Mitchell's Satyr
Programmatic Safe Harbor Agreement

This Programmatic Safe Harbor Agreement, effective and binding on the date of last signature below, is between U.S. Fish and Wildlife Service's East Lansing Field Office Project Leader and the U.S. Fish and Wildlife Service.

Permittee:

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The Service designates the following as the Agreement Contact:

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Tracking Number:

Summary of Purpose of the SHA:

The purpose of this agreement is to outline conservation actions that participating property owners will implement and monitor on their enrolled properties for Mitchell's satyr *(Neonympha mitchellii mitchellii*). The goal of the agreement is to encourage property owners to engage in conservation actions for the Mitchell's satyr that provide a net conservation benefit to recovery.

1.0 Introduction

The U.S. Fish and Wildlife Service (Service) Safe Harbor Program (64 FR 32717) provides regulatory flexibility to non-federal landowners who voluntarily commit to implementing or avoiding specific activities, over a defined timeframe, that are reasonably expected to provide a net conservation benefit to species listed under the Endangered Species Act of 1973, as amended (Act). In exchange for this commitment, enrolled landowners (Cooperators) receive assurances from the Service that no additional future regulatory restrictions will be imposed or commitments required for species covered under a Safe Harbor Agreement.

Sections 2, 7, and 10 of the Endangered Species Act (Act) of 1973, as amended, allow the Service to enter into this Safe Harbor Agreement. Section 2 of the Act states that encouraging interested parties, through Federal financial assistance and a system of incentives, to develop and maintain conservation programs is a key to safeguarding the Nation's heritage in fish, wildlife, and plants. Section 7 of the Act requires the Service to review programs that we administer and to utilize such programs in furtherance of the purposes of the Act. By entering into this Safe Harbor Agreement, we are utilizing our Recovery Programs to further the conservation of the Nation's fish and wildlife. Lastly, section 10(a)(1)(A) of the Act authorizes the issuance of permits to "enhance the survival" of a listed species.

The purpose of this Mitchell's Satyr Programmatic Safe Harbor Agreement (Agreement) is to encourage non-federal landowners to voluntarily engage in conservation activities to benefit and advance recovery of the endangered Mitchell's satyr *(Neonympha mitchellii mitchellii*). The primary conservation activity under this Agreement will be reintroductions of satyrs on properties of willing landowners. Cooperators who enroll in this Agreement may withdraw at any time without penalty, providing they give the Service an opportunity to retrieve any satyrs on their lands.

This Agreement is programmatic in nature and applicable in certain counties in Michigan and Indiana as shown in Appendix A. Based on this Agreement and compliance with all other associated regulations and laws, the Service will issue a section 10(a)(1)(A) Enhancement of Survival Permit (Permit) to the Service's East Lansing Field Office Project Leader (Permittee) for a term of 30 years. Under the Permit, the Permittee may enroll eligible and willing non-federal landowners through Certificates of Inclusion for a minimum term of 10 years under this Agreement. No Federal lands will be enrolled under this permit; therefore, no incidental take coverage or Safe Harbor assurances will be conveyed to the management of Federal lands. The single Permittee approach simplifies the process for private landowners and garners support for non-federal reintroductions.

The Certificates of Inclusion will convey all of the Permit's incidental take authorization and the Safe Harbor assurances to Cooperators. Site-specific Reintroduction Plans will describe the specific conservation and management details of each site within identified Conservation Zones on each enrolled property. Each Reintroduction Plan will be developed by the Permittee and the Cooperator, with technical input from State natural resource agencies and other partners as appropriate. The Permittee will issue a Certificate of Inclusion to each Cooperator after a Reintroduction Plan is approved and signed by the Permittee and the Cooperator. Collectively, the Permittee and the Cooperator are hereafter called the Parties. The programmatic nature of this Agreement provides Cooperators with a streamlined process for obtaining assurances that actions taken to benefit Mitchell's satyr on their land will not restrict current land use or result in additional regulatory obligations associated with the species under the Act.

An attendant Biological Opinion will be developed as a result of an intra-Service section 7 consultation, under the Act, on the effects of the issuance of the Permit and implementation of the Agreement. The Biological Opinion will consider the effects from (1) implementation of habitat management activities on enrolled lands, (2) assurances allowing Cooperators to return enrolled lands to baseline, (3) otherwise lawful activities that may occur on Cooperators' lands outside the Conservation Zone, and (4) otherwise lawful activities occurring on immediately adjacent, non-participating lands that have suitable habitat for Mitchell's satyr.

The Safe Harbor policy allows the Service to grant incidental take authority to the owners of neighboring lands, where occupation of neighboring lands by the covered species is expected as a result of the Agreement. Neighboring landowners would only be required to agree to such conditions as would be necessary to ensure

that the Agreement does not circumvent those obligations or requirements, if any, under section 9 of the Act that were applicable at the time the Agreement was signed. Because this Agreement will be implemented only on lands with a baseline of zero Mitchell's satyrs, neighboring landowners would have no obligations under section 9 of the Act at the time the Agreement is signed. As such, the Incidental Take Statement in the Biological Opinion associated with the Permit will authorize incidental take of Mitchell's satyr resulting from otherwise lawful activities on immediately adjacent, non-participating lands that have suitable habitat for Mitchell's satyr for the length of time that the Permit is in effect.

Neighboring landowners who do not participate in the Agreement are not required to implement any actions on their property to benefit Mitchell's satyr. Normal land use practices on neighboring properties that are otherwise lawful, such as residential and commercial development or agricultural activities, may result in incidental take of Mitchell's satyrs. The prairie fens that Mitchell's satyr inhabits are a type of wetland; as such, certain activities, e.g., discharge of fill material, may be regulated under section 404 of the Clean Water Act. Such activities, if conducted without benefit of any required permits, would not be considered an otherwise lawful activity.

To address these normal land uses that would otherwise not be restricted due to Mitchell's satyr, the Incidental Take Statement in the Biological Opinion associated with the Permit will provide authorization of incidental take of Mitchell's satyr, resulting from otherwise lawful activities, to non-participating landowners (i.e., immediately adjacent landowners) where the presence of Mitchell's satyr from a reintroduction effort under this Agreement may affect their ownership interests for the length of time that the Permit is in effect. Cooperators who withdraw from the Agreement become non-participating landowners and will also be covered through the Incidental Take Statement in the Biological Opinion for future incidental take of satyrs that may occur as a result of otherwise lawful activities for the duration of the Permit.

This Agreement has been developed under section 10 of the Act, the Service's Safe Harbor Policy (64 FR 32717) and final regulations (64 FR 32706), and revisions to the regulations (69 FR 24084). This Agreement supports the intent of the Parties to follow the procedural and substantive requirements of section 10(a)(1)(A) of the Act. The Safe Harbor Policy was developed to encourage private and other non-federal landowners to voluntarily undertake conservation activities on their properties to enhance, restore, or maintain habitat to benefit federally listed species.

2.0 Covered Species

Covered species are those federally listed species that are subject to a Safe Harbor Agreement and accompanying 10(a)(1)(A) Enhancement of Survival Permit, as defined in the Service's final Safe Harbor Policy (64 FR 32717). This Agreement's covered species is the Mitchell's satyr *(Neonympha mitchellii mitchellii*), which is federally listed as endangered.

3.0 Background

The Mitchell's satyr is a medium-sized, dark brown butterfly. Adult wingspan is approximately 4 cm (1.5–1.75 inches). A distinctive series of sub-marginal, yellow-ringed, black circular eyespots (ocelli) with silvery centers are found on the lower surfaces of both pairs of wings. The eyespots are accented by two orange bands along the posterior wing edges, as well as by two orange bands along the central portion of each wing. Females tend to be larger and lighter in color than males. The satyr has a characteristic slow, bobbing flight pattern and tends to fly through vegetation rather than over the top. They often, but not always, stop after a short flight.

In Michigan and Indiana, Mitchell's satyr is found exclusively in prairie fens, which are geologically unique wetlands, found only in the glaciated Midwest (Spieles *et al.* 1999), and open parts of rich tamarack swamps. These systems are a mosaic of open, shrubby, and forested communities, with peat soils and alkaline groundwater seeps. Thin-leaved sedges usually dominate the ground layer in the fens (Kost and DeSteven 2000).

Mitchell's satyr usually is found within 3m (10 feet) of woody vegetation (Barton and Bach 2005). In more open fens, Mitchell's satyr occurs along the shrubby edges of the fen. In fens with more tamarack or other

woody vegetation, the satyr is found in open, grassy patches between lanes of trees and shrubs. Mitchell's satyr butterflies are rarely found in open fens without trees or tamarack swamps without openings.

The Mitchell's satyr spends 95% of its life cycle as a larva or caterpillar. The satyr undergoes complete metamorphosis and progresses through four stages of development: egg, larva, pupa, and adult. Larvae molt five times; each stage between molts is known as an instar. First instar larvae are initially white, with dark velvet-brown heads, but their bodies change to a lime green color after they begin feeding (McAlpine *et al.* 1960). The second through sixth instars are cryptically colored (green or tan, depending on the time of year).

The Mitchell's satyr in the northern portion of its range (i.e., Michigan and Indiana) generally has only one generation per year. The adult flight period lasts two to three weeks, occurring in mid-June to late July. Mating takes place shortly after females emerge. Oviposition (egg-laying) occurs close to the ground on a variety of small forbs and sedges. Several factors may be important in oviposition site selection, including partial shade, humidity, temperature, predator avoidance, food plant availability and density, and niche segregation (Darlow 2000).

Larvae hatch after 7–11 days and immediately move to a nearby food plant. The primary larval host plant is believed to be fine-leaved *Carex* species based on various laboratory and semi-natural caged experiments (McAlpine *et al.* 1960, Legge and Rabe 1996) and the close association between adult Mitchell's satyrs and dense stands of sedges (*C. stricta*, *C. lasiocarpa*) (Shuey 1997). Food preference trials for captive larvae indicate first instar larvae select and feed upon a variety of grasses and forbs, although some may not support successful development. Larval diet trials also identified three species of *Carex—leptalea*, *sterilis*, and *stricta*—and two grasses—*Panicum* spp. and *Poa palustris*—that supported normal development until the third instar diapause around mid- to late summer (Tolson and Ellsworth 2008).

After hatching, larvae undergo three molts before entering diapause in the fourth instar in the autumn. During captive rearing, Tolson and Ellsworth (2010) observed larvae overwintering on the base of Tussock Sedge (*Carex stricta*). In the spring, the larvae continue eating and growing, passing through two more instars. In late-May to late-June, the larvae pupate, forming a chrysalis about 5-68 cm (2-27 inches) from the base of the plant (Tolson and Ellsworth 2008). The chrysalis persists for 10 to 15 days (McAlpine *et al.* 1960) before the adult butterfly emerges from mid-June to late July.

Adults are short-lived and exist primarily to mate, disperse, and lay eggs. While infrequent, adults occasionally feed on nectar and accept nectar daily during captive rearing (Tolson and Ellsworth 2008).

Adult satyrs are weak fliers and move only short distances. The median daily movements observed during a mark-release-recapture study were 32m (105 feet) for females and 35m (115 feet) for males (Barton and Bach 2005) while the maximum distances recorded in another mark-release-recapture study were 478m (1,568 feet) for females and 710m (2,329 feet) for males (Barton 2008). The maximum distance ever recorded for Mitchell's satyr dispersal is under one-half mile. Mitchell's satyr will disperse through forest and shrub-carr, but the degree to which woody vegetation acts as a barrier is unknown.

Mitchell's satyr was listed as endangered, pursuant to the Act, under an emergency listing on June 25, 1991 (56 FR 28825) and a final rule on May 20, 1992 (57 FR 21564). Critical habitat has not been designated for this species.

Habitat loss and fragmentation have been and continue to be the primary threats affecting Mitchell's satyr. The final listing rule cited human-induced destruction and natural succession as leading causes of Mitchell's satyr habitat decline. Loss of habitat has occurred throughout the historic range of the species and continues in some locations as a result of succession, altered hydrology, agricultural conversion, weed plant invasion, and development. Most of the destructive activities are linked in some way to the hydrology that controls the groundwater flow and water quality in the fen.

4.0 Eligible Lands

The geographical lands eligible for enrollment in this Agreement include non-federal lands within counties in

Michigan and Indiana (Appendix A) that have suitable fen habitat for Mitchell's satyr. Comprehensive surveys for the species were not completed throughout the species' range prior to population declines; therefore, we have included all suitable fen habitats within the species range in Michigan and Indiana. Eligible land need not be provided by a single Cooperator. Adjacent landowners can collectively enroll lands together under the Agreement such that a fen complex with multiple owners is enrolled. Potentially suitable lands will be evaluated by the Permittee based on available site information and site visits. Criteria for selecting sites are included in Appendix B. The number of acres required for enrollment will be determined on a site-specific basis and will be identified in the Reintroduction Plan. Land uses of adjacent landowners not enrolling in the Agreement will also be considered in the eligibility to enroll lands.

5.0 Baseline Determination

Baseline is a measure of the conditions associated with the covered species or its habitat that occur on eligible lands at the time of enrollment in the Agreement. The purpose of this Agreement is to reintroduce Mitchell's satyrs to historic sites and/or to introduce satyrs at fens without historic records of Mitchell's satyrs but which provide habitat suitable for the species and occur within the historic range of the species. Therefore, the baseline on eligible lands for this Agreement will be zero Mitchell's satyrs. Once established, this baseline will apply to the entire fen, including property owned by the Cooperator as well as neighboring, non-participating landowners.

Mitchell's satyr populations have been monitored periodically for the last 20 years. Under the current protocol, a Mitchell's satyr site is considered no longer occupied after three consecutive years of negative survey results. A baseline of zero satyrs will be determined for historic sites that have had three consecutive years of negative survey results within the five years prior to the year of reintroduction. For historic sites that have not had surveys within five years prior to reintroduction, two years of negative survey results prior to reintroduction will be necessary to establish a baseline of zero satyrs. For sites in the species' range, but with no historic records of Mitchell's satyrs, the baseline will be determined by two years of negative survey results within the three years prior to the year of introduction.

6.0 Roles and Responsibilities of the Parties

6.1 The Permittee agrees to:

A. Upon consideration of all other applicable legal requirements, obtain and hold a Permit issued by the U.S. Fish and Wildlife Service Region 3, in accordance with section 10(a)(1)(A) of the Act, authorizing incidental take of Mitchell's satyr as a result of lawful activities on the enrolled property in accordance with the provisions of such Permit. The term of the Permit will be 30 years.
B. Develop and sign Reintroduction Plans in coordination with each Cooperator for lands proposed for enrollment in the Agreement, thereby ensuring consistency with the provisions of this Agreement.
C. Upon signature of a Reintroduction Plan developed in coordination with the Cooperator, issue a Certificate of Inclusion to convey incidental take to the Cooperator pursuant to section 6.1 A. hereof.
D. Coordinate all Mitchell's satyr reintroduction efforts with Cooperators and any other appropriate partners.
E. Provide Cooperators with technical assistance in implementing conservation activities and monitoring to the maximum extent practicable, as needed.
F. Ensure that any impacts to cultural and historic resources due to activities to be carried out under this Agreement are avoided or otherwise in compliance with Section 106 of the National Historic Preservation Act.
G. Coordinate monitoring described in Section 14 of the Agreement and in Reintroduction Plans, as applicable.
H. Provide annual monitoring report to the U.S. Fish and Wildlife Service Region 3 office.
I. Address concerns of non-participating neighboring landowners by providing incidental take authorization for any otherwise lawful activities conducted on immediately adjacent lands with

suitable habitat for the Mitchell's satyr for the duration of the Permit.

6.2 The Cooperators agree to:

A. Work cooperatively with the Permittee to develop a Reintroduction Plan acceptable to both Parties that includes all provisions identified in Appendix C.
B. Sign the Reintroduction Plan, enrolling the identified land under this Agreement and managing the land pursuant to the Reintroduction Plan. This will include cooperating with the reintroduction and management of Mitchell's satyr, including habitat management as described in the Reintroduction Plan.
C. Implement all habitat management and satyr monitoring activities as defined in the Reintroduction Plans in cooperation with any other appropriate partners.
D. Except as identified in 6.2 G. and as required by law, allow access to the enrolled property with a 15-day notice by the Permittee (or designee) for purposes related to this Agreement and associated Reintroduction Plan including, but not limited, to Mitchell's satyr reintroduction, monitoring, and habitat management, as described in the Reintroduction Plan.
E. Promptly report to the Permittee any wildfire, chemical spill, or other significant environmental event that occurs on or adjacent to the enrolled property. Notifications should be made to the Permittee and may be by letter, e-mail, or phone.
F. Submit an annual report as specified in the Reintroduction Plan.
G. Notify the Permittee of any planned activity that the Cooperator reasonably anticipates may result in take of satyrs on the enrolled lands so that efforts to recapture any animals can occur, to the extent possible, when capture success can be maximized as described in 7.0.
H. Promptly notify the Permittee of any unexpected incidental take on the enrolled lands. This includes take that may result from conservation activities or other activities, such as emergency maintenance. Notifications should be made to the Permittee and may be by letter, e-mail, or phone.
I. Notify the Permittee within 30 days prior to any transfer of ownership so that the Permittee can attempt to contact the new owner, explain the Agreement and related Certificate of Inclusion applicable to the enrolled lands, and invite the new owner to continue the existing Certificate of Inclusion or enter into a new one that would benefit the covered species on the enrolled lands (enrollment of lands shall not constitute an encumbrance if the Cooperator sells or transfers these same lands, since the Cooperator may withdraw from the Agreement at any time).

6.3 Additional Partners

Additional partners may be necessary and beneficial to implementing the conservation activities identified in this Agreement. These partners may vary for each Reintroduction Plan developed, including, but not limited to, any of the following: State natural resource agencies, U.S. Fish and Wildlife Service Ecological Services Field Offices and Private Lands Offices, U.S. Department of Agriculture Natural Resources Conservation Service, and various non-governmental organizations. The Permittee and Cooperator mutually agree as to the participation of additional parties.

7.0 Notification Requirements

Before carrying out any activities that would result in a return to baseline, Cooperators are required to notify the Service in sufficient time to allow relocation of the satyrs. Late June to mid-July is the most suitable time period for finding and capturing adult satyrs. Therefore, this Agreement requires that Cooperators notify the Permittee by May 1 of any given year to allow logistical planning for the recapture of satyrs from the enrolled lands during the following months of June and/or July, or as otherwise mutually determined by the Permittee and Cooperator. If activities are conducted that result in a return to baseline and the Permittee is not notified and/or access is not granted, the Cooperator would be in violation of the terms of this Agreement and will not receive authorization for any incidental take resulting from the return to baseline.

In addition, Cooperators are required to notify the Permittee of any unexpected incidental take on the enrolled lands and any transfer of ownership, within 30 days of any such transfer, so that the Permittee can attempt to

contact the new owner, explain the Agreement and related Certificate of Inclusion applicable to the enrolled lands, and invite the new owner to continue the existing Certificate of Inclusion or enter into a new one that would benefit the covered species on the enrolled lands.

8.0 Conservation Activities

Conservation activities are those actions that would be implemented on enrolled lands and are expected to provide a net conservation benefit to the Mitchell's satyr. Conservation activities that will provide a net conservation benefit on an individual piece of land may vary by location but at a minimum will include the reintroduction of satyrs. Conservation activities are discussed below and will be identified for each site as necessary and defined within a Reintroduction Plan developed for each enrolled property (Appendix C). Within the enrolled lands, a Conservation Zone will be defined.

The Conservation Zone should be a minimum of approximately five acres of fen habitat, suitable for Mitchell's satyr, with a buffer of 100 meters around the fen. Conservation activities within the Conservation Zone will include Mitchell's satyr reintroduction and habitat management as discussed below. All activities of Cooperators that are compatible with satyr recovery will be allowed to continue in the Conservation Zone, including, but not limited to, routine livestock grazing where it currently occurs, scientific research, recreation, and education or interpretive activities on established walking paths and boardwalks. Land uses and activities of Cooperators that could reduce Mitchell's satyr occupied habitat to a degree that the viability of the satyr population would be impacted would be prohibited under the agreement. Incompatible activities in the Conservation Zone could include discharge of fill material, alteration or disruption of groundwater flow, and use of insecticides unless approved in writing in advance by both the Permittee and Cooperator.

All of the following conservation activities are important in that they support the reintroduction of Mitchell's satyr. It may require coordinated efforts of multiple partners to implement these conservation activities. The Permittee and any Cooperators will determine what partners may participate in conservation activities. Likely partners in the implementation of the conservation activities include but are not limited to State natural resource agencies, U.S. Fish and Wildlife Service Ecological Services Field Offices and Private Lands Offices, local government agencies, and other non-governmental organizations. Partners will vary depending on factors such as the state in which the eligible lands are located, budgets, logistics, and work efficiencies. This Agreement provides a mechanism for the coordinated efforts of multiple partners to contribute to recovery of this species.

8.1 Mitchell's Satyr Reintroduction

Lands enrolled under this Agreement will provide an opportunity to increase the number of Mitchell's satyr populations. Reintroduction of Mitchell's satyr will follow the guidelines in the Mitchell's Satyr Butterfly (*Neonympha mitchellii mitchellii*) Plan for Controlled Propagation, Augmentation, and Reintroduction (Appendix D). Once a Cooperator has a signed Reintroduction Plan and is enrolled under the Agreement (that is, has a Certificate of Inclusion), satyrs (as are available) may be released on the site as described therein.

Once Mitchell's satyrs are released, the necessary efforts will be undertaken to determine the success of reintroduction activities. These efforts are described in Section 14.0 (Monitoring) of this Agreement and would require access to the property.

8.2 Habitat Management

All fens in Michigan and Indiana have been altered, either through changed hydrology, water pollution, overgrazing, exotic species invasions, or nearly a century of fire exclusion. For this reason, fens, including those occupied by Mitchell's satyr, are susceptible to vegetation changes that endanger the native fen biota, thereby further endangering the Mitchell's satyr through degradation and/or destruction of habitat. Thus, Mitchell's satyr habitat requires management; without management, the habitat will become either closed canopy shrub-carr or monocultures of hybrid cattail (*Typha* x *glauca*) and other invasive species, all of which are unsuitable habitat for Mitchell's satyr.

In light of this, the Michigan and Indiana Departments of Natural Resources prepared "Fen and the Art of Butterfly Maintenance" (Appendix E) to serve as a guide to maintaining, managing, and restoring fen habitat that the endangered Mitchell's satyr relies upon for its continued survival. The primary management activities are discussed below.

8.2.1 Restore Hydrology

Most fens worldwide have altered hydrology (Amon *et al.* 2002). Fens as a system (Bedford and Godwin 2003) and the Mitchell's satyr in particular are sensitive to changes in the way groundwater flows through a fen. Thus, restoring hydrology is a critical need in fens, especially where it has been significantly altered. Methods to restore hydrology include removing berms, drainage tiles, wells, or ponds and installing new culverts or adjusting existing culvert height.

8.2.2 Prescribed Burning

Fire is a natural process within fens in Michigan and Indiana (Kost *et al.* 2007) and is recommended to maintain biodiversity (Middleton 2006). Before agriculture and urban development fragmented the landscape surrounding fens, fires would burn extensive areas in southern Michigan and northern Indiana (Nuzzo 1986, Whitney 1994, Albert 1995). Fens can contain cured fine fuels (e.g., dry grasses and sedges) at similar levels to other upland systems that readily propagate fire.

Natural fires no longer occur in the fragmented landscape. Instead, prescribed fire is used for management. Prescribed fire can be a very low-cost management tool. Large fires have a similar cost to small fires. Thus, the per-acre cost of fires (> 1-2 acres in size) is less than other conservation actions, such as mowing, hydro-axing, or manual vegetation removal. Because conservation dollars are limited, and because fen management often competes with other management objectives (especially on lands managed for hunting and trapping), prescribed fire may be the only tool that some land managers can "afford" when restoring fens. For these reasons, land managers in southern Michigan and northern Indiana feel strongly that the use of fire should be expanded and that the size of prescribed burns be expanded unless sound science indicates that the burns will cause harm to important wildlife populations.

Once butterflies are released, fire will not be allowed within occupied areas for three years or while the population is being established. However, fire will be permitted in adjacent, unoccupied areas of the reintroduction site.

Once satyrs have become established, prescribed burns will be allowed within occupied fens. Before implementing a prescribed burn within a Conservation Zone, a detailed fire plan must be completed and approved by the Permittee. All burns within a Conservation Zone are required to: 1) use natural fire breaks where feasible and safe; 2) burn no more than one-third of the fen occupied by Mitchell's satyr annually; and 3) refrain from burning the same patch in consecutive years without prior approval from the Permittee.

8.2.3 Mowing/Hydro-axing

Natural succession, altered hydrology, overgrazing, and invasive species allow woody vegetation to invade, thrive, and convert a fen or tamarack savanna to a closed canopy forest or shrub-carr. Mowing and hydroaxing are important tools to control woody vegetation. Small stems can be cut with a traditional brush mower. Larger stems require a mower that uses hydraulics, called a hydro-ax. In fens, this equipment can be used if and when the fens freeze. Otherwise, the softness of the ground usually prevents the use of wheeled or heavy tracked vehicles. Mowing or hydro-axing in a fen is limited to no more than one-third of habitat occupied by Mitchell's satyr in any one year and shall occur only when the soil is frozen and can support equipment. Elevating mower or hydro-ax decks is required such that sedge tussocks

are not shortened or damaged.

8.2.4 Vegetation Removal

Native and exotic plants, both herbaceous and woody, can be a significant management problem in fens. Often, these invasions occur because of a legacy of overgrazing or altered hydrology. A few exotic plants (*Rhamnus* spp and *Typha* x *glauca*) can invade relatively pristine fens. Other problematic exotic invasives include: multiflora rose (*Rosa multiflora*), purple loosestrife (*Lythrum salicaria*), common reed grass (*Phragmites australis*), reed canary grass (*Phalaris arundinacea*), cattails (*Typha angustifolia*), and others. Removal of invasive plants is required at many sites.

Activities to control native and non-native vegetation include: manual removal with hand tools, mechanical treatments, prescribed fire, and herbicide application. To minimize trampling of Mitchell's satyr, manual and mechanical removal may be conducted during the fall and winter. Because fens have high plant diversity and many state listed plants, herbicide applications should avoid native vegetation to the greatest extent practicable.

8.2.5 Biological Control

One reason often given for the ability of invasive exotic plants to create monocultures is "enemy release". Because the exotic plants are released from the pests and diseases of their native range, the exotics can allocate more resources to out-competing native plants. One method to control invasive exotic plants is to introduce insects or biological material from the plants' native range to control the plant. A successful biological control can be lower-cost, more effective, and less damaging to surrounding native vegetation than other activities. However, poorly tested biological controls can impact native plants, either directly or indirectly. Release of any biological agent must follow all State and Federal laws and must be approved by the Permittee in advance in writing.

8.2.6 Livestock Grazing

Even moderate, seasonal grazing can damage tussock microtopography, change soil types, introduce invasive plant species, and alter successional pathways away from savanna and toward closed canopy shrub-carr or forest (Middleton 2002). However, for fens with a history of livestock grazing, continued grazing is an effective way to set back succession and limit the growth of invasive plants (Tesauro and Ehrenfeld 2007). Like fire, grazing stimulates the growth of short-stature forbs, which are important egg-laying habitat for the Mitchell's satyr. Grazed fens from which livestock are removed will require significant management efforts to maintain the fen community. Therefore, livestock grazing is allowed to continue only in fens with a history of grazing.

8.2.7 Seeding and Planting

Seeding and planting are rarely used within habitat used by Mitchell's satyr. The seedbank of peat wetlands is highly persistent and will express itself when exposed to the right combinations of sunlight and water. However, some invasive species so alter the physical structure of the fen that the seedbank may be unavailable or unable to reestablish native vegetation. Further, the repeated broadcast spraying of herbicides to control long-established monocultures of invasive exotic plants could exhaust the seedbank of a portion of a fen. In these situations, planting native seeds, plugs of herbaceous plants or young trees becomes necessary.

9.0 Return to Baseline

The provisions of this Agreement allow any Cooperator to return the enrolled lands back to a baseline of zero Mitchell's satyrs at any time through any legal means, provided the Cooperator gives notification to the

Permittee, as described in Section 7.0. Such means cannot include deliberate killing of satyrs. A return to baseline may result in incidental take of all satyrs released onto the enrolled lands. Should the Cooperator choose to return to baseline, the most likely means to do so will be through the absence of habitat management or through conversion of enrolled lands to other land uses. In the absence of habitat management, it is likely that woody encroachment or invasive species will reduce the habitat suitability to a level that would no longer support Mitchell's satyr.

10.0 Net Conservation Benefits

Net conservation benefits are the cumulative benefits to the Mitchell's satyr from the reintroduction and management activities minus the impacts of any incidental take allowed by the Permit. Net conservation benefits must be sufficient to contribute, either directly or indirectly, to recovery of the satyr. The conservation activities identified in this Agreement support recovery efforts identified in the Mitchell's Satyr Butterfly (*Neonympha mitchellii mitchellii*) Recovery Plan (USFWS 1998) by reestablishing the satyr on the enrolled lands and by addressing the most significant threats. The net conservation benefits of each conservation activity are discussed below.

Mitchell's Satyr Reintroduction – The principal conservation benefit provided by this Agreement is the opportunity to establish additional populations of Mitchell's satyr on non-federal lands throughout its range in certain counties in Michigan and Indiana identified in Appendix A. As of 2015, the Mitchell's satyr is considered extant at eleven sites, ten of which occur in Michigan and one in Indiana (D. Hyde, Michigan Natural Features Inventory, pers. comm. 2015). The recovery criteria in the Recovery Plan call for 25 geographically distinct, viable populations or metapopulations to consider the species for delisting. Attaining these criteria, therefore, will necessitate establishment of populations in at least 14 more fens.

Successful establishment of a Mitchell's satyr population will likely require releases of satyrs over three to five years. Stable numbers of butterflies at a release site for three to five years, based on annual monitoring results, will indicate successful establishment (USFWS 2016). Therefore, we expect to see a net conservation benefit within six to ten years.

Habitat Management – All fens in Michigan and Indiana have been altered, either through hydrologic changes, water pollution, overgrazing, exotic species invasions, or nearly a century of fire exclusion. For this reason, fens, including those occupied by Mitchell's satyr, are susceptible to vegetation changes that endanger the native fen biota, thereby further endangering the Mitchell's satyr through alteration and/or destruction of its habitat. Thus, satyr habitat requires management, which will provide a net benefit to the species.

11.0 Changed Circumstances

Changed circumstances are changes affecting Mitchell's satyrs within the enrolled lands that can reasonably be anticipated and for which contingency plans can be made. These circumstances include, but are not limited to, drought, wildfire, disease, invasive species, land use changes, new species listings under the Act, and climate change. These changes could impact the habitat necessary for satyrs. Should alterations to the habitat occur, the following actions may be undertaken as necessary and as described in Table 1.

Table 1. Changed Circumstances

Changed Circumstance	Potential Effect to Mitchell's Satyr	Proposed Response
Drought	Prolonged periods of drought, although uncommon in the areas covered by this Agreement, may create conditions that reduce seasonally available habitat beyond normal annual variation and cause changes on the landscape.	In the event of moderate to extreme drought, as determined by National Oceanic and Atmospheric Administration **(**NOAA**)** or if annual monitoring indicates drought conditions, the Permittee and Cooperators will meet and evaluate the drought conditions and, if opportunities exist, employ changes to the conservation

		measures to address local conditions.
Wildfire	Although prescribed fires are a tool for managing satyr habitat, wildfires could burn more acreage of occupied habitat, including areas established as refugia for satyrs, than a controlled fire, resulting in increased mortality of satyrs (adults, larvae, and/or eggs).	Should a fire impact a significant portion of the enrolled lands, the Permittee will determine if adequate habitat is available on the enrolled lands for Mitchell's satyr. Additional satyrs may be reintroduced to the enrolled lands after the lands have recovered from the fire.
Disease	Aside from the *Wohlbachia* bacteria, diseases are not currently known to affect Mitchell's satyr. However, on-going monitoring and research may identify new diseases or pathogens.	In the case where disease is suspected to have impacted satyrs, the Permittee will coordinate efforts to identify the disease with appropriate State agencies and universities. Diseased satyrs will not be relocated off site. If disease causes loss of all satyrs at a reintroduction site, additional satyrs may be reintroduced, if adequate habitat exists that is not impacted by disease.
Invasive Species	The introduction of new invasive species or plant diseases can kill or outcompete fen vegetation that supports Mitchell's satyr. The establishment of invasive insects may also directly compete with or replace Mitchell's satyr.	In the event of an introduction of a new invasive species, the Permittee and Cooperators will meet and evaluate the potential effects to Mitchell's satyr and determine the best method of measuring, monitoring, and eradicating or controlling the invasive species within the affected site. Actions could include mechanical or chemical removal of the invasive species or infested vegetation or the use of prescribed fire to control the invasive species.
Land Use Changes	Land use changes on neighboring, non-participating lands could include development, conversion of uplands to agriculture, use of pesticides, and groundwater withdrawals that could affect the suitability of the enrolled lands as Mitchell's satyr habitat.	In the event of land use changes, the Cooperator(s) will notify the Permittee and within 90 days of notification, the Parties will meet and evaluate the land use changes and, if opportunities exist, employ changes to the conservation measures to address local conditions.
New Species Listings on Enrolled Lands	Conservation activities to benefit Mitchell's satyr may have potential impacts to the newly listed species.	If a non-covered species that occurs within the Agreement area becomes a federally listed species, the Service will assess whether the implementation of the Agreement may affect such species. If implementation may result in incidental take of such species, the Service will work with the Cooperators to determine appropriate modifications to the Agreement's conservation activities to either avoid or minimize incidental take of any newly listed species. If take cannot be avoided, the Service will determine whether amending the Agreement and permit would be necessary to cover such additional species. If the Cooperator wishes to conserve the species and receive assurances for that species, the Service and Cooperator would mutually amend the Reintroduction Plan to document the baseline conditions for the

		newly listed species and potentially modify or add conservation measures. The Service would amend the Agreement, Biological Opinion, and any relevant National Environmental Policy Act documents while providing for required public comment.
Climate Change	Climate change can create conditions that can affect implementation of this Agreement. Effects of climate change can result in increased frequency and intensity of drought, severe weather conditions, floods, and fires that in turn can affect the suitability of habitat for Mitchell's satyr. Climate change may also alter the timing of satyr breeding as well as the availability of host plants.	If changes to the fen habitat or Mitchell's satyr life cycles are documented, based on the best available scientific information, the Permittee and Cooperators will meet and evaluate the site conditions and, if opportunities exist, employ changes to the conservation measures to address local conditions.

12.0 Agreement Duration

The duration of this Agreement must be of sufficient time to realize a net conservation benefit to the Mitchell's satyr. Successful reintroduction of satyrs can vary based on a number of factors that are not fully understood. In addition, enough time must be allowed to work with landowners to establish the 14 populations necessary for recovery.

This Agreement will be in effect for duration of 30 years, following its approval and signing by the Parties. The section 10(a)(1)(A) permit authorizing take of the species will have a term of 30 years from the effective date of the permit. The permit and Agreement may be extended beyond the specified terms through amendment, upon agreement of the Parties.

Reintroduction Plans developed pursuant to the Agreement will be for a term of at least 10 years and up to 20 years within the 30-year term of the Permit. A Certificate of Inclusion issued by the Permittee will extend incidental take coverage for habitat management activities and assurances to the Cooperator for as long as the terms of the Agreement and Cooperator's Reintroduction Plan are upheld. Upon full implementation of the Reintroduction Plan, the Reintroduction Plan and Certificate of Inclusion may be extended or renewed with agreement by both Parties while maintaining the original agreed upon baseline.

13.0 Incidental Take

Implementation of this Agreement and any related Reintroduction Plans could result in the incidental take of Mitchell's satyrs. The regulatory take assurances provided in the Certificates of Inclusion apply only to Mitchell's satyr.

The habitat management actions taken by the Cooperator as identified in the Reintroduction Plan may result in incidental take of Mitchell's satyr. In particular, prescribed fires and mowing/hydro-axing will likely result in harm or mortality of satyrs. The conservation measures outlined in the Agreement will minimize this incidental take.

Through the assurances in the Agreement, a Cooperator may return the enrolled lands to baseline conditions, provided the Cooperator gives prior notification to the Permittee. A Cooperator could return lands to baseline conditions by removing suitable habitat by burning or mowing the entire fen within the Cooperator's ownership. Because some fens are regulated wetlands, other land use activities that would return to baseline may require additional permits (e.g., a Clean Water Act section 404 permit). These potential permit requirements may restrict a Cooperator's ability, unrelated to the presence of Mitchell's satyr, to return to baseline through other land uses of the fen.

Alternatively, a Cooperator could return lands to baseline conditions by ceasing habitat management and allowing woody vegetation to encroach on the fen; however, this process of succession would take multiple years and not immediately make the habitat unsuitable for Mitchell's satyrs. In this case, the enrolled lands of a Cooperator who withdraws from the Agreement and stops habitat management would not return to baseline before the Cooperator must relinquish the Certificate of Inclusion. To address this situation, the Incidental Take Statement in the Permit's associated Biological Opinion will provide incidental take authorization for otherwise lawful activities to Cooperators, who withdraw from the Agreement, for the duration of the Permit. As such, Cooperators become non-participating landowners if they withdraw from the Agreement.

The Cooperator also agrees to restrict certain activities within the Conservation Zone delineated in the Reintroduction Plan; however, other activities outside of the Conservation Zone may occur on the enrolled lands and may affect Mitchell's satyr. These otherwise lawful activities include agricultural practices, use of pesticides, residential or commercial development, gravel mining, and groundwater withdrawal. Incidental take may occur by affecting the habitat of the satyrs through erosion, run-off, or pesticide drift. The 100-foot buffer around the fen as part of the Conservation Zone will minimize any incidental take from these other routine activities or land uses.

These same normal land use practices may also occur on neighboring, non-participating properties and may result in incidental take of Mitchell's satyrs. Also, other lawful activities that a non-participating landowner may conduct within a fen, such as cattle grazing, may result in incidental take if Mitchell's satyrs disperse onto adjacent lands. The prairie fens that Mitchell's satyr inhabits are a type of wetland; as such, certain activities, e.g., discharge of fill material, may be regulated under section 404 of the Clean Water Act. Any activities, if conducted without benefit of any other required permits, would not be considered an otherwise lawful activity. To address these normal land uses that would otherwise not be restricted due to Mitchell's satyr, the immediately adjacent, non-participating landowners will receive incidental take coverage for any otherwise lawful activities via the Incidental Take Statement in the Biological Opinion developed in conjunction with issuance of the Permit for the length of time the Permit is in effect.

The Service recognizes that this level of take is consistent with the overall goal of providing a net conservation benefit to recovery of the species on the enrolled property.

14.0 Reporting and Monitoring

The purposes of this Agreement's monitoring program are to: (1) inform the Service of the status of implementation of the conservation activities, (2) track incidental take of Mitchell's satyrs, and (3) determine success of satyr reintroductions on enrolled properties.

14.1 Biological Monitoring

The Cooperator will provide for all monitoring efforts in coordination with the Permittee. Cooperators who are considered qualified by the Permittee may conduct the Mitchell's satyr monitoring; otherwise, the Cooperator will be responsible for obtaining qualified individuals to perform the monitoring requirements. The monitoring on each enrolled property will vary based on the conservation activities taken and the situation at each site. Surveys for Mitchell's satyr shall follow the Mitchell's Satyr Survey Protocol (Appendix F). These protocols require surveyors to walk a series of transects paralleling each other 5m apart until the entire site has been surveyed. Each surveyor is required to have a GPS unit to record their survey route or transects and Mitchell's satyr locations. Survey results shall be provided in the Cooperator's annual report to the Permittee.

