveniles**	4	5	3	11
Survey effort (person hours)	93	277	404	774
Total EMRs observed/person hour	0.17	0.08	0.19 ³	0.15

* Includes EMRs that were observed but not captured (i.e., sightings).

**Includes both EMRs that were captured and those that were not captured (i.e., sightings).

¹ Totals do not always equal sum of totals for 2011–2013 because of recaptures between years..

² Includes 4 snakes that were initially captured in 2011 and/or 2012 and were recaptured in 2013.

³ Based on 78 total EMR observation instead of 83 as 5 snakes were found outside of survey time period.

We were only able to model and estimate the abundance of adult females in the study area in 2013 because this was the only group and year for which we had sufficient data for the population modeling analysis. In 2013, we documented 78 observations of 51 unique individuals during the surveys, which included 48 observations of 26 adult females, and only 14 observations of 13 adult males. We also focused only on data from 2013 to minimize our chances of violating population closure assumptions for the analysis. After analyzing 13 candidate population models and accounting for detection probability, the best model estimated abundance of adult females within our study area in 2013 to be 39 individuals (SE=9, 95% confidence interval (CI)=34–47) (Bradke and Kiel 2013). Although we were unable to estimate abundance of adult males, it is reasonable to infer the sex ratio is approximately 1:1 (Keenlyne and Beer 1973, Seigel and Sheil 1999, Middleton and Chu 2004). If we assume a 1:1 sex ratio, this would result in an estimated abundance of approximately 78 adult snakes (males and females) (range 68–94 based on the 95% CI), and an estimated density of about 3.5 adults/ha (range 3.1–4.2 based on the 95% CI) within the 22.2-ha study area. Additionally, a number of snakes were found in several areas that had undergone some management, including burning and mechanical and chemical control of invasive shrubs, prior to and/or during the monitoring study, indicating continued massasauga use of these areas.

The mark-recapture surveys at Ives Road Fen from 2011–2013 documented a total of 81 observations of Eastern massasaugas (i.e., 15 in 2011, 23 in 2012, and 43 in 2013; Table 8). These observations consisted of at least 57 unique individuals, of which 45 were adults and 12 were sub-adults or juveniles. These included 29 adult females (at least 19 were gravid or carrying young during the study), 16 adult males, five seven juvenile females, and six juvenile males. Overall catch per unit effort at Ives Road Fen was 0.10 snakes/person-hour, although this varied slightly from year to year. This was based on 81 total massasauga observations documented during 842 total person-survey hours during the 3-year monitoring study (Table 8). Similar to results from PCCI, we were only able to model and estimate the abundance of adult females in the Ives Road Fen study area in 2013 because this was the only group and year for which we had sufficient data for the population modeling analysis. In 2013, we documented 43 observations of at least 35 unique individuals, which included 25 observations of 18 adult females, and 13 observations of 13 adult males (no recaptures).

Table 8. Results from Eastern massasauga (EMR) population monitoring at Ives Road Fen Preserve in Lenawee County in southeast Michigan from 2011–2013.

	2011	2012	2013	Total ¹
Total EMR Observations*	15	23	43	81
Individual/Unique EMRs	13	17 ²	35 ³	57
New/Initial EMRs	13	14	30	57
EMR Recaptures/Resightings	2	3	7	20
Adult Males	0	4	13	16
Adult Females	8	8	18	29
Juvenile Males	3	2	1	6
Juvenile Females	1	3	3	5
Unknown Adults/Juveniles**	1	3	1	5
Survey effort (person hours)	210	308	323	842
Total EMRs observed/person hour	0.07	0.07	0.13	0.1

*Total includes EMRs that were observed but not captured (i.e., sightings).

**Includes both EMRs that were captured and those that were not captured (i.e., sightings).

¹ Totals do not always equal sum of totals for 2011–2013 because of recaptures between years.

² Three of these snakes were first captured in 2011, so were not new/initial captures in 2012.

³ Five of these snakes were first captured in 2011/2012, so were not new/initial captures in 2013

Preliminary model estimates for adult female abundance in the study area at Ives Road Fen in 2013 range from 21 to 28 individuals (SE=2–8, 95% CI=18–29 to 20–56). Based on these estimates and an assumed 1:1 sex ratio, this would result in abundance estimates of approximately 40–60 adult snakes (males and females) (range 36–112 based on the 95% confidence intervals), and density estimates of 2–3 adults/ha (range 1.8–5.6 based on 95% CIs) within the 20-ha study area. However, these results should be viewed with caution given the small sample size and preliminary models upon which these estimates are based. Additionally, massasaugas were found throughout the study area at Ives Road Fen, including areas which have undergone management including prescribed burns, mechanical and chemical control of invasive plants, and hydrological restoration (i.e., tile removal), indicating continued massasauga use of these areas.

The monitoring efforts and results from PCCI and Ives Road Fen are significant in that they represent the first estimates of massasauga abundance and density based on actual mark-recapture data, and only the second and third estimates of massasauga abundance for sites in Michigan. These results provide baseline abundance estimates which managers can use to assess impacts of future land management activities. However, these estimates should be considered preliminary. Continued monitoring and additional analyses are needed to refine these estimates and accurately assess impacts of management activities on the massasauga populations at PCCI and Ives Road Fen. With continued long-term monitoring, it will eventually be possible to obtain survival and population growth estimates which can indicate whether management activities are benefiting or impacting the massasauga populations. Also, because only a portion of the available habitat for massasaugas at PCCI and Ives Road Fen was surveyed and additional habitat occurs on adjacent private properties, surveys of these additional areas would need to be conducted to generate better site-level estimates of massasauga abundance, density, and population size. Although mark-recapture surveys are intensive and are not feasible to conduct at all massasauga sites in Michigan, they provide more useful information for assessing population status and viability and impacts of management than just presence-absence data. Having population demographic information even for a subset of populations in Michigan can provide insights to help us assess the status of and potential impacts of management activities at similar populations in the state.

AmeriCorps and other volunteers at Ives Road Fen, 2013



Eastern massasauga rattlesnake



Although the abundance estimates for PCCI and Ives Road Fen are considered preliminary, the estimates were lower than expected given the number of massasauga observations that have been reported at both sites. This may have been due to small sample size, low detection probability, and/or surveying only a portion of the available habitat. However, estimated snake densities were comparable to or a little higher than estimates from other studies (range from 0.5–2.5 snakes/ha) (USFWS 1998). Continued monitoring of these populations is even more imperative because previous massasauga population viability analyses (PVAs) found that populations with fewer than 50 individuals had a high probability of extinction, whereas populations with 200–300 individuals had low to no probability of extinction (Seigel and Sheil 1999, Bailey 2010, Faust et al. 2011). Previous PVAs also have found that massasauga populations are very sensitive to changes in adult and neonate mortality (Seigel and Sheil 1999, Middleton and Chu 2004, Bissell 2006, Bailey 2010). Therefore, management at PCCI and Ives Road Fen should strive to minimize adverse impacts on the massasauga populations at these sites, especially if the populations turn out to be small.