14.2 Compliance Monitoring

The Permittee will be responsible for specified monitoring and reporting related to implementation of the Agreement and associated individual Certificates of Inclusion and fulfillment of its provisions, including implementation of agreed-upon conservation measures, and incidental take authorized by the permit. The Agreement will grant the Permittee and the Service, after reasonable prior notice to a Cooperator, the right to enter the enrolled lands to ascertain compliance with the Agreement and the

Certificates of Inclusion.

14.3 Incidental Take Monitoring

The Permittee is responsible for working with the Cooperators to record and monitor any incidental take for the duration of the Agreement and individual Certificates of Inclusion.

Cooperators will provide the Permittee with annual reports that include results of Mitchell's satyr monitoring, acres of habitat management completed, and other ongoing routine land use activities occurring on the enrolled lands. These reports will be due to the Permittee by December 31 of each year.

Reports from the Permittee to the Service will be due January 31 of each year and copies will be made available to all Parties. This report will include the state and county for which the Reintroduction Plan and Certificate of Inclusion were issued, the conservation activities implemented, including the number of acres managed and the methods used, the number and life stages of released satyrs and dates of Mitchell's satyr releases, and any incidental take. The Service's Regional Office will review these reports to ensure that the terms of the Permit, conditions of the Agreement, and purposes of the monitoring program are being met.

It is possible that with time and experience in developing Reintroduction Plans, knowledge and skills will evolve. Therefore, every five years (or more frequently if necessary), the Permittee will consolidate information and reports from all enrolled properties to date for the purposes of assessing the implementation and administration of the Agreement. All Cooperators and additional partners will be invited to discuss and provide input. Any necessary changes identified from the information provided will be addressed pursuant to Section 18.0 (Modifications) of this Agreement.

15.0 Funding

Implementation of this Agreement is subject to the requirement of the Anti-Deficiency Act, 31 U.S.C. § 1341, which prohibits the obligation of Federal funds absent a Congressional appropriation for the same, and the availability of appropriated funds. Nothing in this Agreement will be construed to require the obligation, appropriation, or expenditure of any funds from the U.S. Treasury. The Parties acknowledge that the Service will not be required under the Agreement to expend any Federal agency's appropriated funds unless and until an authorized official of that agency affirmatively acts to commit to such expenditures as evidenced in writing.

Cooperators will fund habitat management and satyr monitoring conducted as part of any Reintroduction Plan. However, nothing in the Reintroduction Plan will prohibit Cooperators from seeking and obtaining grants or other funds from Federal agencies, including the Service, to support habitat management efforts on enrolled lands.

16.0 Assurances to a Cooperator

The assurances listed below apply to Cooperators enrolled by a Certificate of Inclusion in this Agreement where the conservation measures specified in the Reintroduction Plan are being properly implemented. The assurances apply only with respect to the Mitchell's satyr butterfly. Through this Agreement, the Service provides each Cooperator with a Certificate of Inclusion with assurances that no additional conservation measures or additional land, water, or resource use restrictions, beyond those voluntarily agreed to and described in Section 8.0 of this Agreement and in the Reintroduction Plan associated with the Certificate of Inclusion, will be required. These assurances will be authorized with the issuance of an enhancement of survival permit under section 10(a)(1)(A) of the Endangered Species Act.

If additional conservation measures are necessary to respond to changed circumstances as set forth in Section 11.0, the enrolled Cooperator will implement the measures specified in the Agreement and Certificate of Inclusion. If additional conservation measures not provided for in the Agreement's operating conservation program are necessary to respond to changed circumstances, the Service will not require any conservation measures in addition to those provided for in the Agreement without the consent of the enrolled Cooperator, provided the Agreement is being properly implemented.

If additional conservation measures are necessary to respond to unforeseen circumstances, the Service may request additional measures of the enrolled Cooperator where the Agreement and Certificate of Inclusion are being properly implemented, but only if such measures are limited to modifications within the Agreement's conservation strategy for the affected species, and only if those measures maintain the original terms of the Agreement to the maximum extent possible. Additional conservation measures will not involve the commitment of additional land, water, or financial compensation, or additional restrictions on the use of land, water, or other natural resources available for development or use under the original terms of the Agreement and Certificate of Inclusion without the consent of the Cooperator.

The Service will have the burden of demonstrating that unforeseen circumstances exist, using the best scientific and commercial data available. These findings must be clearly documented and based upon reliable technical information regarding the status and habitat requirements of the affected species. The Service will consider, but not be limited to, the following factors:

A. Size of the current range of the affected species;
B. Percentage of range adversely affected by the Agreement;
C. Percentage of range conserved by the Agreement;
D. Ecological significance of that portion of the range affected by the Agreement;
E. Level of knowledge about the affected species and the degree of specificity of the species' conservation program under the Agreement; and
F. Whether failure to adopt additional conservation measures would appreciably reduce the likelihood of survival and recovery of the affected species in the wild.

17.0 Non-participating Neighboring Landowners

The Service recognizes that some landowners may be reluctant to participate in the Agreement due to concerns regarding non-participating neighbors' fear of liability under the Act. Therefore, the Safe Harbor Policy (64 FR 32717) provides for incidental take authorization to neighbors, whether or not they choose to participate in the Agreement. For the purposes of this Agreement, non-participating neighboring landowners are defined as any landowner or any landowner interest immediately adjacent to enrolled lands upon whose land satyrs may disperse and/or occupy as a result of reintroductions or whose otherwise lawful actions may affect Mitchell's satyr on the Cooperator's lands. Neighboring landowners also include any owners of subsurface mineral rights on Cooperator or neighboring lands.

Flexible regulatory assurances for non-participating neighboring landowners could contribute to increased enrollment by other landowners and ultimately increased conservation for Mitchell's satyr by helping to maintain good relations with neighbors and by demonstrating that satyr reintroductions will not limit land use, except as agreed to by Cooperators. The Incidental Take Statement in the Biological Opinion, pursuant to the intra-Service section 7 consultation under the Act on the issuance of the 10(a)(1)(A) Enhancement of Survival permit under this Agreement, will provide incidental take coverage to immediately adjacent, non-participating landowners. Non-participating neighboring landowners will not be subject to any land use restrictions due to Mitchell's satyr. Except as authorized through a separate Enhancement of Survival permit or section 7 Biological Opinion for other activities with a Federal nexus, deliberate take of satyrs not related to an otherwise lawful activity would be prohibited.

18.0 Modifications

After approval of the programmatic Agreement, the Service may not impose any new requirements or conditions on, or modify any existing requirements or conditions applicable to, an enrolled Cooperator or successor in interest to the owner, to compensate for changes in the conditions or circumstances of any species or ecosystem, natural community, or habitat covered by the Agreement except as stipulated in 50 CFR 17.22(c)(5) and 17.32(c)(5).

18.1 Modifications of the Agreement

Any party to this Agreement may propose modifications or amendments to this programmatic Agreement, as provided in 50 CFR 13.23, by providing written notice to, and obtaining the written concurrence of, the other Parties. Such notice shall include a statement of the proposed modification, the reason for it, and its expected results. The Parties will use their best efforts to respond to proposed modifications within 60 days of receipt of such notice. Proposed modifications will become effective upon the date of the last signature of all Parties' written concurrence.

18.2 Amendment of the Permit

The 10(a)(1)(A) Enhancement of Survival Permit may be amended to accommodate changed circumstances in accordance with all applicable legal requirements in force at the time of the amendment, including, but not limited to, the Endangered Species Act, National Environmental Policy Act, and Service's permit regulations at 50 CFR 13 and 50 CFR 17. The party proposing the amendment shall provide a statement describing the proposed amendment and the reasons for it. A request for an amendment of the Permit or Certificate of Inclusion would require, at a minimum, a written explanation of why the amendment is needed and an explanation of what, if any, effects the amendment would have on the Mitchell's satyr.

Minor amendments involve routine administrative revisions or changes to the operation and management program associated with the Agreement, and such minor amendments may or may not alter the conditions of the permit. The Service can approve minor amendments to the Agreement if the amendment does not conflict with the purposes of the Agreement or does not result in some material change to the Service's analysis (i.e., with respect to meeting the Agreement standard or the amount of take authorized).

Modifications of the Agreement that could result in outcomes that are significantly different from those analyzed for the original Agreement would be considered major amendments. In particular, amendments for actions that would either: (1) result in a different level or type of take than was analyzed in association with the original Agreement; or (2) result in a change to the cumulative conservation benefits to the covered species such that the Agreement standard might not be met would require additional analysis and would constitute major amendments. A major amendment to the Permit would require the Service to publish a notice in the *Federal Register* of a 30-day public comment period for the proposed amendment.

19.0 Termination of the Agreement

As provided for in Part 12 of the Service's Safe Harbor Agreement Policy (64 FR 32726), a Cooperator participating through a Certificate of Inclusion may terminate implementation of the Agreement's voluntary management actions prior to the Certificate's expiration date, even if the expected benefits have not been realized. Upon termination, the Cooperator is required to surrender the Certificate of Inclusion, thus relinquishing his or her take authority for habitat management activities. However, as provided for in Part 7 of the Safe Harbor Agreement Policy, these assurances run with the enrolled lands and are valid for as long as the Permit is in effect. The Cooperator may terminate the Certificate of Inclusion by May 1 of any given year to allow logistical planning for the recapture of satyrs from the enrolled lands during the following months of June and/or July.

Although a Cooperator who withdraws from the Agreement must surrender the Certificate of Inclusion, that Cooperator would subsequently be regarded as a non-participating landowner interest who receives incidental take authorization via the associated Biological Opinion, provided the Cooperator notifies the Permittee and allows the Service access to recapture satyrs during the following summer, prior to carrying out any otherwise lawful activity that may result in take of Mitchell's satyrs on enrolled lands, including a return to baseline. If a Cooperator fails to notify the Permittee regarding possible take or fails to provide access, the Cooperator would be in violation of the terms of this Agreement and will not receive authorization for any incidental take resulting from the return to baseline.

The Permittee may suspend or revoke a Certificate of Inclusion for an individual enrollee for cause in

accordance with the laws and regulations in force at the time of such suspension or revocation.

The Service may suspend or revoke the programmatic permit for cause in accordance with the laws and regulations in force at the time of such suspension or revocation (50 CFR 13.28(a)). The Service may also, as a last resort, revoke the permit if continuation of permitted activities would likely result in jeopardy to covered species (50 CFR 17.22/32(c)(7)). Prior to revocation, the Service would exercise all possible measures to remedy the situation.

20.0 Other Measures

20.1 Remedies. Each party shall have all remedies otherwise available to enforce the terms of the Agreement and Certificates of Inclusion and the Permit, except that no party shall be liable in damages for any breach of this Agreement, any performance or failure to perform an obligation under this Agreement or any other cause of action arising from this Agreement.

20.2 Dispute Resolution. The Parties agree to work together in good faith to resolve any disputes using dispute resolution procedures agreed upon by all Parties.

20.3 Succession and Transfer. This Agreement shall be binding on and shall inure to the benefit of the Parties and their respective successors and transferees, (i.e., new owners) in accordance with applicable regulations (50 CFR 13.24 and 13.25). The rights and obligations under this Agreement and associated Certificates of Inclusion shall run with the ownership of the enrolled property and are transferable to subsequent non-federal property owners pursuant to 50 CFR 13.25. The enhancement of survival permit associated with the Certificate of Inclusion issued to the Cooperator also will be extended to the new owner(s), if the new property owner agrees to become a party to the original Agreement and enhancement of survival permit. As a party to the original Certificate of Inclusion and permit, the new owner(s) will have the same rights and obligations with respect to the enrolled property as the original owner. The new owner(s) also will have the option of receiving the assurances of the Agreement by signing a new Certificate of Inclusion. The Cooperator shall notify the Service within 30 days prior to any transfer of ownership, so that the Permittee can attempt to contact the new owner, explain the particular responsibilities applicable to the property, and seek to interest the new owner in signing the existing Certificate of Inclusion or a new one to benefit the specific species addressed in the Agreement. Assignment or transfer of the Certificate of Inclusion shall be governed by Service regulations in force at the time.

20.4 No Third-Party Beneficiaries. This Agreement does not create any new right or interest in any member of the public as third-party beneficiary, nor shall it authorize anyone not a party to this Agreement to maintain a suit for personal injuries or damages pursuant to the provisions of this Agreement. The duties, obligations, and responsibilities of the Parties to this Agreement with respect to any third-Party shall remain as imposed under existing law.

20.5 Availability of Funds. Implementation of this programmatic Agreement is subject to the requirements of the Anti-Deficiency Act, 31 U.S.C. § 1341, and the availability of appropriated funds. Nothing in this Agreement will be construed by the Parties to require the obligation, appropriation, or expenditure of any funds from the U.S. Treasury. The Parties acknowledge that the Service will not be required under this programmatic Agreement to expend any Federal agency's appropriated funds unless and until an authorized official of that agency affirmatively acts to commit to such expenditures as evidenced in writing.

20.6 Notices and Reports. Any notices and reports, including monitoring and annual reports required by this Agreement, shall be delivered to the persons listed below, as appropriate:

Field Supervisor
U.S. Fish and Wildlife Service
East Lansing Field Office
2651 Coolidge Road, Ste. 101

East Lansing, MI 48823
(517) 351-2555

Regional Director, Region 3 (Attn: Endangered Species Division)
U.S. Fish and Wildlife Service
5600 American Blvd. West, Suite 990
Bloomington, MN 55437-1458

21.0 Literature Cited

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22.0 Signatures

In witness whereof, the Parties hereto have, as of the last signature date below, executed this Programmatic Safe Harbor Agreement to be in effect as of the date the Service issues the permit.

_____	_____
Assistant Regional Director, Ecological Services U.S. Fish and Wildlife Service, Region 3	Date
_____	_____
Field Supervisor, East Lansing Field Office U.S. Fish and Wildlife Service	Date

Certificate of Inclusion
Mitchell's Satyr Programmatic Safe Harbor Agreement
 # [ ]

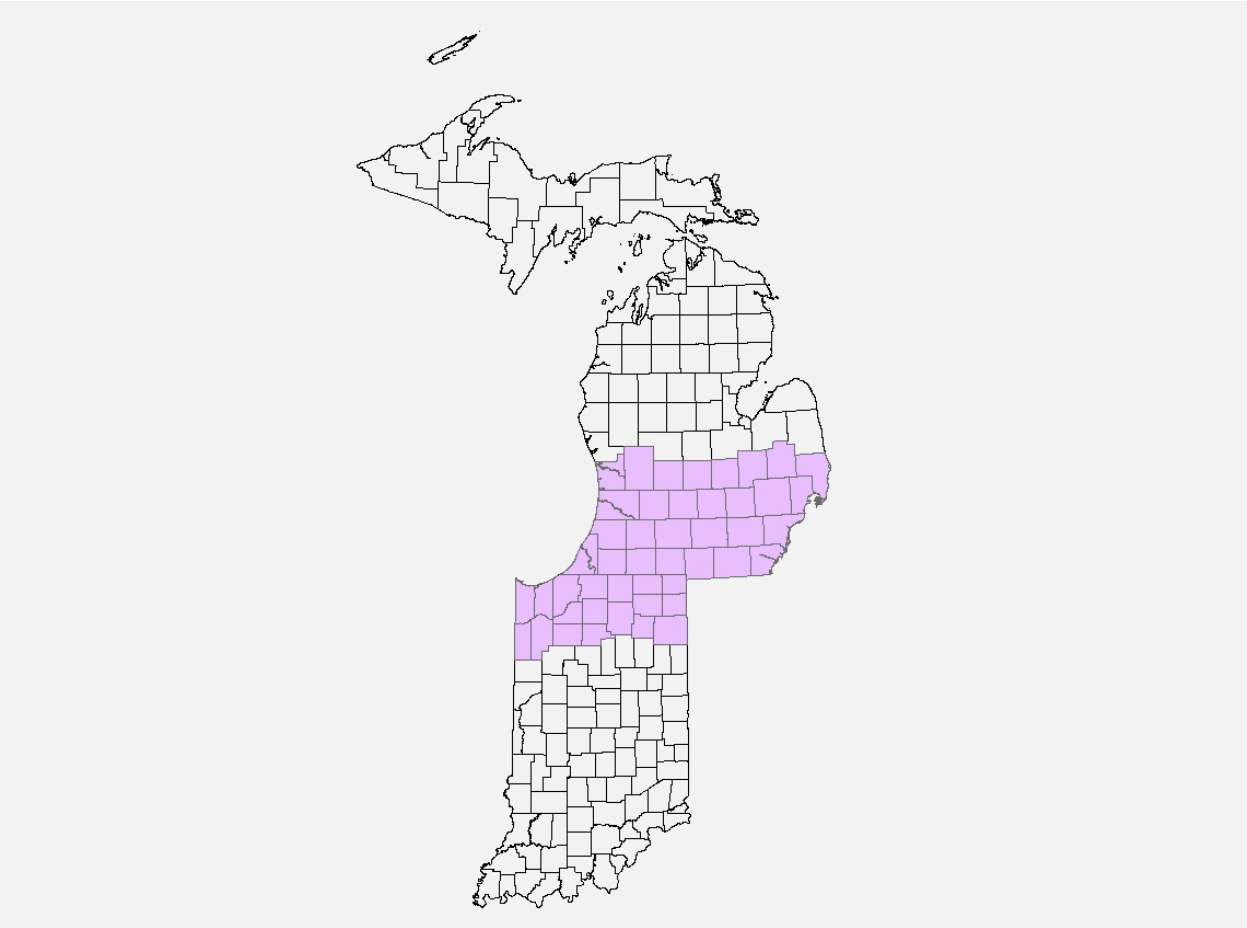
This certifies that the lands described as follows [description of enrolled lands covered by the Safe Harbor permit] owned by [name of Cooperator] are included within the scope of Permit Number [number], held by the U.S. Fish and Wildlife Service, East Lansing Field Office Project Leader (Permittee), issued on [date] under the authority of section 10(a)(1)(A) of the Endangered Species Act of 1973, as amended, 16 U.S.C. 1539(a)(1)(A), and which expires on [date]. The Permit authorizes incidental take of Mitchell's satyr from all lawful activities by participating landowners (Cooperators) as part of the Mitchell's Satyr Programmatic Safe Harbor Agreement (Agreement) to reintroduce and establish new populations of the Mitchell's satyr. Pursuant to the Permit, this Certificate of Inclusion authorizes incidental take of the Mitchell's satyr that may result from any otherwise lawful activity on the above described lands, subject to the terms and conditions of the Permit, the Agreement, and the Reintroduction Plan, entered into on [date].

_____ _____

East Lansing Field Office Project Leader **Date**

Appendix A.

Map of Eligible Lands



Appendix B.

Site Selection Criteria

Matrix for Site Selection & Prioritization for Potential Satyr Introduction, Augmentation or Reintroduction

PRIMARY CRITERIA	*DESCRIPTION*	*JUSTIFICATION*	*SCORING METHODOLOGY*	*DETAIL*	*Pts*
GIS analysis					
Size of Site	**Acres of fen habitat**	Larger sites can provide refugia from stochastic events and incompatible land use and may contain more varied microclimates and greater biodiversity.	Calculate size of fen polygon	Small-<10 ac	0
				Medium- 11-50 ac	2
				Large 51-150 ac	4
				Very Large >150ac	6
Condition, Quality	**Integrity of hydrology**- % of fen with intact hydrology (i.e not directly impacted by roads, ponds, ditching, drain tiles, etc.)	Intact hydrology is critical ecological process for maintaining fens and providing the proper microclimate for satyrs. Altered hydrology is linked to loss of species & vegetation change.	Buffer channelized streams, ditches and roads and calculate % of fen impacted	Highly Disturbed > 30%	0
				Medium Dist- 11-30%	2
				Low Disturbance-<10%	4
Local Matrix of Compatible Habitat	**Percentage of Undeveloped Land** within a 100 meter buffer around fen site.	Fens with a greater buffer of undeveloped land are less vulnerable to negative effects from nutrient loading, sedimentation, invasive species, grazing and ORV use.	Calculate % of land that is developed within 100m - Anderson layers (ag, res, comm, indust.)	< 10 %	0
				11-25%	2
				26-50%	4
				> 50%	6
Landscape Matrix of Compatible Habitat	Wetland is buffered **from agriculture, development and roads with natural community vegetation (2mi)**	Fens within a compatible habitat matrix are less vulnerable to threats to water quality and incompatible human activities.	Calculate % of land that is undeveloped within 2 miles – (Anderson layers)	<38%	0
				38-52%	2
				53-67%	4
				68-100%	6
Field analysis					
Condition and Quality	Native Fen Vegetation- **Percent cover of native vegetation**	The greater the % of native vegetation, the less impacted the fen is by non-natives and invasives which could out-compete the native flora.	Visit site and collect/estimate this data and/or review community field forms	<50%	0
				51-75%	2
				76-90%	4
				>90%	6
SECONDARY CRITERIA	*DESCRIPTION*			*DETAIL*	*Pts*
GIS analysis					
Site Ownership	**Percentage of land that is public land or owned by a conservation organization**	Land in conservation ownership by a public or nonprofit organization is less vulnerable to incompatible land use and more likely to receive stewardship.	Calculate using CARL data layers of ownership supplemented with knowledge of sites not in CARL	0-25% public/cons. owned	0
				26 -50%% public/conservation owned	2
				51-75% - public or conservation owned	4
				>76% public/cons.owned	6
Distance to Occupied Site	**Distance of fen from currently occupied Mitchell's satyr site**	Sites closer to occupied sites have the potential to be reconnected	Calculate distance of fen polygon to satyr site polygon	> 5miles from occupied site	0
				1-5 miles from occupied site	2
				500-1600 m. from occ.site	4
				<500 meters from occ. site	6

Appendix C.

Mitchell's Satyr Site-Specific Reintroduction Plan
TEMPLATE

Cooperator's Name: _____

1. **Legal description and map of enrolled lands:** *Include a written legal description and a map showing the Conservation Zone as discussed in section 8.0 of the Safe Harbor Agreement.*

2. **Baseline for the Covered Species:** *Include the number of Mitchell's satyrs on the lands at time of enrollment.*

3. **Current land use:** *Include a description of current land use practices on the land.*

4. **Conservation Activities:**

    A. **Mitchell's Satyr Reintroduction:** Upon signature by all Parties, the enrolled lands will be eligible to receive Mitchell's satyrs. Reintroduction activities will be carried out by the Permittee or designee. Mitchell's satyrs may be released annually within the Conservation Zone identified on the enrolled lands. [*Include additional specific information as necessary.*]

    B. **Habitat Management:** Upon signature by all Parties, the enrolled lands will be eligible for habitat management activities within the Conservation Zone. These activities will be carried out by the Cooperator. [*Describe specific management activities to be undertaken, such as restoring hydrology, prescribed burning, mowing/hydro-axing, vegetation removal, and/or seeding and planting.*]

5. **Monitoring:** The Cooperator will be expected to implement or provide for monitoring of Mitchell's satyrs on the enrolled lands. [*Include a description of anticipated surveys to be conducted.*]

6. **Reporting:** By December 31 of each year the Certificate of Inclusion is in effect, the Cooperator will provide the Permittee with an annual report that includes results of Mitchell's satyr monitoring, acres of habitat management completed, and other ongoing routine land use activities occurring on the enrolled lands. The Cooperator will also promptly notify the Permittee of any wildfire, chemical spill, or other significant environmental event that occurs on or adjacent to the enrolled property and any unexpected incidental take on the enrolled lands. These notifications may be by letter, e-mail, or phone.

7. **Reintroduction Plan Duration:** The duration of this plan will be [*number—10 years minimum*] years from the date of signature. The Certificate of Inclusion will be in effect for as long as the terms of the Agreement and this Reintroduction Plan are met.

8. **Funding:** The Cooperator will provide funding for habitat management and Mitchell's satyr monitoring conducted as part of this Reintroduction Plan. [*Identify funding sources.*]

9. **Assurances to the Cooperator:** Provided that the Cooperator complies with the provisions outlined in the Agreement and this Reintroduction Plan, all the assurances as set forth in Section 16.0 of the Agreement are provided to the Cooperator.

10. **Modifications:**

    A. Reintroduction Plan: Any party to this Reintroduction Plan may propose modifications by providing written notice to the other parties explaining the proposed modification, the reasons for the proposed modification, and the expected results of the modification. Approval of a modification will require the written consent of the Permittee and Cooperator and must be consistent with the assurances described in Section 9.0 of the Reintroduction Plan. The Parties will use their best efforts to respond to proposed modifications within 60 days of receipt of such notice. Any proposed modification to the

Reintroduction Plan will be considered effective as of the date that all affected parties have agreed in writing to the modification.

B. Early Termination of the Reintroduction Plan: As provided for in Part 12 of the Service's Safe Harbor Policy (64 FR 32717), the Permittee may terminate the Reintroduction Plan prior to the expiration date. In such circumstances, the Cooperator may return the enrolled lands to baseline conditions even if the conservation activities identified in the Reintroduction Plan for the enrolled lands have not been fully implemented. Similarly, the Cooperator may terminate the Reintroduction Plan early. A Cooperator who withdraws from the Agreement must surrender the associated Certificate of Inclusion and would subsequently be regarded as a non-participating landowner interest who receives incidental take authorization via the Incidental Take Statement in the associated Biological Opinion, provided the Cooperator notifies the Permittee and allows the Service access to recapture satyrs during the following summer, prior to carrying out any otherwise lawful activity that may result in take of satyrs on enrolled lands, including a return to baseline. If a Cooperator fails to notify the Permittee regarding possible take or fails to provide access, the Cooperator would be in violation of the terms of this Agreement and will not receive authorization for any incidental take resulting from the return to baseline.

11. Other Measures:

A. Remedies. Each party shall have all remedies otherwise available to enforce the terms of the Agreement, this Reintroduction Plan, Certificate of Inclusion and the permit, except that no party shall be liable in damages for any breach of this Agreement, any performance or failure to perform an obligation under this Agreement or any other cause of action arising from this Agreement.

B. Dispute Resolution. The Parties agree to work together in good faith to resolve any disputes using dispute resolution procedures agreed upon by all Parties.

C. Succession and Transfer. This Agreement shall be binding on and shall inure to the benefit of the Parties and their respective successors and transferees, (i.e., new owners) in accordance with applicable regulations (50 CFR 13.24 and 13.25). The rights and obligations under this Agreement and associated Certificate of Inclusion shall run with the ownership of the enrolled property and are transferable to subsequent non-federal property owners pursuant to 50 CFR 13.25. The enhancement of survival permit associated with the Certificate of Inclusion issued to the Cooperator also will be extended to the new owner(s), if the new property owner agrees to become a party to the original Agreement and enhancement of survival permit. As a party to the original Certificate of Inclusion, the new owner(s) will have the same rights and obligations with respect to the enrolled property as the original owner. The new owner(s) also will have the option of receiving the assurances of the Agreement by signing a new Certificate of Inclusion. The Cooperator shall notify the Service within 30 days prior to any transfer of ownership, so that the Permittee can attempt to contact the new owner, explain the particular responsibilities applicable to the property, and seek to interest the new owner in signing the existing Certificate of Inclusion or a new one to benefit the specific species addressed in the Agreement. Assignment or transfer of the Certificate of Inclusion shall be governed by Service regulations in force at the time.

D. Availability of Funds. Implementation of this Plan is subject to the requirement of the Anti-Deficiency Act and the availability of appropriated funds. Nothing in this Plan will be construed by the Parties to require the obligation, appropriation, or expenditure of any funds from the U.S. Treasury. The Parties acknowledge that the Service will not be required under this Plan to expend any Federal agency's appropriated funds unless and until an authorized official of that agency affirmatively acts to commit to such expenditures as evidenced in writing.

E. No Third-Party Beneficiaries. This Plan does not create any new right or interest in any member of the public as third-party beneficiary, nor shall it authorize anyone not a party to this Plan to maintain a suit for personal injuries or damages pursuant to the provisions of this Plan. The duties, obligations, and responsibilities of the parties to this Plan with respect to any third-party shall remain as imposed under

existing law.

F. Notices and Reports. Any notices and reports, including monitoring and annual reports required by this Agreement shall be delivered to the persons listed below, as appropriate:

Field Supervisor
East Lansing Field Office
U.S. Fish and Wildlife Service
2651 Coolidge Road, Ste. 101
East Lansing, MI 48823
(517) 351-2555

12. Signatures:

Cooperator	**Date**
Field Supervisor, East Lansing Field Office **U.S. Fish and Wildlife Service**	**Date**

Appendix D.

Mitchell's Satyr Butterfly (*Neonympha mitchellii mitchellii*) Plan for Controlled Propagation, Augmentation, and Reintroduction

MITCHELL'S SATYR BUTTERFLY
(*Neonympha mitchellii mitchellii*)

PLAN FOR CONTROLLED PROPAGATION, AUGMENTATION, and REINTRODUCTION
in
MICHIGAN and INDIANA

Cover photographs used with permission:

Adult Mitchell's satyr (top photo) – courtesy of Vince Cavalieri (U.S. Fish and Wildlife Service)
Mitchell's satyr eggs and larval instars (bottom photos) – courtesy of Mitch Magdich (Toledo Zoo)

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Organizations and agencies involved in developing and participating in the Mitchell's satyr propagation, augmentation, and reintroduction plan:

Blue Heron Ministries

Central Michigan University

Fort Wayne Children's Zoo

Indiana Department of Natural Resources

Kalamazoo Nature Center

Michigan Department of Natural Resources

Michigan Department of Transportation

Michigan Department of Veterans Affairs

Michigan Natural Features Inventory

Michigan Nature Association

Michigan State University

Mississippi State University Entomological Museum

Sarett Nature Center

Southwest Michigan Land Conservancy

The Nature Conservancy

Toledo Zoo

U.S. Fish and Wildlife Service

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INTRODUCTION

Mitchell's satyr is a federally endangered medium-sized, dark brown butterfly that currently occurs in Michigan, Indiana, Alabama, Mississippi, and Virginia. In the northern portion of the range (Michigan and Indiana), Mitchell's satyr occurs in prairie fens and open parts of rich tamarack swamps. In the south, where there are no prairie fens, Mitchell's satyrs are found in beaver-influenced wetlands or areas associated with low, semi-open riparian areas and saturated depressions within floodplain forests, or supported by a spring and possibly groundwater intrusion.

The Mitchell's satyr population has been in decline for several years. The species was once documented from 30 historical locations within five states, ranging from Michigan, Indiana, Ohio, several disjunct populations in New Jersey, and possibly Maryland (Figure 1). After listing the species as endangered in 1992 and upon issuance of the recovery plan in 1998, Mitchell's satyr occurrences had decreased by 50%. Only 15 extant populations were documented, with 13 occurring in Michigan and two in Indiana. Currently in the northern portion of the range, only 11 Mitchell's satyr occupied sites or populations occur in Michigan (10) and Indiana (1) (Figure 2). Of these, habitat conditions have declined to such a degree that the Michigan Natural Features Inventory (MNFI) considers only seven of these sites viable (Daria Hyde, MNFI, pers. comm. 2015) (Appendix A).

From 1998 to 2003, new populations of Mitchell's satyr were discovered in three states (Figure 2). In 1998, satyrs were found in Floyd County, Virginia (Roble *et al*. 2001). In 2000, populations were found in Alabama, and additional sites were discovered in Mississippi in 2003 (Hart 2004). These populations conform morphologically to Mitchell's satyr and are treated as such until more conclusive genetic evidence indicates otherwise.

Much more is known about the historical and current populations of Mitchell's satyr in Michigan and Indiana than those in the southern portion of the range. The species' status, threats, and recovery actions in Michigan and Indiana have been documented and tracked for many years. Because of the ongoing threats and declining populations in the northern portion of the range, we are concentrating our captive propagation, reintroduction, and augmentation efforts in Michigan and Indiana. The historical declines of Mitchell's satyr warrant the use of these activities to ensure the species' recovery. These efforts are expected to increase the overall population and number of viable occurrences of Mitchell's satyr in Michigan and Indiana.

Species' Status

1. *Federal*: listed as endangered pursuant to the Endangered Species Act of 1973, as amended, under an emergency listing in June 25, 1991 and final rule on May 20, 1992. Critical habitat has not been designated for this species.

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2. *States*:
    a. *Michigan* – listed as endangered under the Michigan Endangered Species Protection Law (Public Act 451 of 1994, Part 365)
    b. *Indiana* – insects are not included under the Indiana Nongame and Endangered Species Act of 1973 (IC 14-22-34); management authority for insects comes from general authority by the state to manage wildlife resources
    c. *Alabama* – listed as an imperiled species (S1/S2) under the state's Invertebrate Species Regulation (220-2-.98).
    d. *Mississippi* – listed as endangered under Mississippi law
    e. *Virginia* – listed as endangered under the Virginia Endangered Plant and Insect Species Act (Chapter 10 § 3.2–1003)
3. *NatureServe*: global status as G2T2 imperiled
4. *Recovery Plan*: Mitchell's Satyr Butterfly Recovery Plan was approved in 1998, with the primary objective of removing the butterfly from the List of Endangered and Threatened Wildlife and Plants.

Restoration and Recovery Needs

The recovery criteria within the Mitchell's Satyr Butterfly Recovery Plan (U.S. Fish and Wildlife Service [USFWS] 1998) states that reclassification from endangered to threatened may be considered when 16 geographically distinct, viable populations or metapopulations are established or discovered range-wide. These will include, at a minimum, 12 populations or metapopulations in southern Michigan, two in Indiana, one in Ohio, and one metapopulation in New Jersey. At least 50 percent of these sites will be protected and managed to maintain Mitchell's satyr habitat by federal or state agencies or by private conservation organizations. Because the southern populations were discovered after the recovery plan was written, they are not included in the plan or recovery criteria.

Delisting the species may be considered when nine additional, for a total of 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 conservations organizations before delisting will be considered.

Specific actions listed in the recovery plan to facilitate propagation, reintroduction, and augmentation:

1. Action 2.2.5 – Conduct captive rearing/reintroduction studies
2. Action 5.0 – Reintroduce into suitable but unoccupied habitats

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Objectives and Goals of Propagation and Augmentation/Reintroduction Efforts

One of the goals of this propagation, augmentation, and reintroduction program is to restore and increase the number and distribution of viable populations of Mitchell's satyr in Michigan and Indiana through augmentation of existing populations or reintroduction. Another goal is to provide for recovery and the potential for delisting. The objectives of this plan are to:

1. Establish protocols for propagation, rearing, and placement of Mitchell's satyr into appropriate augmentation and reintroduction locations;
2. Prepare and/or update site conservation plans at viable or potentially viable sites and reintroduction sites;
3. Evaluate existing populations at sites proposed for collection for propagation purposes, or translocation;
4. Screen Mitchell's satyr eggs or larvae to determine *Wolbachia* status; and
5. Communicate and coordinate with partners and Mitchell's Satyr Recovery Working Group (Working Group) before release of butterflies and throughout the program.

U.S. Fish and Wildlife Service Policy Regarding Controlled Propagation of Species Listed Under the Act

The joint U.S. Fish and Wildlife Service (Service) and National Marine Fisheries Service Policy (65 FR 56916) established a protocol for coordinating and developing controlled propagation, augmentation, and reintroduction plans for candidate, proposed and listed wildlife and plants indigenous to the U.S. and its territories for which the Service has, or intends to prepare recovery plans. This Policy supports the controlled propagation of listed species when recommended in recovery strategies identified in approved recovery plans, supplements to approved recovery plans, or when necessary to prevent extinction of a species. Appropriate uses of controlled propagation include:

- Supporting recovery-related research,
- Maintaining refugia populations,
- Providing plants or animals for reintroduction or augmentation of existing populations, and
- Conserving species or populations at risk of imminent extinction or extirpation.

Controlled propagation protocols will follow accepted standards, such as those employed by the American Zoo and Aquarium Association, the Center for Plant Conservation, and Federal agency protocols, to the extent practical. All efforts will be made by the Service and partners to ensure that the genetic makeup of propagated individuals is representative of that in free-ranging populations and that the propagated individuals are behaviorally and physiologically suitable for introduction.

Controlled propagation has been used successfully to reverse population declines and return

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listed species to suitable habitat, which has ultimately led to species reclassification. Although other listed insects have been successfully produced and reintroduced using controlled propagation, only limited controlled propagation has occurred using Mitchell's satyr (i.e., larval host and food plants identification and over-wintering experiments). Therefore, we will consider any controlled propagation attempts of Mitchell's satyr as experimental until we deem initial trials as successful. In order to ensure successful controlled propagation of Mitchell's satyr, surrogate species will be used before attempts are made with the target species.

The Toledo Zoo has conducted captive rearing experiments on surrogate species, as well as Mitchell's satyr for several years. The zoo is currently rearing Mitchell's satyrs for reintroduction in 2016. The Kalamazoo Nature Center (KNC) is experimenting with rearing surrogate species in preparation for propagation and rearing of Mitchell's satyrs. Any facility participating in the propagation and reintroduction plan must have a Service approved endangered species permit and follow the protocols established in this plan.

Maintenance of Sufficient Resources for Implementation, Monitoring, Habitat Management, and Adjustments

A National Fish and Wildlife Foundation grant was supplied to the Toledo Zoo via the Indiana Chapter of The Nature Conservancy (TNC-Indiana) for obtaining, rearing, and release of Mitchell's satyr into Swamp Angel, which is owned and managed by TNC-Indiana. This funding also includes management of the site prior to reintroduction of Mitchell's satyr. TNC protects ecologically important lands all over the world, some of which provide habitat for endangered and threatened species. For Swamp Angel, the organization has committed to implementation of reintroduction, habitat maintenance, and monitoring of reintroduced populations of Mitchell's satyr.

The Toledo Zoo and KNC will also use operational funding from their respective institutions to support collection and rearing of Mitchell's satyr in their facilities, in addition to placement of butterflies into reintroduction and augmentation sites.

SPECIES POPULATION TRENDS and BIOLOGY

Historical distribution (Figure 1)

Michigan

At the time of listing and according to searches for species conducted from 1985 to 1990, Mitchell's satyr was believed to exist in nine counties in Michigan and Indiana (57 FR 21564). The recovery plan (USFWS 1998) reports that Mitchell's satyr is historically known from 22 sites in 11 counties in Michigan.

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Indiana

The recovery plan (USFWS 1998) states a total of four or five sites in the counties of LaGrange, LaPorte, and Steuben are known to have supported Mitchell's satyr.

Ohio

Mitchell's satyr was known from a single Ohio county at the time of listing (57 FR 21564). According to the search results from 1985 to 1990, no extant populations were found in Ohio. The recovery plan (USFWS 1998) lists Portage and possibly Seneca counties as supporting historical populations of Mitchell's satyr.

New Jersey

At the time of listing, several disjunct populations of Mitchell's satyrs were historically documented as occurring in New Jersey (57 FR 21564). In 1985, only one population remained and in 1991, during the surveys in the state, no Mitchell's satyrs were found, possibly lost to over-collection (57 FR 21564).

Maryland

Mitchell's satyrs were documented from Anne Arundel County, Maryland by two brothers who reportedly collected a Mitchell's satyr from a "military marsh" near the railroad yard at Fort Meade during World War II (USFWS 1998, Hamm 2012). However, a voucher specimen is not available (USFWS 1998, Hamm 2012). Without a specimen for confirmation and because suitable habitat no longer exists in the vicinity of Fort Meade, the validity of this report remains questionable (USFWS 1998, Hamm 2012).

Current distribution

Mitchell's satyr is currently known from 10 sites in Michigan and one in Indiana, with newer populations discovered in the late 1990s and early 2000s in Virginia, Alabama, and Mississippi (Figure 2). Populations in Ohio, New Jersey, and Maryland are extirpated.

Michigan

Mitchell's satyr is currently found in six counties: Berrien, Branch, Cass, Jackson, Van Buren, and Washtenaw.

Indiana

As of 2008, the butterfly occurs only in LaGrange County.

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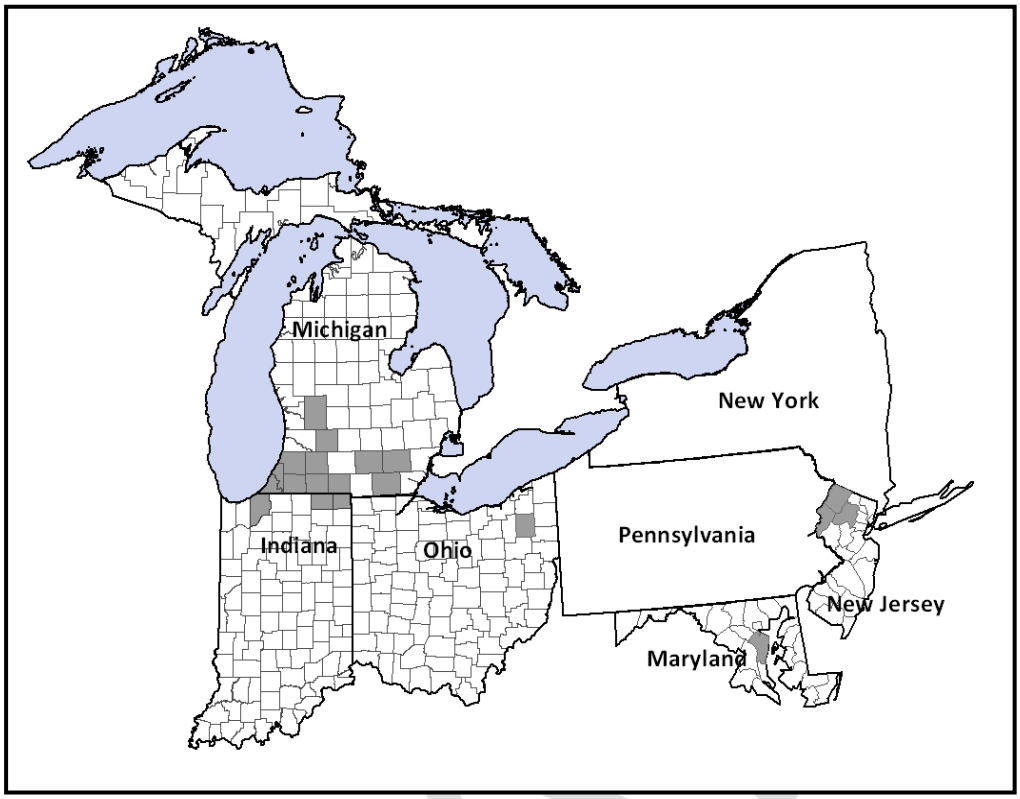

Figure 1. Historical distribution of Mitchell's satyr butterflies within the states of Michigan, Indiana, Ohio, New Jersey, and possibly Maryland. Shaded areas represent counties of documented or reported occurrences.

Alabama

Twenty-eight sites are occupied by Mitchell's satyr in the central portion of the state within the Fall Line Hills physiographic province in the counties of Bibb, Hale, Fayette, and Tuscaloosa (Hart 2004). Most sites occur within the Oakmulgee Ranger District of the Talledega National Forest (Hart 2004).

Mississippi

Three populations of Mitchell's satyr were first documented by Terence Schiefer, Mississippi Entomological Museum, along the Natchez Trace Parkway (Parkway) in Prentiss and Tishomongo counties in 2003. Mr. Schiefer returned to the Parkway in 2008 and found only one of the three populations (Hill *et al*. 2015). Surveys in other locations documented two new colonies in 2010: one colony each in Itawamba County and Tishomongo County (Surrette *et al.* 2010). The occupied sites are located within the Fall Line Hills region (Hart 2004). Additional surveys of the original three sites along the Parkway during the flight periods of 2012–2015 found only one extant site with population numbers ranging from one to six individuals (Hill *et al*. 2015). Currently, there are extant populations in the counties of Alcorn, Itawamba, Monroe, Prentiss, and Tishomongo (JoVonn Hill, Mississippi Entomological Museum, pers. comm. 2016).

Virginia

Based on surveys conducted during 2000–2001, Mitchell's satyr is known from 17 sites in the southwest portion of the state (Roble *et al*. 2001). These populations lie within the Blue Ridge Mountains region in Floyd County (Roble *et al*. 2001; Roble, pers. comm. 2012).

The southern populations are highly disjunct, with Alabama and Mississippi populations occurring closer together, although they are separated by 115 miles (Goldstein 2004). Populations in Virginia are nearest to the northern range of Mitchell's satyr but separated by approximately 300 miles from the nearest population, which is an extirpated site in Ohio (Goldstein 2004). Abundance and population trends are unknown for these sites.

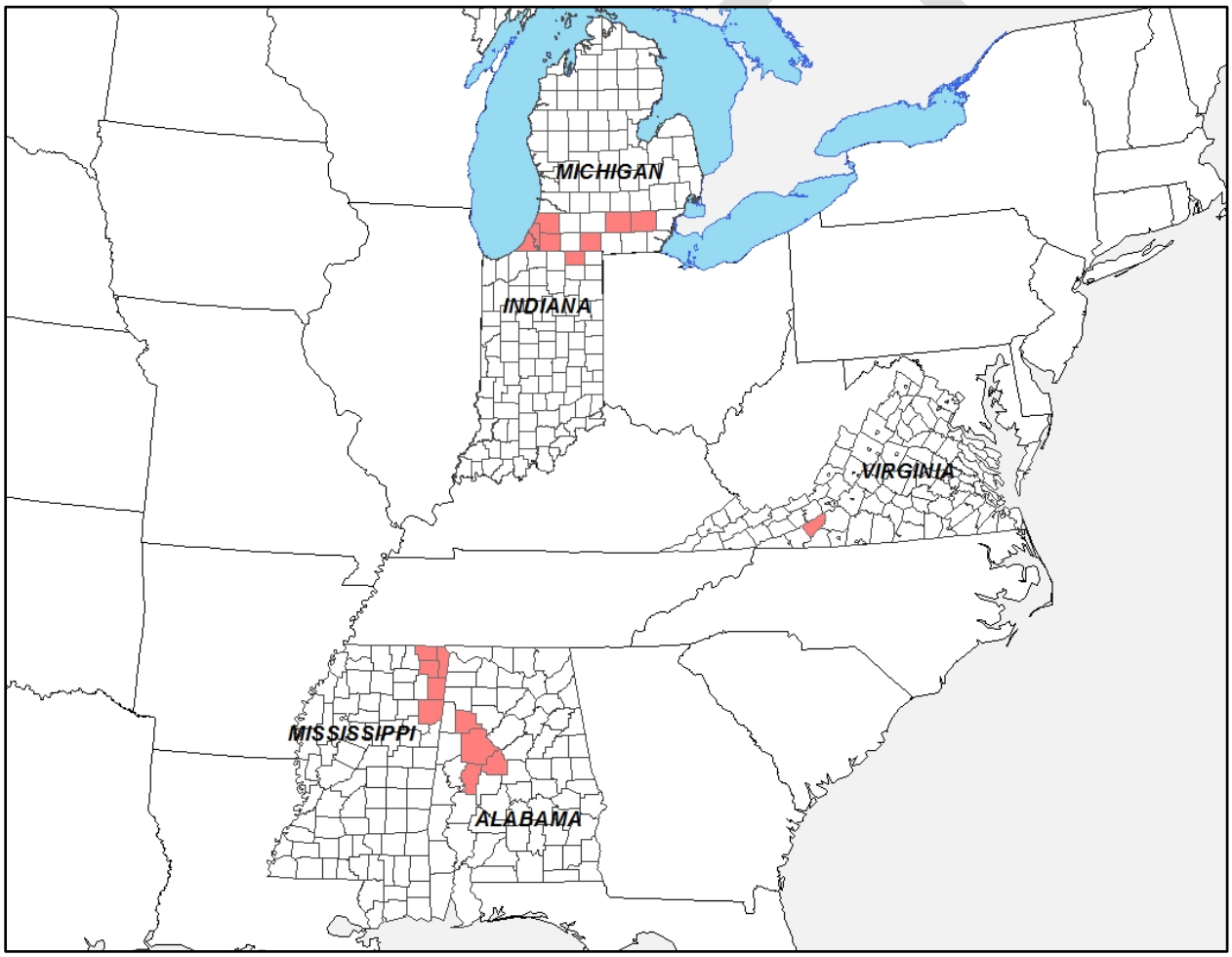

Figure 2. The current distribution of Mitchell's satyr in Michigan, Indiana, Virginia, Alabama, and Mississippi.

Life History

Mitchell's satyr butterflies undergo complete metamorphosis and progress through four stages of development: egg, larvae, pupae, and adult. In Michigan and Indiana, the satyr has one brood,

with adults flying in late-June through mid-July. The flight period lasts for approximately two weeks during which the butterflies mate, lay eggs, and die (USFWS 1998).

Eggs and larvae are difficult to locate in the field (Darlow 2000). Documentations and descriptions of egg and larvae are based on individuals reared in captivity (McAlpine *et al*. 1960; Wilsman and Schweitzer 1991; Legge and Rabe 1996; Darlow 2000; Tolson *et al*. 2006; Tolson 2009; Tolson and Ellsworth 2007, 2008, 2010). The Toledo Zoo has conducted captive-rearing studies on Mitchell's satyr and found that eggs were not usually laid on food-source plants, but instead, eggs were often laid on short-statured forbs or wildflowers (Tolson and Ellsworth 2008). In the field, oviposition (egg-laying) occurs close to the ground on a variety of small forbs and sedges during the afternoon (Darlow 2000). Larvae hatch from eggs after seven to eleven days then move onto neighboring food plants to begin feeding throughout the summer (USFWS 1998, Tolson and Ellsworth 2007). During this period, larvae proceed through several phases of molts or instars (USFWS 1998).

Larvae complete the first three instars during summer and then enter diapause in August (Tolson and Walsh 2015) in which feeding stops and the larvae overwinter on the leaves of tussock sedge until the following spring. In spring, the larvae continue eating and growing, while proceeding through two additional instars. In late-May to June, the larvae form a chrysalis about 40 cm (15 inches) from the base of the tussock sedge plant (Tolson and Ellsworth 2008). The chrysalis persists for 10 to 15 days (McAlpine 1960). The chrysalis transitions in color from light green to medium green about 48 hours prior to the adult butterfly emerging (eclosion) (Hamm *et al*. 2013).

Flight

Mitchell's satyrs in Michigan, Indiana, and Virginia are univoltine, having only one flight season per year (Roble *et al*. 2001). In Alabama and Mississippi, the satyrs are bivoltine, having two generations with flight periods ranging from late-May to late-June and from early-August to early-September (Hart 2004). During the Toledo Zoo's captive-rearing experiments, Tolson *et al*. (2006) found that Mitchell's satyr is only facultatively constrained to a single flight in Michigan, and that more eggs could be produced from conservation breeding by artificially producing two flights in captivity.

Oviposition Behavior

Observing Mitchell's satyrs ovipositing in the field is rare. Oviposition was first recorded *in situ* during Szymanski's (1999) study. Since that time, several other researchers have also observed egg-laying in the field or in captivity. During a three year period, Szymanski (1999) observed seven oviposition events, all of which occurred on the underside of small forb or sedge leaves within 5cm of the ground. Eggs are laid in clusters varying in size from 1 to 11 eggs, and averaging 4.7 per cluster (Darlow 2000). Captive-reared Mitchell's satyrs at the Toledo Zoo

primarily oviposited on *Pilea pumila* and *Viola nephrophylla* even though *Carex stricta* was offered (Tolson and Ellsworth 2007). In the wild, Darlow (2000) recorded oviposition on a variety of forbs: marsh shield fern (*Dryopteris thelypteris*), tall meadow rue (*Thalictrum polygamum*), Joe-pye weed (*Eupatorium maculatum*), goldenrod (*Solidago* spp.), and a few unidentified forbs. Females caged by Legge and Rabe (1996) in a southwest Michigan fen preferred northern bog violet (*Viola neprophylla*). Roble *et al*. (2001) and Hart (2004) observed the southern populations of Mitchell's satyr engaging in mate-locating patrolling by the males, and Hart (2004) further noted oviposition on *Carex bromoides* in Alabama.

Darlow (2000) documented certain behaviors prior to oviposition. During his study of a Michigan population, Darlow (2000) noted two general stages in the selection of oviposition sites: (1) selection of location, which is possibly chosen based on structural attributes, such as shade, microclimate, humidity, or temperature; and (2) selection of suitable host plants. More specifically, Darlow (2000) found that after a resting period, females engaged in a dispersal flight, which later changed to an inspection flight, characterized by flying in a circle just below or at vegetation level. This was followed by another resting period, then a short, direct hop down low in the vegetation below the sedge and grass canopy, either landing on a forb for oviposition or rejecting the plant (Darlow 2000, Hyde *et al*. 2000). In a mark-release-recapture study, Barton and Bach (2005) noticed females flying at greater frequencies during what was designated in the study as the mating period (when male and female ratios are equal) and throughout the flight season than were previously reported in Szymanski *et al*. (2004).

Upon selecting a suitable plant, females would land on the edge of a leaf, curl their abdomen below the leaf surface, lay an egg, uncurl the abdomen, and repeat the process until a cluster of eggs was laid (Darlow 2000). Hyde *et al*. (2000) documented egg-laying events about 2 to 4 inches from the ground surface and on the underside of small forb leaves. After laying eggs, the female would make a direct hop higher up in the vegetation, near the oviposition site, to rest before pre-oviposition behavior recommenced (Darlow 2000). Several studies (Szymanski 1999, Darlow 2000, Hyde *et al*. 2000) have documented ovipositioning occurring only during the afternoon hours (between 1345 and 1745, with the majority occurring between 1517 and 1627).

Upon hatching, Mitchell's satyr larvae migrate to food plants and will select and feed upon a variety of plants, including those that do not support successful development (Tolson *et al*. 2006; Tolson and Ellsworth 2007, 2008, 2010, 2012; Tolson 2009). The Toledo Zoo's food preference trials for captive larvae identified six species of sedges (*Carex buxbaumii, C. lasiocarpa, C. leptalea, C. prairea, C. sterilis,* and *C. stricta*) and two grasses (*Panicum amplicatum* and *Poa palustris*) that support normal development until the third instar diapause in August (Tolson *et al*. 2006; Tolson and Ellsworth 2007, 2008, 2010, 2012; Tolson 2009; Ellsworth and Tolson 2012).

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Adult Mitchell's satyrs are generally short-lived, with the average male living between two to five days and the female two to four days (Szymanski *et al*. 2004). It is also rare to observe them feeding, especially in the northern portion of the species' range. Szymanski (1999) did not report Mitchell's satyrs nectaring; however, Darlow (2000) observed Mitchell's satyrs nectaring on mountain mint (*Pycanthemum virginianum*), black-eyed Susan (*Rudbeckia hirta*), and swamp milkweed (*Asclepia incarnata*). Nectaring by Mitchell's satyrs has been observed on several occasions in the south (Hart 2004). In Virginia, Roble *et al*. (2001) recorded 14 nectaring events with adults visiting swamp milkweed, common milkweed (*Asclepias syriaca*), yarrow (*Achillea millefolium*), Queen Anne's lace (*Daucus carota*), and crown vetch (*Coronilla varia*). Mitchell's satyr has been observed nectaring only twice in Alabama (Hart 2004). Two female butterflies were recorded nectaring on *Sagittaria latifolia* near the end of the second flight period in September 2002 and 2003 (Hart 2004).

Habitat

Extant populations of Mitchell's satyr in Michigan and Indiana are found within prairie fen complexes (Kost and Hyde 2009). Prairie fens are globally rare, groundwater-dependent peatland communities restricted to discrete portions of the glaciated north-central United States where limestone bedrock or calcareous glacial till lies close to the surface (Landis *et al*. 2012, Amon *et al*. 2002, Godwin *et al*. 2002, Spieles *et al*. 1999, Wilcox *et al*. 1986). In Michigan, prairie fens are concentrated in the Kalamazoo-Battle Creek and Jackson interlobate region (Landis *et al*. 2012). Where the groundwater meets the surface, it creates a constantly wet and cool environment, with water relatively high in pH and continuous in its supply (Landis *et al*. 2012).

Vegetation of prairie fens occupied by Mitchell's satyr is most often dominated by narrow-leaved sedges with scattered tamarack and poison sumac (Kost and Hyde 2009). It is typically open and often associated with oak savanna, barrens or prairie communities (Kost and Hyde 2009, Curtis 1971). Prairie fens occur in groundwater discharge zones, within a complex subsurface hydrology composed of hummocky topographies of glacial moraines and an extensive network of small streams, lakes, and other wetlands (Abbas 2011). Within the fens, Mitchell's satyrs occur usually within three meters of woody vegetation (Barton and Bach 2005). They also prefer forest edges and shrub/tree areas and avoid open sedge meadows (Barton and Bach 2005).

Captive-rearing efforts by the Toledo Zoo have shown that Mitchell's satyr is quite susceptible to desiccation during its overwintering period, suggesting that groundwater is not only important in supporting habitat structure, but in maintaining critical humidity levels (Tolson and Ellsworth 2008).

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THREATS and CONSERVATION

Past and Current Threats

Habitat loss and fragmentation have been and continue to be the primary threats affecting Mitchell's satyr. The final listing rule cited human-induced destruction and natural succession as leading causes of Mitchell's satyr habitat decline. Loss of habitat has occurred throughout the historic range of the species and continues in some locations as a result of succession, altered hydrology, agricultural conversion, weed plant invasion, and development. Most of the destructive activities are linked in some way to the hydrology that controls the groundwater flow and water quality in the fen.

The final listing rule (57 FR 21567) identified characteristics of Mitchell's satyr that may limit the species' ability to colonize new or historical habitat patches or provide significant gene flow among extant populations. As such, isolation of small populations makes the species more susceptible to local extinction if habitat degradation and/or collection pressure are also occurring (Wilsmann and Schweitzer 1991).

The recovery plan identified collection of Mitchell's satyr for the black market, which may have eliminated a few populations, as a threat (USFWS 1998). Collection of Mitchell's satyr is allowed only with a permit issued by the U.S. Fish and Wildlife Service (Service). Currently, illegal collection of the butterfly does not appear to be a significant threat, as the Service is not aware of any such collection activities. Mitchell's satyr is a very rare butterfly, and illegal collecting can likely become a significant threat as long as the monetary reward exceeds the perceived risk of knowingly violating federal and state laws (USFWS 1998).

Pesticide use (e.g., gypsy moth control, agriculture), pollution, flooding, and cattle grazing are potential threats at some sites. In addition, a few sites adjacent to power line or railroad rights-of-way need to be maintained by the utility companies. If not performed properly, vegetation removal at these sites could damage habitat or harm Mitchell's satyrs. In addition, increased range-wide use of neonicotinoid insecticides (neonics) on agricultural lands is suspected in the recent declines of some native butterfly populations (Pecenka and Lundgren 2015; Main *et al*. 2014; Pisa *et al*. 2014; Lisa Williams, USFWS, pers. comm. 2014).

Gravel mining projects have occurred in the vicinity of a Mitchell's satyr occupied fen and nearby unoccupied fen that contains potential habitat for the species in Kalamazoo County, Michigan. This type of project has the potential to adversely affect the satyr through impacts on groundwater quantity, quality, and flow. The property owners have worked with the Service to develop groundwater monitoring plans that include installation of monitoring wells and data loggers to track groundwater levels and fluctuations in the area.

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Also in Michigan, historical practices at a copper tubing manufacturing facility in Cass County have contaminated the groundwater, soil, and surface water with trichloroethene (TCE) and other volatile organic compounds (VOCs) in the vicinity of the facility and surrounding areas. An occupied Mitchell's satyr site is located near the facility, and the groundwater is impacted with the contaminants. Mitchell's satyrs persist at the site, but their numbers have declined and the habitat is becoming more degraded through invasive species encroachment (Hyde, pers. comm. 2011). The U.S. Environmental Protection Agency (USEPA) has worked with the facility's owner on a Resource Conservation and Recovery Act Corrective Action Administrative Order on Consent that requires the facility to address its release of hazardous waste and hazardous constituents into the environment. The company has completed a Corrective Measures Proposal to address and remove contaminants from the environment. The Service and USEPA provided comments on the facility's proposal.

Past and Current Conservation Activities

Prior to listing Mitchell's satyr as an endangered species, the Service sponsored intensive searches from 1985 to 1990 at known or historical sites throughout the range of the species to determine presence or absence of habitat and to see if the species could be relocated. Mitchell's satyr was subsequently found at only 15 sites, two of which were not historically known. These results indicated that the species had disappeared from half of its historical locations. Further surveys were conducted in 1994 and 1995 to assess the distribution of Mitchell's satyr within large wetland complexes.

MNFI conducted host plant affinity studies in 1993 within one Mitchell's satyr site. Based on observations from these studies, they found early instar larvae to feed primarily upon newly sprouted sedge seedlings or roots. Larval diet studies, in addition to rearing and propagation research of Mitchell's satyr, began at the Toledo Zoo in 2006, in coordination with MNFI. The Zoo (Tolson *et al*. 2006, 2007, 2008, 2009, 2010) discovered several new findings about the species. For example, Mitchell's satyr will readily oviposit in tubs, although higher survival rates were documented from large planted tubs; adults will mate in small enclosures; and larvae preferred mid-sized *Carex stricta* shoots. First instar larvae will select and feed upon several different grasses and sedges, not all of which support successful development. Six species of *Carex* and two grass species support normal development until diapause. Additionally, captive rearing of Mitchell's satyr in Bug-dorm tents yields the best results.

1998–99	Recovery plan released, surveys, land acquisition of three sites: Tamarack Swamp, Liberty Fen (Michigan Chapter of TNC – [TNC-Michigan]), and Blue Creek Fen (Michigan Department of Transportation [MDOT]).
2000–01	Surveys continue; vegetation study; behavior and oviposition studies

2002–04	Surveys and management continue; GIS habitat modeling to identify potential release sites; mark-release-recapture study at Grand River Fen; site conservation plans developed; genetic studies begin on southern U.S. populations (study was inconclusive); burn no more than 1/5 of occupied habitat recommendation.
2005–07	More mark-release-recapture studies; captive rearing program begins; Habitat Conservation Plan (HCP) proposal; surveys continue; larval food study begins. Michigan and Indiana Departments of Natural Resources held public meetings in March 2007 to seek public comment on the development of a HCP for Mitchell's satyr.
2008–09	Larval food study continues; degree-day model completed; Mitchell's satyr genetic study initiated by Michigan State University; Mitchell's satyr outreach brochure developed; prairie fen book completed; 42 fens surveyed between 2007–2009.
2010–13	Groundwater modeling initiated and completed; fen ranking for reintroduction developed; genetics study completed by Michigan State University (inconclusive results) and new genetic analyses started at Mississippi State University (using whole butterflies mapping the entire genome); Mitchell's satyrs are still in decline; reintroduction plan presented; Mitchell's Satyr Recovery Working Group develops the Mitchell's Satyr Butterfly Conservation Strategy.
2014–Present	Planning for augmentation and reintroduction of Mitchell's satyr

METHODS

MNFI, TNC-Indiana, and Toledo Zoo have developed criteria and a protocol for Mitchell's satyr reintroduction (MNFI *et al*. 2015) (Appendix B). The Toledo Zoo and KNC, with potential facilities being added in the future, will capture and rear Mitchell's satyr. All rearing facilities will coordinate with partners in the Working Group to collect, rear, propagate, and release Mitchell's satyr at sites within the historical range of the species in Michigan and Indiana. Each captive-rearing facility will operate under its own permit from the Service.

Definitions

1. Propagation or Controlled Propagation refers to the production of individuals within a managed environment for the purpose of supplementing or augmenting a wild population(s) or reintroducing to the wild to establish new populations. The Toledo Zoo and KNC are the rearing facilities that will be conducting these activities. Upon approval, additional facilities may be included for propagation and rearing of Mitchell's satyr.

DRAFT

2. Augmentation describes the increase in numbers of Mitchell's satyr within a defined area of habitat through the transplantation of adults or larvae from other locations or through the release of propagated individuals. Augmentation is appropriate when the population size of a listed species is minimal within an occupied area, the population is experiencing recruitment failure, or both. It is also appropriate where the species may be absent within apparently suitable habitat that is contiguous with and accessible to occupied habitat. It may be used to expand the range of a species within habitats accessible to existing populations, reducing the likelihood of extirpation due to localized catastrophic events.

3. Reintroduction describes the establishment of adults or larvae into unoccupied prairie fens within the historical range of the species where the species is not extant and where we do not expect natural immigration from extant populations. Reintroductions may be accomplished by transplanting adults from extant populations or through the release of propagated individuals. Adult translocation would likely occur only in the event of a severe threat that would likely result in significant adult mortality (e.g., species is declining due to encroachment by invasive species and habitat management is not supported on-site) or if we determine that propagation may not be a feasible means of establishing reintroduced populations. The reintroduction of Mitchell's satyrs will be considered when the Service has established that potential threats at the reintroduction site have been addressed (e.g., hydrology, invasive species, habitat management, etc.) to the extent that reintroduced populations of Mitchell's satyr are likely to grow and persist.

Propagation

Our efforts will focus on rearing, propagation, and head-starting to increase the founding population. Current rearing facilities have tested or are in the process of testing capturing, rearing, and release methods on the Mitchell's satyr surrogate species, eyed-brown (*Satyrodes eurydice*) and Appalachian brown (*S. appalachia*), with successful results to confirm that their methods will apply to Mitchell's satyr. Any prospective rearing facilities must successfully follow the same procedures with surrogates before obtaining a permit to conduct these activities with Mitchell's satyr.

Each facility will collect up to ten female Mitchell's satyrs (or maximum number allowed per respective federal endangered species permits) from sites in Michigan. Chosen sites will contain the largest populations of Mitchell's satyrs. Captured butterflies will be transported to the respective institutions for oviposition.

Captured female satyrs will be housed individually in Bug-dorm tents planted with a variety of small forbs, grasses, and sedges. They will be observed continuously during daylight hours to determine the number of eggs oviposited and time of hatching. Females will be held at each facility until 300 total eggs are oviposited. Females will then be returned to their original capture

DRAFT

sites. Additionally, any female not ovipositing within two days will be released at the capture site. It is therefore possible that release of females can occur prior to obtaining 300 eggs. Our goal is to successfully raise 100 adults from the collected 300 eggs obtained from the original captured females.

Larvae will be retained *ex situ* in Bug-dorm tents with a selection of grasses and sedges for food. *Carex stricta* and *Panicum amplicatum* will be available to all larvae. A maximum of ten larvae will be raised per enclosure. Larval habitats will be checked every day, and larvae will be visually located and counted every second day. Enclosures will be checked for spiders every day during the larval feeding period. Larvae will be over-wintered at the bases of sedge tussocks packed with *Sphagnum* on a sand substrate within Bug-dorms in outdoor enclosures. Larvae will be kept at high humidity at all times by watering, misting, or evaporative cooling.

Augmentation/Reintroduction

If adults develop and eclose normally in the year following hatching and overwintering, they will be held until there are at least 20 adult Mitchell's satyrs for release, with at least 50% of the cohort composed of females. If less than 20 adults are available, those would be released. Non-sibling pairs will be placed in breeding groups in an attempt to get the females inseminated before release. Adults will be taken to pre-selected release sites. All released larvae will be placed on appropriate sedges or other grasses that support successful development until the third instar. Depending on the rate and synchronicity of hatching and sex ratios, there will likely be multiple releases of adults.

In 2016, KNC will test an alternative method of augmentation. Female satyrs will be collected for oviposition, and larvae will be reared in Bug-dorm tents as described above. Before larvae reach the fourth instar, they are actively feeding and quite mobile. Once larvae reach the fourth instar, they begin to enter diapause, whereby they are rather inactive until the following spring. Rather than overwintering the larvae, KNC will release late third-instar larvae in mid- to late-summer at the site from which their parents were collected. Prior to moving larvae, KNC will cut the blades of sedges on which larvae are placed in their mini-fens *ex situ* and place sedge blades and larvae in clear plastic Amac-made display boxes. The larvae will be kept cooled (between 40 and 50 degrees F) while in transit. Once in their habitat, the satyrs will be placed at the base of sedge tussocks in the fen, in areas marked by flagging, to ensure that anyone accessing the area in the fall or spring will avoid these areas. This method will be evaluated for future use.

Timeframes

Year 1 – 2015

- Surveys for Mitchell's satyr
- MNFI assists Toledo Zoo with collection of females for captive-rearing

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- Selected females sent to Mississippi State University Entomological Museum for *Wolbachia* and genetics testing
- Eggs remain at Toledo Zoo for rearing.
- KNC begins rearing Mitchell's satyr surrogate species, Appalachian brown (*Satyrodes appalachia*) and eyed brown (*S. eurydice*), for preparation of rearing Mitchell's satyr.

Year 2 – 2016

- Mitchell's satyrs overwintered from 2015 at Toledo Zoo will be released at Swamp Angel, Indiana. Multiple releases are likely necessary for successful establishment of a population.
- Each facility collects up to ten female Mitchell's satyrs for oviposition and rearing of eggs. Toledo Zoo will collect from Coldwater Fen, while KNC will collect from Lime Lake Fen.
- KNC will raise eggs to third instar larvae and release within a suitable unoccupied pocket within the Lime Lake fen.
- Toledo Zoo, TNC-Indiana, and MNFI will conduct at least two visits to Swamp Angel post-release during mid-flight to survey and assess status of adult Mitchell's satyrs.

Year 3 – 2017

- Butterflies overwintered from 2016 at Toledo Zoo will be released at Swamp Angel, Indiana; multiple releases are likely.
- Each facility will collect up to ten female Mitchell's satyrs for oviposition and rearing of eggs. Toledo Zoo will collect from Coldwater Fen, while KNC will collect from Lime Lake Fen.
- Toledo Zoo, TNC-Indiana, and MNFI will conduct at least two visits to Swamp Angel post-release during mid-flight to monitor the flight and assess status of adult Mitchell's satyr.
- With each year of sampling, the intensity could change depending on natural events occurring during the year and amount of releases each year.
- KNC will survey Lime Lake Fen, including the site of augmentation, to assess flight and monitor post-larvae releases and adult Mitchell's satyrs.
- The Service and Working Group will evaluate results from the release of third instar larvae into Lime Lake Fen and the Service and KNC will evaluate survival of overwintering of surrogate species larvae at KNC.

Year 4 – 2018

- Last year of releases into Swamp Angel and Lime Lake Fen
- Butterflies overwintered from 2017 at Toledo Zoo will be released at Swamp Angel, Indiana; multiple releases are likely.

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- Each facility will collect up to ten female Mitchell's satyrs for oviposition and rearing of eggs.
- At least two visits to Swamp Angel to survey and monitor butterflies.
- KNC will survey Lime Lake Fen, to assess flight and monitor post-larvae releases and adult Mitchell's satyrs.
- KNC may release third instar larvae into Lime Lake Fen, or dependent upon the evaluation of survival of overwintered surrogates, begin overwintering Mitchell's satyr.

Years 5–8 (2019–2021) will consist of annually monitoring the reintroduced and augmented populations at Swamp Angel and Lime Lake Fen. Habitat management that may result in take of Mitchell's satyrs may now be used within Swamp Angel and Lime Lake Fen if needed. During this time period, Mitchell's satyr collection and rearing will continue, while reintroduction and augmentation take place in new sites chosen by the Working Group. Reintroduction, augmentation, and monitoring at the new sites will be similar to previous years and will follow the established protocol.

Plan for Disposition of Unfit and Surplus Individuals

Facilities rearing eggs and larvae for augmentation will release them all at the third instar stage, regardless of amount. Larvae that appear to be unfit will not be released. All reared adult Mitchell's satyrs will be released at appropriate sites each flight season. Adults that are considered genetically unfit may not be released. Unfit individuals may be disposed of or retained for further analyses. If parasitism is suspected, individuals could be frozen or preserved for parasite identification.

Monitoring Success

MNFI and other partners within the Working Group will conduct a minimum of two surveys at each butterfly release site during the adult peak flight for a minimum of three years after the last release. Surveys will follow the protocol established in the Criteria and Protocol for Mitchell's Satyr Introduction (Cuthrell *et al.* 2015) (Appendix B). The number of butterflies counted during the surveys will allow the Working Group and Service to assess population growth or decline at each site. If there are stable numbers of butterflies at each release site for at least three to five years post-release, we will consider the program successful. Stable numbers will be defined on a per site basis. Due to natural population fluctuations, monitoring of the reintroduced and augmented populations for the next several years is important in order to determine any significant changes in population size. All program activities will be compiled in an annual progress report.

Anticipated Challenges

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The reintroduction program may present some challenges. Because we are anticipating success of this program, the capacity of existing rearing facilities will come into question. A third rearing facility may need to be engaged for the continued production of butterflies. Site specific issues may also arise, such as an activity occurring outside of an occupied fen but impacting the groundwater within the fen. Finding enough protected sites for release in the future could also present problems. This is a novel program for Mitchell's satyr and will need to be revisited in the future and updated.

GENETIC RISK IDENTIFICATION and MANAGEMENT

Captive rearing has increasingly been used as a technique to help recover endangered populations of butterflies and other species (Snyder *et al*. 1996, Mattoni *et al*. 2003, Crone *et al*. 2007, Miller *et al*. 2014). It has been demonstrated that captive rearing can be a way to successfully increase viability in butterfly populations (Crone *et al*. 2007), but comes with potential genetic risks, such as introducing deleterious alleles or diseases into a wild population, or can quickly lead to phenotypic or behavioral changes in captive-reared individuals (Snyder *et al*. 1996, Crone *et al*. 2007). Limited genetic diversity is a major threat for the development of a successful captive-rearing program (Mattoni *et al*. 2003, Miller *et al*. 2014). The establishment of captive populations or captive-rearing efforts is often only begun after species have dwindled to small population sizes in the wild and are thus possibly suffering from lower genetic diversity before efforts are even begun (Miller *et al*. 2014). Additionally due to financial and other constraints, captive populations are small and even more at risk for inbreeding depression (Couvet 2002, Miller *et al*. 2014). Due to these and other issues, butterfly captive-rearing programs must be designed carefully (Miller *et al*. 2014).

A well designed captive-rearing program seeks to retain as much of the genetic variation present in the wild population as possible (Mattoni 2003). To retain more genetic variation, the Mitchell's satyr captive-rearing program has elected to use head-starting and to make new collections of wild individuals each year. This will effectively increase the number of founders, which increases the probability of maintaining the greatest genetic diversity possible (Miller *et al*. 2014; Peter Tolson, Toledo Zoo, pers. comm. 2015). To help ensure that as much genetic variation as possible is captured from the wild population, founder individuals will be collected from different parts of the fen to capture different lineages (Tolson, pers. comm. 2015). To ensure a high level of homozygosity in the donating population, collections will be made at the beginning, middle and end of the flight period. Animals that emerge at different times are more likely to be offspring of different individuals, which should help capture more of the available variation (Tolson, pers. comm. 2015). To ensure the project will not diminish the long-term viability of the source population, the permit allows for the take of no more than 10 individuals each year.

Taking butterflies for captive rearing from large populations has been shown to be consistently better than taking from smaller ones (Crone *et al*. 2007). For the Mitchell's satyr, individuals will

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be taken only from Grand River Fen or Coldwater Fen. By virtue of their size, these populations have the greatest chance of retaining genetic variability (Tolson, pers. comm. 2015).

When founding a population from only a few individuals, it is important to expand the new population as rapidly as possible in order to increase the likelihood of maintaining genetic diversity because any loss of positive alleles will not be significant given the numbers produced in the expanded population (Mattoni 2003; Tolson, pers. comm. 2015). The strategy, therefore, is to put out hundreds of butterflies, rather than just a few or 10, at a site so as to rapidly increase the population. A larger cohort of butterflies released at the same time will have a greater ability to breed together, which will help maintain genetic diversity in the released population (Tolson, pers. comm. 2015).

ECOLOGICAL RISK IDENTIFICATION and MANAGEMENT

The number of adults collected for egg retrieval, rearing, and propagation are expected to be small relative to population size (i.e., less than 5%) and will be removed from only a few sites. In addition, only sites with healthy, robust populations will be considered for this purpose in order to reduce the impact on the species. Once eggs are collected, most of the adults will be returned to the site of collection. A few may be retained for genetic studies. We understand the survival rate of collected females may be reduced due to intraspecific competition or increased predation. Conversely, if individuals are returned to the site following successful overwintering during captive-rearing efforts, survival rates may be greater than those found *in situ*.

The existing Mitchell's Satyr Recovery Programmatic Biological Opinion (Log No. 03-R3-ELFO-03) considers the effects to the species resulting from activities related to collection of females and eggs for captive rearing and propagation, surveys, monitoring of populations and habitat, and management. Anticipated adverse effects resulting from Mitchell's satyr collection, captive rearing and propagation, surveys, and monitoring are likely to be short-term and temporary, and are likely to result in an improvement in the conservation status of the species. Adverse effects are likely to occur to individuals and are not expected to reach the population-level. Further, captive rearing and monitoring will contribute greatly to the conservation and recovery of Mitchell's satyr.

Fens chosen for reintroduction will have natural boundaries, such as unsuitable habitat, stream channels, or dense forests that will confine the population to the fen. Adult Mitchell's satyrs are highly unlikely to escape any site where it has been placed due to the species restriction to certain areas of prairie fens and their poor dispersal capabilities. Their home range sizes and dispersal distances are likely related to geographic barriers, such as stands of dense shrub or unsuitable habitat (Barton 2005).

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HEALTH and DISEASE MANAGEMENT

Many species of arthropods face the threat of heritable endosymbiotic bacteria, particularly those in the genus *Wolbachia* (Baldo *et al*. 2006, Werren *et al*. 2008, Nice *et al*. 2009, Hamm *et al*. 2013). *Wolbachia* bacteria are passed on to offspring maternally through cytoplasm in eggs and can cause a wide variety of problems in host populations, including feminization or killing of male offspring, parthenogenesis and most commonly, cytoplasmic incompatibility in which the sperm of infected males cannot fertilize the eggs of uninfected females or females infected with another strain of *Wolbachia* (Baldo *et al*. 2006, Werren *et al*. 2008, Nice *et al*. 2009).

Wolbachia infections can present serious problems for captive management programs (Nice *et al*. 2009) and potentially could pose a serious challenge for recovery of Mitchell's satyr (Hamm *et al*. 2013). Recent work has documented the presence of *Wolbachia* in at least three Mitchell's satyr populations (Doug Landis, Michigan State University, pers. comm. 2010), but the effect that these infections have on individual populations or the overall population of the satyr is unknown (Landis and Hamm 2013). Further research is necessary to understand the full extent of *Wolbachia* infections in Mitchell's satyr, the individual strains of *Wolbachia* present, and the effects of the strains (Hamm 2012).

Releasing different strains of *Wolbachia* at a site could lead to localized extirpation events (Landis, pers. comm. 2010). To prevent this potential issue, releases of captive-reared butterflies will consist only of genetic stock taken from the fen where the release is occurring (augmentation) or will occur in unoccupied fens (reintroduction). Additionally, mixing butterflies from multiple source populations will not occur in fens selected for reintroduction. Currently, genetic samples have been taken from all founder females, so testing for *Wolbachia* presence and strain will be completed prior to releases (Tolson, pers. comm. 2015).