Bradford S. Slaughter, MNFI

Figure 14. Mechanical removal of woody species, in conjunction with application of prescribed fire, has increased acreage of open prairie fen at Pipestone Creek Fen, Berrien County, Michigan.

Case Study: Pipestone Creek Fen

Ownership and management:

Michigan Nature Association

Site description:

This is a large wetland complex associated with Pipestone Creek that supported approximately 2 ha (4.5 ac) of high quality prairie fen when it was first surveyed by MNFI in 2004. Despite its small size, this prairie fen supports high species richness and is especially notable for supporting populations of at least 10 rare plant and animal species, including the federally endangered Mitchell's satyr, federal candidate eastern massasauga, two other state-listed animals, and six state-listed plant species.

Management objectives and history:

Beginning in 2004, with the assistance of LIP funds from the MDNR Wildlife Division, MNA staff and volunteers began clearing native shrubs (primarily red-osier and gray dogwood) from Mitchell's satyr-occupied prairie fen habitat in an attempt to both increase the amount of suitable habitat and create corridors through otherwise unsuitable habitat between occupied patches of habitat. A prescribed burn was conducted in this area in April 2006. Mechanical woody species removal and prescribed burns have continued in this area since 2006, and the same treatments have also been applied and are ongoing in a larger discontinuous area of fen and shrub-carr habitat that is not occupied by Mitchell's satyr. The current management plan aims at maintaining an area of open fen of adequate size to conserve rare species through the use of both mechanical woody species removal in a patchy pattern and the implementation of prescribed burns (A. Bacon, pers. comm.).

Management results and current challenges:

- Areas indicated as potential connecting corridors were opened up as specified in the site conservation plan. Tamaracks and poison sumac were left but most other trees and shrubs were cleared.
- Mechanical woody species removal and prescribed burns significantly increased acreage of open southern wet meadow and prairie fen habitat east of the road, increasing the size of the open fen complex from approximately 2 ha (4.5 ac) to approximately 4.5 ha (11 ac) (Figure 14).
- The population of the state-threatened purple milkweed (*Asclepias purpurascens*) responded strongly to a spring prescribed fire,

increasing from one flowering stem pre-burn to at least 82 flowering stems post-burn (Figure 15). Numbers subsided in following non-burn years.

- Despite management to improve and increase habitat in the occupied zone, Mitchell's satyrs were last observed at this site in 2010.
- The fen and adjacent wetland community is impacted by a variety of stressors. Reconstruction and enlargement of an artificial pond on uplands immediately adjacent to the fen appears to have impacted groundwater flow in the fen. Drainage ditches along and perpendicular to the road have apparently lowered the water table within the fen and promoted an increase in tall shrubs. Following recent road maintenance and drain replacement, narrow-leaved cattail invaded the ditches along the road and poses a threat to the fen.

Lessons learned:

- This site illustrates several common conservation challenges associated with prairie fens. Fen hydrology is impacted by human infrastructure, including a road that compacts peat soils, ditches that drain the fen, a man-made pond that intercepts the water table and presumably reduces infiltration to the fen, and a lawn that is a source for polluted surface water run-off into the fen. These disturbances have more-or-less permanently altered hydrology and prevent restoration to "original" undisturbed conditions.
- Most of the cleared shrub-dominated areas in occupied habitat reverted to southern wet meadow, dominated by tussock sedge, marsh fern, and coarse forbs. This may reflect in part natural zonation, in which swamp forest and southern shrub-carr develop on better-decomposed peat at the margins of groundwater discharge zones. Care should be taken when developing and implementing management plans to predict and monitor changes in vegetation to focus efforts on areas with the highest potential to revert to desired conditions.
- Rare plant and animal species in prairie fens respond individually to management efforts. Woody species removal significantly reduced populations of the state-threatened Jacob's ladder (*Polemonium reptans*). On the other hand, the state threatened purple milkweed responded with vigor to prescribed fire. Most rare plant species occupy very specific zones within the fen and popula-

tions did not substantially increase or decrease over the course of management.

- The small population of Mitchell's satyr at this site is apparently extirpated despite conservation efforts. To date, it is not clear that we understand the needs of this species to the degree that we can prescribe and implement habitat management that results in increased populations. At many sites, populations may be so small that extirpation is nearly certain regardless of habitat conditions. Alternatively, stress associated with habitat management may have a negative effect on small Mitchell's satyr populations, potentially including direct effects such as trampling and disturbance of vegetation and soil to indirect effects such as creating conditions that increase predators or invasive plant species.

The positive and negative changes at this site support implementing an open-ended, "meandering" ecosystem management approach that eliminates the need to define a priori desired conditions and promotes sustainable ecosystem trajectories by focusing on process and allowing physical and biological processes to shape ecosystem structure and composition.



Bradford S. Slaughter, MNFI

Figure 15. The state threatened purple milkweed (*Asclepias purpurascens*), formerly widespread in prairie, savanna, and oak woodland, now finds refugia in prairie fens. The population of this species at Pipestone Creek fen responded vigorously to a prescribed fire conducted in spring 2006.



Case Study: Turner Creek Fen

Ownership and management:

State of Michigan Department of Natural Resources, Wildlife Division

Site description:

Turner Creek Fen is located within the Barry State Game Area in Barry County. The primary portion of the fen complex (approximately 1 ha, or 2.5 ac) is characterized by a narrow corridor of prairie fen and sedge meadow interspersed with shrub-carr along both sides of an unnamed tributary that flows into Turner Creek. The surrounding wetland habitat (approximately 145 ha, or 359 ac) is primarily composed of southern hardwood swamp, southern shrub-carr, rich tamarack swamp, and southern wet meadow. A number of rare plants and animals have been documented at this site including the federally endangered Mitchell's satyr, federal candidate eastern massasauga, three state-listed animals and two state-listed plants.

Mitchell's satyr history:

Mitchell's satyr was first documented at this site in 1974 in an approximately 3 ha (7 ac) prairie fen just north of Bowen's Mill Road. Despite many searches since that time, satyrs have not been redocumented at this original site, which now supports shrub-carr habitat. In 1986, a new population of Mitchell's satyr was found just east and west of Bassett Lake Road near the source of the unnamed stream in the southern portion of the site. Mitchell's satyrs were later found in a small fen opening west of a cornfield (1992) and near the center of the wetland complex (1993). In 1998 and in subsequent years (1999–2009), small numbers of Mitchell's satyrs were found along the creek just south of Bowen's Mill Road. The highest numbers of Mitchell's satyr at Turner Creek fen were documented in 2005 (69) and 2007 (37). Numbers of satyrs drastically declined and were critically low in 2009 (8), 2010 (0), 2011 (5) and 2012 (2). In 2013, surveyors did not document any satyrs.

Management objectives:

In 2005 MNFI and DNR staff jointly prepared a Mitchell's satyr site conservation plan for the Turner Creek fen complex. The primary goal outlined in the plan was to protect, maintain and enhance the popula-

Opposite page:

Turner Creek

Photo: Daria A. Hyde

tion of Mitchell's satyr with a target of several viable sub-populations maintained and connected by dispersal corridors throughout the wetland complex. Critical to this goal was the maintenance of a functional wetland and protection of the ecological processes that create and maintain suitable Mitchell's satyr habitat as well as habitat for a host of other wetland species. The plan identified threats to the fen and outlined specific strategies to address these threats and locations where management was needed to protect and enhance Mitchell's satyr habitat.