Although few disease problems have been noted, other potential diseases or parasites that could present difficulties for captive propagation are poorly understood. Some larvae at the Toledo Zoo have turned yellow and then died, but the causal agent for this is currently unknown. Testing is being conducted by Mississippi State University, Mississippi Entomological Museum (Tolson, pers. comm. 2015). Under current protocols, animals are kept isolated and are not overcrowded, limiting disease potential. If any animals show sign of disease, they will be further isolated and sent to Mississippi State University for diagnosis (Tolson. pers. comm. 2015).

INVASIVE SPECIES MANAGEMENT

Prior to reintroduction, sites may be intensively managed using fire to remove and control invasive plant species. Once butterflies are released, fire will not be allowed within occupied areas for three years or while the population is being established. However, fire will be permitted in adjacent, unoccupied areas of the reintroduction site, as long as refugia are established for dispersing Mitchell's satyrs.

DRAFT

Once the butterflies are established within the reintroduction sites, surveys and monitoring will be required before fire may commence. More specifically, maps created from survey and monitoring efforts will provide locations of the occupied portion of a site, including the core Mitchell's satyr population areas, and areas to be burned and/or managed. The maps will be provided to the Working Group for review and approval by the Service prior to the use of fire.

To prevent and minimize the spread of invasive plant species, boots and equipment will be cleaned prior to entering Mitchell's satyr habitat.

CATASTROPHIC EVENT IDENTIFICATION and MANAGEMENT

Removing a portion of a population of Mitchell's satyr increases the risk of affecting the long-term viability, particularly if the captive population were to be lost. However, the numbers of butterflies collected for eggs are expected to be small relative to population size (i.e., less than 5%), they will be removed from only a few sites, and effects are likely to be short-term and temporary. A list of potential threats to captive –held populations has been identified and the necessary measures and precautions taken to alleviate these potential risks have been described below.

- Security and Alerts

  The Toledo Zoo's butterfly greenhouse is surrounded by a six-foot perimeter fence and patrolled by Zoo security personnel twenty-four hours each day. Environmental chambers have temperature alarm systems, which are checked multiple times per night by Zoo security. The Zoo also has comprehensive emergency protocols established for fires, flooding, power failures, and tornados.

  KNC also uses a datalogger (TR-702NW-H temperature and humidity data logger by CAS Dataloggers) to monitor temperature and humidity within its greenhouse. The data logger has a threshold of -30 to 80 degrees Celsius and a humidity range of 0–99%. When butterflies are present in the facility, KNC staff receives email and/or text alerts whenever the temperature exceeds their window for butterfly productivity. Larvae are kept at high humidity with daily spritzing both manually and by the Ecologic Technologies Rainmaker misting system (Ecologic Technologies, Pasadena, MD). The Rainmaker is set up to mist for two minutes every ten minutes during the day. From April 22 to July 2, 2015, the average temperature of the greenhouse was 23.6 ˚C and the average relative humidity was 74.5%. Should electricity fail on-site, a generator is automatically activated.

- Escape Prevention

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Toledo Zoo uses triple confinement for all *Neonympha* to prevent accidental escapes. Mitchell's satyr in its various life-stages are housed in the greenhouse, within environmental chambers, or overwintered outside.

- Disease and Predation

  Toledo Zoo raises Mitchell's satyr larvae in a predator-free environment. Soil and sand used for planting sedges and other food plants are sterilized in a microwave for three minutes prior to placement into Bug Dorm tents. All sedges are planted bare root and examined closely for spiders before planting. The zoo uses insect-rearing tents constructed of engineered polyester netting which prevents predatory insects from entering.

  KNC monitors daily every life stage of the butterfly for any abnormal situations to prevent any potential disease or parasites. If there is parasitism, evidence of fungal outbreaks, or anything else irregular, KNC will quarantine either individual butterflies or entire pots. The best vigilance in this case is daily visual assessments and rapid responses. KNC staff also checks the butterflies and host plants daily to eliminate any predators or parasites manually. In 2015, they collected all specimens to identify the most common pests and how to control them in future years.

  If a *Wolbachia* analysis is being considered for a site where females are proposed for collection, each captive female will placed in an individual tent for oviposition. The female will oviposit exclusively in that tent or additional tents as needed, resulting in cohorts of offspring from a single maternal source. If a female tests positive for *Wolbachia*, each larva will be able to be identified to the maternal source and offspring tested for further analyses or disposal, if required.

New rearing and propagation facilities considered for the reintroduction program in the future will have their protocols reviewed and approved by the Service prior to participation.

SITE SELECTION

Protocols

Protocols for selecting and prioritizing sites for potential Mitchell's satyr augmentation or reintroduction were developed by MNFI in 2010 and revised in 2015 (Appendix C).

Site identification

MNFI maintains the State's natural heritage database, which contains the known locations and condition of natural communities, including prairie fens, in Michigan. Potential augmentation or

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reintroduction sites in Michigan will be drawn from this database. In addition, MNFI worked with TNC-Indiana to identify potential sites in Indiana.

The primary criteria for selecting sites include the size of the site, condition and quality, local matrix of compatible habitat, and the landscape matrix of compatible habitat. Site ownership is a consideration in selecting sites; however, any landowner who is willing to manage a site for the benefit of Mitchell's satyr is eligible. Monitoring and habitat management will be required at any augmentation or reintroduction site. The Working Group will evaluate potential sites.

Site description

Swamp Angel Preserve

Swamp Angel Preserve in Indiana has been selected as a reintroduction site. TNC-Indiana owns and manages Swamp Angel, which is a dedicated State nature preserve. The site is located in Orange Township, Noble County, Indiana.

Swamp Angel is a diverse fen/wetland/lake complex. The preserve features several freshwater marl substrate lakes, which have not been dredged or altered in any way, and a high-quality fen that is surrounded by oak uplands. The site provides suitable fen habitat with stands of tamarack that the Mitchell's satyr requires and the fine-leaved sedges upon which Mitchell's satyr larvae feed. Although Mitchell's satyr is not historically known from this site, the preserve is approximately 16 miles south of another known satyr occurrence.

The source for reintroduction at Swamp Angel is from the Coldwater Lake Fen in Branch County, Michigan. Swamp Angel is within approximately 30 miles of the source site. Current evidence (Hamm 2010) indicates little genetic difference among the Mitchell's satyr populations in Michigan and Indiana.

TNC-Indiana has developed a site conservation plan for Swamp Angel. The site plan includes management objectives to maintain the ecosystem processes that will support the functioning of the fen as habitat for Mitchell's satyr. These objectives include:

- Protect and monitor aquifer recharge area to maintain fen hydrology.
- Cessation and prevention of agricultural runoff.
- Reintroduce fire through prescribed burning of the fen and surrounding area.
- Determine the intensity and frequency of fire necessary to maintain a dynamic balance between woody encroachment into fen meadow and shrub-carr maintenance surrounding the fen meadow.
- Acquisition of buffer areas in order to ensure connectivity of habitat for animals.

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- Control Exotics: Multiflora Rose (*Rosa multiflora*), Queen Anne's Lace (*Daucus carota*), Sweet Clover (*Melilotus alba*), Buckthorn (*Rhamnus cathartica*), Fescue (*Festuca rubra*), Reed Canary grass (*Phalaris arundinacea*).

The Service is developing a Safe Harbor Agreement (SHA) for non-Federal landowners to participate in a Mitchell's satyr reintroduction program and will issue a section 10(a)(1)(A) permit for enhancement of survival. The agreement will include incidental take authorization for Mitchell's satyr during habitat management activities and will also provide assurances to adjacent, non-participating landowners in the event that satyrs disperse onto nearby properties.

Much of the fen is within the ownership boundaries of TNC-Indiana; however, some areas of the fen extend onto other adjacent landowners' properties. TNC-Indiana will be eligible to participate in the SHA through a Certificate of Inclusion, and the adjacent, non-participating landowners will receive incidental take coverage. As required in the SHA, TNC-IN will conduct monitoring and habitat management activities at the reintroduction site.

Lime Lake Fen

Lime Lake Fen in Van Buren County, Michigan has been selected as an augmentation site. It is approximately 225 acres and Mitchell's satyr occupies close to seven acres of the site. During the last survey in 2015, only 14 satyrs were counted; however, the entire site was not surveyed. Mitchell's satyrs were found in the lower pocket of the fen along the creek. The average number of Mitchell's satyrs counted in the last 15 years of surveys is approximately 42 satyrs. The site has two private landowners. Southwest Michigan Land Conservancy (SWMLC) conducts habitat management on both parcels and is in the process of purchasing 188 acres of the complex from one of the landowners. The site is located in Almena Township, Van Buren County, Michigan.

The portion of the fen complex that is currently occupied by Mitchell's satyr features Cedar Creek, Cedar Lake, and Lime Lake, in addition to prairie fen, swamp forest, sedge meadow, and shrub-carr, surrounded by oak forest. A wetland corridor along the creek flows from Cedar Lake into Lime Lake. Pockets of open habitat suitable for the satyr are separated by dense shrub-carr composed of poison sumac, speckled alder, and various dogwood species.

SWMLC will continue habitat management and, in conjunction with KNC, will monitor the Mitchell's satyr population at this site. The Service, in cooperation with the Working Group, will evaluate the success of the augmentation program.

ASSESSMENT of ACTIONS

The Service is developing a Safe Harbor Agreement for non-Federal landowners to participate in a Mitchell's satyr reintroduction program and will issue a section 10(a)(1)(A) permit for

enhancement of survival. The agreement will include incidental take authorization for Mitchell's satyr during habitat management activities and extend the incidental take authorization to adjacent, non-participating landowners in the event that satyrs disperse onto nearby properties. As part of this permit, section 7 consultation and NEPA compliance will be completed. Collection of females for captive rearing, as well as activities related to captive rearing and propagation have been contemplated in an existing biological opinion for issuance of section 10(a)(1)(A) permits for recovery activities (Log No. 03-R3-ELFO-03).

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APPENDIX A.

Current ranks of viable and non-viable Mitchell's satyr sites in Michigan and Indiana (Hyde, pers. comm. 2015). The ranks are not reflective of any viability studies; as such studies are difficult to conduct on small populations of endangered butterflies (Hyde, pers. comm. 2016). MNFI (Hyde, pers. comm. 2015) has assigned ranks A–C to each viable population and those ranked D are considered non-viable. These rank specifications were authored by Dale Schweitzer in 2007 (NatureServe 2007).

Likely Viable			
Site name	**County**	**Rank**	**Acres of occupied habitat**
Lime Lake Fen	Van Buren	BC	6.5
Coldwater Lake Fen	Branch	B	43
Grand River Fen	Jackson	AB	68
Potentially viable			
Cedar Lake (Indiana)	La Grange	C	5
Cook Lake/Rudy Rd. Fen	Cass	C	10
Sarett Nature Center	Berrien	CD	3
Shavehead Lake	Cass	C	11
Nonviable			
Mill Creek-East	Washtenaw	D	22
Skiff Lake Fen	Jackson	D	3.5
Wakelee Fen	Cass	D	20
Blue Creek Fen*	Berrien	D	5

*Status is uncertain

DRAFT

APPENDIX B.

MICHIGAN NATURAL FEATURES INVENTORY

Criteria and Protocol for Mitchell's Satyr Reintroduction

Dave Cuthrell, Daria Hyde - MNFI; John Shuey - TNC; Peter Tolson - Toledo Zoo

Overview:

Captive propagation and organism reintroduction are regularly used conservation techniques to help promote the recovery of imperiled organisms. The methods employed to accomplish butterfly reintroductions are often based on protocols developed for similar species despite possible differences in life history, habitat, climate, ecology and behavior. The Mitchell's satyr butterfly continues to decline at most sites and we are reaching a point where introduction and/or reintroduction has become a major discussion topic at each yearly Mitchell's satyr working group meetings.

With the assistance of Dr. John Shuey, we have developed a Mitchell's satyr reintroduction criteria and protocol flow-sheet (Figure 1). Two propagation facilities have been identified for captive rearing of Mitchell's satyr. We essentially decided on a "not to put all of our eggs in one basket" approach. The two facilities identified are the Toledo Zoo, Toledo, Ohio and the Kalamazoo Nature Center (KNC), Kalamazoo, Michigan.

The Toledo Zoo has been participating in Mitchell's satyr conservation with the Mitchell's Satyr Recovery Working Group (Working Group) since 2003. Working with the eyed brown (*Satyrodes eurydice*), a sympatric sedge-feeding species, Dr. Peter Tolson, Mitch Magditch, and former assistant Candee Ellsworth developed husbandry and breeding protocols that can be applied to the satyr. They subsequently bred Mitchell's satyr through several generations commencing in 2005. From 2006–2010 they investigated which species of wetland grasses and sedges are utilized by early-instar larvae as host plants. Their research reconfirmed that first instar Mitchell's satyr larvae will select and feed upon several different grasses and sedges, not all of which can support successful development. They identified six plants which support normal development until the third instar diapause in August including 6 sedges: *Carex-buxbaumii, C. lasiocarpa, C. leptalea, C. prairea, C. sterilis*, and C. *stricta* and two grasses*: Panicum implicatum* and *Poa palustris*,.

The Zoo received a grant to develop Mitchell's satyr rearing facilities. In October 2014 the new greenhouse facility for Mitchell's satyr propagation was constructed at the Zoo and has been stocked with the necessary equipment. With permission from Service and Michigan Department of Natural Resources, up to 300 Mitchell's satyr eggs from ten females were collected in July

DRAFT

2015. Larvae were hatched and reared in Bug-dorm tents as in previous years. Permit TE-106217-2 is current until 31 DEC 16.

Dr. Tolson and Dr. Magditch will lend their knowledge and assistance to Ashley A. Wick at the KNC who is gearing up to begin raising Mitchell's satyr at their newly constructed rearing facility. The first priority of these two facilities are to renew or secure the necessary federal and state permits to do the collection of eggs and rearing of satyrs.

Release Protocol

Larvae

With global warming arriving in Michigan and Ohio, we have faced a series of extremely hot summers with temperatures exceeding 90°F for extended periods in July and August. During at least two of these episodes, our Zoo experimental population of Mitchell's satyrs have not diapaused as fourth instar larvae, but have continued development to adulthood. These premature adults have reproduced, but the resultant second instar larvae have not over-wintered well, with a survival rate below 10%. We will rear at least 50% of larvae in environmental chambers to mitigate the risk of premature development. The environmental chambers provide a mechanism for controlling temperature and humidity more closely. If any larvae continue development into adulthood, we will release them at the original collection site.

Adults

Our goal is to successfully raise 100 adults from the initial target collection of 300 eggs from 10 females. If adults develop and eclose normally in the year following hatching and overwintering, they will be held at the Zoo until we have at least 20 butterflies for release, with at least 50% of the cohort composed of females. We will place non-sibling pairs in breeding groups in an attempt to get the females inseminated before release. The adult butterflies will be taken to release site(s) and released in habitat selected by staff of MNFI. Depending on the rate and synchronicity of hatching and sex rations there will likely be multiple releases of adults in 2016.

Post-release Monitoring – Evaluating the Fate of Reintroduced Satyrs:

Determining the success or failure of this satyr reintroduction program requires understanding the processes that affect re-sighting of released satyrs. Recaptures or re-sightings clearly demonstrate satyr survival; failure to recapture individuals does not necessarily indicate that the reintroduction attempt has been unsuccessful. The probability of recapturing a released satyr can be divided into distinct categories: mortality, movement out of the monitoring site, or failure of the observers to find the butterfly.

It is expected that the potential release of both larvae and adult organisms into apparently appropriate habitat will help ensure success. Re-sighting frequency of released individuals

DRAFT

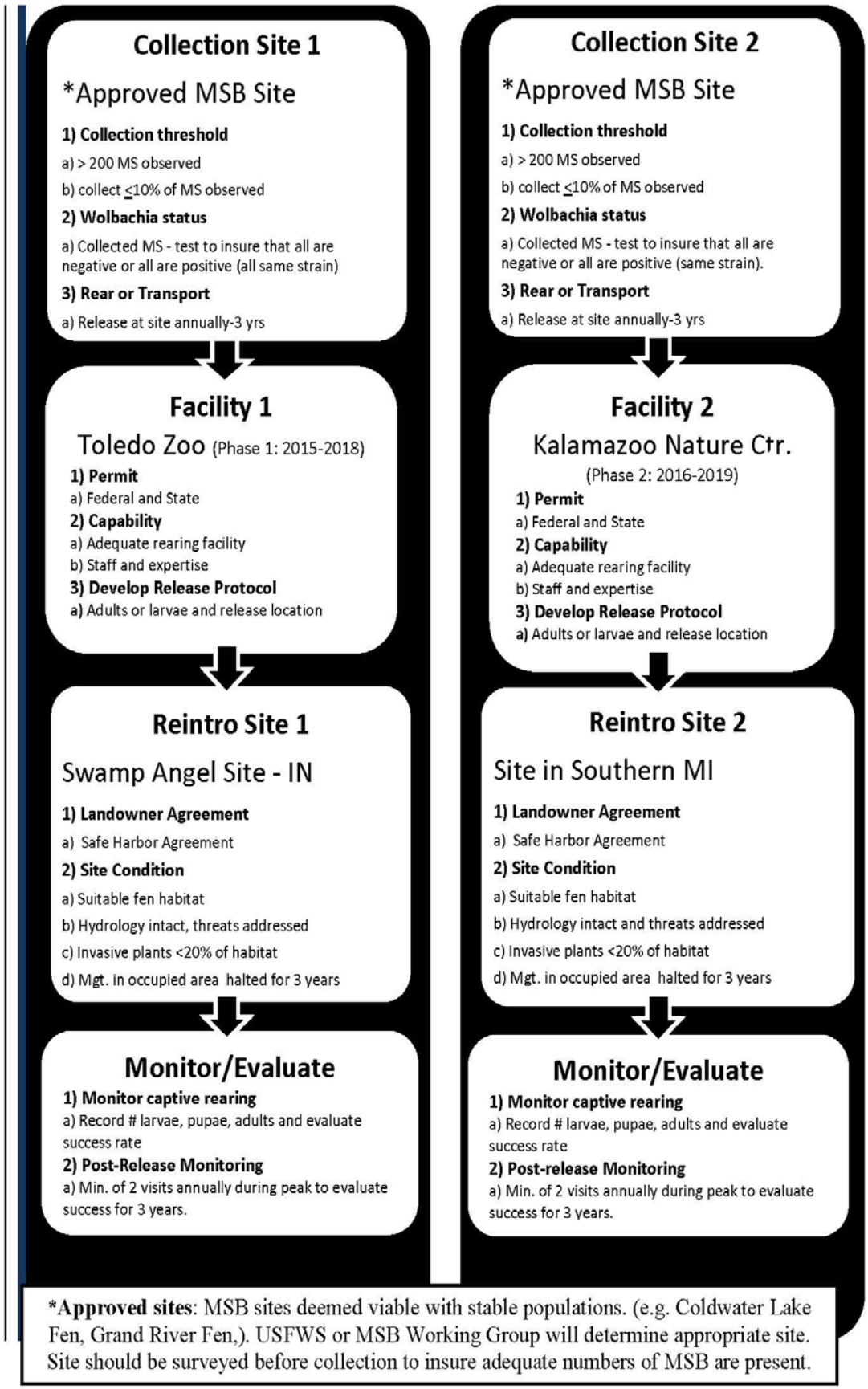
generally is expected to be quite low. Larvae are very difficult to detect amongst the sea of larval host plants. Adults very rarely nectar and have slow, bobbing flights low and amongst the vegetation and do not generally disperse very great distances (usually less than 50 m). As such, the low frequency of re-sightings should not immediately be equated to mortality.

We propose to assess the success of this reintroduction program by conducting a minimum of two visits to the release sites during the suspected peak adult flights, the year of the release, and up to three years after the last releases if resources are available. These visit dates will be collaborated with information on peak flights at the few remaining populations in southern Michigan, and could vary from year to year, but generally is from early to mid-July. Surveys will employ the protocol developed by Monfils and Cuthrell (2014) for the Poweshiek skipperling, another prairie fen associated butterfly (Appendix 1). A standard Mitchell's satyr survey form (Appendix 2) will be used when implementing the survey protocol.

DRAFT

Fig. 1. Recommended Criteria/Protocol for Mitchell's Satyr Introduction

Does not apply for Head-Starting (rear/release larvae in same year)



***Approved sites**: MSB sites deemed viable with stable populations. (e.g. Coldwater Lake Fen, Grand River Fen,). USFWS or MSB Working Group will determine appropriate site. Site should be surveyed before collection to insure adequate numbers of MSB are present.

Appendix 1 of Appendix B.

MICHIGAN NATURAL FEATURES INVENTORY
MITCHELL'S SATYR (*NEONYMPHA MITCHELLII*) SURVEY PROTOCOL

Acceptable Survey Conditions
Surveys should not be conducted when the temperature is below 15° C (60° F), during rain, or when winds exceed 25 km/h (15 mph). When temperatures are 15 - 21° C (60 - 70° F), cloud cover should be ≤50% of the sky. There is no cloud cover restriction if the temperature is above 21° C (70° F). If weather conditions deteriorate during a survey, observers should terminate the survey and resurvey the entire site on a suitable day. Be sure to note that the survey was ended on the data form and record the final weather conditions.

Survey Area
Mitchell's satyr surveys will be conducted at prairie fens with recent/historical occurrences and sites containing potential habitats. All open portions (canopy cover of mature trees <25% and/or tall shrubs [>1.5 m] <50%) of each site should be surveyed. Portions of the study sites with the following conditions can be avoided: (1) woody vegetation greater than the above thresholds or (2) invasive plant species (e.g., *Typha* [cattails], *Phalaris arundinacea* [reed canary grass], *Lythrum salicaria* [purple loosestrife], *Phragmites australis* [common reed]) combined area cover >50%.

Timing
Surveys can be conducted between 10 AM and 7 PM (EDT).

Survey Methodology
***Visual survey*:** Whenever possible, surveys should be done using teams of two people working together. The survey will consist of a series of transects paralleling the outer boundary of the prairie fen (or particular patch within a large fen or complex). The first transect will begin 5 m inward from the outer edge of the prairie fen wetland or patch. The second transect will be located 10 m inward from the first transect. The two surveyors will slowly walk parallel to one another along the first two transects until the entire periphery of the site has been surveyed. Then two new transects will be started inward from the first two, and so on, until the entire wetland or patch is surveyed. If it is not possible to have two surveyors, one person can conduct surveys using the same approach by surveying all transects separated by 10 m.

Butterfly counts: Each surveyor will look for and count butterflies within area 5 m to either side of the transect, 5 m forward along the transect, and 5 m above the transect (imagine a 10 m x 5 m x 5 m, box-shaped, survey area). Surveyors should walk at a steady, slow speed of approximately 35 m/min. When Mitchell's satyrs fly ahead of the observer, they can be ignored if the surveyor

DRAFT

is certain that the individual was already counted. If the observer is uncertain as to whether or not the individual was counted, it should be counted and considered a new individual. It will be important that team members communicate about Mitchell's satyrs moving between transects (e.g., individual counted by one team member that flies into the area being surveyed by the other team member).

***Waypoints*:** To facilitate an accurate count of Mitchell's satyr and collection of geospatial information, a waypoint should be collected for each individual Mitchell's satyr observed. For example, if five satyrs were seen in one area, five waypoints should be collected at the same location. Surveyors may need to move off of transects slightly in order to record waypoints. If you walk off of a transect to collect a waypoint, be sure to move back to the point where you left off before continuing on with the survey. The number observed should also be recorded on the data form (we suggest using "hash" marks) under the "total number detected" box.

***Mitchell's satyr observations*:** Record the number of Mitchell's satyrs detected by sex, activity and condition (i.e., wing wear) ranking. Using the same example of five individuals observed in one area, if two were male, two were female, and one the sex was uncertain, you would record those numbers in the appropriate boxes on the data form. The number of Mitchell's satyrs exhibiting particular behaviors or activities (e.g., flying, chasing, ovipositing) should be recorded on the data form in the same manner. We will rank the condition of Mitchell's satyrs according to the following 1–5 numeric scale presented by Watt *et al*. (1977): (1) freshly emerged, wings still damp; (2) wings and other cuticle dry and hard, no visible damage; (3) noticeable wear of scales from wings or body; (4) wings showing fraying or tearing in their cuticle; and (5) wings with extensive scale wear and cuticle damage. If no Mitchell's satyrs are observed during the survey of a site, write "None" in the box provided on the data form for "Total Number Detected."

Poweshiek skipperling Observations: If Poweshiek skipperling (*Oarisma poweshiek*) is detected during a survey, collect the same spatial, abundance, sex, and activity data in the same way as described above for Mitchell's satyrs. Be sure to denote waypoints used for Poweshiek skipperlings with a "P" (e.g., P01, P02, etc.), so they are not confused with satyr points.

Survey tracks: Each surveyor should have a GPS unit and should record their survey route or transects using the tracking function. Set the GPS unit to collect your location along the track at 30 sec intervals. Once your track has been recorded during the first visit to a particular site, the tracking function can be turned off during the second visit and the same tracks can be followed during the second survey. It will be critical that each surveyor download their survey tracks at the end of the season as an ArcMap shapefile to facilitate surveying the same routes in future years. Use the following naming format when saving your survey tracks: year_observer last name_satyr_tracks (e.g., 2014_smith_satyr_tracks). Waypoints collected for Poweshiek

DRAFT

skipperling locations should also be downloaded at the end of the season as a shapefile and named using a similar format: year_observer last name_poweshiek_locations (e.g., 2014_smith_poweshiek_locations).

Overall Butterfly Diversity: All butterfly species observed during Mitchell's satyr surveys should be listed on the data form used for each site. Because estimating relative abundance would be difficult for multiple species and likely to distract observers from surveying for the satyrs, observers should only note when the species of butterflies are seen and should not attempt to count species other than Mitchell's satyr and Poweshiek skipperling. We have attached a list of butterfly species that could be encountered in prairie fens in Michigan.

Weather: At the start and end of the survey, record the temperature (°C), percent relative humidity, cloud cover (expressed as the % of sky occluded), and maximum wind speed (km/h). If a survey needs to be terminated because of poor weather conditions, collect that same weather information at the time the survey is ended.

Site characterization: Observers will collect general information about survey sites during each visit, such as potential threats and nectar sources. At least one representative photograph should be taken of each survey site. Record file identifiers of the photographs on the data form. Pesticide use on agricultural lands near occupied sites could pose a threat to Mitchell's satyr survival, so we would like surveyors to record the nearest row crop field to the survey site using a GPS waypoint. Note the name of the waypoint and type of field (e.g., corn, soybean, wheat) on the data form.

Threats: Several potential threats to prairie fens and Mitchell's satyr are listed on the data form. Place a check mark next to all those that apply to the survey site. Potential threats not listed can be added to the form under "Other" in the space provided. For invasive plant species, rank the abundance of those species observed as dominant (D), abundant (A), frequent (F), occasional (O), or rare (R) on the data form. Invasive species not listed can be added to the form under "Other." Below is more specific guidance on using the DAFOR scale.

<u>Dominant (D)</u>: In practice, the dominant ranking is rarely, if ever used. To be scored as D, a species would have to be the most common plant by far, covering over 75% of the wetland. If you are not sure if a species should be scored as D, then assign it a score of A.

<u>Abundant (A)</u>: Only use A if the species is common in many parts of the wetland. For most species, this would mean that there are thousands of individual plants present. At most sites, few species will be ranked as A. If you are unsure if a species should be scored as A or F, then give it a ranking of F.

DRAFT

Frequent (F): Use F if you find a species at several places within the survey area and more than just a few individuals are present at each location. You could also use F if a plant species only occurs at one part of the site but is common at that location, with many individuals observed and a substantial area covered (e.g., between one eighth and one quarter of the site). If you are not sure if a species should be scored as F or O, then assign it a score of O.

Occasional (O): Use O for species that occur in several places in the wetland, but whose populations are small at those locations. You could also use O for species that are common at one location but occupy a small area (e.g., less than one eighth of the site). If you are not sure if a species should be ranked as O or R, then give it a score of R.

Rare (R): Use R for species that occur as a small number of individuals within the site. These individuals may be located in one place, or scattered over several locations within the wetland. If you are unsure if a species should be scored O or R, then assign it an R.

A list of possible nectar plant species for Mitchell's satyr is provided on the data form. Rank the abundance of each available (i.e., flowering) nectar species observed at the site using the same DAFOR scale described above for invasive plant species. Nectar sources not on the list can be added in the blank boxes provided on the form.

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Appendix 2 of Appendix B. Michigan Natural Features Inventory – Mitchell's Satyr Survey

SITE INFORMATION			
SITE:	DATE:	VISIT (1 or 2):	OBSERVER:

	Time (24-hr)	Temperature (°C)	Relative Humidity (%)	Cloud Cover (%)	Wind Speed (km/h)
START					
END					

PHOTOGRAPH NAMES (minimum of 1 per site):				

NEAREST ROW CROP FIELD	Waypoint Name/ Coordinates:	Crop Type:

COMMENTS:

SATYR SURVEY INFORMATION		
TOTAL NUMBER DETECTED	NUMBER BY ACTIVITY	NUMBER BY WING WEAR (see below)
	Nectaring	1
	Flying	2
NUMBER BY SEX		
Male	Perched	3
Female	Copulating	4
Unknown	Ovipositing	5

BUTTERFLY DIVERSITY (LIST ALL SPECIES DETECTED BELOW)	

POTENTIAL THREATS (CHECK ALL THAT APPLY)			
ALTERED HYRDROLOGY (ditching, tiles)		**INVASIVE PLANT SPECIES**	
LIVESTOCK GRAZING		**(rank abundance using DAFOR scale – see below)**	
ORV DAMAGE		**Lythrum salicaria (purple loosestrife)**	
HUMAN DEVELOPMENT		**Typha spp. (cattails)**	
SHRUB ENCROACHMENT		**Phalaris arundinacea (reed canary grass)**	
ADJACENT AGRICULTURE		**Phragmites australis (common reed)**	
OTHER		**Frangula alnus (glossy buckthorn)**	
		Other	
NECTAR SOURCES (rank abundance using DAFOR scale – see below)			
Rudbeckia hirta (black-eyed Susan)			
Lobelia spicata (pale spike lobelia)			
Triantha glutinosa (sticky tofieldia)			
Galium boreale (northern bedstraw)			
Apocynum cannabinum (dogbane/indian-hemp)			
Anticlea elegans (white camas)			
Pycnanthemum virginianum (Virginia mountain mint)			
Asclepias incarnata (swamp milkweed)			
Trifolium repens (white clover)			
Lilium philadelphicum (wood lily)			

Butterfly Condition Ranking:

1: Freshly emerged, wings still damp.
2: Wings and other cuticle dry and hard, no visible damage.
3: Noticeable wear of scales from wings or body.
4: Wings showing fraying or tearing in their cuticle.
5: Wings with extensive scale wear and cuticle damage.

DAFOR Scale Descriptions:

Dominant (D): In practice, the dominant ranking is rarely, if ever used. To be scored as D, a species would have to be the most common plant by far, covering over 75% of the wetland.

Abundant (A): Only use A if the species is common in many parts of the wetland. For most species, this would mean that there are thousands of individual plants present. At most sites, few species will be ranked as A.

Frequent (F): Use F if you find a species at several places within the survey area and more than just a few individuals are present at each location. You could also use F if a plant species only occurs at one part of the site but is common at that location, with many individuals observed and a substantial area covered (e.g., between one eighth and one quarter of the site).

Occasional (O): Use O for species that occur in several places in the wetland, but whose populations are small at those locations. You could also use O for species that are common at one location but occupy a small area (e.g., less than one eighth of the site).

Rare (R): Use R for species that occur as a small number of individuals within the site. These individuals may be located in one place, or scattered over several locations within the wetland.

APPENDIX. C.

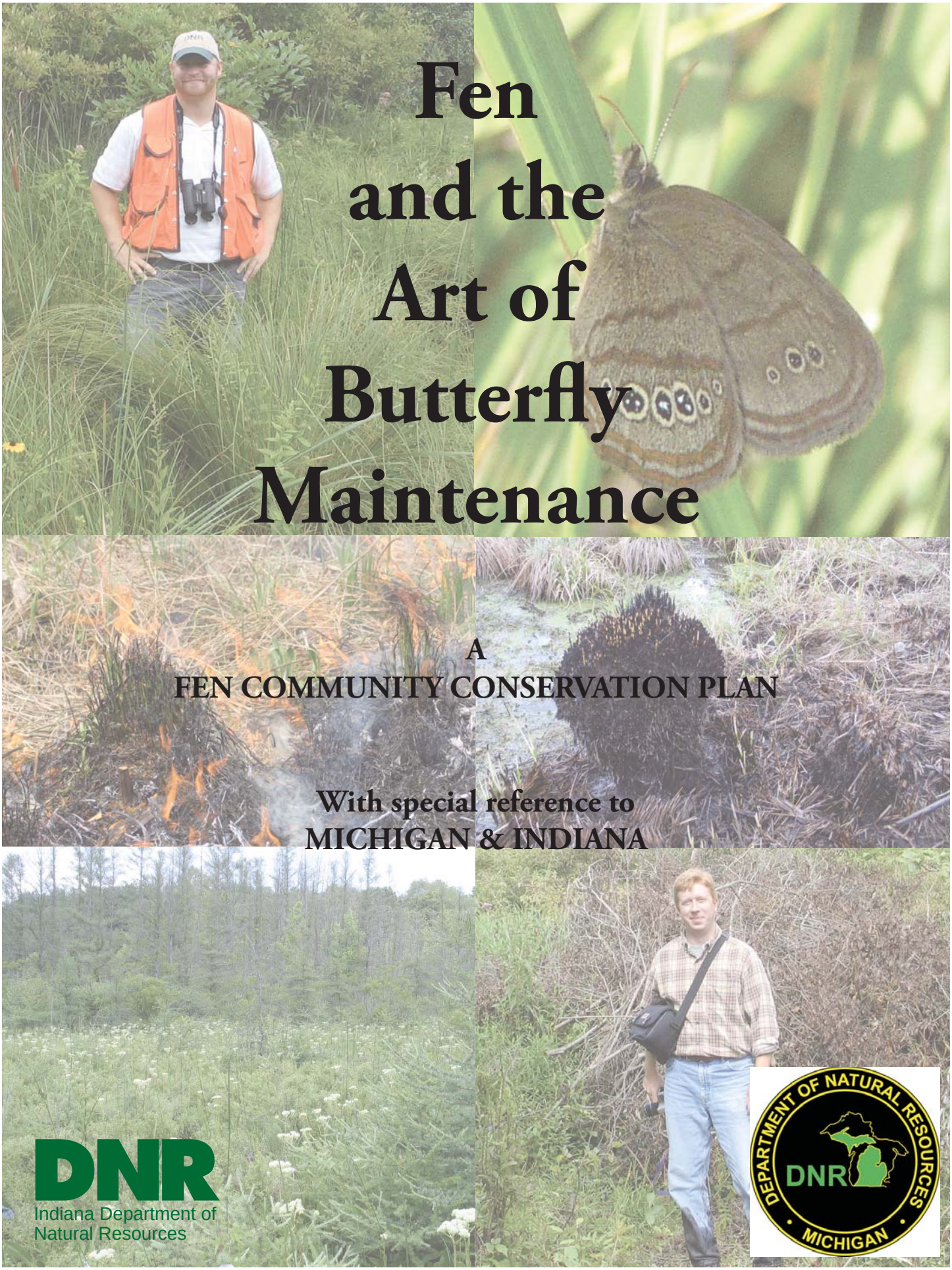
MNFI Matrix for Site Selection & Prioritization for Potential Mitchell's Satyr Reintroduction or Augmentation

PRIMARY CRITERIA	***DESCRIPTION***	***JUSTIFICATION***	***SCORING METHODOLOGY***	***DETAIL***	***Pts***
GIS analysis					
Size of Site	**Acres of fen habitat**	Larger sites can provide refugia from stochastic events and incompatible land use and may contain more varied microclimates and greater biodiversity.	Calculate size of fen polygon	Small-<10 ac	0
				Medium- 11-50 ac	2
				Large 51-150 ac	4
				Very Large >150ac	6
Condition, Quality	**Integrity of hydrology**- % of fen with intact hydrology (i.e not directly impacted by roads, ponds, ditching, drain tiles, etc.)	Intact hydrology is critical ecological process for maintaining fens and providing the proper microclimate for satyrs. Altered hydrology is linked to loss of species & vegetation change.	Buffer channelized streams, ditches and roads and calculate % of fen impacted	Highly Disturbed > 30%	0
				Medium Dist- 11-30%	2
				Low Disturbance-<10%	4
Local Matrix of Compatible Habitat	**Percentage of Undeveloped Land** within a 100 meter buffer around fen site.	Fens with a greater buffer of undeveloped land are less vulnerable to negative effects from nutrient loading, sedimentation, invasive species, grazing and ORV use.	Calculate % of land that is developed within 100m - Anderson layers (ag, res, comm, indust.)	< 10 %	0
				11-25%	2
				26-50%	4
				> 50%	6
Landscape Matrix of Compatible Habitat	Wetland is buffered **from agriculture, development and roads with natural community vegetation (2mi)**	Fens within a compatible habitat matrix are less vulnerable to threats to water quality and incompatible human activities.	Calculate % of land that is undeveloped within 2 miles – (Anderson layers)	<38%	0
				38-52%	2
				53-67%	4
				68-100%	6
Field analysis					
Condition and Quality	Native Fen Vegetation- **Percent cover of native vegetation**	The greater the % of native vegetation, the less impacted the fen is by non-natives and invasives which could out-compete the native flora.	Visit site and collect/estimate this data and/or review community field forms	<50%	0
				51-75%	2
				76-90%	4
				>90%	6
SECONDARY CRITERIA					***Pts***
GIS analysis					
Site Ownership	**Percentage of land that is public land or owned by a conservation organization**	Land in conservation ownership by a public or nonprofit organization is less vulnerable to incompatible land use and more likely to receive stewardship.	Calculate using CARL data layers of ownership supplemented with knowledge of sites not in CARL	0-25% public/cons. owned	0
				26 -50%% public/conservation owned	2
				51-75% - public or conservation owned	4
				>76% public/cons.owned	6
Distance to Occupied Site	**Distance of fen from currently occupied Mitchell's satyr site**	Sites closer to occupied sites have the potential to be reconnected	Calculate distance of fen polygon to satyr site polygon	> 5miles from occupied site	0
				1-5 miles from occupied site	2
				500-1600 m. from occ.site	4

				<500 meters from occ. site	6

Appendix E.

Fen and the Art of Butterfly Maintenance



Fen and the Art of Butterfly Maintenance

A
FEN COMMUNITY CONSERVATION PLAN

With special reference to
MICHIGAN & INDIANA

DNR
Indiana Department of
Natural Resources

DEPARTMENT OF NATURAL RESOURCES
DNR
MICHIGAN

Table of Contents

Table of Contents

1. Introduction A-1
2. Overview of Prairie Fens in Michigan and Indiana A-2
2.1 What is a fen? A-2
2.2 Landscape Context A-3
2.3 Physical Features A-4
2.4 Ecological Processes A-5
2.5 Biological Diversity A-8
3. Threats to Prairie Fens in Michigan & Indiana A-9
3.1 Loss of Landscape Integrity A-9
3.2 Loss of Ecological Processes A-13
3.3 Loss of Biological Diversity A-17
4. Goals and Objectives A-23
4.1. Maintain and Restore Fen Distribution and Context A-23
4.2 Restore or Mimic Natural Processes A-24
4.3 Maintain or Restore Native Biological Diversity A-24
5. Conservation Strategies A-24
5.1 Protect Prairie Fens A-24
5.2 Increase Public Awareness A-26
5.3 Incorporate Predicted Climate Change A-26
5.4 Protect and Restore Natural Surface and Ground Water Flow A-27
5.5 Minimize Adverse Changes to Water Quality. A-28
5.6 Use Fire as a Management Tool. A-30
5.7 Limit Grazing and Browsing A-31
5.8 Manage Invasive Species. A-33
5.9 Minimize Adverse Impacts of Recreational Activities. A-37
5.10 Reintroduce Missing Prairie Fen Components A-38
6. Monitoring, Evaluation, and Adaptive Management A-38
6.1 Continue Mapping and Monitoring to Assess Status and Health of Fens A-38
6.2 Conduct Active Research to Support Science-based Prairie Fen Conservation A-39
6.3 Adaptive Management A-40
7. Implementation A-41
7.1 Partner Participation A-41
7.2 Public Involvement A-41
8. Literature Cited A-41

Table of Contents

Appendix A-1 Fire Sensitivity and the Phenology of Rare Species A-1.1
Table 1. State Listed Plants of Prairie Fens in Michigan and Indiana A-1.2
Table 2. State Listed Animals of Prairie Fens in Michigan and Indiana A-1.4
Table 3. Hypothesized Plant Sensitivity to Fire.....A-1.7
Table 4. Hypothesized Animal Sensitivity to Fire A-1.9
Considerations and Caveats of the Fire and Species Phenology Tables..... A-1.13

Appendix A-2: Directions to Make your own Herbicide Wand..... A-2.1
Parts Required.....A-2.1
Tools/Materials Required.....A-2.1
Assembly Instructions A-2.1
How To Use the Wand A-2.2
Helpful Hints A-2.2

Appendix A-3: Methods and Guidelines for Assessing Restoration Progress in Prairie Fens Using Coarse-Level Metrics A-3.1
Introduction.....A-3.1
General Methods A-3.1
Guidelines for Field Estimates A-3.2
Establishing Management Units.....A-3.2
Supplies and Equipment.....A-3.2

Appendix A-4. Techniques and Timing to Manage Some Common Invasive Exotic Plants..... ..... A-4.1

Appendix A-5 Photo Credits A-5.1

Introduction

1. Introduction

Fens provide habitat for a disproportionate amount of our States' plant and wildlife species. The management of prairie fens in Michigan and Indiana is critical to the biodiversity of this region. This plan provides strategic and operational guidance to land managers who are responsible for prairie fen complexes. The plan is a tool to help managers to: 1) maintain or increase the existing number, area and distribution of functioning prairie fen complexes; 2) maintain, restore, and simulate ecological processes in prairie fens; and 3) maintain or increase native biological diversity and overall health of prairie fen complexes.

Diverse conservation partners collaborated to write this plan. The plan reflects a considerable investment of time and energy on the part of many federal and state agencies, non-governmental organizations, consultants and other private interests. It provides guidance to the many types of managers who have an interest in the conservation of prairie fen complexes in Michigan and Indiana.

Through its focus on landscape distribution, ecological processes, and biological diversity, the Fen Conservation Plan (FCP) provides a natural community context for the Mitchell's satyr and the Poweshiek skipperling Habitat Conservation Plans (HCP). The HCP outlines measures to avoid, minimize and mitigate (see definition of "mitigation" in HCP), take of the federally endangered Mitchell's satyr butterfly (Neonympha mitchellii mitchellii) and the federally endangered Poweshiek skipperling (Oarisma poweshiek) during management activities in occupied habitat. These measures are required for the issuance of an Incidental Take Permit (ITP,) pursuant to provisions of Section 10 of the Federal Endangered Species Act. The Fen Conservation Plan outlines goals and strategies for the conservation of fen complexes and their components, including Mitchell's satyr butterflies (MSB) and PS (PS); the HCP ensures that associated management activities will not jeopardize local MSB and PS populations.

This plan integrates a diverse collection of strategic plans that have been developed to guide natural resource conservation in Michigan and Indiana. Some of those plans include the Federal Recovery Plan for Mitchell's Satyr Butterfly (U.S. Fish and Wildlife Service 1998), the Indiana Wildlife Action Plan (Anonymous 2006), the Michigan Wildlife Action Plan (Eagle et al. 2005), and the Conservation Plan [for the] North Central Tillplain Ecoregion (The Nature Conservancy 2003). This plan will help implement these other plans by giving targeted direction, addressing key threats, and providing quantitative goals for prairie fens.

2. Overview of Prairie Fens in Michigan and Indiana

2.1 What is a fen?

A fen is a type of wetland. Groundwater is the main water source which is often recharged in areas miles from the fen itself (Figure 1.). In prairie fens, the groundwater has been in contact with calcium and magnesium rich soil or bedrock, which results in high mineral content and low plant nutrients (Bedford and Godwin 2003, Grootjans et al. 2006). Species associated with fens vary from region to region and from continent to continent, but fens worldwide share similar landscape contexts, plant communities, and conservation threats (van Diggelen et al. 2006). Fens are sedge-dominated peatlands, often with scattered trees and shrubs, and have greater species diversity than surrounding landscapes.

This plan is focused on what NatureServe (2008) defines as a North-Central Interior Shrub-Graminoid Alkaline Fen: a "fen system… found in the glaciated portions of the Midwest and southern Canada. Examples of this system can be located on level to sloping seepage areas, in pitted outwash or in kettle lakes associated with kettlekame-moraine topography. Groundwater flows through marls and shallow peat soils, and groundwater is typically minerotrophic and slightly alkaline. Examples of this system contain a core fen area of graminoids surrounded by scattered trees and shrubs. Herbaceous and shrub cover is variable with little to no tree cover. Characteristic species include prairie grasses such as *Andropogon gerardii* and *Spartina pectinata* with prairie forbs and sedges (*Carex* spp.). Common shrub species include *Dasiphora fruticosa* ssp. *floribunda*, *Cornus* spp., and *Salix* spp." (NatureServe 2008). In less technical terms, fens are unforested, grassy wetlands, and have muck soil with very hard water. The classification in Michigan is "prairie fen" (Kost et al. 2007) and "fen" in Indiana. The terms "fen" and "prairie fen" are used interchangeably throughout this Plan. Shrub-Graminoid Alkaline Fens occur in a band from the middle of Indiana to the middle of southern Lower Michigan. Other types of fen occur both north and south of this zone.

Experts who study community systematics define prairie fen in different ways. Some experts define fens only in terms of a particular subset of fen zones (see Sec. 2.5.1) or in terms of particular indicator species. Here a broader definition is adopted. For the purpose of this plan, fen includes the full range of zones from the inundated zone through the savanna zone. This plan also follows Kost et al. 2007 by differentiating prairie fen from forested wetland based on canopy coverage. Fens have less than 25% canopy coverage produced by mature trees or less than 50% canopy coverage produced by tall shrubs and trees. The definition is pragmatic because much of this plan concerns restoring prairie fen from forested wetland (usually shrub-carr).

Groundwater conservation is the key to fen conservation.

Fens are sedge-dominated peatlands, often with scattered trees and shrubs.

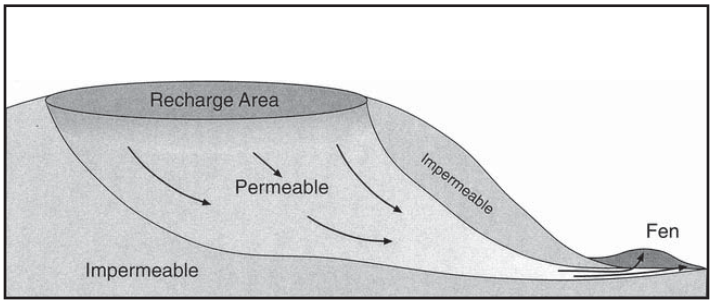


Figure 1. Fen hydrology includes recharge areas, which are often miles from the fen itself.

Overview

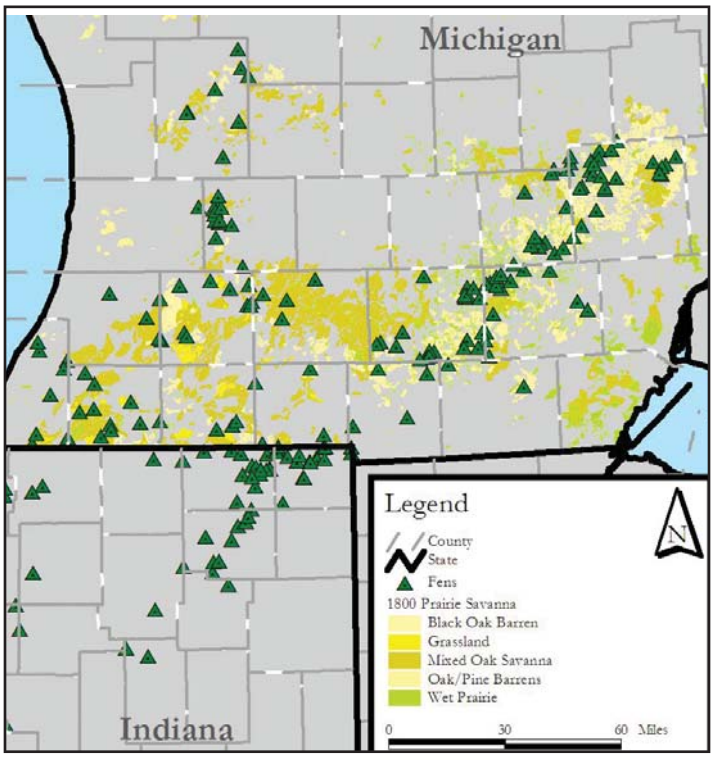


Figure 2. Prior to landscape changes associated with European American settlement, fens were often found in association with oak savannas and other fire dependent communities.

2.2 Landscape Context

Prairie fens occur throughout the Midwest on glacial outwash from Ohio and Ontario to Iowa and Minnesota (Amon et al. 2002). Historically, they occurred in the context of fire-dependent communities, such as prairie, oak savanna or oak woodlands (Figure 2). Today, they most often occur in the context of closed canopy oak forest or agriculture. Prairie fens rarely occur in isolation of other wetland communities, but rather form one type of wetland community within the context of emergent marshes, sedge meadows, and tamarack swamps. Increasingly, prairie fens are found as small fragments of landscapes dominated by shrub-carr or hardwood swamp. Fens are frequently found adjacent to lakes or along streams (Figure 3).

Prairie fens are ranked as a G3 community by NatureServe. They are deemed vulnerable to extinction or extirpation, both on a global scale and within Michigan and Indiana. In Michigan other G3 communities include prairies (dry sand, dry-mesic, and wet prairies) and dunes (open dune and dune/swale complexes). As of 2008, 142 prairie fens were known from Michigan and 66 fens from Indiana.

The distribution of prairie fens is determined by geomorphology and hydrology (Amon et al. 2002, Miner and Kettering 2003). However, prairie fens occur in the context of other natural communities and land uses. The integrity of prairie fens is dependent on the composition and configuration of surrounding communities and land use.

Prairie fens share species in common with prairies and savannas. By comparing circa 1800 land cover (Comer et al. 1995) and contemporary distributions of prairie fens in Michigan (Biotics database, MNFI, accessed 10/08/2009,) 89% of prairie fens in Michigan occurred within one mile (1.6 kilometers) of prairies or savannas (Figure 4). Many prairie/savanna species that are now found mainly within prairie fens (such as purple milkweed, *Asclepias purpurascens*) were once part of larger, contiguous populations that spanned both fen and surrounding uplands. For these prairie/savanna species, prairie fens represent small fragments or remnants of what were once much larger, unbroken habitats.

Similarly, prairie fens share many species in common with other wetlands in Michigan and Indiana. These wetland species were once connected, at least intermittently, to larger landscapes of wetlands. Populations of common wetland plants, such as tussock sedge (*Carex stricta*), occurred across many wet natural communities; these common plants were once parts of larger populations that are now separated by land uses that function as barriers to genetic exchange and dispersal.

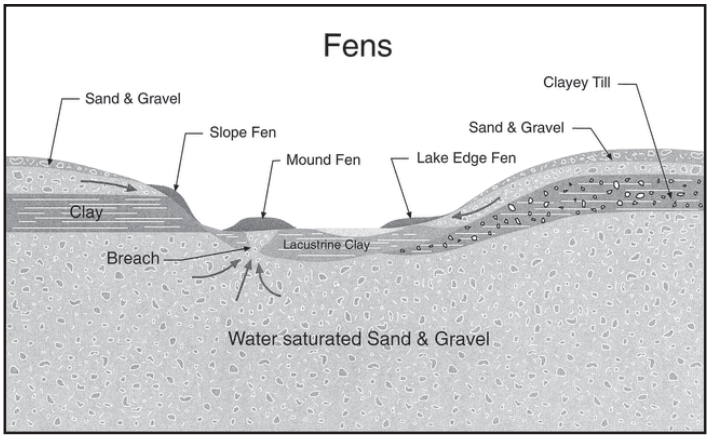


Figure 3. Different types of prairie fen occur in different parts of the landscape.

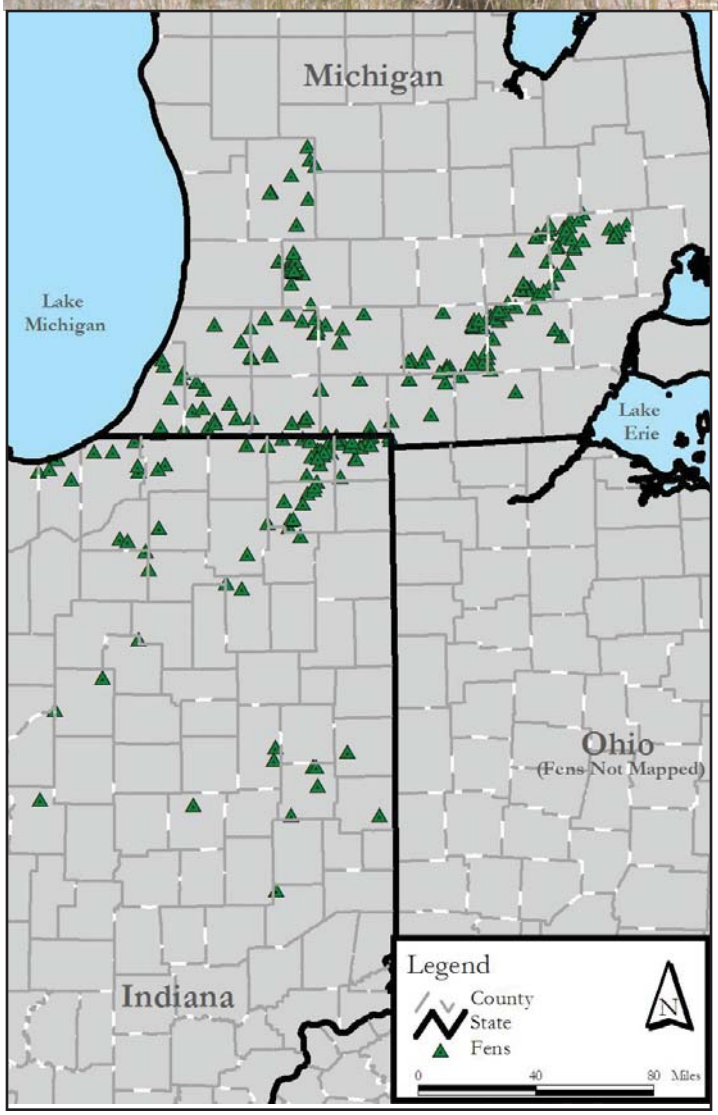


Figure 4. Fens occur in specific bands with rolling topography and coarse soils.

2.3 Physical Features

2.3.1 Geology and hydrology

Fens are peat wetlands that receive most of their water through groundwater (Bedford and Godwin 2003, Grootjans et al. 2006), as compared to bogs, which are peat wetlands that receive most of their water through precipitation. Prairie fens in the Midwestern United States occur on poorly drained outwash plains (Spieles et al. 1999, Kost et al. 2007). The hydrology of these wetlands is maintained through inputs of minerotrophic groundwater. This groundwater passes through coarse glacial deposits and picks up significant mineral loads. The resultant groundwater is cold, rich in minerals, low in plant nutrients, and has a high pH (alkaline).

The groundwater occurs near the surface of the fen, either through seeps or sheet flow. Most fens occur adjacent to steep hills and rolling glacial topography; however, many fens also occur as upwellings within otherwise level wetlands. Because fens are dependent on groundwater, precipitation events and droughts have little effect on the amount of water in fen soils. The water table in fens is remarkably constant and consistently high (Figure 5). The fen community evolved in a system that neither dries nor floods as much as other wetlands. Because fens so rarely dry, plant matter decomposes slowly and accumulates as peat, as in bogs, and similar to bogs, the lack of decomposition limits the availability of plant nutrients. The consistent high water table also limits most trees and shrubs from establishing in fens. For these reasons, groundwater conservation is key to the conservation of fens.

The groundwater that feeds fens is rich in ions, such as carbonates, magnesium and iron, which the groundwater picks up from the glacial outwash through which it percolates. However, plant nutrients, such as nitrogen and phosphorus, are naturally limited in fens. The terminology of prairie fens as “rich” fens can be confusing. In other contexts, “rich” connotes soils high in plant nutrients. Prairie fens are “rich” in plant diversity and ions in the water, but are naturally poor in the key plant nutrients of phosphorus and nitrogen (Wheeler and Proctor 2000, Bedford and Godwin 2003).

Prairie fens are unique among wetlands in that they often have a discernible slope. With the exception of upwellings, the lowest part of the slope ends in an emergent marsh, stream or lake. In contemporary prairie fens, the lowest part of the fen is often the most open; shrubs and trees become more common higher on the slope. Historically, fires burning from the prairie and savannas probably thinned trees and shrubs along the fen margin, and the zones from open to wooded fen were probably less pronounced.

2.3.2 Regional climate

Prairie fens occur in a narrow climate range. The combination of precipitation and temperature prevents soil evaporation from exceeding groundwater inputs. Where prairie fens occur, precipitation is high enough and temperatures are low enough for saturated peat to accumulate. This peat accumulation is balanced by temperatures that are high enough and precipitation low enough to foster a prairie or savanna landscape context.

Prairie fens in Indiana and Michigan occur across a climatic gradient from the warmer and wetter middle of Indiana to the cooler and drier middle of Michigan's Lower Peninsula. Temperatures for this region are: average January minimum 13° to 19° F (-7° to -11° C); average maximum July 83° to 87° F (28° to 31° C); with 11–16 days with maximum temperatures above 90° F (32° C); and 113–160 days with minimum temperatures below 32° F (0° C). Precipitation for this region is: average annual total of 34–45 inches (86–114 cm); and average annual snowfall of 18–86 inches (46–218 cm).

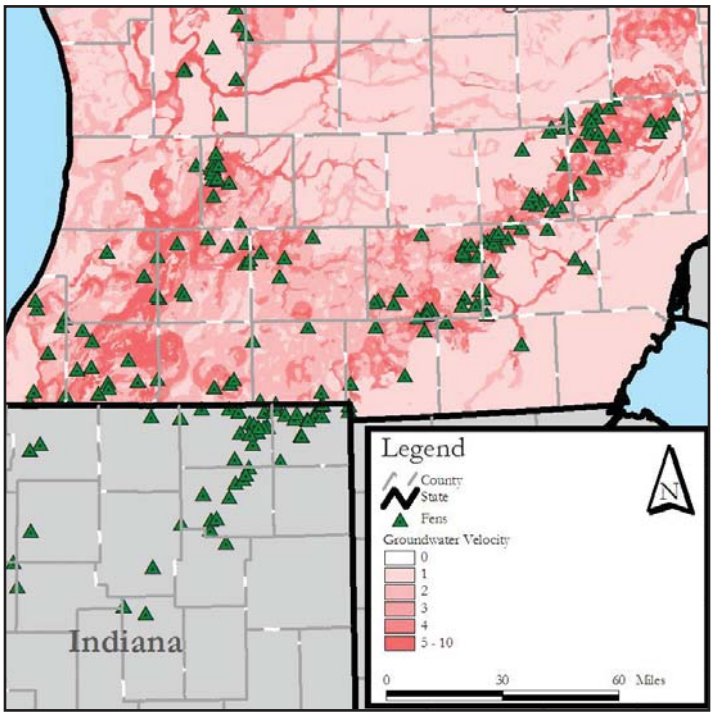


Figure 5. Fens are associated with high velocity groundwater, as predicted from the "Darcy model" for Michigan.

2.3.3 Microclimate

Fens have a microclimate that sets them apart from the surrounding landscape as they consistently have a higher humidity. Visitors to fens often remark that they feel hotter in the summer. The constant groundwater near the surface also dampens extremes in humidity and temperature, both on a daily and seasonal basis. Relative humidity near the soil surface is more consistently damp, compared to greater swings in humidity from dry to wet in adjacent ecosystems. Soil temperatures do not get as warm or as cold as the soils in surrounding ecosystems. Fen soils rarely freeze, which limits use of heavy mechanized equipment in management, even during exceptionally cold winter weather.

2.3.4 Microtopography

One of the dominant plants in fens is the tussock sedge (*Carex stricta*). Tussock sedges produce new vegetation on top of older plant growth to form characteristic pillars, or tussocks. These tussocks provide a variety of different niches for fen vegetation (Figure 6). Each tussock has a moisture gradient: saturated near the peat and drier toward the top. Each tussock also experiences a full range of daily sun exposures: southern sides tend to be warmer and northern sides tend to be cooler. These various zones provide unique moisture and aspect niches and result in high plant and insect diversity. Furthermore, the presence of tussock sedges increases the surface area of fens, which can be used by a diversity of plants, insects and other animals.

2.4 Ecological Processes

Ecological communities are maintained by the frequency and extent of disturbances or ecological processes. When the frequency and extent of ecological processes change, communities change. This change is often called "succession." The frequency and extent of processes that historically produced and maintained prairie fen communities have changed, and those changes are resulting in widespread conversion to more common and less diverse ecological communities, such as shrub-carr and hardwood swamp.

Unless hydrology or grazing regimes are altered, intact fens do not proceed through the typical successional

trajectory of old field to forest, or do so very slowly. The groundwater inputs to most fens in Michigan and Indiana have been altered, and most have experienced grazing, to a greater or lesser degree. These fens will experience a successional trajectory to shrubland, and maybe to hardwood swamp, unless woody vegetation is managed appropriately.

2.4.1 Wildfire and aboriginal burning

Large, landscape fires were common in southern Michigan and Indiana before settlement by European Americans (Chapman 1984, Nuzzo 1986, Whitney 1994). These fires burned both uplands and adjacent wetlands, including prairie fens (Kost et al. 2007). Indeed, many of the plants of prairie fens compete poorly with trees and shrubs, and only persist in areas that are kept free of such woody vegetation through saturated soil, fire, or other ecological processes (Spieles et al. 1999, Kost et al. 2007).

Fens exist worldwide in a specific geomorphology that creates a constant input of groundwater at the root zone of plants (Amon et al. 2002, Gootjans et al. 2006). Thus, hydrology appears to be the primary ecological process structuring fens. However, the prairie character of fens in Michigan and Indiana is derived from a landscape context of prairie and savanna communities. Fire and climate interacted to structure prairie and savanna ecosystems (Whelan 1995, Anderson 2006).

The presence of prairie flora in most extant prairie fens indicates that they were associated with prairies and savannas. Maps of pre-settlement vegetation (Comer et al. 1995) also show savannas near or adjacent to modern fens. Wetlands in general burn less often and less intensely than surrounding uplands, but this pattern does not hold for fens. Fire intensity observed in modern fens can be similar to fire intensity on prairies and savannas. The morphology of *C. stricta* tussocks holds fine fuels suspended in the air column, which makes the fuel drier and more flammable. Thus, fens will often burn when surrounding uplands will not, and fens are especially flammable when surrounding uplands will burn. Natural fuel breaks, such as marl seeps, springs, and streams, likely caused fens (especially larger fens) to burn in a mosaic with frequent skips and unburned areas.

Fire has profound effects on many ecological services, including vegetation structure, plant diversity, predator/prey dynamics, herbivory, plant reproduction, and nutrient cycling

> *Fens existed within a prairie and savanna landscape that burned frequently.*

(Whelan 1995). As one of the oldest ecosystem management tools, humans have created a large store of knowledge in applying fire to achieve specific fire effects, which can be found in the scientific literature (Whelan 1995, Panzer 2002, Andrew and Leach 2006, Middleton et al. 2006b, Langford et al. 2007) and in management guidance (Anderson et al. 2001, O'Connor 2007). A useful entry into the voluminous literature on fire effects is the U.S. Forest Service's Fire Effects Information Service (http://www.fs.fed.us/database/feis/). By altering the ignition pattern, season of the burn, etc., a fire might, for example, stimulate woody vegetation or set back woody vegetation. Because fire effects vary and the results of a burn are complex, profound, and (usually) predictable, fen managers who employ this tool should have either detailed knowledge of fire effects in fens or they should work with prescribed fire professionals who can craft prescriptions to meet specific management goals.

2.4.2 Beaver floodings

Intermittent flooding by beavers (*Castor canadaensis*) has been posited as one ecological process that maintained the open character of prairie fens and maintained habitat for some rare species within fens, including the Mitchell's satyr butterfly (USFWS 1998). The historical and recent effect of beaver activity on fens is complex.

The beaver is a keystone species and ecosystem engineer (Naiman et al. 1988, Jones et al. 1994, Wright and Jones 2006). Beavers will build dams to impound riparian areas and create emergent marsh, often at the expense of other wetland communities (Naiman et al. 1988). These dams are often temporary, and impoundments will revert to wet meadow before returning to shrubs or forest. The shifting mosaic of emergent marsh, wet meadow, and forest can create a landscape that increases habitat for amphibians (Cunningham et al. 2006) and grassland birds (Askins 2002),

changes biogeochemical dynamics (Naiman et al. 1994), and increases overall species richness (Wright et al. 2002). One early surveyor and geologist estimated that "fully one-fifth part" (~20,000 acres) of the landscape surrounding Detroit was affected by beavers (Hubbard 1887 quoted in Whitney 1994). Beaver activity increases overall landscape heterogeneity (Remillard et al. 1987). Concerning wetland and especially wet meadow communities, beaver activity decreases isolation, an important metric of landscape fragmentation.

Historically, beaver activity in Michigan and Indiana affected the landscape context of prairie fens by decreasing the distance between patches of grassy wetland. However, floodings created by beavers probably had little effect on prairie fens themselves (Figure 6). Fens are distinguished from other wetland types, in part, in their remarkably stable, flood resistant, water table (Amon et al 2002, Grootjans et al. 2006). Fens often occur high in watersheds and usually have a discernible slope, two characteristics avoided by beavers, which usually impound areas low in watersheds and with little slope (Cunningham et al. 2006). Beaver also appear to avoid areas subject to regular fire (Cunningham et al. 2006, Hood et al. 2007), which might discourage their activity in prairie and savanna landscapes. For these reasons, beaver activity probably existed in and around fens, but at levels lower than in the landscape as a whole.

Figure 6. Unlike emergent wetlands, fens are not created by beaver activity. Beaver activity can set back woody vegetation in fens.

Contemporary beaver activity is more closely associated with prairie fens. Many fens now exist in landscapes with little or no fire management. Large, level areas that might have been used by beavers in the past have now largely been converted to other land uses, most notably urban development and agriculture. Fens, which are often remote and less visited by people, are not ideal habitat for beavers, but they are available habitat. Several privately-owned fens managed through the Michigan Landowner Incentive Program have or recently have had beaver activity in or (more often) adjacent to the fen (C. Hoving, personal communication). A similar pattern is evident at the Fort Custer Military Training Center in southwestern Michigan (M. Richards, personal communication). Beavers can destroy small fens through persistent flooding (Reddoch and Reddoch 2005), but the small and ephemeral floodings in southwestern Michigan appear to set back woody shrubs, including buckthorn, in the landscape surrounding prairie fens.

> *Beavers do not create fens, but their floodings can set back woody succession.*

2.4.3 Grazing and browsing

The flora (and fauna) of prairie fens evolved in a landscape rich in herbivores. Grazers, such as bison, musk-oxen, moose, caribou, elk, and horses (Holman 2001) fed primarily on grasses and sedges; whereas browsers, such as deer, camelids, mammoths and mastodonts selected forbs and twigs of trees and shrubs (Holman 2001). At the end of the Pleistocene Era the diversity of large herbivores decreased markedly, coinciding with the extinction of most large predators, and fire became more prevalent (Anderson 2006).

Prior to European American settlement, white-tailed deer (*Odocoileus virginianus*), elk (*Cervus elaphus*) and bison (*Bison bison*) were present and locally common in Michigan and Indiana (Allen 1942, Seton 1929, Whitney 1994). These species were common to savannas and prairies, but their use of peatlands, such as fens, is unknown. Grazing by bison

and elk had profound effects on the structure of ecological communities where they occurred (Steuter 1997, Anderson 2006). However, early observers noted that bison were poorly adapted to cross wetlands (Seton 1929). Small feet, short legs, and the heavy bodies of bison make them poorly adapted to deep snow (Tefler and Kelsall 1984), and would have been a similar liability in the wet peat soil of prairie fens. Even humans, with foot-loadings 2-3 times less than bison, can become mired in prairie fens.

Domesticated livestock grazed in many fens in the 1800s and the early 1900s. Pigs, sheep, and cattle were a significant force in maintaining an open landscape in this era (Whitney 1994), and may have contributed to seed dispersal across the landscape (Middleton et al. 2006a). Grazing by sheep and cattle maintained an open landscape, but grazing at the intensity necessary to suppress woody vegetation may have had a negative impact on species of plants that are sensitive to grazing. Grazing in prairie fens facilitated later shrub invasion of these wetlands. Deer populations in the region were locally extirpated or very low during this era (Whitney 1994).

Since the mid-1900s, grazing in fens by livestock has lessened, but deer populations have increased dramatically. These shifts from 1) little grazing or browsing to 2) high grazing pressure from livestock and then to 3) high browsing pressure from deer has affected plant communities, invasive species, and successional trajectories in prairie fens (Figure 7).

Figure 7. Deer populations have increased dramatically resulting in increased browsing pressure on prairie fen plant communities.

2.4.4 Insect/disease outbreak

Insect outbreak is a minor process within existing prairie fen communities. However, it can be a significant process when it causes high levels of tree mortality in nearby rich tamarack swamps (relict conifer swamps) or upland oak forest. Tamarack trees are shade intolerant, and like many shade intolerant species, are adapted to periodic, stand-replacing disturbance. Outbreaks of the native larch sawfly (*Pristiphora erichsonil*) and eastern larch beetle (*Dendroctonus simplex*) and the invasive exotic tamarack casebearer (*Coleophora laricella*), occur periodically. These infestations cause a synchronized death of mature trees, thus opening the seedbank to full sunlight and conditions in which shade-intolerant tamaracks can successfully compete.

Disease outbreaks and the open canopy also cause a significant build-up of fine and coarse fuels. Disease outbreaks probably interacted with periodic fire to lengthen the time that particular areas remained open prairie fen. The interaction may have competitively favored tamarack over red maple (*Acer rubrum*), other hardwood trees, and many common shrubs.

2.5 Biological Diversity

Prairie fens deserve special conservation status and management effort because they contain a disproportionate number of rare, threatened, and endangered plants and animals compared to their number and size (The Nature Conservancy 2003). Maintaining healthy fens is an efficient way to conserve a wide variety of species on a relatively small amount of land.

2.5.1 Vegetation

Prairie fens comprise about 4790 acres or 0.01% in Michigan, but provide habitat for 5% of the threatened or endangered plants in the state. Fens in Indiana comprise 0.005% of the state, but provide habitat for 2% of the state's listed plants (See Appendix A-1, Table 1). Fens in Michigan and Indiana thus have 500 (MI) and 300 (IN) times more rare species than the average acre of land in that state. This is a minimum estimate of diversity of rare plants in fens. When all records of rare plants in and near fens are considered, the proportions are considerably higher. Of the

362 plant species classified as threatened, endangered or special concern in Michigan, 26% of the species (94) occur on or near one of the prairie fens. Thus, management dollars invested in the health of fens and their surrounding lands protects a disproportionately large number of threatened and endangered plants.

Although some common plants exist throughout much of the fen, many plants can be found in distinct zones (Kost et al. 2007). These zones exist along hydrological and chemical gradients, and include from wettest to driest: an inundated flat near the lake or stream margin, a sedge meadow, and a wooded zone that often grades into rich tamarack swamp. Many fens also contain sparsely vegetated marl flats where groundwater is particularly calcareous. All zones do not occur in all fens.

2.5.2 Animals

The diversity of rare animals in fens is similar to that of plants. Prairie fens in Michigan comprise 0.01% of the state, but provide habitat for 5% of the listed animals in the state. Fens in Indiana comprise 0.005% of the state, but provide habitat for 1.6% of the state's listed animals (both vertebrates and invertebrates) (Appendix A-1,Table 2). When all records are considered, 25 (or 24%) of the animal species occur on or near a prairie fen in Michigan. Similar to plant diversity and conservation, management dollars invested in the health of fens protects a disproportionately large number of threatened and endangered animals.

Fens provide habitat for many insects and reptiles. The insects use the high diversity of plants and unique microclimate that fens provide. Reptiles use fens for a variety of needs; the presence of moving groundwater near the surface is especially important for hibernating snakes, such as the eastern massasauga rattlesnake (*Sistrurus catenatus catenatus*).

Those that hunt for turkey and deer in fens know that fens are used by game animals as well. Fens often occur as grassy openings in otherwise dense swamps, and provide especially valuable nesting and fawning areas for turkeys and white-tailed deer. Fens are rarely visited by humans, and offer a unique and quality recreational opportunity.

2.5.3 Fungi, protists, bacteria and viruses

The bulk of biological diversity in any ecological community, including fens, is microscopic. This diversity is fungi, protists, bacteria, and viruses. The importance of these organisms in the function of ecological communities is only recently becoming apparent. The diversity of mycorrhizal fungi, for example, may be a determinant of plant diversity (van der Heijden et al. 1998, Bever et al. 2001), and viruses may mediate the invasiveness of exotic plants (Malmstrom et al. 2005). No rare fen-dependant microorganisms are currently listed in Michigan or Indiana, probably because survey data and benchmarks are lacking for these organisms. However, given the high proportion of rare plants and animals in healthy, functional fens, it is reasonable to assume that these fens also support rare microorganisms. Conservation mycologists promote community-level conservation as a surrogate for conserving individual species of rare fungi (Staley 1997, Courtecuisse 2001).

3. Threats to Prairie Fens in Michigan & Indiana

Threats to fens are diverse, interrelated, and often interconnected. Like taxonomy of species, threats defy classification, or at least defy agreement on classification schemes. Threats in this plan follow a hierarchical approach in which broad-scale; high-level threats are discussed first, followed by threats to ecological processes, and then specific threats to species, genotypes, and genetic diversity.

3.1 Loss of Landscape Integrity

Landscape level threats to fens include human attitudes toward wetlands, land use change, habitat fragmentation, and climate change. These processes occur over large areas or over long periods of time. As such, these threats are not always included in plans because changes to these high level threats are beyond the power of individual land managers to address with short-term plans. However, these threats provide an important context to realistic

management and planning. Including these threats also highlights the importance and need for broader scale solutions for decision-makers at the state, national, and international level.

3.1.1 Social attitudes and land use changes

Fens provide society with many benefits (Bragg and Lindsay 2003). Fens are a kind of peatland, and peatlands worldwide account for 70% of the carbon stored in biotic systems (more than all upland forests and grasslands combined). Thus, fens play a key role in regulating global greenhouse gases and climate. Intact fens purify water, keep sediments out of streams, and reduce flooding downstream. The constantly cold groundwater of fens can provide habitat to cold water fish, such as trout. People value biological diversity and desire to see rare species preserved. Prairie fens are highly diverse and provide habitat to many endangered species, far out of proportion to their acreage on the landscape. Finally, prairie fens are aesthetically valuable. The colors of fens are diverse and vary with the seasons, from wildflowers in spring and summer, to fall foliage, to the rolling tussocks under winter snow. Fens are valuable to society in many ways, but many citizens do not yet recognize that those things they value are concentrated in prairie fens.

The vast majority of citizens in Michigan and Indiana could draw a forest or a prairie by the time they are in grade school. Most adults would be challenged to provide even a rough sketch of a "fen." Those who have encountered fens often have a negative experience; either because they encounter poison sumac, have difficulty walking the uneven terrain, or are frustrated that the property is not drier and more amenable to recreation, agriculture, or development. Ironically, many people avoid fens out of a fear of mosquitoes and biting insects, which are less common in fens than other wetlands because of the scarcity of standing, stagnant water.

> *Fens are small parts of the landscape with a high proportion of the State's endangered species.*

Figure 8. Because of their small size, lack of open water, and lack of surface water input, fens are poorly protected from draining and development protection, especially under federal wetland regulations.

A lack of public appreciation for prairie fens and the benefits they provide can impede efforts to generate support for conservation efforts. Even worse, negative attitudes can lead to actions that directly threaten prairie fens (Figure 8.). Some of these actions can include many of the conservation threats noted in other sections, including: habitat fragmentation, over-grazing, introduction of invasive species, water quality changes, or interruption of groundwater dynamics, or neglect of needed management.

Ecological historians have noted that landscapes are social constructs (Cronan 1996). Thus, the pattern of land use surrounding and impacting prairie fens is a social phenomenon, and the long-term persistence of prairie fens and their surrounding landscape will depend on society's awareness and value of prairie fens and their landscape context.

3.1.2 Habitat loss and fragmentation

In Michigan, approximately 50% of the state's wetlands have been converted to upland. In Indiana, the estimate is that 86% have been lost (Dahl 1990). Across the Midwest, 99.98% of oak savannas have been lost (Nuzzo 1986). Urbanization has eclipsed agriculture as the main

Threats

Historically, draining of fens for agriculture and development were the greatest threats to fens.

cause of wetland loss in many partsof the country (Syphard and Garcia 2001). Indeed, conversion of agricultural land back to wetlands under the Farm Bill and programs like the Landowner Incentive Program has resulted in a net increase in wetlands nationwide in recent decades (Dahl 2006).

Much of the loss and fragmentation of natural communities is the result of poorly planned development (Paskus and Hyde 2006), but the loss of beaver flooding dynamics has also isolated populations of some common wetland plants and animals from each other. This loss of wetlands, prairies, savannas, and intermittent beaver floodings has isolated populations of plants and animals now found in prairie fens.

Fragmentation of habitat affects many species, and is not limited to edge-sensitive species, such as forest-interior birds (Wilcove 1987, Ewers and Didham 2006, Cozzi et al. 2008). Edge is only one measure of fragmentation. Other important aspects of fragmentation include habitat area, edge, shape complexity, isolation, and matrix quality (Ewers and Didham 2006). Even common wetland plants can be adversely affected by fragmentation (Hooftman and Diemer 2002).

The quality of non-habitat matrix can affect biological diversity within patches of habitat. A prairie fen isolated in an agricultural landscape will support fewer fen species than a fen in a more intact landscape of prairie, savanna, and other wetlands. Recent research on fen dependent butterflies in Europe has shown that the proportion of non-fen, non-habitat wetland on the landscape around a fen predicted the presence of three fen dependent butterflies. The effect was less strong than altitude, but stronger than management regime (Cozzi et al 2008).

The loss of wetlands, prairies, and savanna in the landscape surrounding prairie fens can have direct and indirect negative effects on vertebrates in prairie fens. The eastern massasauga rattlesnake and eastern box turtle (*Terrapene carolina carolina*) use fens and adjacent uplands and wetlands to complete their life cycle. However, rattlesnakes will rarely cross improved roads (Shepard et al. 2008) and turtles face significant mortality when trying to cross roads (Gibbs and Shriver 2002). This direct effect of fragmentation on the survival or movement of animals is probably shared by other species of reptiles, amphibians, and some invertebrates, such as snails.