Management history:

Management activities prior to development of the site conservation plan were focused on the uplands adjacent to the fen. Around 2003, a corn field east of the fen was converted to warm season grasses to create habitat conditions closer to what would have been present in the oak savannas that once bordered the fen. Ultimately, the DNR planned to replace the red pine planting and red maple-dominated forested areas adjacent to the fen with vegetation associated with oak savannas as resources allowed. The site plan called for restoration of 8 ha (20 ac) of "potential Mitchell's satyr habitat" over three years. During the winters of 2007, 2008, and 2009 trees and shrubs were cleared by a private contractor from approximately 8 ha of "potential Mitchell's satyr habitat" adjacent to occupied habitat, following the plan recommendations. All shrubs and trees except for mature tamarack and some residual poison sumac were hand-cut, piled, and the stumps treated with herbicide. In 2007, a prescribed burn was conducted on the converted grassland and adjacent forest/shrub areas outside of the satyr-occupied habitat to rejuvenate the warm season grasses and forbs, remove some of the slash left over from woody species removal, augment the reduction of woody species that had occurred during the winter, and to create softer transitions among habitat types. Some follow-up treatment was conducted in 2010 and 2011 using a backpack sprayer to apply herbicide to invasive species.

Management results and current challenges:

- Areas indicated as potential connecting corridors were opened up as specified in the site conservation plan. Tamaracks and poison sumac were left but most other trees and shrubs were cleared.
- Invasive species are prevalent and have colonized much of the area within the corridors created to connect fen openings. In some areas there is a monoculture of cattail (*Typha* spp.) in areas that used to be prairie fen. In 2012, DNR staff documented several

patches of non-native common reed (*Phragmites australis*) growing in one of the newly created corridors directly adjacent to the fen. The change between 2010 and 2013 has been dramatic. In 2010, cattail was rare, autumn olive (*Elaeagnus umbellata*) was occasional and reed canary grass (*Phalaris arundinacea*) was common. By 2013 cattail was abundant and autumn olive and reed canary grass were also reported as common.

- The headwaters of the unnamed tributary to Turner Creek have become altered and the stream is now backed up into a semi-permanent pond. It is unclear when or how this change occurred but it is probable that beaver flooded this area. This change in hydrology has likely resulted in an increase in nutrients which contributes to conditions more favorable to cattail (Figure 16).
- The amount of suitable habitat adjacent to the tributary has been reduced by at least half due to the influx of invasive species.
- The population of Mitchell's satyr was likely too small at the time the corridors were created for individuals to take advantage of these openings and disperse to new areas. Even if the population



Figure 16. Photos taken west of where the tributary crosses Bassett Lake Road in 1999, 2005, 2011 and 2013 demonstrate the dramatic change that has occurred to the stream.

had been augmented with captive-reared or translocated butterflies, the habitat has become degraded by the altered hydrology and the influx of invasive species, and the butterflies likely would not have persisted.

Lessons learned:

- Potential Mitchell's satyr habitat must have appropriate underlying hydrology. Shrubs and trees can be cleared to create open conditions, but fen vegetation structure and composition suitable for Mitchell's satyr and other species requires the appropriate underlying hydrology and soils.
- Stochastic events (e.g., beaver flooding) can have a tremendous impact on a small site such as Turner Creek which is not part of a larger functional fen complex. Larger fens are more likely to support "refugia" that Mitchell's satyr can utilize when portions of their habitat are altered by these types of events.
- It is important to monitor groundwater quality, water flow, and water quality, as these are critical components of a functioning fen complex. Hydrological changes can have long lasting impacts to a prairie fen, and may limit the ability of land managers to restore original conditions
- Coordination between the Mitchell's Satyr Working Group and those entities trying to implement the recommendations outlined in the site conservation plans could be improved. Opportunities to prioritize strategies in this habitat management plan and other plans, identify and retain needed resources, and implement actions to address threats and improve fen habitat have not always been capitalized.

DNR wildlife biologists and MNFI staff developed a set of strategies to improve habitat for Mitchell's satyr and other fen species at the Turner Creek site and mobilized the resources to implement specific actions. It was hypothesized that opening corridors between small isolated areas currently or historically occupied by Mitchell's satyr would encourage movement of butterflies between these sites and improve population viability. The factors which influenced the success of these efforts are primarily related to the small size of this fen complex and our lack of understanding of the underlying local hydrology. Stochastic events can have devastating consequences for isolated populations of rare butterflies at small sites. The changes which occurred at the headwaters to the tributary flowing through the fen likely impacted

the hydrology of the fen and tipped the balance in favor of invasive species. Since the plan was written, we have learned how critical intact hydrology is to the functioning of a fen ecosystem. Recently, DNR staff engaged Michigan State University faculty, with expertise in hydrology, to install water level loggers at the site, measure flow and collect water samples. Analysis of these data should contribute to a better understanding of the local hydrology and help guide future actions.

Prairie Indian plantain at Turner Creek fen



David L. Cuthrell, MNFI



Case Study: Grand River Fen—Weaver Tract

Ownership and management:

Private Landowner- Scott Weaver

Site description:

The Weaver property is a 32 ha (80 ac) parcel located within the larger 116 ha (287 ac) Grand River Fen Preserve located in Jackson County. The largest portion of the preserve is owned by The Nature Conservancy (TNC), which also holds conservation easements with several of the private landowners who own the remaining portion of the complex. The fen is part of a larger high quality wetland complex which also includes southern hardwood swamp and southern shrub-carr communities. The wetlands occupy a glacial outwash channel that forms a portion of the headwaters of the Grand River. The macrosite provides critical habitat to 15 species of rare plants and animals and has a high diversity of flowering plants, sedges and grasses intermixed with shrubs and tamarack. The Weaver site includes approximately 4 to 6 ha (10 to 15 ac) of fen habitat.

Mitchell's satyr history:

Mitchell's satyr was first documented at Grand River Fen in 1974 and at the Weaver tract in 1998. Mitchell's satyr currently occupies approximately 16 to 20 ha (40 to 50 ac) within the larger wetland complex and approximately 4 to 6 ha (10 to 15 ac) at the Weaver site and the adjacent property owned by Jackson County. Mark-release-recapture studies were conducted in 2003, 2005 and 2007. The population estimates for the entire site ranged from 1106 butterflies in 2003 to 3000 butterflies in 2007. This is the largest known population of Mitchell's satyr in the world. Timed meander counts conducted during the peak of the flight at the entire site average approximately 400 butterflies per count while counts at the Weaver tract and Jackson County property average around 30 to 40 butterflies at peak flight.

Opposite page:

Daniel Kennedy, MDNR, surveying for Mitchell's satyr in the Weaver Tract of Grand River Fen

Photo: Daria A. Hyde

Management objectives:

Mr. Weaver's overall management objective is to restore and maintain prairie fen on his property while retaining high quality hunting habitat. A secondary objective is to improve habitat for Mitchell's satyr. The DNR LIP program provided funds for management and the majority of the work has been conducted by TNC, with assistance from the landowner during some years.