Habitat fragmentation compounds other conservation threats. Fragmented landscapes alter groundwater recharge and could cause fens to become drier. Invasive species disperse along roads that fragment the landscape. Fragmentation limits the ability of many plants and animals to disperse in the wake of climate change.

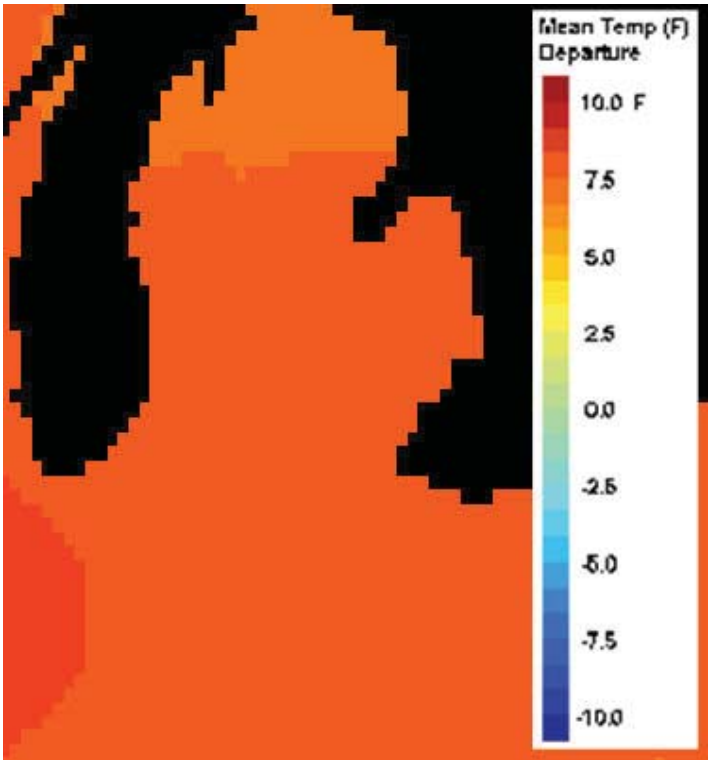


Figure 9. Predicted temperature change by 2080. This prediciton is from the median model. Half of all models predicted greater temperature change, half predicted less extreme change. All models predicted an increase in temperature. Map created by The Nature Conservancy's Climate Wizard.

3.1.3 Climate change

Human-induced climate change is recognized to exist (IPCC 2007) and is increasingly recognized as a threat to native biodiversity (Hannah et al. 2002, Green et al. 2003, Thomas et al. 2004, Lovejoy and Hannah 2005) (Figure 9.). Impacts to biodiversity are predicted to be most severe:

1) in regions where climate changes more than the global average,
2) on species with limited distributions, or
3) on species with limited abilities to disperse.

Extinctions rates could be greater than one-third for regions or species sensitive to climate change (Thomas et al. 2004). These exacerbating circumstances apply to many species found in fens, including the Mitchell's satyr butterfly.

Managers and planners struggle to adapt to climate change (Inkley et al. 2004). Our usual approach to conservation threats is to remove the threat or to buffer the conservation target from the threat. Climate change is not within any one manager's ability to control. Nor can a manager buffer prairie fens from climate change. Instead managers must seek to adapt conservation plans to consider a climate that will change, while communicating to other policy-makers the importance of reducing the human-induced causes of climate change. Climate can be measured in many ways. For the purpose of this Plan, three variables will likely have the greatest impact on fen conservation and management: changes in temperature, changes in precipitation, and changes in carbon dioxide concentrations.

The mean temperature in Indiana and Michigan is expected to warm from 5° – 20° F by 2100 (Kling et al. 2003, IPCC 2007). As noted in Section 2.2.2, prairie fens currently exist within a mean temperature range of 4° – 6° F. Thus, in 100 years, the climate of the northernmost prairie fens will be slightly or extremely warmer than the climate now existing in the southernmost fens. At first glance it appears that, in the long term, prairie fens cannot be preserved within their current geographic range. However, climate is not the only determinate of ecological communities. During periods of climate change in the past, species moved at widely variable rates (Pielou 1992), and microclimates (such as cold groundwater seeps) could provide a refuge for rare species.

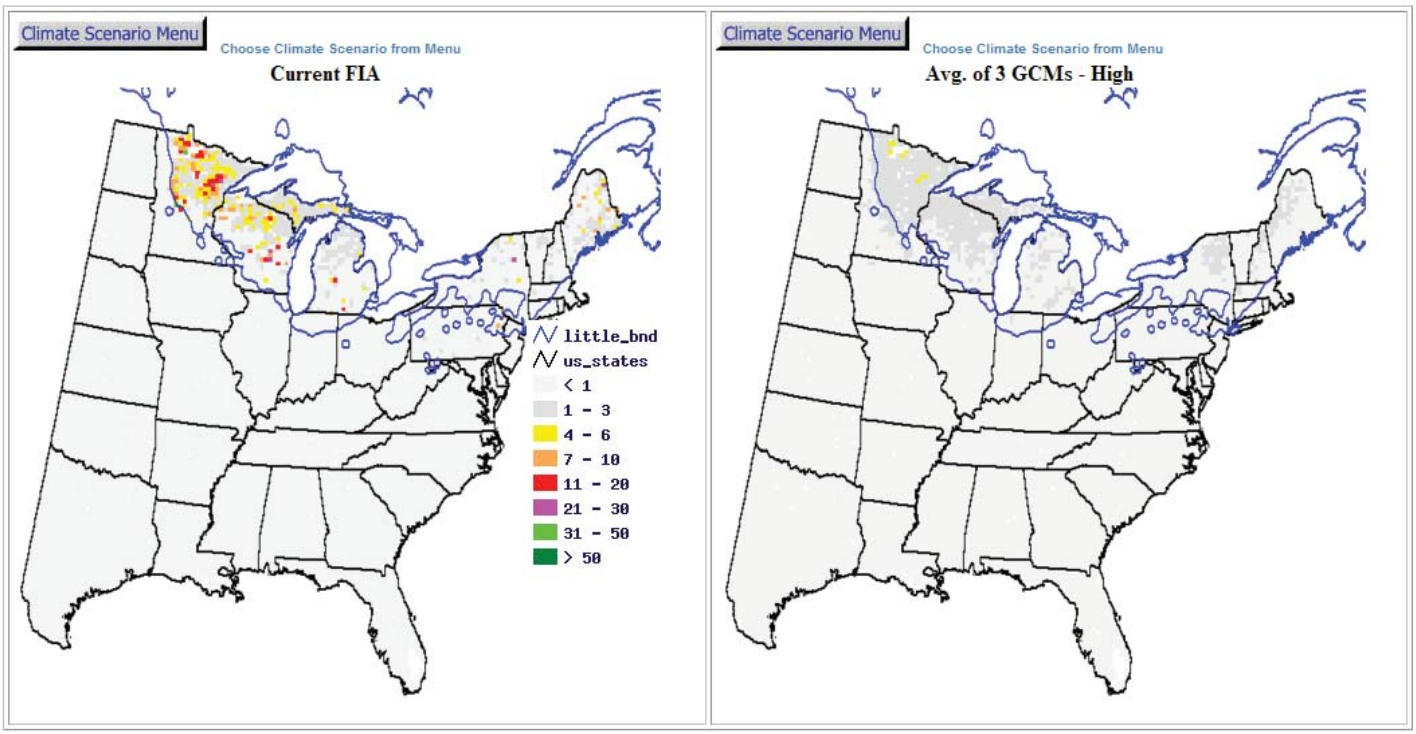


Figure 10. Current (left) and predicted future (right) climate envelopes for tamarack, an important tree species often found in prairie fens. Although coarse analyses such as these are grim for many fen species, groundwater may preserve suitable microclimates in fens, independent of changing air temperatures (Prasad et al. 2007).

Cold groundwater may make fens a refuge for many species threatened by climate change.

Cold groundwater may make fens a refuge for many species threatened by climate change when most vegetation is dormant (IPCC 2007). Because of higher temperature and changed seasonal patterns of precipitation, soil moisture during the growing season is expected to decrease. Models of tree species response to changes in temperature, precipitation, soil moisture, and growing season length are discouraging for the future of tamarack in Michigan and Indiana (Figure 10). However, precipitation pattern changes should affect wetlands with groundwater recharge less than wetlands with surface water recharge because surface waters will be more prone to evaporation. Reduced hydraulic potential from decreased groundwater inputs, at least during the summer, could change fen hydrology and change succession patterns by favoring woody shrubs and trees (Siegel 2006).

As climate changes, some species of plants and animals within the fen will find themselves in a less than optimum climate. These plants and animals will be stressed and will compete poorly with other species, especially introduced species that will be better adapted to the changing climate. This process will occur progressively over a number of years. For any given fen, the result will be that invasive species will become increasingly invasive and native plants will become increasingly poor competitors.

Climate change as a threat to specific species or ecological communities is only beginning to be recognized. While there are many unknowns regarding ecological effects, the certainty regarding the actual changes to climate is increasing. Climate change will likely have a synergistic effect with other conservation challenges, amplifying the effects of habitat fragmentation and invasive species especially.

3.2 Loss of Ecological Processes

3.2.1 Altered flow of ground water and water quality

Fens exist as relatively nutrient poor wetlands with a constantly high water table. Changes in the quantity, seasonality, or chemistry of water entering and flowing through fens are a major threat to these ecological communities.

Most fens worldwide have an altered hydrology and are too dry (Bragg and Lindsay 2003). Many fens exist in landscapes where the flow of groundwater has been changed. The potential causes of these changes are diverse, but include ditching in agricultural landscapes, gravel mining, pond creation, or more subtly through the proliferation of impervious surfaces like asphalt and lawn. A current trend in rural property development is to dig ponds (legally in upland areas or illegally in wetlands) where the water table is shallow. When dug near fens, this may disturb springs, alter groundwater dynamics, and increase evaporation, and thus cause drying of the fen (Figure 11).

Drier conditions cause peat formation to cease. Even small hydrological changes can cause peat to begin to decompose, thus releasing many nutrients to the soil and

Figure 11. The water in fen wetlands arrives underground. Intercepting this water in ditches or ponds can seriously degrade adjacent fens.

large amounts of greenhouse gases to the atmosphere. Small changes toward a drier hydrology can shift plant communities toward less diverse sedge meadows or facilitate the invasion of exotic plants.

Even as many fens have less groundwater input, they also experience increased surface water flow and flooding. Wetland destruction elsewhere on the landscape and the proliferation of impervious surfaces has caused streams associated with fens to become warmer and more prone to flood events. These floods can introduce sediment and reduce the tussock micro topography unique to fens. Another threat to fens is permanent flooding from poorly designed roads (small or perched culverts) or poorly planned wetland management. Overzealous property owners or managers sometimes mistake fens that lack open water for degraded (silted in or drained) emergent marshes. They then impound water over prairie fens that had no history of open water, and replace a rarer, more diverse wetland with a more common, less diverse wetland.

The quantity of water in fens is not the only water-related threat. The quality of the water is also threatened. Two aspects of water quality are especially important to fens: sediments and nutrients. The two are related in that sediments are the main source of problematic nutrients. Fens exist in peat soils, which have a high organic content and little to no mineral soil or available nutrients. Poor land management elsewhere in the watershed often results in significant erosion and flooding in fens. The flood waters deposit a layer of mineral sediment over the organic peat. This sediment has profound effects on the plant community: the fen seed bank is buried and a novel soil type and seeds are introduced. Sedimentation of fens facilitates invasion of fens by exotic plant species.

Figure 12. Groundwater in prairie fens is often so full of calcium and magnesium that it precipitates as "marl." Where they occur, marl flats are one of the more obvious features of prairie fens.

Sources of sediment to fens vary. Sediments can also be introduced to the fen through drains from adjacent roads or agricultural fields or from sheet flow across adjacent roadways and agricultural fields themselves.

Another potential source of sediments is the forested hillsides surrounding the fen. Fens are often surrounded by steep bluffs of glacial deposit, which usually consist of gravel, sand, or other coarse sediment. Historically, these coarse deposits would have been drought and fire prone, and the vegetation would likely have been grasses and wildflowers typical of prairies or savannas. The fine, deep roots of these prairie plants would have held the steep hillsides in place more efficiently than the closed canopy forest and ephemeral spring vegetation surrounding many modern fens. Thus, restoring the natural fire regime in the fen and surrounding landscape should improve water quality in the fen.

Nutrients can enter the fen though many vectors. Nutrients can be introduced to the fen water and by sediments. Thus, flooding, erosion, ditching, and road runoff are all contributors of nutrients. Fens often occur in rural areas where most residences are served by septic systems. Nutrients can leach from old, poorly designed, or ineffective septic systems in the fen watershed (Szymanski and Shuey 2002). Accidental releases of manure from confined animal feeding operations (CAFOs) are also a potential threat to nearby fens. Like individual septic systems, the primary issue with CAFOs is not the facility or the development itself, but rather poorly designed or poorly implemented manure management plans. Poor fertilizer management (in lawns, golf courses, or agricultural lands) can also impact local waterways and wetlands, including fens.

The diverse plant and animal community that comprises the prairie fen has evolved to thrive in extremes of alkalinity, low nutrients, and constantly saturated soils. This highly alkaline, low nutrient environment depends on high water quality (Figure 12). Even small changes to the water quality and nutrient availability in prairie fens can have profound negative consequences for the fen itself. The prairie

Fire played a complex role in fens historically. In contemporary landscapes, it is an important conservation tool.

fen community exists because many of the organisms in this community can only compete in a low nutrient environment. An increase in nutrient loads to the fen facilitates invasion of the fen by invasive plants. This invasion results in a simplification of the vegetation community, a shift toward monocultures, and a loss of biodiversity (see section 3.3.1. on Invasive Species for more details).

3.2.2 Altered fire regimes

By one measure of conservation need, the world's temperate grasslands, including the oak savanna and prairie landscape around fens, are the most imperiled biome on the globe. Temperate grasslands have seen more conversion and are less protected than any other biome. By this measure, savannas require conservation more than arctic tundra or tropical rainforest (Hoekstra et al. 2005). One reason (of many) for the conversion of grasslands to other types is fire suppression. Although many grasslands are maintained through environmental extremes (very wet, very dry, very acid, or very basic soils) or other disturbance regimes (grazing, high winds, frequent beaver flooding), fire has been a major determinant of the landscape distribution of grasslands until recently (the past 100 – 200 years).

The lack of fire in grassland landscapes, including fens, has allowed many historically open grassy wetlands to convert to shrubs or forest. Most fires that occur within the geographic range of the prairie fen are wildfires. They are ignited accidentally or maliciously, without planning for safety, control, and smoke management. These wild fires are appropriately suppressed, sometimes at a significant cost to society.

The conversion of fens to shrub-carr or forested wetlands reduces habitat for many species, including shade-intolerant plants, birds and mammals that prefer an open or semi-open habitat structure, and reptiles and amphibians, which depend on sunlight to regulate their body temperature. Plants, such as the small white lady slipper (*Crypripedium candidum*) and poikilotherms ("cold-blooded" organisms), such as the eastern massasauga rattlesnake and the Mitchell's satyr butterfly, are often the first species to disappear from fens when ground level sunlight becomes restricted by shrubs and trees.

Direct mortality of rare animals from prescribed fire is a concern to many conservationists, who worry that aggressive use of prescribed fire may act more as a conservation threat than conservation strategy. Fire effects on rare species are sometimes negative (Panzer 2003, Durblan 2006, Swengel and Swengel 2007), sometimes neutral (Andrew and Leach 2006) and sometimes positive (Panzer 2002, Pickens and Root 2009) (Figure 13). An extensive review of fire related literature in the Great Lakes region concluded that fire effects across many taxa of animals was species-specific and varied by timing, burn extent, and pattern (Roloff and Doran, In Prep).

Figure 13. Many species, such as this box turtle, are insensitive to fire during some seasons and extremely sensitive during other seasons.

Grazing regimes in fens should be changed with caution and only with careful planning.

3.2.3 Altered grazing and browsing regimes

The effects of all herbivores on prairie fens are not the same. Invertebrates differ from vertebrates. Browsers eat more woody plants and flowering plants, and eat less grass and sedges. Grazers concentrate on grasses and sedges, and consume less woody vegetation or flowers.

Grazers

Is the long-term composition of plant communities dependent on large, vertebrate grazers, such as bison and elk? Can cattle grazing mimic grazing by native herbivores, or is grazing by domestic livestock itself a threat? As discussed in the Overview, grazing by large vertebrates was probably minimal prior to settlement, and thus, the lack of large vertebrate grazers does not pose a conservation threat. Many of the ecosystem services provided by grazing are also provided by fire, including greater light penetration to the seedbank and the creation of spatial and temporal heterogeneity within the fen. Because grazing by bison was probably minimal, cattle grazing in fens probably do not mimic a previous natural process. Finally, the degree to which grazing is a threat or useful management tool will likely vary from fen to fen. Grazing by cattle changes the successional pathway of prairie fens (Middleton 2002) and is thus not appropriate for fens that have not been grazed upon previously (Middleton et al 2006b). In fens with little or no grazing history, hydrology and fire are sufficient to limit the encroachment of woody vegetation. Grazing by cattle damages the tussock and soil structure of fens, and allows woody vegetation to invade. Continued grazing will suppress the woody shrubs, but when livestock are removed from the system, the suppressed woody shrubs rapidly shade the native fen vegetation (Middleton 2002).

Livestock should not be used as a management tool in fens without a documented history of grazing. Grazing damages fens. However, once grazing has occurred, the damage is done. Ceasing grazing (at a low to moderate animal stocking density) then becomes a conservation threat, unless considerable resources are available to control invasive plants and woody vegetation (Figure 14).

In fens where grazing occurred and has now ceased, both woody and herbaceous invasive plants become problematic. They often out-compete native plants by growing taller and shading nearby native vegetation. In comparing fens grazed by livestock at low intensity to fens where grazing had ceased, the actively grazed fens had significantly more native grasses, sedges, forbs, and mosses and significantly less tall woody vegetation; actively grazed fens also had significantly shorter invasive plants compared to formerly grazed fens (Tesauro and Ehrenfeld 2007). Thus, re-initiating grazing may be a valuable management tool to control invasive plants, when and where other management tools are either unavailable or are deemed too expensive.

Figure 14. The soft ground of fens is inappropriate for livestock grazing. Fens already damaged by livestock grazing can be grazed lightly in late summer or fall to manage woody vegetation and invasive species.

Browsers

In contrast to grazing, the historical and contemporary levels of browsing in fens are better established. White-tailed deer make use of fens for food and as escape cover. Deer trails are ubiquitous in prairie fens, and it is likely that these patterns of use have not changed greatly over the past several thousand years. The numbers of deer, and subsequent browsing pressure, however, have changed through time. Prior to European-American settlement, deer populations were abundant, although less abundant than contemporary populations. Unregulated hunting and commercial exploitation reduced populations dramatically by 1900, when deer were extirpated from much of northern Indiana and much of southern Michigan (Bartlett 1937). Restocking efforts were initiated in Michigan and Indiana in 1934. Through careful management, deer populations rebounded. By mid-century deer populations were abundant enough that protections on antlerless deer (females and 0.5 year old males) were removed in some counties in Michigan (Ryel et al. 1980, Langenau 1994). Deer populations continued to increase and deer are considered to be overabundant throughout the range of prairie fens in Indiana and Michigan. In northern Indiana, deer populations are consistently 5% – 10% above desired levels. In southern Michigan, the estimated population in 2005 (868,000) was 53% above the 1999 goal (566,000). Heavy deer browsing can significantly decrease plant diversity in grassland systems (Anderson et al. 2005). Thus, the presence of native browsers in prairie fens is not a conservation threat, but their current population densities do constitute a significant threat to the biological diversity of prairie fens.

Invertebrates

Most species of herbivores in prairie fens are invertebrates. Relatively little is known of their historic or current role within the prairie fen community. Herbivory by invertebrates only constitutes a threat when related to invasive exotic invertebrates, such as the tamarack casebearer (*Coleophora laricella*).

3.3 Loss of Biological Diversity

3.3.1 Invasive species

Invasive species cause significant economic and environmental damage in the United State and around the world. Non-native invasive species cause an estimated $120 billion dollars in economic losses in the United States, annually (Pimental et al. 2005). These economic damages include decreased crop yields, loss of rangeland, damage to lawns, death of shade and ornamental trees, termite damage to structures, and mussel damage to electrical power plants. Invasive species are the second leading cause of biodiversity loss, after direct habitat destruction, and over half of the species listed under the federal Endangered Species Act are threatened in whole or in part by invasive species (Wilcove et al 1998).

Invasive non-native species pose a grave threat to biodiversity (Vitousek et al. 1997, Simberloff 2005). Although each new invasive may temporarily and locally increase species richness, the long-term and broad-scale effects on species richness are generally negative (Simberloff 2005). Furthermore, biodiversity is not a simple measure of the number of species in an area, but includes genetic, species, and ecosystem diversity (Gaston and Spicer 2004).

Wetlands are threatened by more non-native plants than uplands, and invasive plants in wetlands are more likely to cause monocultures (Zedler and Kircher 2004). Prairie fens in Michigan and Indiana are not an exception, and are threatened by a wide array of invasive plants and insects (Spieles et al. 1999, Eagle et al. 2005, Anonymous 2006, Kost et al. 2007; Table 3).

Invasive species are most often a problem in natural communities that have been disturbed in some way by human activities. Most fens worldwide have been subjected to some form of disturbance, either indirectly through landscape changed in hydrology, changing climate, CO2 fertilization, and historic use as pasture for livestock (Bedford and Godwin 2003, van Digglen et al. 2006). In theory, at least, a few invasive species are capable of invading and damaging high-quality, "undisturbed" ecological communities. Non-native species invasions occurred repeatedly in geological history as land bridges formed between North America and Eurasia, causing widespread loss of native flora and fauna before humans were present on this continent (Flannery 2001).

Focus on Invasive Plants

Eurasian buckthorns

(Rhamnus cathartica and R. fragula)

Buckthorns invade fens, even those that are relatively undisturbed. Glossy buckthorn is a problem in fens more often than common buckthorn. Buckthorns are a fast growing tree that can spread rapidly. Adult buckthorns create a deep shade that kills most native fen vegetation. They are also efficient nitrogen fixers. The leaves are rich in nitrogen and will greatly accelerate decomposition of vegetation and eliminate fuel for fire. The nutrient enrichment of the soil paves the way for other invasive plants to invade what is otherwise a nitrogen limited ecological community. Adult buckthorn are not sensitive to fire, but fire is often a necessary tool to manage buckthorn invasions, especially expression of the buckthorn seedbank.

Narrow-leaf cattail

(Typha angustifolia) and hybrids

Narrow-leaf cat-tail is a significant and rapidly spreading threat to prairie fens. Narrow-leaf cat-tails can form dense monocultures that decrease the area available to native plants. Because cat-tail leaves and stems are highly succulent, they do not burn well when green and monocultures can preclude growing season burns. Cat-tails respond quickly to changes in nutrients, and are a good indicator of water quality issues. Invasion can also indicate a slight (or not so slight) drying of the soil, either from climate or changes in the groundwater.

Narrow-leaf cat-tail hybridizes with native cat-tails (*T. latifolia*) easily. Hybrid cat-tails (*T. x glauca*) can be as invasive as or more invasive than pure narrow-leaf cat-tail. Recent surveys of genetic material from several National Parks in the Great Lakes failed to find pure native cat-tail individuals, except in Voyageurs National Park. They found only narrow leaf cat-tail and hybrid cat-tail (Travis et al. 2006). The native cat-tail may be extirpated from the geographic range of prairie fens in Michigan and Indiana. **All cat-tail populations in prairie fens now should be considered invasive hybrids and should be monitored. They should be managed if they show signs of invasion.**

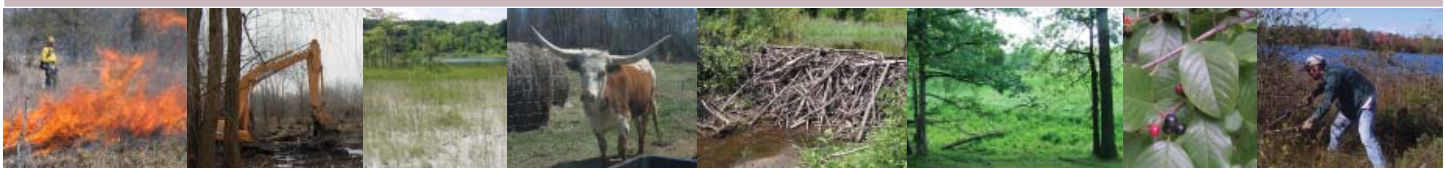
Focus on Invasive Plants

Reed canary grass
(Phalaris arundinacea)

The status of reed canary grass as an invasive native or exotic species is uncertain. Many strains are invasive over a wide variety of conditions (Galatowitsch et al. 1999). Reed canary grass spreads rapidly via seed and rhizome, and quickly forms a monoculture. In wetlands, reed canary grass is difficult to control without damaging the fen community. This species should be monitored and managed when only scattered individuals are present. Multiple years of follow-up are often necessary because the seedbank persists. Fire may help keep the species out, but does not harm established populations. Repeated herbicide applications are the most efficent management tool.

Multiflora rose *(Rosa multiflora)*

Multiflora rose is a rapidly growing shrub that is native to Europe. It is commonly used as an ornamental, a wildlife food. Native roses do grow in fens, but lack the curved thorns and "beard" at the base of each leaflet. Multiflora rose will be set back by fire,. Herbicide treatment is effective, but painful.



Focus on Invasive Plants

Japanese knotweed
(Polygonum cuspidatum)

Japanese knotweed is currently invading southern Michigan, and has not yet been detected invading fens in this region. However, in the United Kingdom, it is listed as the invasive plant that most threatens fens in that country. For this reason, Japanese knotweed should be considered a serious potential threat to fens in this region. Herbicide is the best management tool, and often must be repeated for several years. Pieces of plant material will root in moist soils. Mechanical treatment is discouraged.

Purple loosestrife *(Lythrum salicaria)*

Purple loosestrife is invasive in prairie fens and will form monocultures. However, a biological control, beetles of the genus *Galuracella* has been released widely in southern Michigan and northern Indiana. The Galuracella beetles can disburse naturally across the landscape, and many fens now have small Galuracella beetles in the fen or nearby. For this reason, loosestrife invasions of fens are becoming less common.

However, where beetles have not naturally dispersed, or where introductions have failed, further reintroductions should be encouraged. At one Mitchell's satyr butterfly site where beetles were introduced, the loosestrife population has continued to expand.

Focus on Invasive Plants

Japanese barberry *(Berberis thunbergii)*

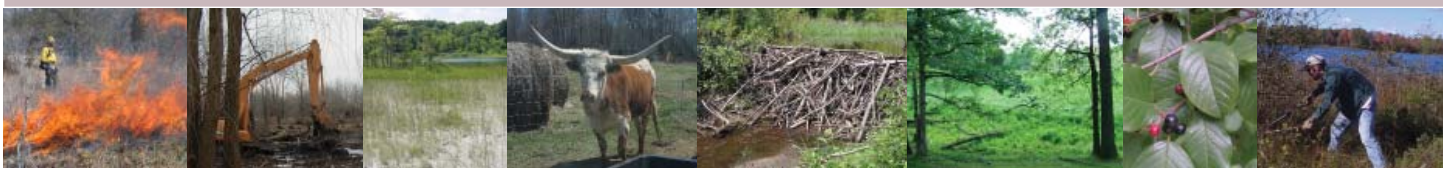
Japanese barberry is a widely planted ornamental shrub. Birds and small mammals spread the berries to natural areas. The ecology of barberry invasions is similar to buckthorn. The barberry vegetation shades nearby vegetation and adds nitrogen to the soil, thus decreasing plant diversity and fuel for fires. Problematic invasions of barberry have been found in only a few fens, but this may change as more barberry shrubs are planted as landscaping.

Phragmites or Common Reed *(Phragmites australis)*

Phragmites may be the most widely distributed flowering plant on Earth, and is native to every continent except Antarctica. The genetic strain from Eurasia is invasive on other continents, and tends to form extensive, dense monocultures, which displace native wetland vegetation. Native phragmites occurs in fens; the invasive strain is a serious threat to fens.

Invasive phragmites differs from native phragmites in several ways. No one character is diagnostic, but the combination of characters is useful. Invasive phragmites has:

1) greater height (greater than 8 feet),
2) blue-ish green vegetation
3) higher stem density
4) thicker stems
5) a denser, bushy plume
6) vertical ridges around the stem
7) leaf sheaths that stay on the stem through winter
8) lack a red chestnut color near the base
9) lack stem spots



> *Invasive plants often indicate other threats, such as water contamination or past grazing.*

For these reasons, invasive species should be considered a significant threat to all fens, and not only those that have been impacted by other conservation threats, such as draining, overgrazing, or water pollution.

3.3.2 Incompatible recreational activities

Fens are not commonly used for recreational activities. The uneven terrain, lack of mineral soil, presence of poison sumac (and sometimes rattlesnakes), and constant high water table discourage use by motorized or non-motorized vehicles. In conversations with private landowners in the Landowner Incentive Program, the recreational activities most often mentioned are hunting, fishing, and wildlife viewing. Fens are also visited by entomologists, herpetologists, and botanists interested in finding or collecting rare specimens of various taxa. As long as these recreational activities are conducted in accordance with the law, these activities are not considered a threat to the health of the fen.

Incompatible recreational activities are those that have either a short- or long-term negative impact on the ecological function of fens. These include off-road vehicle (ORV) use, horse use, and snowmobiling. There may be manners and intensities of these recreational activities that are compatible with fen management, but considerable alterations to the normal recreational activity would be necessary. These incompatible recreational activities become less compatible with increasing intensity of use. For example, one snowmobile crossing a fen over deep snow with a well-developed base is unlikely to cause damage. A trail with high traffic volume on marginal snow conditions is likely to affect hydrology through ruts, damage vegetation, and introduce invasive plants from other areas.

Off-Road Vehicles (ORVs)

ORVs which serve as all-terrain vehicles, are wheeled vehicles supporting 3 or more wheels, and are capable of negotiating rough terrain. Some definitions also include motorcycles in this group as they have similar capabilities. In fens, ORVs are capable of crushing vegetation, compressing and disturbing soils, disturbing hummocks, and suppressing revegetation. Impacts are magnified when ORV use is repetitive over the same trails or areas. Impacts are primarily on habitats and communities, although crushing and killing state or federally listed insects and plants is possible.

ORV use on adjacent uplands has the potential to increase erosion into the fens. It also impacts plant communities that support corridors between habitat sites, and facilitates invasions of exotic plants. The removal of vegetation by ORV use can also contribute to greater water runoff and lesser water recharge into the soil. This phenomenon can also contribute to increased soil/water temperatures within the fen.

Horse Use

Horse activity within fens is similar to ORVs. It has the potential to crush vegetation, compress and disturb soils, stir soil organic and inorganic components, disturb hummocks, and suppress revegetation. Impacts are also magnified with increased activity. In addition through their droppings, horses can inadvertently introduce exotic plant species to fen, especially because soil disturbance by horses' hooves predisposes the trail to exotic plant invasion. Horse activity can have impact on adjacent upland similar to ORV impact. However, horse activity is generally assessed to have lesser impact than that from ORVs.

Snowmobiling

Snowmobiling can have impacts to fens through the crushing of vegetation, especially woody vegetation. Snowmobiles can also disturb hummocks and impact soils if the machine breaks through the snow layer and comes into contact with the soil. Where the snow layer is broken, soils are exposed to a greater degree of freezing and thawing that can compromise both flora and fauna. The action of the machines also compresses and condenses the snow layer resulting in delayed thawing in the spring and delayed natural community response. Unless snowmobile activity is concentrated in fens, this activity is generally assessed to have less impact than horseback riding and ORV use.

3.3.3 Extinction and extirpation

The loss of biodiversity is usually thought of as a negative outcome of conservation threats, such as invasive species or fragmentation. Extirpation of species from specific fens or extinction of species across all fens is not generally categorized as a threat itself. However, the loss of species, locally or globally, can affect other species within a fen system. These processes include flower/pollinator interactions, larval host plants, predator/prey dynamics, and mycorrhizal associations.

The swamp metalmark (*Calephelis muticum*) is a tiny (2.5 – 3 cm wingspan) butterfly (Figure 15.), whose larvae feed solely on rosettes of the swamp thistle (*Cirsium muticum*). Recent reports of feeding of seed weevils *Rhinocyllus conicus* (a biocontrol introduced in the 1960s to control invasive musk thistle, (*Caardus nutans*) on native swamp thistle have coincided with surveys suggesting that swamp metalmarks might have been extirpated from many wetlands where they occurred in Michigan. However, swamp metalmarks are particularly difficult to survey, and populations may be irruptive. Thus, further research will need to be done to confirm the widespread extirpation of this butterfly and the relative impacts of seed weevils, shrub encroachment, and invasive plants.

Figure 15. The swamp metalmark is one of many rare species that occur in prairie fens.

Sometimes a species may persist, but a critical life stage or form can be lost. Tussocks of *Carex stricta* play a key role in the biodiversity of prairie fens (Peach and Zedler 2006; see Figure 3). Siltation or heavy grazing can destroy the tussock topography and remove many ecological niches from the wetland that are critical to the persistence of many plants. Tussocks form slowly over 50 years or more. Thus, the loss of this one species (or form of this species) can have long-term effects on the biological diversity of the prairie fen.

4. Goals and Objectives

4.1. Maintain and Restore Fen Distribution and Context

Goal: Maintain or increase the spatial distribution of functioning prairie fen complexes (and associated upland and wetland buffers).

Objectives:

4.1.1 Work with partners to protect prairie fen complexes through acquisitions and easements.

4.1.2 Maintain or restore connectivity of prairie/savanna/wetland landscapes around fens through acquisitions and easements at a 3:1 ratio of prairie/savanna/wetland to prairie fen.

4.1.3 Increase public awareness of the value of prairie fens in fen surface watersheds and ground watersheds through targeted outreach and education

4.1.4 Research the threat of predicted climate change to rare species in prairie fens, and the possibility that fens could act as a climate refuge for rare species.

4.2. Restore or Mimic Natural Processes

Goal: Maintain, restore, and simulate ecological processes in prairie fens.

Objectives:
4.2.1 Use groundwater protection models and evaluation tools to determine threats to rare species in prairie fens

4.2.2 Support policies to protect the groundwater sources and connections to wetlands.

4.2.3 Increase the use of prescribed fire as a management tool in fens and the surrounding landscape matrix, where appropriate.

4.2.4 Protect fens from changes in grazing regime, and decrease browsing pressure by decreasing deer densities in accordance with regional deer population goals

4.3. Maintain or Restore Native Biological Diversity

Goal: Maintain or increase native biological diversity of prairie fen complexes.

Objectives:
4.3.1 Monitor for invasive species on managed fens on both private and public lands

4.3.2 Manage invasive species on fens on both private and public lands

4.3.3 Manage motorized and equine recreation activities to avoid impacts prairie fens

4.3.4 Reintroduce missing prairie fen species

5. Conservation Strategies

5.1 Protect Prairie Fens, Associated Upland Habitats, and Landscape Connections

5.1.1 Refine priorities for the protection and management of prairie fens and adjacent lands.

Priority is difficult to quantify. Land managers must weigh several factors in determining what priority to give to fens within their jurisdiction. Factors such as opportunity, long-term commitment on the part of the landowner, viability of the fen itself, the presence of threatened or endangered species, and other factors all must be considered.

The viability of the fen and the presence of endangered species can be evaluated through Natural Heritage databases. Element occurrences for fens (in Indiana) or prairie fens (in Michigan) will include an alphabetical rank from A (most viable) to E (least viable). In general, it is most cost-effective to manage area to maintain a high rank, rather than manage to improve a low rank. However, where opportunity and long-term protection exist, the management and restoration of low rank fens may be a priority.
Protection of adjacent lands should also be a priority. Focus should be on maintaining or improving water quality in the surface watershed of the fen itself. The water quality of watershed of the stream, river or lake of the fen is important, but secondary.

The groundwater should also be protected, although new tools will be needed for managers to evaluate threats to the groundwater of specific fens. The ground watershed of the fen may extend up to several miles from the fen itself.

5.1.2 Work with private landowners and public agencies to identify protection options.

Protecting lands requires targeted outreach to private landowners. Landowners often have many questions. They need to develop trust with individuals within organizations and agencies. Cultivating relationships takes time.

5.1.3 Identify funding sources for land acquisition and for staff capacity to administer grants and purchased lands or easements.

The Mitchell's Satyr Butterfly Habitat Conservation Plan will allow state agencies in Indiana and Michigan Michigan to seek grant funds to protect lands to conserve MSB habitat. These funds will be less competitive than traditional Section 6 funds. However, careful thought and planning will need to go into the staff capacity needed to administer these grants and to administer the lands once they are purchased.

5.1.4 Acquire land or protect with conservation easements

Approximately, one-third (1,610 acres) of prairie fens are currently on public land or on lands owned by conservation organizations. Thus, to protect one half of fens, approximately 800 acres of prairie fens will need to be protected.

Until recently, land and conservation easement acquisition has focused on protecting parts of fens. Upland properties surrounding fens have been a lower priority. However, given threats to water quality and the important effects of habitat matrix on the fen itself (Cozzi et al. 2008), equal priority should be given to protecting groundwater recharge areas and adjacent uplands. The prairie fen, adjacent uplands, and groundwater recharge areas are one system, and should be protected as such. The minimum ratio of surrounding protected area should be at least 3:1 for any given fen.

Because resources for land acquisition are limited, this strategy will result in fewer acres of prairie fen protected and more acres of nearby upland protected. Efforts should be focused on the highest quality fens, fens with viable populations of listed species, and fens in landscapes already targeted for other conservation values (headwaters initiatives, water quality, land conservancy priorities, etc). Developing creative ways to protect priority lands will allow limited resources to be used most effectively.

5.1.5 Restore prairie, savanna, and wetlands surrounding fens

Currently, few if any fens occur in an ecologically functional landscape of wetlands, savannas, and prairies. Natural vegetation is rare and scattered (The Nature Conservancy 2003). Prairies, savannas, and wetlands should be restored, where soils and hydrology are amenable to restoration, within the surface-watershed and ground-watershed of fens.

Prairie and savanna plants are deep-rooted and promote infiltration of rain and snowmelt. This helps decrease sedimentation and maintains water quality. Because some prairie fen plants and animals exist both in the fen and prairie/savanna, restoration will increase patch size, decrease isolation, and facilitate dispersal. Restored savannas and prairies are important habitat for many rare species, but also provide quality habitat for deer, turkey, and pheasants.

Restoring wetlands will decrease isolation, improve genetic exchange, and facilitate dispersal of wetland species. The restored wetlands will provide habitat for rare plants and animals, as well as important breeding habitat for waterfowl. In addition, the restored wetlands will improve water quality in the watershed and could decrease flooding (and sedimentation) in fens. Between 1998 and 2004 there was a net increase in wetlands in the United States; for the first time in recent history, wetland restorations outpaced wetland loss (Dahl 2006). Continuing restoration will make reducing wetland isolation at the landscape scale a realistic management goal.

Restoration efforts, like land acquisition, should be prioritized according to fen quality, distance from a viable fen community, and likelihood of successful restoration.

5.1.6 Manage beaver activity to promote the long-term health of prairie fens.

Beaver activity should not be discouraged, except in very small or gently sloped fens where the flooding threatens to submerge significant areas of fen vegetation. Beaver activity can set back woody succession and counteract drying of the fen, but can also cause sedimentation, which can upset the nutrient balance of fens and facilitate future invasions of exotic plants. Impoundments to mimic beaver activity are not the preferred management option in most cases, but can be useful in certain topographies or to achieve shrub control. Water levels should be drawn-down more often than flooded where impoundments exist to maintain prairie fens.

5.1.7 Maintain natural vegetation and promote groundwater recharge

Most fens in Michigan and Indiana occur on private land, and private landowners will not always have the resources or the ability to restore prairie, savanna, or other wetlands. Also, fens are not always surrounded by degraded prairie or savanna. Some fens are bordered, at least in part, by high quality forested communities. Where prairie, savanna, or wetland restoration is not a viable management option, areas should be maintained to promote groundwater recharge.

Impervious surfaces should be limited, or less impervious options considered. Mat forming grasses, especially mowed lawn, should also be avoided and replaced with clump forming grasses.

Many conservation strategies to improve water quality, such as filter strips in agricultural fields or water gardens to manage storm water, will also reduce fragmentation and create connectivity across the landscape.

5.2 Increase Public Awareness and Understanding of Prairie Fens and Associated Conservation Issues.

5.2.1 Develop and implement an education and information program focused on prairie fens.

5.2.2 Support training opportunities for staff and conservation partners.

5.2.3 Evaluate the effectiveness of the education and information program.

5.3 Incorporate predicted climate change into conservation planning for prairie fens

5.3.1 Adjust management actions to address predicted effects of climate change on fens

The tools necessary to address climate change are similar to other tools common to good conservation plans: using scientific research to guide conservation actions, reducing fragmentation of natural communities, combating alien invasive species, monitoring, and adaptive management. Thus, climate change does not require a fundamentally new approach. Instead, the predicted effects of climate change need to inform traditional conservation planning with the goal of reducing the impact of climate change and assisting species and communities in adapting to inevitable climate change.

Predicted effects of climate change include:

- Increased invasiveness of invasive species
- Increased weediness of common, easily dispersed species
- Increased competition from species at the northern edge of their range (i.e., tulip poplar) and decreased fitness from species at the southern limit of their range (i.e., tamarack)

5.3.2 Predict climate sensitivity and future geography of conservation targets based on regional climate models (if available) or global climate models

Species within ecological communities will not respond uniformly to climate. Instead, responses will be species specific. Thus, to conserve all components of the community, each species should be evaluated for its sensitivity to predicted change. While this is not feasible for every species it is imperative for conservation targets (state and federally listed plants and animals) or species that appear to play a significant role in the community (tamarack, *Carex stricta*).

Some traits to evaluate include geographic breadth (widely distributed or localized and endemic), placement in context of range (north end of range or south end), dispersal ability (coefficient of conservatism in plants?), population size, and habitat fragmentation.

5.3.3 Identify trigger points to begin planning the facilitated migration (introductions) of dispersal-limited species to northern fens

Facilitated migration should be a measure of last resort, and trigger points should consequently be set high. Metrics should be statistically rigorous (as much as possible given the low number of sites for many species). For example, the loss of one MSB site at the southern extreme of the geographic range does not justify facilitated migration. However, loss of several sites in Indiana and the southern tier of Michigan counties would be another matter. (This is complicated by the unique geography of the Great Lakes: precipitation and temperature patterns are not oriented strictly north-south. Thus, sites need to be ranked by climate, not latitude.)

The key is to develop trigger points before facilitated migration is necessary. The direct effects of climate will not likely be obvious. Instead, the indirect effects are more likely to dominate (increased invasiveness of non-native invasive species, for example). If we wait to set trigger points until extirpation has begun, then there will likely be a lengthy debate on the direct and indirect causes of individual extirpations.

Facilitated migration should be used cautiously. There is significant risk to those systems receiving the more southerly endangered species. A successful facilitated migration will result in the "invasion" of the northern system by a species of more southern distribution. This would then stress conservation targets in the northern system.

5.3.4 Reduce non-climate stressors on the prairie fens

Climate change is likely to disproportionately impact those species already in need of conservation while simultaneously favoring common or invasive "weedy" species. Climate change will likely magnify the negative effects of other threats. Thus, the conservation strategies outlined in other sections of this Plan will also address the threat of climate change.

5.4 Protect and restore natural surface and ground water flow and flooding regime.

Prairie fens are unique wetlands that rarely flood; soil is constantly saturated throughout the year. Thus, many management practices differ for fens as compared to other wetlands. Permanent water control structures, such as dams, are inappropriate for fens, and long-term or seasonal flooding will replace the rare fen community with the more common emergent marsh community. Small, temporary structures to flood portions of a fen can be used to set back woody succession in fens already degraded by a history of livestock grazing.

5.4.1 Identify and protect regions of critical groundwater recharge around fens

Fens exist where significant amounts of groundwater are under pressure, either causing lateral movement or upwelling. This pressure is caused by topographic relief. The significant amounts of groundwater come from deep coarse soils, such as sand or gravel. Thus, deep coarse soils at elevations significantly above the fen are the critical groundwater recharge areas for the fen itself. These areas of recharge may be many miles from the fen. Impervious surfaces, such as pavement, rooftop, and lawn, in these areas can decrease groundwater penetration. Conversely, deep rooted, native savanna and prairie plants can increase groundwater penetration.

5.4.2 Restore native upland savanna and prairie over groundwater recharge areas

The restoration of native plant communities in the landscape surrounding fens can allow precipitation to penetrate the soil surface. In addition to benefiting biodiversity through reducing landscape fragmentation, native vegetation facilitates groundwater recharge and reduces flooding. The use of so-called "rain gardens" and other low-impact development methods to manage storm water should be encouraged in communities within the groundwatershed of prairie fens.

5.4.3 Limit activites in uplands that interrupt groundwater flow.

Worldwide, fens are primarily threatened by draining or reduction in groundwater inputs to the fen itself (Bragg and Lindsay 2003, Grootjans et al. 2006). Historically, many fens were ditched or tiled to facilitate agriculture. Current regulations in the United States prohibit such actions, and these regulations should be enforced. A much more common threat to fen hydrology is the creation of ponds in uplands adjacent to fens. This can disrupt springs that feed the fen. The flow of groundwater into or through a fen is altered, which changes plant diversity, insect diversity, or facilitates invasion by exotic plant species. Excavation into the groundwater adjacent to fens should not occur.

5.4.4 Remove barriers to groundwater flow, where feasible

Open water ponds that have been excavated adjacent to fens can cut the groundwater connection between the mineral soils under uplands and peat soils under the fen. This reduces the hydraulic potential to the subsurface peat, and converts a groundwater system to surface water system. Filling excavated areas with peat has been successful in some restorations (i.e. Ives road Fen in Michigan), but filling of ponds is still experimental. The quantity and type of peat necessary are not known.

Poorly designed culverts on roads downstream of fens can cause flooding and a conversion of fen to an emergent marsh. Roads and culverts upstream can cause drying and shrub or cattail invasions. Extensive earth moving and road redesign is rarely feasible for the sole purpose of fen restoration. However, managers should work with road commissions to re-design culverts and drainages when major roadwork or culvert replacement is already scheduled. Simply moving the culvert up or down in elevation may restore at least some natural hydrology to the fen.

5.4.5 Restore non-fen wetlands in the landscape around fens to reduce landscape isolation

5.5 Minimize adverse changes to water quality.

5.5.1 Support strict enforcement of state and federal regulations regarding water quality in watersheds of prairie fens.

The quality of water in Indiana and Michigan is protected under several statutes, including provisions of Michigan's Public Act 451, Indiana Code 13-18 et. seq. (Water Pollution Control), and the federal Clean Water Act. The regulator of water quality in Indiana is the Indiana Department of Environmental Management (IDEM); Questions regarding water quality should be directed to IDEM at 317-232-8603. The regulators of water quality in Michigan are the Michigan Department of Natural Resources (DNR). Regulations are only effective if they can be enforced. In an era of streamlined staff, it is imperative that managers of prairie fens work closely with staff responsible for enforcing water quality regulations. A close collaboration across agencies can help managers understand the limits and opportunities that regulators possess, and will allow regulators to learn the value of particularly biologically diverse and fragile wetlands, such as prairie fens.

5.5.2 Identify and minimize salt and sediment inputs from roads.

Cattails (*Typha* spp.) can tolerate higher salt concentrations than many plants native to prairie fens. In fens in northeastern Illinois, cattail monocultures coincided with groundwater plumes of Na+ and Cl-, consistent with private septic systems and roadway de-icing agents (Panno et al. 1999). At many fens in Michigan, cattail monocultures are often adjacent to roads or septic systems (Hoving, personal communication.) While treatment of cattails as an invasive species is warranted at these sites, a long-term solution must include minimizing salt and sediment run-off from roads.

5.5.3 Identify and minimize artificial nutrient inputs through an array of water quality initiatives and private lands programs.

Nutrient inputs to fens in Michigan and Indiana come from five main sources:

Conservation Strategies

• Atmospheric deposition from power plants, heavy industry, and agriculture,
• Septic systems discharging adjacent to fens
• Animal waste from livestock operations near fens
• Fertilizer and sediments from agricultural fields near fens
• Fertilizer and sediments from urban/suburban lawns near fens

Atmospheric deposition, while a problem, is beyond the purview of the land manager.

Nitrogen, salts, and phosphorus commonly contaminate the soil immediately around septic tanks. The distance from the tank to the fen is significant, but tanks in the steep bluffs that often surround fens are of particular concern. The amount of contamination can depend a great deal of how the septic system is designed and how well it is maintained. The potential for nutrient contamination from septic systems varies from site to site. Fens without residential development nearby will not likely be affected by this source. Much like atmospheric deposition, this source is less tractable for the land manager of the fen.

Contamination from livestock operations and fertilizer run-off are easier to address. Considerable resources exist within the Food, Conservation, and Energy Act of 2008, more commonly referred to as the Farm Bill. Within the Farm Bill there are many programs, each geared to specific goals. The NRCS district conservationist in each county's USDA Service Center should be able to guide individual farmers through the process of signing up for the correct program. Those who administer these programs are often limited in time and staff; any help a manager can offer (writing a management plan, soliciting information from the landowner for an application, etc.) will increase the chance that the project will be funded. Wastewater treatment facilities for livestock operations (through EQIP) and buffer strips (through Continuous CRP) are most likely to have the most dramatic increase in water quality.

Some fens occur in watersheds that are urban or suburban. Lamberton Fen, for instance, occurs within the limits of Michigan's second largest city and is bordered on one side by an Interstate highway and on the other by well-manicured lawn (Figure 16). In such areas, neighbors to the fen and local officials should be taught the importance of water quality and how to maintain it. Smart management of lawn herbicides and fertilizers can go a long way in protecting the water quality of these fens.

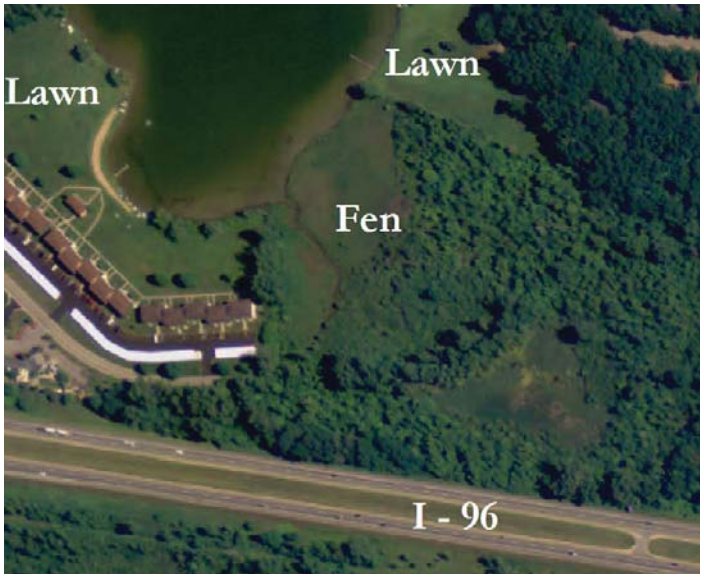


Figure 16. The landscape context of a fen is important. Both surface water and groundwater inputs should be considered.

Private lands programs that can improve water quality near prairie fens include:

Michigan:

- Michigan Natural Resources Conservation Service - (517) 324-5270
- Michigan Farm Service Agency - (517)324-5110
- Michigan Department of Natural Resources (Wildlife Division) - 517-284-WILD (9453)
- Michigan Department of Environmental Quality – 1-800-662-9278

Indiana:

- Indiana Natural Resources Conservation Service - (317)-290-3200
- Indiana Farm Service Agency - 317-290-3315
- Indiana Department of Natural Resources - (317) 232-4200 or (877) 463-6367
- Indiana Department of Environmental Management (317) 232-8603

Federal

- USFWS Partners for Fish and Wildlife MI: 517-351-6236; IN: 812-334-4261

5.6 Use Fire as a Management Tool to Restore or Maintain Fens and Landscape.

To avoid or minimize take, land managers working in habitat occupied by Mitchell's satyr butterflies or Poweshiek skipperling should refer to the Mitchell's satyr and Poweshiek skipperling HCP, for management guidelines:

5.6.1 Conduct prescribed burns in prairie fens and surrounding landscapes.

Restoring the full fire regime that existed historically in prairie fens and the surrounding landscape matrix is neither practical nor desirable. Past fires were large and often intense. A century of fire suppression has changed landscape structure and fuel models; non-native species have been introduced; and rare species sometimes require special accommodation.

Certain aspects of the historical fire regime are informative, and should be reproduced as much as possible. For example, fire most often occurred in fens when the surrounding landscape was dry. Thus, prescribed burns during periods of low rainfall and low humidity are more likely to favor the fen community. Similarly, lightning ignited fires in July and August in this region, and thus, growing season burns may be appropriate.

Figure 17. Care must be exercised in using fire within fen ecosystems. Some species are sensitive to fire, especially at certain times of the year.

Because of changes in landscape structure, fuel models, invasive species, and rare species, the prescription for fire in and around fens should be planned carefully (O'Connor 2006) (Appendix A-1.). All management, including management using fire, entails some risk to individuals, populations, and aspects of the prairie fen community. A good manager will weigh those risks of management against the risks of applying no management (Figure 17).

The management of ecological communities can be counter intuitive to those focused on the conservation of specific rare species. Managers must often employ tools that kill individuals for the long term benefit of rare species. The ecosystem manager's goal may be very different from those who would like to see the population of a given species maximized and mortality of that species minimized in all situations and at all times. The goal of the ecosystem manager is to preserve fluctuating, dynamic populations of a full suite of native species appropriate to that ecological community. Thus, the loss of some individuals of a rare insect is appropriate if it is necessary to allow the seeds of several species of plants to germinate and reproduce, assuming that the rare insect is not extirpated from the system or the population is not impacted too severely.

The loss of individuals from fire to increase populations is appropriate for short-lived, prairie or fen dependent species that have high reproductive output. However, the value of adults of species that are long-lived, have low reproductive output, and occur in (but are not dependent upon) fire-driven ecosystems is different. For example, eastern box turtles occur throughout a wide range of ecological communities in Michigan and Indiana, including prairie fens. Individuals can live (in captivity) to be over 100 years old. Recruitment from egg to reproductive adult is naturally low. The conservation value of older box turtles is very high. Loss of even one individual adult female from a population every few years could effectively send the population to extinction. For long-lived species, the loss of individuals might not always increase the overall population. In these situations managers must make difficult and sometimes controversial decisions (Figure 16).

Discussions of the relative impacts of fire (or other management tools) to different plants or animals often occur on a hypothetical level. Ideally management decisions should

be made on the basis of ongoing, long-term monitoring. Managers of prairie fens should use an adaptive management framework. Many managers object to monitoring because it takes valuable resources from other management projects, especially if the monitoring is too detailed or poorly planned. However, the level of monitoring can be scaled to the resources available (O'Connor 2007) Conservation partners, especially in academia, might be used to complete monitoring projects. The wisest use of time and money, in the long term, is to monitor the effectiveness of management tools such as fire. More importantly, monitoring can also address the real effect that fire has on populations thought to be threatened by or thought to benefit from fire.

5.6.2 Mimic effects of fire in fens and surrounding landscapes

Prescribed fire has long been recognized as the most cost-effective way to manage prairie fens and other ecological communities (Jenkins 1954). Costs per acre for a burn over a few acres in size range widely from public land to private land. Although the cost may seem high, less expensive alternatives are unlikely to mimic all of the ecosystem services of a fire.

When and where fire cannot be used, several tools are available to mimic the effects of prescribed fire. For degraded fens with a grazing history, restoring livestock to the fen may be the quickest and least expensive way to mimic the effects of fire. See section 5.7 for more on grazing. Grazing should never be started in fens where there is not a clear, documented history of grazing by livestock.

Another good option is to cut aggressive woody vegetation while minimizing soil disturbance. This approach can be expensive. Succession to shrub carr, especially native shrubs, likely indicates damage from past livestock grazing. If grazing and fire are not management tools, woody species should be cut and stumps treated with herbicide labeled for use over open water (Figure 18). An herbicide wand (Appendix A-2.) will allow targeted herbicide application without harming rare plants. Shrubs can be piled and then burned, or left to rot.

If the fen has dried somewhat and the tussock micro topography has been lost, the fen can be hayed. This is a common management practice in Europe. Haying must be annual (or nearly so) to keep woody species in check. Haying cuts tall species, removed biomass, and allows sunlight to reach plants of shorter stature. Mowing will cut the tall vegetation, but the cut vegetation tends to smother shorter stature plants. As mentioned in the Invasive Species section 5.8. it is imperative that all equipment (saws, herbicide applicators, mowers, tractors, etc.) be thoroughly cleaned before being brought into a fen. Cutting woody vegetation will not improve the quality of the fen if herbaceous invasive plants are introduced by the cutting equipment.

Figure 18. Because fens are small and difficult to access with mechanized equipment, management often occurs at a small scale.

5.7 Limit grazing and browsing, except in already damaged fens

5.7.1 Limit grazing on fens that lack a grazing history

Livestock grazing alters the successional trajectory of prairie fens (Middleton 2002). Fens without grazing history exist on the landscape, but are relatively rare. Those fens with no grazing history are less likely to be invaded by shrubs, and will thus have much lower management costs. These fens should be protected from livestock grazing (Middleton et al. 2006b).

5.7.2 Maintain grazing on fens where it currently occurs

Grazing creates a niche for shrubs and other invasive plants to invade prairie fens. It alters the successional trajectory of prairie fens, and we do not currently have management tools that can undo this effect. However, light to moderate seasonal grazing can keep shrubs and invasive herbaceous plants from spreading. Thus, grazing where grazing has already occurred can maintain a fen in an open condition with a diversity of plants (Tesauro and Ehrenfeld 2007).

Grazing is a viable and valuable management tool for those fens already degraded by grazing. However, because grazing has negative effects, it should only be used when other management techniques (fire, shrub control, herbicide, etc.) are not available. Grazing a degraded fen is preferable to no management, but less preferable than fire and other tools (Figure 19).

5.7.3 Encourage hunting in and around prairie fens to manage for healthy populations of deer, turkey, and other game species.

Hunting is a valuable part of prairie fen management, and it should be promoted on lands where prairie fen and biodiversity are the main goals. Fens and other densely vegetated wetlands are often used by deer and turkey for fawning/nesting cover, as escape cover, and for food. Fens are especially valuable habitat in landscapes dominated by urban development or extensive agriculture.

Just as high densities of livestock can damage fens, high deer densities can also be a threat. For fen vegetation and the health of the deer herd itself, deer densities should be managed to maintain population levels in balance with their habitat. Recreational hunting should be encouraged in and around prairie fens, and hunters should be encouraged to harvest antlerless deer.

The exact density of deer that will not damage fens will vary from one landscape to another. In general, developed landscapes that focus deer activity in fens will have lower density thresh holds. Landscapes in which deer can be more evenly distributed across the landscape will be able to support a higher density of deer.

5.7.4 A note on insect/disease outbreak

Disease outbreaks and insect infestations are common in prairie fens, especially in mature tamarack trees. Disease and insect outbreaks do not require management or conservation actions. However, management should focus on promoting the successful regeneration of tamarack trees in prairie fens and rich tamarack swamps.

Figure 19. Many fens were grazed historically, but modern conservation practices limit livestock use of wetlands and streams. Fens with a grazing history can be grazed, but with caution. Fens without a grazing history should be managed with other tools.

Tamarack trees are an important part of the prairie fen community. Many plants and insects (including the MSB) are associated with tamaracks. Tamaracks are shade intolerant, and will not germinate or persist in the shade of deciduous trees and shrubs. Many fens and tamarack swamps contain mature tamarack trees with an understory of deciduous trees and shrubs. If the mature tamarack trees succumb to insects or disease and are not replaced by young regenerating tamaracks, this important component of the fen community could be lost.

Management of fens with mature tamarack trees should focus on maintaining tamarack regeneration and suppressing or removing deciduous trees and shrubs. Where the tamarack component has already been lost, deciduous trees and shrubs should be removed and tamarack trees should be planted.

5.8 Manage invasive species

The threat of invasive species can be overwhelming; the complete eradication of all invasive exotic species from all managed natural areas is not possible. It is possible to waste considerable resources attempting unsuccessfully to manage entrenched invasive species. In fact, eradication efforts that are unsuccessful can cause enough disturbance to stimulate further invasions. However, with careful planning, invasive species often can be managed successfully with reasonable amounts of time and money.

5.8.1 Support modifications in law, policy or enforcement that could more effectively prevent the spread of invasive species.

The least expensive method to control an invasive species is to prevent its introduction (McNeely et al. 2001). Roughly one in one thousand exotic species will prove to be invasive and cause significant ecological damage (Williamson and Fitter 1996, Lockwood et al. 2001). Thus, if introductions of new exotic species are not managed, new invasive species of similar impact to glossy buckthorn or narrow leaf cattail will become established in the future. Australia and New Zealand have pioneered many policies and models to significantly slow the introduction of new invasive species (Gordon et al. 2008a, 2008b).

Figure 20. Seeds of invasive plants, such as reed canary grass seeds on this boot, are sometimes accidentally introduced to high-quality fens by researchers and managers. Tools and clothing should be washed after every visit to a fen (or other natural community).

5.8.2 Refine and implement best management practices to limit spread of invasive species.

In addition to policies and tools to limit the introduction of invasive species from outside a jurisdiction, we also need to limit introduction from nearby wetlands or uplands to a given prairie fen. A vector unique to wetlands is the spread of seeds, roots, or viable plant fragments through the water. Thus, special attention should be made to the presence of invasive plants upstream of fens. Roads are also common corridors for invasive plants. Finally, an efficient vector to transfer viable seeds from fen to fen is the transport on boots and saws of fen managers and researchers (Figure 20). Thus, a standard set of guidelines for cleaning boots, clothing, equipment, and vehicles should be developed and implemented to limit the spread of invasives directly from one fen to another and also within the same fen.

Focus on Prescribed Fire

Figure 21. Prairie fens occurred in landscapes that burned on a regular basis. The high loads of fine fuels in fens would have been suceptible to fire as well. Today, fire is a useful tool to manage woody succession in fens.

Wetlands can be burned, and fire is often a valuable management tool (Figure 21). Consider these management recommendations when using prescribed fire as a management tool. These special considerations should always be balanced against the threat to the species and other species if no management action is taken.

1. Avoid soil disturbance in fens or adjacent wetlands. Use natural burn breaks (streams, shrub-carr, etc) or existing features (roads, trails, etc.) wherever possible (Figures 22 and 23).

2. Timing burns at the same time of year, every year, will likely reduce species diversity. Vary the timing to include spring, summer, fall, and winter burns. Pyro-diversity equals biodiversity in systems with diverse fire histories.
   - Dormant season, spring burns favor grasses, sedges, turtle, and snakes over wildflowers. They do little to control woody vegetation.
   - Shrubs, turtles, and snakes are most sensitive to fire after green leaves have emerged.
   - Summer burns are usually more patchy and smoky.

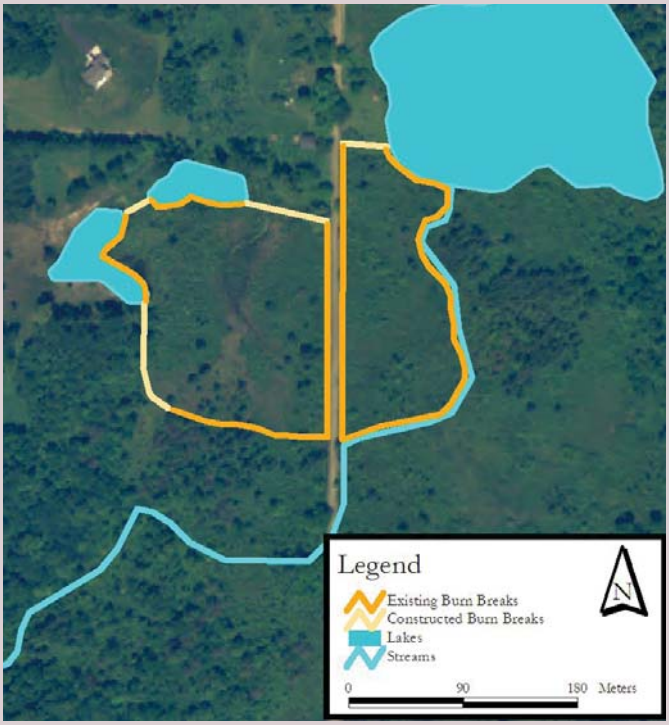


Figure 22. Existing burn breaks can be utilized in prairie fens. Created burn breaks often consist of lanes cleared with a weed whip and then sprayed with water. Pumps and hose can often provide ample water.

Focus on Prescribed Fire

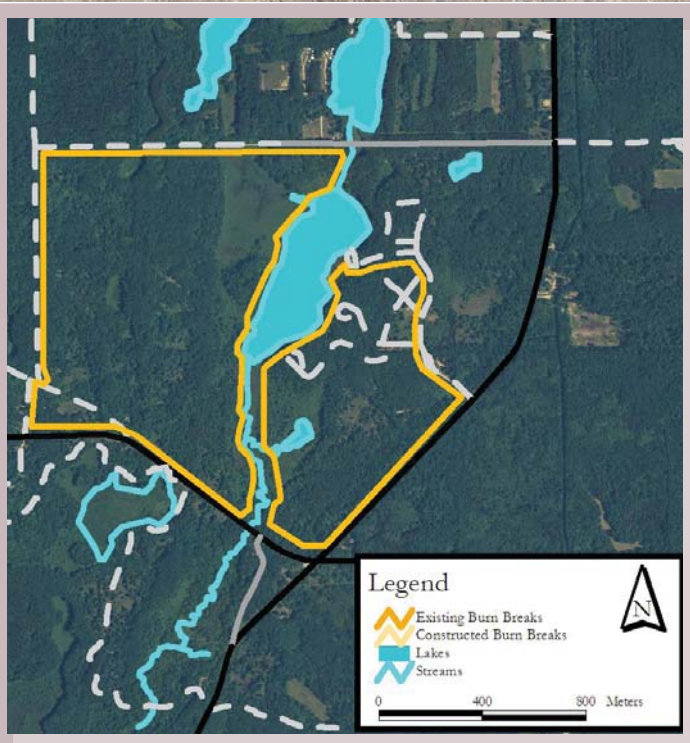
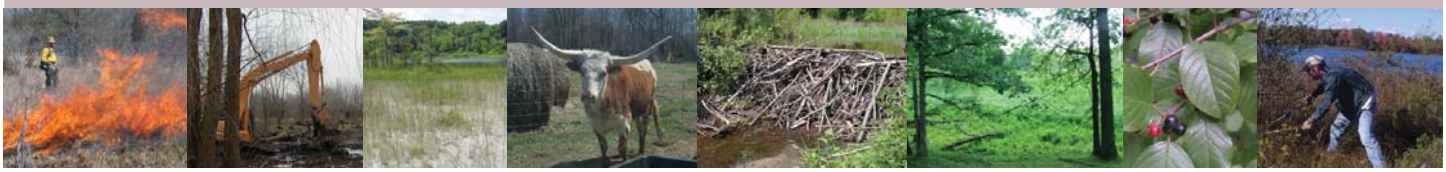


Figure 23. The use of existing burn breaks has the added advantage of restoring adjacent upland communities, such as 400 acres of degraded oak savanna around this small prairie fen.

- A burn will favor those plants and animals that are dormant or not growing quickly at the time of the burn. The burn will set back or kill those plants and animals that are flowering or otherwise attempting reproduction.
- The timing of burns should be driven, in part, by the science of prescribed fire and the effect of the timing fire on biodiversity, and not entirely on convenience for recreational activity, wildfire activity, or ease of predicting fire weather (Figure 24).
- Tamarack trees are especially important to specific plants and insects, and should not be targeted with aggressive ignition patterns (i.e., rings around the tree).

3. Invasive species require special planning:
   - Like many fen shrubs, exotic invasive buckthorn (*Rhamnus* spp.) is not sensitive to fire in any season once it is over one year of age. Seedlings are highly susceptible to fire. Thus, fire is effective up to one year after mechanical/chemical removal of adult buckthorn, after the buckthorn seedbank has expressed itself.
   - Japanese barberry *Berberis thunbergii* is fire sensitive in most seasons and age groups.
   - Once established, many invasive shrubs and trees (black locust *Robinia pseudoacacia*, autumn olive *Elaeagnus umbellata*, or Japanese barberry *B. thunbergii*) increase soil nitrogen and thus accelerate the break down of fuel in their immediate vicinity, effectively creating their own burn break.
   - Fire provides a nutrient pulse to the soil, which can cause an increase in herbaceous invasive plants, especially cat-tails (*Typha* spp.) If water quality is degraded in the fen, the nutrient pulse may make the invasive plant problem worse.
   - Targeted chemical or mechanical control of herbaceous plants during the growing season immediately after a burn is highly recommended.

Figure 24. Crayfish burrows or "chimneys" are often found in uplands adjacent to fens. These are often used a hiberancula for rare snakes, and should be burned rarely and with extreme caution.



Focus on Prescribed Fire

Figure 25. This box turtle survived the initial fire but its long term injuries are unknown. Special care must be taken to avoid impacts to rare, sensitive, or slowly reproducing species.

4. Rare species require special consideration in timing, extent, and intensity of prescribed burns.
    - Fire is more likely to harm rare species when they are attempting to reproduce. (Tables 3 and 4 in Appendix A-1).
    - For rare species with high reproductive potential (most insects, many plants) and that are suspected to be sensitive to fire, no more than 1/3 of the available habitat for that species should be burned in any one year.
    - For rare species with low reproductive potential that are suspected to be sensitive to fire, most fires should occur only during the dormant season (Figure 25). The exception would be a fire to manage a more immediate threat to that species, such as a buckthorn invasion.
    - In general, a slow fire will be **less** patchy, have **lower** peak temperature, but generate **more** net heat (fewer refuges in burn unit, but may allow species to move out of the burn area.) A fast fire will be **more** patchy, reach **higher** peak temperature, but create **less** total heat over time (more refuges in burn unit, but may kill species that try to flee rather than seek refuge) (Figure 26).
    - To avoid or minimize take, land managers working in habitat occupied by Mitchell's satyr butterflies or Poweshiek skipperlings must abide by the Mitchell's satyr and Poweshiek skipperling HCP, for management restrictions. These restrictions constitute the terms of an Incidental Take Permit.

Figure 26. Marls flats, seeps, springs, and small headwater streams create a natural patchiness to prairie fen burns. Prescibed burn plans should explicitly recommend patchiness.

5.8.3 Monitor fens regularly to detect new invasions early in the process of invasion.

Early detection and rapid response is more expensive than prevention, but considerably more cost effective than other management efforts. It is a wiser use of resources to monitor a 2 acre fen annually and to cut and kill the first five buckthorn invaders, than to wait to cut the 50,000 buckthorn invaders that fill that same 2 acre fen.

Resources and protocols should be developed to direct early detection and rapid response, on public and private lands, and in wetlands and uplands.

5.8.4 Provide the public with information on invasive species.

Many managers are now cognizant of the threat of invasive species and can identify the most aggressive invaders. However, many private landowners lack this expertise. Thus, it is important that outreach materials target owners of prairie fens so that 1) they recognize that invasive species threaten values they hold in their property, and 2) they are taught to identify the invasive plants that may threaten their prairie fen.

5.8.5 Reduce distribution and abundance of problematic invasive species.

To avoid or minimize take, land managers working in habitat occupied by MSB or PS should refer to the Mitchell's satyr and Poweshiek skipperling HCP for management guidelines. In Michigan, land managers working in areas occupied by eastern massasauga rattlesnakes should refer to the guidelines in the Candidate Conservation Agreement with Assurances for this species, or the latest draft. In Indiana, this species is state listed and the Indiana Division of Fish and Wildlife should be consulted.

Many good resources on the identification and control of invasive species are available to land managers. In addition to these resources, the following sections reflect the practical experience of many land managers with a long history of managing invasive species within and near prairie fens.

Invasive Plants of the Upper Midwest (Czarapata 2005) provides a good overview of specific invasive plants across the geographic range of the prairie fen. The book contains many useful pictures of ecologically significant invasive species, and gives much useful information on control techniques.

The Michigan Natural Features Inventory has recently created two handbooks on invasive plant identification: a Guide to the Invasive Plant Species of Michigan (Borland et al. 2009) and A Field Guide to Invasive Plants of Aquatic and Wetland Habitats for Michigan (Campbell et al. 2010). The handbook is geared toward identification. It contains succinct information on management, but does not have detailed information on treatment, herbicides, etc. The detailed information on management techniques and the ecological effects of herbicides in the Weed Control Methods Handbook (Tu et al. 2001) on the website for the TNC Global Invasive Species Initiative is also a useful resource.

5.9 Minimize Adverse Impacts of Recreational Activities.

5.9.1 Minimize and guide trail development.

Prairie fens are inappropriate for most recreational trails. The substrate is uneven, unstable, and waterlogged. Footing for humans and horses alike is treacherous. Using mineral soil to fill the trail is a violation of wetland statutes and is rarely effective. Because of the sheet flow of water through the fen, water will pool on the up-slope side of the trail until the filled section is again inundated. Culverts are ineffective with the fen itself because they would need to be constantly moved to reflect changes in sheet flow. Poison sumac can seriously harm trail users. The rash from poison sumac is more serious than poison ivy, and often requires medical attention and prescription drugs.

Cross-country ski trails may be appropriate where snow is reliably deep enough to cover the tussock topography of the fen. This is unlikely, except in the lake effect snow belt east of Lake Michigan.

Boardwalks can be installed in fens, but must be carefully designed not to alter sheet flow, violate wetland statutes, or create niches and/or vectors for invasive plants. Where appropriate, boardwalks can provide a good opportunity for people to learn about fen ecology.

5.9.2 Restrict access by off-road vehicles.

Prairie fens offer poor recreation for ATV riders and off-road vehicles, and thus there is little demand or damage from the threat. However, a vehicle stuck and then towed out of a fen can cause significant damage. Trails for ATVs and off-road vehicles should be planned away from fens, and recreationists should be encouraged to avoid prairie fens.

5.10 Reintroduce Missing Prairie Fen Components

5.10.1 Identify missing prairie fen components.

Detailed plant lists exist for many prairie fens in Michigan and Indiana. Many fens have been surveyed repeatedly for rare butterflies. Some reptile and amphibian assemblages have been made for some fens, but distribution of cryptic or fossorial species are less well known. Other important groups, such as native pollinators and mollusks have been less studied, and nearly no information is available on fungi or bacteria diversity in unique fen soils. Thus, we are likely to detect extirpation of some taxa, but not others.

5.10.2 Assess the need and feasibility of a species reintroduction program.

Reintroduction programs are not simple. Many variables must be considered, including:

- Genetic effects (founders effects, ideal population size of reintroduced population, source genetics)
- Best life stage to reintroduce (gravid females, eggs, larvae?)
- Social aspects (are neighbors ready for an endangered species that might spread to their property?)
- The presence and strains of diseases in the population, such as *Wolbachia* (Werren et al. 2008, Nice te al. 2009, Hamm et al. 2014.)
- And conservation threats (has the original reason that the MSB disappeared been fixed at this site?)

5.10.3 Prioritize components and areas for species reintroduction.

What are the most appropriate areas for introduction? Is the site owned by a public entity or conservation organization?

5.10.4 If necessary and feasible, develop, test and implement a species reintroduction program.

6. Monitoring, Evaluation, and Adaptive Management

Fens are sensitive to land management within the fen, in adjacent wetlands, and in uplands surrounding the fen. Poor land management will result in a degraded fen. Good land management will protect the integrity of the fen. This sensitivity makes fens both a good conservation target and a good indicator of the ecological health of the surrounding landscape. This sensitivity also makes monitoring of fen health and integrity a priority for all land managers, and not only those interested in particular endangered plants, butterflies, or reptiles.

6.1 Continue Mapping and Monitoring to Assess Status and Health of Fens

6.1.1 Monitor and map fen communities and populations of rare species within fen communities.

Prairie fens provide habitat for a disproportionate number of rare plant and animal species. Both the status of the fen and populations of rare species within the fen community should be monitored. Presence/absence surveys for some fen species have been conducted as resources have been available for decades. Over the past ten years, annual

surveys have been conducted for the MSB. In addition, surveys for the PS have increased over the past several years due to concern about declining populations. Recently, community level protocols have been developed specifically for prairie fens (Pearsall and Woods 2006 in Appendix A-3., O'Connor 2007).

Monitoring results should be communicated to the land manager (usually the private landowner) responsible for the fen. When management is warranted, the monitoring results must be communicated in the context of specific management actions. Monitoring without recommending management (when and if needed) does little more than document the loss of the system. Recommending management in vague ("You should spray that.") rather than specific ("You should spray this plant with 20% solution of Aquastar or Rodeo in June this year.") terms accomplishes little for most private landowners. Recommendations to experienced land managers can be more vague than recommendations to those inexperienced private landowners who manage most fens.

Appropriate recommendations now accompany many monitoring survey results that are reported to professional land managers. Private lands biologists provide appropriate recommendations to many private landowners in Michigan. This communication among those monitoring, those managing, and those in private lands programs is valuable and should continue.

6.1.2. Map connectivity between fens and among adjacent natural communities

Fens do not persist independent of the landscape context in which they were formed. For this reason, monitoring programs for fens should explicitly include uplands and wetlands on the surface-watershed and the ground-watershed of the fen. Land use in these areas should be mapped, and categorized by its positive or negative impact on fen integrity.

6.2 Conduct Active Research to Support Science-based Prairie Fen Conservation

Some professional managers and some private landowners have amassed considerable knowledge of prairie fen management over the past several decades. We now know some of the correct (and incorrect) ways to control buckthorn, dogwood, or phragmites. We know that Mitchell's satyr butterflies require some woody vegetation, and that they are very sensitive to changes in hydrology.

6.2.1. Identify uncertainties and support research to inform fen management

There is still much that we do not know. Many research questions remain including:

- What are the impacts of hydrological changes to prairie fens and associated rare species and how do we monitor these changes? Do these changes limit the ability of land managers to restore original conditions? Can these changes be ameliorated?

- Are there fen management techniques that are more efficient (less time or money for the same or better ecological outcome)?

- How can managers predict and monitor changes in fen vegetation to focus efforts on areas with the highest potential to revert to desired conditions.

- What is the historic fire return interval of prairie fens and how can this inform the use of prescribed fire to mimic natural processes?

- Can the fen and associated species be conserved with the responsible use of prescribed fire?

- What are the long-term effects of regular use of herbicides to combat invasive plants?

- How do MSB and PS respond to habitat structure and management at occupied sites? Do they utilize newly managed habitat?