Management and monitoring history:

Management at this site was first initiated by the DNR in 2004. Between 2004 and 2013 management activities have included at least four prescribed burns (Figure 17) and cut and stump treatment of native and non-native shrubs and spot-spraying of cattails. When funding allowed, reed canary grass was treated twice a year and the cattails and non-native glossy buckthorn (*Frangula alnus*) have been treated annually. Most prescribed burns and herbicide treatment of shrubs and cattails were paid for by the DNR LIP program and conducted by



Daniel Kennedy, MDNR

Figure 17. A controlled burn was conducted in the western portion of the Weaver fen to introduce fire as a natural disturbance and to assist with invasive species control.



Suzan Campbell, MNFI

Rebecca Schillo, MNFI

Glossy buckthorn

Narrowleaf cattail

TNC, although the landowner has occasionally contracted with others to complete some of this work and TNC has provided additional resources. Multiple photo points were established at this site in the mid-2000s by a University of Michigan intern but it is unclear how often photos were taken or how regularly they are reviewed. TNC conducts monitoring using a coarse metric approach (% herbaceous cover, % native cover, and % of management unit that will carry a fire).

Management results and current challenges:

- Over the past ten years glossy buckthorn and cattails have been removed from the fen and fire has been restored as a natural disturbance. TNC stewardship staff recommend that cattails and glossy buckthorn be treated annually and reed canary grass be treated twice a year to prevent encroachment into the fen.
- The uplands adjacent to the fen have been thinned and non-native shrubs have been treated. The landowner does not want the uplands thinned too much since he is a hunter and values this habitat as cover for deer and other game species.
- Although the original plan did not include an objective for increasing Mitchell's satyr numbers, it appears that they have remained stable at this site.
- TNC has gradually been creating a corridor between the Weaver site and the main fen by clearing shrubs. In addition, the emerald ash borer has killed trees in this area resulting in a more open

canopy. Two Mitchell's satyrs were documented flying in this corridor in 2012. This corridor should be monitored to ensure that it is not colonized by invasive species and to document Mitchell's satyr use.

Lessons learned:

- Overall management efforts have been very effective in restoring and maintaining fen habitat at this site. It helps tremendously to work with an enthusiastic and committed landowner and to have the support of a knowledgeable and resourceful partner such as TNC.
- It takes time, effort and diplomacy to develop and nurture relationships with landowners so that long term habitat management can be facilitated. The DNR biologist took the time to work with the landowner and coordinate with TNC to encourage effective use of the resources.
- Funding through the LIP program as well as through other grant programs has been short-term and priorities have not always been clearly communicated. It is challenging for landowners and conservation organizations to implement long-term management strategies when resources are not stable and secure. High priority sites require a long-term commitment from federal, state and local agencies to ensure adequate resources are available to conduct needed management.
- In some years, the landowner contracted privately to conduct habitat work on his property and the work may not have been synchronized with what had been done in previous years. A coordinated management plan should be developed with the landowner, TNC, and the DNR to make sure that all parties agree on the management objectives and approach and to determine the most effective methods for implementing this strategy.
- It is important to continue monitoring before and after management is conducted to ensure that the desired objectives are achieved and to adapt methods as needed.

Opposite page:

Weaver Tract of Grand River Fen

Photo: Daria A. Hyde





Case Study: Long Lake Fen

Ownership and management:

Springfield Township, North Oakland Headwaters Land Conservancy, and private individuals.

Site description:

Long Lake Fen is located within Springfield Township in the village of Davisburg, Oakland County. This extensive fen complex (approximately 91 ha, or 226 ac) is located in the Shiawassee watershed in the northern portion of the Jackson Interlobate sub-subsection. The Shiawassee River flows along the main channel of the outwash plain and is connected to Long Lake and Davis Lake as well as Rattalee Lake to the northwest of the site.

Poweshiek skipperling history:

The Poweshiek skipperling was first documented at this site in 1995 in the hanging fen just northeast of Long Lake. During late June 1998, a new deme was located and 35 adults were seen flying. The site was not surveyed again until 2005 when the LIP program was in place and after a spring burn was implemented. In July of 2005, 15–20 adults were found at a newly discovered portion of fen accessed from Eaton Road. The entire management unit where Poweshiek skipperlings were found was burned that spring. The Springfield Township Parks and Recreation staff worked with MDNR in 2006 and divided the fen into several management units. Subsequent Poweshiek skipperling survey work was conducted in 2007–2008 and all areas of fen with likely Poweshiek habitat were visited during the flight period and GPS points were taken where adults were recorded. Throughout the period 2008–2013, numbers of Poweshieks were monitored at this site (Figure 18). There appeared to be a general site trend of butterfly numbers dropping in the burn year, followed by a rebound of numbers greater than the original baseline. However, in 2013, numbers of adults surprisingly crashed in all surveyed occupied fen pockets. No spring burns were conducted in 2013 in occupied habitat, so current-year prescribed fire was not responsible for this decline.

Management objectives:

In the master plan for the Shiawassee Basin Preserve, the primary goals outlined were to protect the natural features of the park by limiting recreation in the northern section to conservation and passive recreation; and to provide guidance for an ecosystem management plan

that controls the spread of exotic invasive species, preserves sensitive natural areas, protects threatened and special concern species, and encourages native species to thrive. No specific strategies to address these threats or specific locations where management was needed were included in that plan.

Management History:

Prior to LIP involvement, very little management was taking place in the Long Lake Fen complex. The most important conservation action prior to 2004 was the acquisition of land from private landowners in the identified potential conservation natural area.

Management results and current challenges:

- Continued burn management at the site will need to be evaluated and in some occupied fen pockets fire frequencies may need to be re-evaluated.
- Dense colonies of glossy buckthorn are located at the margins of some of the fen pockets and continue to invade areas near occupied habitat. Without control efforts, it is likely that buckthorn will become a much larger issue in occupied fen habitat.
- In some areas there are monocultures of cattail that appear to have responded vigorously to recent prescribed burns in occupied fen. The increase in cattails between 2010 and 2012 was dramatic. Future burns should be implemented following mechanical or chemical treatment of cattails in these areas to discourage the continued invasion of the fen.
- One small patch of common reed has been treated near the Eaton Road occupied habitat, but there were some re-sprouts that will need a follow-up herbicide treatment.
- Very little is known about the dispersal capability of Poweshieks at sites in Michigan. We do not have any confirmation that adult Poweshieks are moving between management units other than some limited casual observations of adults moving between the NW and SW units.
- Pre-management baseline data sets are lacking for a wide variety of rare plants and animals at prairie fen sites.

Lessons learned:

- Prescribed spring burns are unlikely to completely eliminate Poweshiek populations if fires are patchy and do not burn all areas of the fen within each management unit

- Larger fens are more likely to support “refugia” that Poweshiek skipperlings can utilize when portions of their habitat are burned.
- Required quotas of acres of fen habitat managed in any particular year (whether these quotas derive from a specific grant, plan, or organization) should be adjustable as Poweshiek skipperling mortality may be exacerbated by multiple stressors in the same year. It is important to consider the weather when planning prescribed fires. For example, during or following extreme drought years, burns may have to be cancelled or rescheduled.
- There has been a lack of coordination between the species experts and those entities trying to implement the recommendations outlined in conservation plans. Opportunities to prioritize strategies, identify and retain needed resources, and implement actions to address threats and improve fen habitat have not always been capitalized.
- Despite our efforts to manage for rare insect species in fens, we still continue to see unexplained, steep declines in populations. Determining the culprit is an extremely challenging undertaking due to the number of potential explanations for these declines, some of which are likely out of our control.

Poweshiek skipperling nectaring on shrubby cinquefoil



Bradford S. Slaughter, MNFI



Photo provided by Harlow Steffey

The week we spend together doing this research is so important, it has also fueled a passion of mine to help educate the public throughout the entire year about the importance of the species, thanks to the knowledge I've gained from you and some of the other snake experts I've been fortunate enough to work with through the program.

... I'm proud to say that thanks to the tools and knowledge I've gained through you and these monitoring studies, I've had great success in changing many people's views of snakes.

Harlow Steffey, 2013

Case Study: Public Outreach and Partnerships

Public awareness and support are critical for efforts to protect and conserve prairie fens and associated species. MNFI's volunteer-based massasauga monitoring efforts provided a unique opportunity for land managers, researchers, students, and the public to see and learn more about massasaugas, prairie fens, and their management and conservation. The monitoring efforts also allowed volunteers to get involved and actually contribute to massasauga research and conservation. Over 230 volunteers (over 120 at Pierce Cedar Creek Institute (PCCI) and over 110 at Ives Road Fen) from a variety of agencies and organizations assisted with the massasauga monitoring efforts at PCCI and Ives Road Fen from 2011–2013 (Figure 19). Volunteers included PCCI and The Nature Conservancy (TNC) staff; biologists and seasonal staff from the MDNR, U.S. Fish and Wildlife Service, and U.S. Forest Service; faculty and undergraduate and graduate students from over 13 different colleges and universities; high school and elementary school students and teachers; staff from zoos, nature centers and conservation organizations; and interested members of the general public. The feedback from the volunteers regarding the experience was very positive. Participation in the monitoring effort also helped reduce fears and increase interest in and support for conservation of massasaugas and other snakes. For example, one of the AmeriCorps crew members who assisted with massasauga surveys at Ives Road Fen was very fearful of massasaugas and snakes in general at the start of the surveys, but was much more comfortable being around them (and even held a garter snake) by the end of the surveys. Also, one of the students from Grand Valley State University (GVSU) who helped conduct the intensive monitoring effort at PCCI in 2013 continued working with massasaugas as a field assistant for a population demographics study at another site in southwest Michigan.

Partnerships are also essential to prairie fen and massasauga conservation and recovery efforts. We were able to cultivate partnerships with various organizations to develop and initiate long-term massasauga monitoring efforts at PCCI and Ives Road Fen. We developed a partnership among PCCI, MNFI, Dr. Jennifer Moore at GVSU, and a private donor to continue and expand massasauga monitoring at PCCI in 2013 and hopefully beyond. We worked with Dr. Jennifer Moore and PCCI to secure funding through PCCI's URGE program to support Dr. Moore and two undergraduate students to continue the massasauga moni-

toring and population demographics study. A private donor provided additional support for MNFI staff to train and work with Dr. Moore and the two students from GVSU to ensure methods were consistent between the surveys in 2013 and previous years. PCCI, Dr. Moore, and MNFI are interested in collaborating to continue the massasauga monitoring and population demographics study at PCCI. Although volunteer-based surveys during 2011–2013 alone did not generate sufficient data for the closed population modeling analysis, the volunteers did contribute significant data to the monitoring efforts, documenting 17 (22%) of the 78 observations in 2013 and 35 (30%) of the 117 massasauga observations over the three years. Volunteer-based surveys could be a valid approach for monitoring massasaugas if we can increase the number of snake captures/recaptures (e.g., by increasing sampling effort or number of survey days, or developing and maintaining a core group of more experienced volunteers). We also developed partnerships with several groups/organizations who are interested in assisting with massasauga monitoring in the future (e.g., Eastern Michigan University, University of Toledo), and with organizations conducting massasauga monitoring at other sites in Michigan (e.g., Edward Lowe Foundation, Northern Illinois University, Lincoln Park Zoo and the Eastern Massasauga Species Survival Plan).

Luke Vroegon, volunteer



Yu Man Lee, MNFI

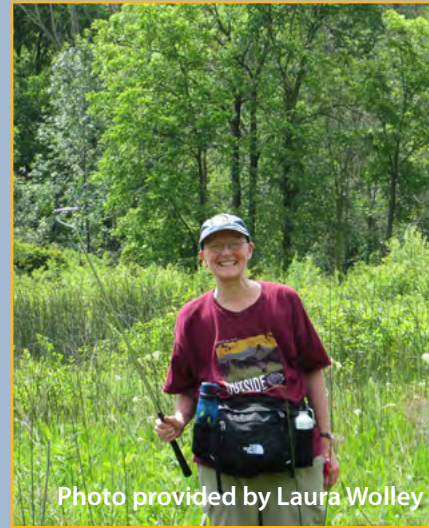


Photo provided by Laura Wolley

Laura Woolley



Photo provided by Laura Wolley

Dorothy Yenni

Dorothy and I could both go on and on about the wonderful experience we had with the Massasauga monitoring - even the first time when we didn't see any!

... the opportunity to actually participate in a study with trained researchers, naturalists, students, and other volunteers to gather information about this magnificent animal has got to be a one of a kind experience - particularly because the data collected will aid in preserving the species.

... Seeing Massasaugas this year was like winning the lottery! When we heard someone holler, "Here's one!" it was just awesome.

Laura Woolley, 2013



Recommendations for future work

We recommend the identification of high priority prairie fen sites for future conservation and management efforts. Potential criteria to consider for this process include (1) ownership and/or management by an individual or organization with the interest and ability to manage the site long-term; (2) habitat condition and size, including consideration of successional trajectories based on current and potential future disturbances (e.g., invasive species populations, groundwater depletion or disruption, and infrastructure development); and (3) presence of significant populations of target species or concentrations of target species. Below are some of our specific recommendations for different aspects of our work.

Habitat monitoring

- Conduct reconnaissance surveys prior to the implementation of management, and discuss management goals and specific focal areas prior to the establishment of photo monitoring points to ensure their placement in the most appropriate areas
- Establish photo monitoring points in only those sites that are expected to be consistently managed over at least 10 years, preferably longer
- Photo points may be effective at sites where short-term management focuses on eradicating dense stands of invasive species, such as cattails (*Typha* spp.), common reed (*Phragmites australis*), and glossy buckthorn (*Frangula alnus*)
- Photo points are less likely to adequately assess the impacts of fire management or other management on relatively intact, open fens
- Reduce frequency of photo monitoring point visits to ensure significant management activity takes place between visits
- Developing an appropriate monitoring design for long-term monitoring of prairie fens is challenging for several ecological and practical reasons.

Opposite page:

Mike Sanders, MNFI

Photo: David L. Cuthrell

Ecological challenges

- Within-site and across-site heterogeneity in vegetative structure and species composition varies in space and time
- Natural processes and appropriate ecological management strategies vary by site
- Unpredictable ecological trajectories due to historic and continuing changes in land use, hydrology, species ranges, climate, and other factors

Practical challenges

- Resources for consistent, long-term management are often limited
- The implementation of statistically rigorous, detailed vegetation monitoring requires a significant investment of time, resources, and expertise

The utilization of coarse-level visual estimates of vegetation percent cover over the course of management is one “middle ground” strategy for assessing changes in habitat at a finer scale than the use of photographic monitoring points. For example, The Nature Conservancy utilizes coarse metrics to monitor the impacts of management on prairie fens that incorporates percent cover of herbaceous species, percent cover of native species, and percent of a pre-defined management unit that will carry a prescribed fire. Coarse metrics are potentially cost-effective, but their implementation requires that management units be pre-defined and that changes in cover are significant enough to be detected in a qualitative fashion (O'Connor 2007).

Moreover, coarse-level metrics require defining targets that are not naturally consistent among all sites classified as “prairie fen” in Michigan. Among these are the percent of “open” or herbaceous-dominated fen versus percent of shrub- or tree-dominated fen and the role of fire in maintaining these systems. Due to the ecological challenges listed above, ecological management, monitoring, and evaluation of prairie fens in Michigan may benefit from an “open-ended” approach that focuses on promoting natural processes, creating and/or maintaining vegetation heterogeneity in space and time, and promoting ecosystem services (Hughes et al. 2011). This approach differs from the traditional species and habitat “target” approach that our work has largely followed over the past decade.

Although the open-ended “meandering” ecosystem management approach is suggested especially for habitat creation projects (Hughes et

al. 2011), it appears to have several advantages over the traditional approach that aims to restore a pre-defined target for prairie fen systems:

- Eliminates the need for an a priori “model” of prairie fen. Fens are heterogeneous ecosystems that vary within-site and across sites, and the natural processes and species that are characteristic of or appropriate for one fen may not be so for other fens.
- Promotes sustainable ecosystem trajectories by focusing on process and allowing physical and biological processes to shape ecosystem structure and composition
- Utilizes status assessments as a monitoring tool, rather than measurements intended to show progress towards a pre-determined target that may be undefinable (such as the number of Mitchell's satyr butterflies a fen can support, or the percentage of graminoid-dominated fen required for the continued persistence of a specific species)
- Allows for the development of more specific management goals based on status assessment data

Conservation outcomes are difficult to demonstrate when the number of target sites is too high, resulting in a fragmented, inconsistent monitoring approach that cannot address the breadth of appropriate ecological indicators. Therefore, we promote defining and implementing a flexible, open-ended monitoring approach at one to a few pilot sites if additional funding is secured for future fen management.





Mitchell's satyr monitoring recommendations

- Continue monitoring Mitchell's satyr populations at extant sites at least every two to three years to provide the DNR and USFWS with information that will help assess Mitchell's satyr population status and evaluate their response to management.
 - Share spatial and population count data of Mitchell's satyr at monitored sites to help land managers adapt their management prescriptions (e.g. frequency and location of prescribed fire).
- Focus management and monitoring efforts at high priority sites (most viable).
- If introduction and/or augmentation of Mitchell's satyr is pursued by the Mitchell's satyr working group:
 - Develop and utilize standard monitoring protocols to evaluate captive reared Mitchell's satyr at zoos, including daily inventory of larvae.
 - Develop and utilize standard monitoring protocols to evaluate introduced populations at selected introduction sites and/or augmented populations at extant sites.
- Continue to look for additional occupied habitat at known sites and search for new occurrences of Mitchell's satyr as resources allow.

Poweshiek skipperling monitoring recommendations

- Continue to search additional prairie fens for possible new occurrences of Poweshiek skipperlings in Michigan, with highest priority given to those fens that contain prairie dropseed, mat muhly, and little bluestem.
- Work with our conservation partners (MI DNR, MN DNR, WI DNR, USFWS, university researchers) to investigate the reasons for the rapid decline of Poweshiek skipperling populations, recorded first in the western portions of its range and now apparent in Michigan and Wisconsin.
- Continue monitoring Poweshiek skipperling populations as described above and use both the spatial and population information provided by such counts to continue management. Adaptive management ideas include:
 - Using spatial data to refine management units either by re-designing burn lines or further subdividing units, or

providing areas of permanent refugia as described by Swengel and Swengel (2007).

- Use the count data, in conjunction with other ecological data, to help determine appropriate frequencies of burns within specific management units.

Eastern massasauga monitoring recommendations

- Continue eastern massasauga population monitoring at PCCI and Ives. Collect habitat data in conjunction with population demographics data, and also data on prey availability and genetics data.
- Initiate population monitoring at 1–2 additional fen sites in southern Michigan. Also investigate monitoring massasaugas across fen sites using occupancy modeling (more than just presence but less intensive than mark-recapture), and develop approach for monitoring a larger number of sites. Investigate using other population parameters to monitor impacts of management on the massasauga populations (e.g., monitoring habitat and/or indicators of population health such as individual growth rate). Investigate the relationship between habitat quality and/or quantity and population size, abundance, and/or density.
- Figure out a better way to facilitate increased and more timely communication and information sharing between managers and researchers to facilitate adaptive management and do a better job of keeping track of management and monitoring activities and outcomes/results, especially spatially—e.g., via a fen management database.
- Collaborate with researchers and individual site/land managers to develop a model and tool for predicting massasauga emergence to help guide timing of management activities (e.g., burning prior to emergence or after ingress).
- Continue to refine, improve, and expand volunteer-based monitoring efforts. Find ways to increase sample size. Investigate other survey methods (e.g., using dogs to locate snakes) or increase sampling effort (e.g., with students and/or volunteers).
- Focus management on priority sites (e.g., viable populations, large complexes) for EMR and other rare species. Develop process for identifying high priority sites. Focus management and monitoring at these sites. More intensive monitoring at smaller number of sites.

Literature cited

- Borkin, S.S. 1994. Ecological studies of the Poweshiek Skipper (*Oarisma poweshiek*) in Wisconsin. Report to WI Bureau of Endangered Resources, Madison, WI. 13 pp.
- Borkin, S.S. 1995. 1994 Ecological studies of the Poweshiek Skipper (*Oarisma poweshiek*) in Wisconsin. Report to Bureau of Endangered Resources, Wisconsin Department of Natural Resources, Madison, Wisconsin. 13 pp. + ii.
- Borkin, S.S. 1996. Ecological studies of the Poweshiek Skipper (*Oarisma poweshiek*) in Wisconsin- 1995 Season Summary. Report to Bureau of Endangered Resources, Wisconsin Department of Natural Resources, Madison, Wisconsin. 5 pp. + Appendix and Table.
- Cuthrell, D.L., and B.S. Slaughter. 2012. Special animal abstract for *Oarisma poweshiek* (Poweshiek skipperling). Michigan Natural Features Inventory, Lansing, MI. 5 pp.
- Dana, R. P. 1991. Conservation management of the prairie skippers *Hesperia dacotae* and *Hesperia ottoe*. Minnesota Agricultural Experiment Station Bulletin 594-1991. University of Minnesota, St. Paul, MN. 63 pp.
- Hughes, F.M.R., P.A. Stroh, W.M. Adams, K.J. Kirby, J.O. Mountford, and S. Warrington. 2011. Monitoring and evaluating large-scale, 'open-ended' habitat creation projects: A journey rather than a destination. *Journal for Nature Conservation* 19: 245-253.
- Hyde, D.A., B.S. Slaughter, D.L. Cuthrell, H.D. Enander, Y. Lee, M.R. Penskar, B.J. Barton, M.A. Kost, M.A. Sanders, P.J. Badra, and M.J. Monfils. 2009. Development of a multi-state Mitchell's satyr habitat conservation plan: Michigan portion 2009 Annual Report. Michigan Natural Features Inventory, Report No. 2009-18, Lansing, MI. 75 pp. + appendices.
- McAlpine, W.S. 1972. Observations on the life history of *Oarisma poweshiek* (Parker) 1870. *Journal of Research on the Lepidoptera* 11: 83-93.
- Nielsen, M.C. 1999. Michigan butterflies and skippers: A field guide and reference. Michigan State University Extension Bulletin E-2675. 248 pp.
- O'Connor, R.P. 2007. Development of monitoring strategies and methods for the DNR Landowner Incentive Program. Michigan Natural

Features Inventory, Report No. 2007-15, Lansing, MI. 24 pp.

Selby, G. 2005. Status assessment and conservation guidelines: Poweshiek Skipperling, *Oarisma poweshiek* (Parker), (Lepidoptera: HesperIIDae). Prepared for Twin Cities Field Office, U.S. Fish and Wildlife Service, Bloomington, MN. 53 pp.

Selby, G. 2010. Status Assessment Update: Poweshiek Skipperling, *Oarisma poweshiek* (Parker), (Lepidoptera: HesperIIDae). Prepared for Twin Cities Field Office, U.S. Fish and Wildlife Services, Bloomington, MN. 29 pp.

Wolcott, R.H. 1893. The butterflies of Grand Rapids, Michigan. Canadian Entomologist 25: 98-107.



General references/resources

Fen ecology and distribution

Albert, D.A., Cohen, J.G., M.A. Kost, B.S. Slaughter, and H.D. Enander. 2008. Distribution Maps of Michigan's Natural Communities. Michigan Natural Features Inventory, Report Number 2008-01, Lansing, MI. 166 pp.

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

Kost, M.A., D.A. Albert, J.G. Cohen, B.S. Slaughter, R.K. Schillo, C.R. Weber, and K.A. Chapman. 2007. Natural Communities of Michigan: Classification and Description. Michigan Natural Features Inventory, Report Number 2007-21, Lansing, MI. 314 pp. Available at: <http://mnfi.anr.msu.edu/communities/index.cfm>.

Kost, M.A., and D.A. Hyde. 2009. Exploring the prairie fen wetlands of Michigan. Michigan State University Extension Bulletin E-3045, East Lansing, MI. 106 pp.

O'Connor, R.P. 2007. Development of monitoring strategies and methods for the DNR Landowner Incentive Program. Michigan Natural Features Inventory, Report No. 2007-15, Lansing, MI. 24 pp.

O'Connor, R.P., M.A. Kost, and J.G. Cohen. 2009. Prairies and Savannas in Michigan: Rediscovering our Natural Heritage. Michigan State University Press, East Lansing, MI. 139 pp.

Spieles, J.B., P.J. Comer, D.A. Albert, and M.A. Kost. 1999. Natural community abstract for prairie fen. Michigan Natural Features Inventory, Lansing, MI. 5 pp.

Rare species associated with prairie fens

Borkin, S.S. 1994. Ecological studies of the Poweshiek Skipper (*Oarisma poweshiek*) in Wisconsin. Report to WI Bureau of Endangered Resources, Madison, WI. 13 pp.

Borkin, S.S. 1995. 1994 Ecological studies of the Poweshiek Skipper (*Oarisma poweshiek*) in Wisconsin. Report to Bureau of Endangered Resources, Wisconsin Department of Natural Resources, Madison, Wisconsin. 13 pp. + ii.

- Borkin, S.S. 1996. Ecological studies of the Poweshiek Skipper (*Oarisma poweshiek*) in Wisconsin- 1995 Season Summary. Report to Bureau of Endangered Resources, Wisconsin Department of Natural Resources, Madison, Wisconsin. 5 pp. + Appendix and Table.
- Choberka, E.G., M.R. Penskar, and P.J. Higman. 2000. Special plant abstract for *Asclepias purpurascens* (purple milkweed). Michigan Natural Features Inventory, Lansing, MI. 2 pp.
- Cuthrell, D.L. 1999. Special animal abstract for *Papaipema beeriana* (blazing star borer). Michigan Natural Features Inventory, Lansing, MI. 3 pp.
- Cuthrell, D.L. 1999. Special animal abstract for *Prosapia ignipectus* (red-legged spittlebug). Michigan Natural Features Inventory, Lansing, MI. 3 pp.
- Cuthrell, D.L. 2000. Special animal abstract for *Papaipema silphii* (silphium borer moth). Michigan Natural Features Inventory, Lansing, MI. 3 pp.
- Cuthrell, D.L., and B.S. Slaughter. 2012. Special animal abstract for *Oarisma poweshiek* (Poweshiek skipperling). Michigan Natural Features Inventory, Lansing, MI. 4 pp.
- Dana, R. P. 1991. Conservation management of the prairie skippers *Hesperia dacotae* and *Hesperia ottoe*. Minnesota Agricultural Experiment Station Bulletin 594-1991. University of Minnesota, St. Paul, MN. 63 pp.
- Higman, P.J., and M.R. Penskar. 1998. Special plant abstract for *Cypridium candidum* (small white lady's-slipper). Michigan Natural Features Inventory, Lansing, MI. 3 pp.
- Higman, P.J., and M.R. Penskar. 1999. Special plant abstract for *Sporobolus heterolepis* (prairie dropseed). Michigan Natural Features Inventory, Lansing, MI. 2 pp.
- Hyde, D.A., B.S. Slaughter, D.L. Cuthrell, H.D. Enander, Y. Lee, M.R. Penskar, B.J. Barton, M.A. Kost, M.A. Sanders, P.J. Badra, and M.J. Monfils. 2009. Development of a multi-state Mitchell's satyr habitat conservation plan: Michigan portion 2009 Annual Report. Michigan Natural Features Inventory, Report No. 2009-18, Lansing, MI. 75 pp. + appendices.
- Hyde, D. 2012. Update of Lee, Y. 2000. Special animal abstract for Mitchell's satyr butterfly (*Neonympha mitchellii mitchellii*). Michigan Natural Features Inventory, Lansing, MI. 7 pp.
- Lee, Y. 2000. Special animal abstract for *Clemmys guttata* (Spotted Turtle). Michigan Natural Features Inventory, Lansing, MI. 4 pp.
- Lee, Y. and J. T. Legge. 2000. Special animal abstract for *Sistrurus catenatus catenatus* (Eastern Massasauga). Michigan Natural Features Inventory, Lansing, MI. 8 pp.
- Nielsen, M.C. 1999. Michigan butterflies and skippers: A field guide and reference. Michigan State University Extension Bulletin E-2675. 248 pp.
- Norris, R.A., and B.S. Slaughter. 2012. Special animal abstract for *Calephelis mutica* (swamp metalmark). Michigan Natural Features Inventory, Lansing, MI. 4 pp.
- O'Connor, R.P., and M.R. Penskar. 2007. Special Plant Abstract for *Filipendula rubra* (Queen-of-the-prairie). Michigan Natural Features Inventory, Lansing, MI. 3 pp.
- Penskar, M.R., and P.J. Higman. 1999. Special plant abstract for *Drosera anglica* (English sundew). Michigan Natural Features Inventory, Lansing, MI. 2 pp.
- Penskar, M.R., and P.J. Higman. 1999. Special plant abstract for *Muhlenbergia richardsonis* (mat muhly). Michigan Natural Features Inventory, Lansing, MI. 2 pp.
- Penskar, M.R., and P.J. Higman 2000. Special Plant Abstract for *Cacalia plantaginea* (prairie Indian plantain). Michigan Natural Features Inventory, Lansing, MI. 3 pp.
- Penskar, M.R., E.R.G. Choberka, and P.J. Higman 2000. Special Plant Abstract for *Zizania aquatic* (southern wild-rice). Michigan Natural Features Inventory, Lansing, MI. 2 pp.
- Penskar, M.R., and S.R. Crispin. 2007. Special Plant Abstract for *Dodecatheon meadia* (shooting star). Michigan Natural Features Inventory, Lansing, MI. 4 pp.
- Penskar, M.R., and S.R. Crispin. 2009. Special Plant Abstract for *Polemonium reptans* (Jacob's ladder). Michigan Natural Features Inventory, Lansing, MI. 3 pp.
- Selby, G. 2005. Status assessment and conservation guidelines: Poweshiek Skipperling, *Oarisma poweshiek* (Parker), (Lepidoptera: HesperIIDae). Prepared for Twin Cities Field Office, U.S. Fish and

Wildlife Service, Bloomington, MN. 53 pp.

Selby, G. 2010. Status Assessment Update: Poweshiek Skipperling, *Oarisma poweshiek* (Parker), (Lepidoptera: Hesperidae). Prepared for Twin Cities Field Office, U.S. Fish and Wildlife Services, Bloomington, MN. 29 pp.

Peer-reviewed research articles

Barton, B.J., and C.E. Bach. 2005. Habitat use by the federally endangered Mitchell's satyr butterfly (*Neonympha mitchellii mitchellii*) in a Michigan prairie fen. *American Midland Naturalist* 153: 41-51.

Barton, B.J., C.D. Kirschbaum, and C.E. Bach. 2009. The impacts of ant mounds on sedge meadow and shrub carr vegetation in a prairie fen. *Natural Areas Journal* 29: 293-300.

Bess, J.A., and K.G.A. Hamilton. 1999. A new *Flexamia* (Homoptera : Cicadellidae : Deltocephalinae) from southern Michigan. *Great Lakes Entomologist* 32: 9-14.

Bowles, M., J. McBride, N. Stoyhoff, and K. Johnson. 1996. Temporal changes in vegetation composition and structure in a fire-managed prairie fen. *Natural Areas Journal* 16: 275-288.

Derieg, N.J., S.J. Weil, A.A. Reznicek, and L.P. Bruederle. 2013. *Carex viridistellata* sp nov (Cyperaceae), a new cryptic species from prairie fens of the eastern United States. *Systematic Botany* 38: 82-91.

Fiedler, A.K., and D.A. Landis. 2012. Biotic and abiotic conditions in Michigan prairie fen invaded by glossy buckthorn (*Frangula alnus*). *Natural Areas Journal* 32: 41-53.

Fiedler, A.K., D.A. Landis, and M. Arduser. 2012. Rapid shift in pollinator communities following invasive species removal. *Restoration Ecology* 20: 593-602.

Hamm, C.A. 2012. Development of polymorphic anonymous nuclear DNA markers for the endangered Mitchell's satyr butterfly, *Neonympha mitchellii mitchellii* (Lepidoptera: Nymphalidae). *Conservation Genetics Resources* 4: 127-128.

Hamm, C.A. 2013. Estimating abundance of the federally endangered Mitchell's satyr butterfly using hierarchical distance sampling. *Insect Conservation and Diversity* 6: 619-626.

Hamm, C.A., B.L. Williams, and D.A. Landis. 2012. Natural history and conservation status of the endangered Mitchell's Satyr butterfly:

an update and expansion of our knowledge regarding *Neonympha mitchellii mitchellii* French 1889. *Journal of the Lepidopterists' Society* 67: 15-28.

Hughes, F.M.R., P.A. Stroh, W.M. Adams, K.J. Kirby, J.O. Mountford, and S. Warrington. 2011. Monitoring and evaluating large-scale, 'open-ended' habitat creation projects: A journey rather than a destination. *Journal for Nature Conservation* 19: 245-253.

Landis, D.A., A.K. Fiedler, C.A. Hamm, D.L. Cuthrell, E.H. Schools, D.R. Pearsall, M.E. Herbert, and P.J. Doran. 2011. Insect conservation in Michigan Prairie fen: addressing the challenge of global change. *Journal of Insect Conservation* 16: 131-142.

McAlpine, W.S. 1972. Observations on the life history of *Oarisma poweshiek* (Parker) 1870. *Journal of Research on the Lepidoptera* 11: 83-93.

Shuey, J.A. 1997. Conservation status and natural history of Mitchell's satyr, *Neonympha mitchellii mitchellii* (Insecta: Lepidoptera: Nymphalidae). *Natural Areas Journal* 17: 153-163.

Shuey, J.A., and J. Szymanski. 2012. Modified Pollard transects do not predict estimated daily population size for the secretive butterfly, *Neonympha mitchellii mitchellii* French. *Journal of the Lepidopterists Society* 66: 221-224.

Summerville, K.S., and C.A. Clampitt. 1999. Habitat characterization of five rare insects in Michigan (Lepidoptera: Hesperidae, Riodinidae, Satyridae; Homoptera: Cercopidae). *Great Lakes Entomologist* 32: 225-238.

Szymanski, J., J.A. Shuey, and K. Oberhauser. 2004. Population structure of the endangered Mitchell's Satyr, *Neonympha mitchellii mitchellii* (French): Implications for conservation. *American Midland Naturalist* 152: 304-322.

Wolcott, R.H. 1893. The butterflies of Grand Rapids, Michigan. *Canadian Entomologist* 25: 98-107.