- How can we efficiently obtain pre-management baseline data for MSB, PS, eastern massasauga and other rare plants and animals at prairie fen sites to help us evaluate the impacts of fen management.

- What are the potential impacts of climate change on fens and associated rare species?

The diverse groups of conservation partners that are collaborating to promote the conservation of prairie fens and associated rare species are developing a framework to address these uncertainties through conservation plans and strategies. Opportunities to prioritize strategies, identify and retain needed resources, and implement actions to address threats and improve fen habitat have not always been capitalized in the most effective manner. Resources should be directed to secure necessary funding, conduct focused applied research, continue habitat management and promote timely communication and information sharing between managers and researchers to facilitate adaptive management.

The challenges for the future are to mentor and train younger managers while at the same time quantifying and documenting the results of our management. This will ensure that future fen managers are building on our hard-earned knowledge and not repeating our past mistakes.

6.3 Adaptive Management

Adaptive management is necessary to address the many uncertainties about the best way to manage fens while minimizing potential negative impacts to associated rare species. Adaptive management can be successful, when management goals and objectives are clearly stated so that monitoring benchmarks can be developed accordingly (Noon 2003). Successful ecosystem management allows conservation approaches to change appropriately based on new information. Conservation actions must be evaluated so that relative success can be documented and subsequent actions can be adapted for greater effectiveness. Thus, effective monitoring is a key component of adaptive management.

6.3.1 Monitor the effectiveness of management to maintain fens.

Just as monitoring without follow-up management (when needed) is ineffective, so also is management without follow-up monitoring. For example, clearing part of a fen of woody shrubs may offer an obvious and dramatic improvement, but without monitoring one cannot know the extent of woody re-sprouts and seedlings. Perhaps herbicide concentrations need to be changed, or maybe a few hours of follow-up treatment is necessary. Monitoring can protect the investment of significant resources in restoration and improve future management.

Examples of fens that were not helped or were harmed by management without monitoring abound. In one fen, the mature buckthorn shrubs were cut, and stumps were treated with herbicide. However, no monitoring was conducted. The seeds of the buckthorn sprouted, and within a few years these trees had replaced the older buckthorn, but at a higher stem density than previously. Similarly, a fen was burned in the early spring, and monitoring in that summer indicated that shrub cover was decreased and herbaceous cover increased. However, the monitoring did not continue into subsequent years. The shrubs re-sprouted and stem density increased. In another small fen, repeated annual late spring and early summer burns effectively reduced shrub cover, but the abundance of spring blooming plants and some animals were greatly reduced. These are hypothetical examples, based on the experiences of many managers and researchers.

Managers cannot monitor all fens, in all years, for all species. However, managers should monitor some fens in some years. Rare species in these fens should be monitored by the manager or by researchers, such as natural features staff. If specialists monitor for rare species, it is critical that they communicate their results to managers in a timely fashion.

For managers with limited time to devote to monitoring, a protocol is needed that is sensitive to fen health and integrity and that is also quick and efficient. The Nature Conservancy in cooperation with the Michigan DNR has developed a community-based monitoring strategy (Pearsall and Woods 2006) that is relatively simple, with only three metrics to estimate for each management unit of fen (Appendix A-3).

6.3.2 Explicitly include monitoring and adaptation for a changing climate.

As climate changes one would expect the geographic ranges of some species to shift. These shifts may be associated with means or extremes of temperature or precipitation. Rare species at or near their geographic range limit should be sensitive to climate change. These species should be mapped, and changes in distribution monitored. Our best guess is that this will be a long-term slow change that may not be apparent without explicit long-term monitoring. However, because the rate of change in greenhouse gases is unprecedented in recent history, the rate of climate change and ecosystem responses is essentially unknown. This uncertainty is another important reason to monitor changes. Finally, a climate related range contraction without an accompanying range expansion may trigger other conservation actions for a particular species.

6.3.3 Change management as necessary to meet plan objectives.

Adaptive management requires managers to change approaches based on the results of monitoring. This may be as simple as including follow-up herbicide treatments for herbaceous invasives into plans for prescribed burns. It may be as profound as to replace prescribed fire with low intensity grazing as the main disturbance regime, if monitoring and research warrant such a change. Adaptive management is popular on paper, but managers tend to resist exchanging familiar practices with new ones.

7. Implementation

7.1 Partner Participation

In Indiana and Michigan, approximately 60% of fens occur entirely on private land, and 40% occur partially or entirely on public lands. Of those fens on private land, about one-fifth (usually the largest and highest quality fens) are managed or protected by conservation partners, such as land conservancies or bird sanctuaries. Conservation partners are thus critical to the implementation of this multi-state plan.

7.2 Public Involvement

Many people, especially landowners with fens, were eager to be involved in the conservation of prairie fens. Thus, this plan will need to have an outreach and private landowner assistance component. Without these the plan will not be adopted, used, and implemented by the managers (private landowners) who own and protect over half of all fens.

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Appendix A-1

Fire Sensitivity and the Phenology of Rare Species

Fire sensitivity is a hot topic among biologists, ecologists, and land managers. Fire kills individuals, and poorly timed or poorly planned fires can wipe out local populations. Fire is also a natural process, and forgoing fire can change successional trajectories and wipe out local populations. To complicate matters, the effects of timing or configuration of fire on individual species is difficult to research, and results are sometimes contradictory.

In order to help land managers plan fire in fens responsibly, the following tables have been constructed. For the most part, they reflect initial hypotheses regarding relative sensitivity of different life history stages. A salamander hibernating in oak leaf litter is more sensitive than salamanders breeding in a pond. A lupine plant is more sensitive to fire when flowering than when dormant. However, sensitivity varies greatly among species, and that variation is not captured in these tables. For example, salamanders are much more sensitive to fire than lupine throughout the season.

Management of fens, like other systems, requires one to balance coarse and fine filters. These tables are one tool for land managers to consider when evaluating fine filters and considering the timing and configuration of prescribed burns. For more information on how the phenology tables were pulled together and the differing definitions of vulnerability, see Pages A-1.13 to A-1.19.

Table 1.
State Listed Plants of Prairie Fens

Table 2.
State Listed Animals of Prarie Fens

Table 3.
Plant Species Phenology and Fire Sensitivity

Table 4.
Animal Species Phenology and Fire Sensitivity

Fire and Rare Species

Table 1. State listed plants of prairie fens in Michigan and Indiana. Threatened and endangered plants are protected; state rare, watch list, and special concern are tracked through natural heritage databases, biut are not legally protected.

Common name	Scientific name	Indiana Status	Michigan Status
Purple milkweed	*Asclepias purpurascens*		State threatened
Rushlike aster	*Aster borealis*	State rare	
Willow aster	*Aster praealtus*		Special concern
Cut-leaved water parsnip	*Berula erecta*		State threatened
Prairie Indian plantain	*Cacalia plantaginea*		Special concern
Narrow-leaved reedgrass	*Calamagrostis stricta*		State threatened
Yellow sedge	*Carex flava*	State threatened	
Livid sedge	*Carex livida*	State endangered	
Hemlock parsley	*Conioselinum chinense*	State endangered	
Small yellow lady's-slipper	*Cypripedium calceolus var. parviflorum*	State rare	
Small white lady's-slipper	*Cypripedium candidum*	Watch list	State threatened
Tufted hairgrass	*Deschampsia cespitosa*	State rare	
Shooting star	*Dodecatheon meadia*		State endangered
English sundew	*Drosera anglica*		State threatened
Variegated horsetail	*Equisetum variegatum*	State endangered	
Narrow-leaved cotton-grass	*Eriophorum angustifolium*	State rare	
Slender cotton-grass	*Eriophorum gracile*	State threatened	
Green-keeled cotton-grass	*Eriophorum viridicarinatum*	State rare	
Rattlesnake master	*Eryngium yuccifolium*		State threatened
Queen-of-the-prairie	*Filipendula rubra*	Watch list	State threatened
Whiskered sunflower	*Helianthus hirsutus*		Special concern
Great St. John's-wort	*Hypericum pyramidatum*	State threatened	
Baltic rush	*Juncus balticus var. littoralis*	State rare	
Mat muhly	*Muhlenbergia richardsonis*		State threatened
Northern witchgrass	*Panicum boreale*	State rare	

Table 1 continued.			
Common name	**Scientific name**	**IN Status**	**MI Status**
Leiberg's witchgrass	*Panicum leibergii*	State threatened	State threatened
Wild sweet William	*Phlox maculata*		State threatened
Leafy white orchis	*Platanthera dilatata*	State endangered	
Leafy northern green orchis	*Platanthera hyperborea*	State threatened	
Prairie white-fringed orchid	*Platanthera leucophaea*	Federal threatened	Federally threatened
Jacob's ladder	*Polemonium reptans*		State threatened
Broad-leaved mountain-mint	*Pycnanthemum muticum*		State threatened
Autumn willow	*Salix serissima*	State threatened	
Canada burnet	*Sanguisorba canadensis*	State endangered	State endangered
Calamint	*Satureja glabella var. angustifolia*	State endangered	
Rosinweed	*Silphium integrifolium*		State threatened
Shining ladies'-tresses	*Spiranthes lucida*	State rare	
Hooded ladies'-tresses	*Spiranthes romanzoffiana*	State threatened	
Prairie dropseed	*Sporobolus heterolepis*		Special concern
False asphodel	*Tofieldia glutinosa*	State rare	
Marsh arrow-grass	*Triglochin palustris*	State rare	
Horned bladderwort	*Utricularia cornuta*	State threatened	
Lesser bladderwort	*Utricularia minor*	State threatened	
Hairy valerian	*Valeriana edulis*	State endangered	State threatened
Marsh valerian	*Valeriana uliginosa*	State endangered	
White camas	*Zigadenus elegans var. glaucus*	State rare	
Wild rice	*Zizania aquatica var. aquatica*		State threatened

Fire and Rare Species

Table 2. State listed animals of prairie fens in Michigan and Indiana. Threatened and endangered animals are protected; state rare, watch list, and special concern are tracked through natural heritage databases, biut are not legally protected.

Common name	Scientific name	IN Status	MI Status
Blanchard's cricket frog	*Acris crepitans blanchardi*		State threatened
Spatterdock darner	*Aeshna mutata*	State threatened	
Black-tipped darner	*Aeshna tuberculifera*	State threatened	
No common name?	*Agrotis stigmosa*	State threatened	
Opalescent apamea	*Apamea lutosa*	State endangered	
Black-dashed apamea	*Apamea nigrior*	State rare	
A noctuid moth	*Bellura densa*	State threatened	
Silver-bordered fritillary	*Boloria selene myrina*	State threatened	
Swamp metalmark	*Calephelis muticum*	State threatened	Special concern
A noctuid moth	*Capis curvata*	State threatened	
Praeclara underwing	*Catocala praeclara*	State rare	
Spotted turtle	*Clemmys guttata*	State endangered	State threatened
Kirtland's snake	*Clonophis kirtlandii*	State endangered	State endangered
Star-nosed mole	*Condylura cristata*	State special concern	
Brown spiketail	*Cordulegaster bilineata*	State endangered	
Arrowhead spiketail	*Cordulegaster obliqua*	State rare	
Two-lined cosmotettix	*Cosmotettix bilineatus*	State threatened	
Catocaline dart	*Cryptocala acadiensis*	State threatened	
A moth	*Dasychira cinnamomea*	State rare	
Racket-tailed emerald	*Dorocordulia libera*	State endangered	
Kansan spikerush leafhopper	*Dorydiella kansana*	State threatened	Special concern
Blanding's turtle	*Emydoidea blandingii*	State endangered	Special concern
Baltimore checkerspot	*Euphydryas phaeton*	State rare	
Sedge skipper	*Euphyes dion*	State rare	
Scarce swamp skipper	*Euphyes dukesi*	State threatened	State threatened

Table 2 continued.			
Common name	**Scientific name**	**IN Status**	**MI Status**
Pitcher window moth	*Exyra rolandiana*	State endangered	
Marsh fern moth	*Fagitana littera*	State threatened	
Leafhopper	*Flexamia delongi*		Special concern
Huron river leafhopper	*Flexamia huroni*		State threatened
Indiangrass flexamia	*Flexamia reflexus*	State threatened	State special concern
Watercress snail	*Fontigens nickliniana*		Special concern
Rapids clubtail	*Gomphus quadricolor*	State threatened	State special concern
Skillet clubtail	*Gomphus ventricosus*	State threatened	
Dragonhunter	*Hagenius brevistylus*	State rare	
Barrens buckmoth	*Hemileuca maia*		Special concern
Midwestern fen buckmoth	*Hemileuca sp. 3*	State threatened	same as *Hemileuca maia*
A noctuid moth	*Homophoberia cristata*	State rare	
A noctuid moth	*Iodopepla u-album*	State rare	
Angular spittlebug	*Lepyronia angulifera*	State threatened	Special concern
A moth	*Leucania inermis*	State rare	
No common name?	*Leucania multilinea*	State rare	
Dorcas copper	*Lycaena dorcas dorcas*	State rare	
Purplish copper	*Lycaena helloides*	State rare	
A moth	*Macrochilo absorptalis*	State rare	
A noctuid moth	*Macrochilo hypocritalis*	State rare	
Shadowy arches	*Melanchra assimilis*	State endangered	
Huckleberry eye-spot moth	*Melanomma auricinctaria*	State rare	
Newman's brocade	*Meropleon ambifuscum*	State threatened	State special concern
Dwarf skimmer	*Nannothemis bella*	State endangered	
Sphagnum sprite	*Nehalennia gracilis*	State endangered	

Table 2 continued.			
Common name	**Scientific name**	**IN Status**	**MI Status**
Mitchell's satyr	*Neonympha mitchellii mitchellii*	Federal endangered	Federal endangered
Poweshiek skipper	*Oarisma poweshiek*	Federal candidate	Federal endangered
Elegant prominent	*Odontosia elegans*	State rare	
Tamarack tree cricket	*Oecanthus laricis*		Special concern
Pitcher plant borer moth	*Papaipema appassionata*	State endangered	
Beer's blazing star borer	*Papaipema beeriana*	State threatened	Special concern
Golden borer moth	*Papaipema cerina*		Special concern
Ironweed borer moth	*Papaipema limpida*	State rare	
St. John's wort borer moth	*Papaipema lysimachiae*	State rare	
Giant sunflower borer moth	*Papaipema maritima*	State threatened	Special concern
Culvers root borer	*Papaipema sciata*		Special concern
Silphium borer moth	*Papaipema silphii*	State threatened	State threatened
Royal fern borer moth	*Papaipema speciosissima*	State threatened	Special concern
A moth	*Parasa indetermina*	State rare	
Eastern veined white	*Pieris oleracea*	State endangered	
Big broad-winged skipper	*Poanes viator viator*	State threatened	
Red-legged spittlebug	*Prosapia ignipectus*		Special concern
Northern leopard frog	*Rana pipiens*	Special concern	
Eastern massasauga	*Sistrurus catenatus catenatus*	Federal candidate	Federal candidate
Clamp-tipped emerald	*Somatochlora tenebrosa*	State rare	
Included cordgrass borer	*Spartiniphaga includens*	State threatened	
Spartina moth	*Spartiniphaga inops*		Special concern
Riverine clubtail	*Stylurus amnicola*	State threatened	State special concern
Band-winged meadowhawk	*Sympetrum semicinctum*	State rare	
Gray petaltail	*Tachopteryx thoreyi*	State rare	State threatened
Eastern box turtle	*Terrapene c. carolina*		Special concern

Focus on Prescribed Fire

Table 3. Hypothesized plant sensitivity to fire based on life history and phenology. Only short-term acute sensitivities to individuals are considered in this table. Sensitivity also varies from species to species, by fire intensity and ignition pattern, and according to time scales considered.

Plant Species Phenology and Fire Sensitivity

Plant Guilds	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Forbs												
Annuals - early season		D		E	FL		FR	SD	D		D	
Annuals - late season			D			E		FL	FR	SD		D
Biennials - early season		D		E	FL		FR	SD		D		
Biennials - late season			D			E		FL	FR	SD		D
Perennials - early season		D		E	FL		FR	SD		D		
Perennials - late season			D			E		FL	FR	SD		D
Sedges												
Annuals-early season		D		E	FL		FR	SD		D		
Annuals-late season			D				E		FL	FR	SD	D
Perennials-early season		D		E	FL		FR	SD		D		
Perennials-late season		D				E		FL	FR	SD		D
Grasses												
Annuals-cool season		D		E	FL		FR	SD		D		
Annuals-warm season			D				E		FL	FR	SD	D
Perennials-cool season		D		E	FL		FR	SD			D	
Perennials-warm season		D				E		FL	FR	SD		D
Vines												
Early season		D			E	FL	FR		SD		D	
Late season		D				E		FL	FR	SD		D
Trees												
Early season		D	E	FL		FR		SD		E		D
Late season		D			E	FL	FR			SD		D

Rare Plant Species	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Purple milkweed *Asclepias purpurascens*		D			E		FL	FR	SD		D	
Cut-leaved water parsnip *Berula erecta*		D			E		FL		FR	SD	D	
Prairie Indian plantain *Cacalia plantaginea*		D			E		FL		FR	SD	D	
White lady-slipper *Cypripedium candidum*		D		E		FL	FR	SD			D	
Rattlesnake master *Eryngium yuccifolium*			D			E	FL		FR	SD	SD	D
Queen-of-the-prairie		D				E	FL		FR	SD	SD	D

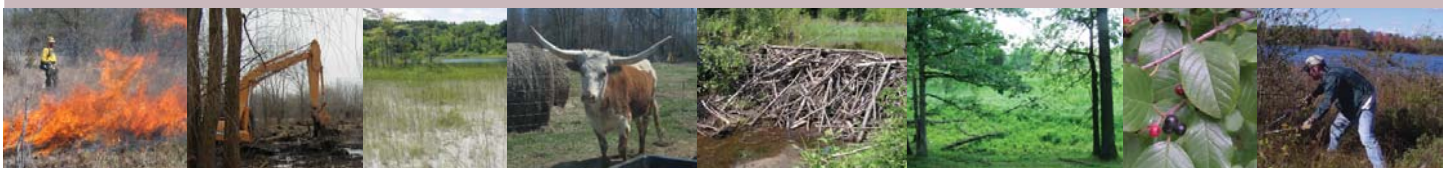


Table 3. continued.

Plant Species Phenology and Fire Sensitivity

Rare Plant Species - Continued	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Whiskered sunflower *Helianthus hirsutus*	D				E	E		FL	FR	SD SD		D
Mat muhly *Muhlenbergia richardsonis*			D			E	E	FL	FR	SD	SD	D
Wild sweet William *Phlox maculata*		D			E	E	FL	FR	SD	SD	D	
Jacob's ladder *Polemonium reptans*		D		E		FL	FR	SD	SD		D	
Rosinweed *Silphium integrifolium*		D			E	E		FL	FR	SD	SD	D
Prairie dropseed *Sporobolus heterolepis*		D			E	E	FL	FR	SD		D	
Edible valerian *Valeriana edulis* var. *ciliata*		D		E	FL	FR	SD	SD	SD		D	
Critical Food Plants for Rare Insects												
Swamp thistle *Cirsium muticum* (Swamp metalmark)		D			E	E		FL	FR	SD		D
Blazing star *Liatris* spp. (Blazing star borer moth)		D		E		E		FL	FR	SD		D
Regal fern *Osmunda* spp. (Regal fern borer moth)		D				E			E		D	
Giant sunflower *Helianthus giganteus* (Maritime sunflower borer moth)		D			E	E		FL	FR	SD SD		D
Culver's root *Veronicastrum virginicum* (Culver's root borer moth)		D			E	E	FL		FR	SD	D	

Phenology Key

Dormant **D**
Emergent **E**
Flowering **FL**
Fruiting **FR**
Seed Dispersal **SD**

Fire Sensitivity Key

Vulnerable
Potentially Vulnerable
Not Vulnerable

Table 4. Hypothesized animal sensitivity to fire based on life history and phenology. Only short-term acute sensitivities to individuals are considered in this table. Sensitivity also varies from species to species, by fire intensity and ignition pattern, and according to time scales considered.

BIRDS	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DE
Ground- nesting												
American bittern *Botaurus lentiginosus*				A	N	NY	Y		P			
American woodcock *Solopax minor*			A	AN N	NY	Y			P			
Blue-winged teal *Anas discors*				A	N	NY	Y		P			
Blue-winged warbler *Vermivora pinus*					A N	NY Y		P				
Henslow's Sparrow *Ammodramus henslowii*				A	N	NY	Y		P			
Northern harrier *Circus cyaneus*			A	N	NY	Y			P			
Wilson's snipe *Gallinago delicata*			A	N	Y				P			
Virginia Rail *Rallus limicola*				A	N	NY	Y		P			
Sedge wren *Cistothorus plantensis*					A	N	NY	P				
Sora *Porzana carolina*				A	N	NY	Y		P			
Cavity- nesting												
Northern flicker *Coaptes aurautus*			A	N	NY	Y			P			
Shrub-nesting												
Black-&Yellow-billed cuckoos *Coccyzus spp*					A N	NY		Y		P		
Green heron *Butorides virescens*				A	N	NY	Y		P			
Yellow-breasted chat *Icteria virens*					A N	NY	Y	P				
Tree-nesting												
Eastern kingbird *Tyrannus tyrannus*					A N	NY	Y	P				

HERPETOFAUNA	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DE
Blanchard's cricket frog *Acris crepitans blanchardii*		HT		A		BA		M		A	HT	
Blanding's turtle *Emydoidea blandingii*		HA		BA		NT	A/E E	E/M		A	HA	
Eastern box turtle *Terrapene c. carolina*	HT	HT	HT	BT		NT	A	E	BT/M		HT	H

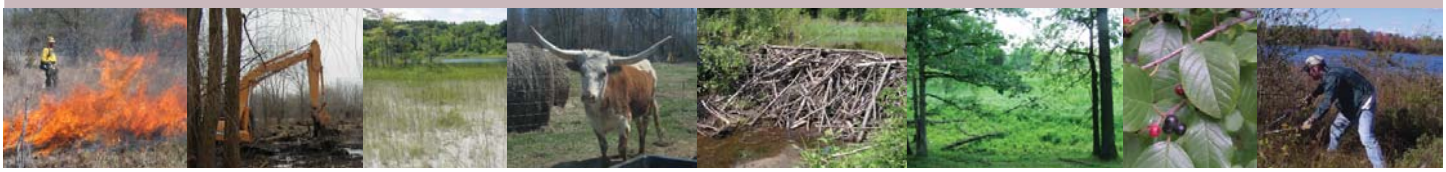


Table 4. continued.

Animal Species Phenology and Fire Sensitivity

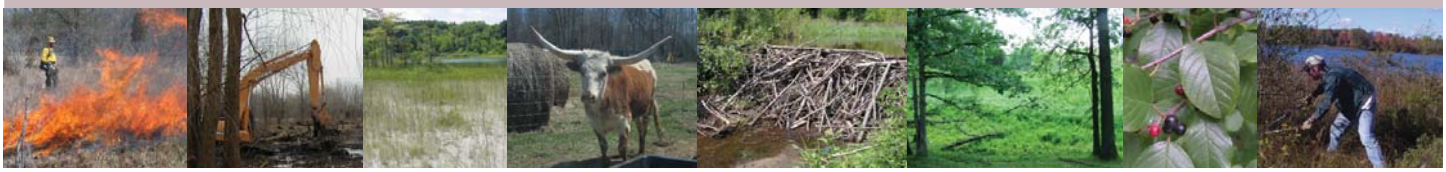
HERPETOFAUNA Continued	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Eastern massasauga rattlesnake *Sisturus c. catenatus*		HT			BT			NT		BT	HT	
Kirtland's snake *Clonophis kirtlandii*		HT		A	BT		A		NT		A	HT
SNAILS												
Watercress snail (aquatic) *Fontigens nickliniana*			H				A				H	
Pleistocene cantinella *Catinella exile*		H	A?				A			A?	H	
Six-whorl vertigo *Vertigo morsei*			H		A?			A		A?	H	
Snail (no common name) *Euconulus alderi*		H	A?				A			A?	H	

INSECTS Butterflies and Moths	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Barrens buckmoth *Hemileuca maia*			E			L		P		A	E	
Blazing star borer moth *Papaipema beeriana*			E		L	L		L	P	A	E	
Culver's root borer moth *Papaipema sciata*			E		L	L		L	P	A	E	
Duke's skipper *Euphyes dukesi*				L		P	A	E		L		
Golden borer moth *Papaipema cerina*			E		L	L		P		A	E	
Maritime sunflower borer moth *Papaipema maritime*			E		L	L		L	P	A	E	
Mitchell's satyr *Neonympha m. mitchellii*			L		P	A		E		L		
Newman's brocade *Meroplean ambrifusca*			E			L		P	A		E	
Poweshiek skipperling *Oarisma poweshiek*				L		P	A	E		L		
Regal fern borer moth *Papaipema speciosissima*			E		L	L			P	A	E	
Siphium borer moth *Papaipema silphii*			E		L		L		P	A	E	
Spartina moth *Spartiniphaga inops*			E				L		P	A	E	
Swamp metalmark				L			P	A	E		L	

Table 4. continued.

Animal Species Phenology and Fire Sensitivity

INSECTS Continued	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Beetles												
Cantrall's bog beetle *Liodessus cantralli*	N	P	A	E		N			P	A	E	N
(aquatic) *Stenelmis douglasensis*			N		P			A		E		N
Cicadas and Leafhoppers												
Angular spittlebug *Lepyronia angulifera*				A			N/A			A		
Huron R, leafhopper *Flexamia huroni*			E			N		A				E
Leafhopper *Flexamia delongi*		E			N			A				E
Leafhopper *Flexamia reflexa*		E			N			A				E
Kansan spike-rush leafhopper *Dorydiella kansana*			E			N		A				E
Red-legged spittlebug *Prosapia ignipectus*			E		N		N	A			E	
Dragonflies												
Gray petaltail *Tachopteryx thoreyi*			N				A		E		N	
Grasshoppers and Crickets												
Bog conehead *Neoconocephalus lyristes*			E			N		A			E	
Hoosier locust *Paroxya hoosieri*		E			N			A			E	
Red-faced meadow katydid *Orcheliimum concinuum*			E			N		A			E	
Tamarack tree cricket *Oecanthus laricis*			E			N		A			E	
MAMMALS												
Southern bog lemming			B?				B			B?		



Focus on Prescribed Fire

Fire Sensitivity

Vulnerable
Potentially Vulnerable
Not Vulnerable
Unknown

Bird Phenology

Pre-nesting Period A
Nesting Period N
Flightless Young Y
Post-nesting Period P

Herp Phenology

Active A

Breeding-Aquatic/Terrestrial BA/BT
Nesting, eggs, young - Aquatic/Terrestrial NA/NT
Metamorph,Hatchling Emigration,Emergence M

Aestivation E
Hibernation-Aquatic/Terrestrial HA/HT

Snail Phenology

Hibernation H
Active A

Insect Phenology

Adult flight/active A
Larvae/nymphs L/N
Pupae P
Eggs E

Mammal Phenology

Breeding/Nesting B

Considerations and Caveats of the Fire and Species Phenology Tables

Tables 1-4 are intended to advise managers of what is known about the life history and phenology of rare plants and animals (E, T, SC and SGCN) as well as critical food plants for rare insects. The scientists that contributed to this table caution that assumptions made regarding the vulnerability of plants and animals to prescribed fire are based on the best available knowledge of life history as well as information gleaned from the very limited research that has been conducted on the impacts of fire on plants and animals in prairie fen wetlands. Therefore, this table is just a starting point and should be viewed as a working draft that can be considered when reviewing potential management strategies for a particular site.

Monitoring is needed to better understand how to best use fire as a management tool. Resources should be prioritized to conduct monitoring of sites prior to prescribed burns so that managers have adequate information to consider including: 1) the presence of plants and animals that occur or have the potential to occur at a site; 2) whether there is appropriate refugia habitat available to plants and animals (especially those that are rare) and 3) the relationship between the proposed burn unit and the distribution of rare plants and animals. In addition it is critical that post burn monitoring be done so that managers can evaluate the response of the vegetation to the burn as well as any impacts to rare plants and animals, both positive or negative.

Plants

Phenology Information

The depiction of phenologies was based on broadly summarizing vascular plant species into five principal life stage categories (dormant, emergent, flowering, fruiting, and seed dispersal). These categories work well with the exception of one taxon included in the food plant list, Osmunda spp. (Regal fern), which by definition does not flower (although it does develop spore-producing fronds) and thus was simply noted as being either dormant or emergent for the purposes of this table. Information to develop the species phenologies was obtained by consulting several important resources, including the MNFI Rare Species Explorer (http://mnfi.anr.msu.edu/explorer/search.cfm), detailed MNFI species abstracts where available (http://mnfi.anr.msu.edu/pub/abstracts.cfm), and species occurrence data provided in the MNFI Biotics database where there was specific reference to emergence, flowering, fruiting, and seed dispersal dates. All of the phenologies, however, should be considered as approximate dates, owing the wide variation known to occur between and within different fen sites as well as the variation in phenologies yearly due to climate patterns.

Because of an emerging and widespread interest in plant phenologies, particularly with regard to the advent of climate change, a national monitoring network (http://www.usanpn.org/) has been created to engage government agencies, citizen scientists, educators and others to monitor plants to determine the potential impacts due to climate change. This site was consulted for information, and while no pertinent data were obtained for populating the plant phenology table, it is suggested that this website be consulted in the future as pending maps and other materials become available. The posting of first blooming dates, for example, of plant species in our area, based on a wide monitoring network, can assist land managers in planning prescribed burns and other management activities.

Fire Vulnerability

The variation in fire sensitivity among the species and various plant groups and guilds noted largely reflects the wide variation in emergence, growth, and flowering and fruiting periods. Annual species, for example, may emerge and flower

and fruit at any time during the growing season, but for purposes of the table were segregated into early flowering/fruiting species and late flowering/fruiting species. "Early" species were defined as those emerging and flowering/fruiting from spring to mid-July, whereas "late" species were defined as those emerging and flowering/fruiting from mid-July to the fall. These are comparable to the categories commonly known for grasses when referenced as "cool" season or "warm" season species. The vulnerability of a species was generally assumed to be high during the flowering and fruiting periods, but vulnerability is also dependent on life history and growth form. For example, a perennial species may sustain some damage if burned before or during emergence (with impacts dependent on burn intensity), but these species often have the ability to re-sprout. Flowering and fruiting may not occur or may be set back, but the individual can persist. Annuals, which do not have taproots, thick rhizomes, and other sustaining features, would not persist or have the ability to re-sprout.

The relationship of many fen species to fire is well known, as several taxa occur in western prairie communities, including upland types that have long been managed via prescribed burning as described by Curtis (1959) and others. However, the specific role and/or impacts of fire on Midwestern prairie fens is not known for all species, including such rarities as Jacob's ladder (*Polemonium reptans*), Edible valerian (*Valeriana edulis* var. *ciliata*), and Cut-leaved water parsnip (*Berula erecta*), and thus further investigation and monitoring is warranted.

BIRDS

Phenology Information

Dates used for breeding phenology should be viewed as approximate. The information used to determine arrival, nesting, and departure timing in this table was limited and dated. Although changes to bird migration and breeding phenology associated with climate change have been documented in many locations throughout the world, recent data on bird phenology are lacking. Bird migration and breeding phenology can also vary due to normal annual weather fluctuations. Therefore, we suggest managers use caution when interpreting this table and take local conditions into account.

We indicated the timing for four broad bird phenology periods: 1) pre-nesting (A); 2) nesting (N); 3) flightless young (Y); and 4) post-breeding (P). The pre-nesting period encompasses the time from spring arrival to the start of egg laying. We used the nesting period to describe the time from the beginning of egg laying through incubation and hatching. The flightless young period spans the part of the year when juvenile flightless birds could be present at or near nests. We designated the time after young achieve flight until departure for fall migration as the post-nesting period.

Fire Vulnerability

While there is substantial research on bird responses to fire one or more years after the event, we found no studies of bird species' vulnerability (e.g., mortality) at the time of a fire occurrence. Given this lack of information, we made several assumptions when building this table: 1) birds are vulnerable to fire upon arrival on breeding grounds; 2) birds are highly vulnerable during the nesting and flightless young period; 3) ground-nesting species are more vulnerable to fire than shrub or tree nesting species; and 4) these species are not vulnerable during the post-breeding period. We indicated that birds are vulnerable to fire upon arrival to breeding sites, because they typically begin selecting and defending territories shortly after spring arrival. Fire during this period would likely interrupt the breeding cycle, cause territory abandonment, and require adults to find new breeding sites. We assumed that birds are most vulnerable during the nesting and flightless young periods, because adults may be unable to re-nest at another location and could lose an entire season's breeding effort as a result of fire. Because shrub or tree nesting bird species are less likely to be impacted by fire and possibly better able to re-nest at the site if affected, we listed those species as less vulnerable than ground-nesting species. We felt the bird species examined would not be vulnerable to fire during the post-breeding period, because they often have less specific habitat requirements during this period compared to the breeding season and would be more likely to find suitable habitats at other locations. While some species could be negatively impacted during the season when the fire takes place, there could be benefits during subsequent breeding seasons due to improved habitat conditions.

AMPHIBIANS AND REPTILES (HERPETOFAUNA/HERPS)

Phenology Information

For the purposes of this table, we indicated the phenology or timing for six broad amphibian and reptile, or herp, life stage categories: 1) active (A) which includes spring emergence, basking, foraging, resting, travelling, dispersing, migrating to breeding and nesting sites and hibernacula/overwintering sites; 2) breeding in water/aquatic habitat (BA) or on land/terrestrial habitat (BT); 3) nesting, egg-laying, or giving birth to live young/parturition in water/aquatic habitat (NA) or on land/terrestrial habitat (NT); 4) metamorph or hatchling emigration or emergence from breeding or nesting sites (M); 5) aestivation (E) or state of dormancy or inactivity during hot or dry weather; and 6) hibernation or overwintering in water/aquatic habitat (HA) or on land/terrestrial habitat (HT). It is important to note that not all herp species go through all these life stages (e.g., species that give birth to live young do not have a metamorph or hatchling emergence stage, and not all species aestivate), and that life stages can overlap (e.g., different individuals in a population can be breeding and nesting during the same time period). It also is important to note that many amphibian and reptile species use different habitats during different life stages (e.g., hibernate in or utilize a terrestrial habitat during most of the active period but breed in water or aquatic habitat, or utilize wetlands during most of the active period but nest or give birth in upland habitats).

Dates used for life stage categories should be viewed as approximate. The information used to generate dates were obtained from a variety of literature and other sources, including the MNFI's Species Explorer website (http://mnfi.anr.msu.edu/explorer/search.cfm), detailed species abstracts when available (http://mnfi.anr.msu.edu/pub/abstracts.cfm), and the "Amphibians and Reptiles of the Great Lakes Region" field guide (Harding 1997). The information used to determine the phenology of the life stages included in this table was limited or fairly general for some species. For example, Harding (1997) states that "Eastern Box Turtles may mate at any time during the active season, but breeding activity is most frequent in spring and fall," or "Mating can occur anytime from April to November, but is most frequent in spring" for Blanding's Turtles. Life stage phenologies also can vary due to annual weather fluctuations and local weather conditions. Therefore, we suggest managers use caution when interpreting this table and take local conditions into account.

Fire Vulnerability

Amphibians and reptiles may be vulnerable to fire in any of these life stages and to what degree depends largely upon individual species' life stage at the time of the fire/prescribed burn, life history, behavior, ecology, habitat use, and species specific dispersal capabilities. Unfortunately, limited information exists about the effects of prescribed fire on amphibians and reptiles, particularly in the southern Great Lakes region (McLeod and Gates 1998, Ford et al. 1999, Russell et al. 1999, Pilliod et al. 2003, Langford et al. 2007, Roloff and Doran 2010). Some research has indicated that, in general, fire appears to have little direct effect on amphibians and reptiles because they are able to retreat to underground burrows, find moist refugia, or spend considerable time underground, all of which provide protection from fire (Vogl 1973, Main 1981, Bamford 1992, Friend 1993, Russell et al. 1999, Pilliod et al. 2003). However, some studies have documented direct as well as indirect effects of fire on herps (Vogt 1973, Polliod et al. 2003, Schurbon and Fauth 2003). Most studies also have focused primarily on immediate and short-term responses, and only a few have examined long-term effects of fire on herps.

Herpetofaunal responses to prescribed fire are species specific, vary among habitats, and require further study (Russell et al. 1999, Pilliod et al. 2003). There is a lack of published information on the effects of fire specific to many of the rare species listed in the table. Given this lack of information, we made several assumptions when building this table regarding species vulnerability to fire: 1) species will have access to some refugia on-site or nearby during and after prescribed fires; 2) species are or may be vulnerable to fire in any life stage in which individuals occur mainly on the ground, on vegetation, or in/under the duff layer in terrestrial habitats; 3) species are not vulnerable or less vulnerable to direct effects of fire when they occur in water or aquatic habitats or below the soil surface (e.g., during hibernation or aestivation), but species may still be vulnerable to indirect effects; and 4) species may be particularly vulnerable during the least mobile stages such as when animals are aestivating or overwintering at or near the soil surface in terrestrial habitats.

Species vulnerability to prescribed fire also will be influenced by local weather conditions and the type, seasonality and size or extent of prescribed burns. It is also important to remember while some species could be negatively impacted during the active season when the fire occurs, there could very well be benefits to the species during subsequent seasons due to improved habitat conditions. More research on the effects of prescribed burning on amphibians and reptiles is necessary, especially in prairie fen wetlands in the Great Lakes. This table should be refined as additional information about specific impacts and benefits of prescribed fire to herp species is generated and compiled.

SNAILS

Phenology Information

Limited information is available about the distribution and life history of snails in Michigan, and much remains to be learned about this taxon. Much of what we know about Michigan's snails comes from Dr. Burch, University of Michigan. Recent information, especially regarding snails in the Upper Peninsula, has been gleaned from work conducted by Dr. Jeffrey Nekola, especially surveys that took place in the late 1990's. Three of the land snail species listed in this table are known from northern fens, and have not yet been documented in southern Michigan. They are included as they have potential to occur in prairie fens and occur at similar latitudes in other states. The watercress snail (*Fontigens nickliniana*), an aquatic snail, has been recently documented from fens in Barry and Kalamazoo counties.

Dates used for life stage categories should be viewed as approximate and have been gleaned from a variety of literature, mostly distilled thorough the MNFI's Species Explorer website available at: (http://mnfi.anr.msu.edu/explorer/search.cfm), detailed species abstracts where available (http://mnfi.anr.msu.edu/pub/abstracts.cfm), and field data provided in the MNFI Biotics database with specific reference to adult activity dates. In addition, life history information was reviewed from (Burch, J.B. 1962) "How to Know the Eastern Land Snails". Snail life stage phenologies can also vary due to annual weather fluctuations. Therefore, we suggest managers use caution when interpreting this table and take local conditions into account. For the purposes of the table we indicated the timing for two broad life stage categories: 1) hibernation (H) and 2) active (A). Although many snails experience periods of aestivation, especially during dry periods (often on the surface of the ground), this was not included as it is difficult to predict when this period of inactivity occurs.

Fire Vulnerability

Snails may be vulnerable to fire in any of these life stages and to what degree depends largely upon individual species' location at time of ignition, since snails have extremely limited dispersal capabilities. The two most important environmental variables important to land snails are temperature and soil moisture. There is a lack of published information specific to many of the rare/remnant-dependent species listed in the table. Given this lack of information, we made several assumptions when building this table: 1) land snails are highly vulnerable to fire in any life stage that occurs mainly on the vegetation, exposed on downed logs or trees or in the uppermost soil layer; 2) snails are potentially vulnerable as eggs deposited in a nest a few centimeters below the soil or in the leaf litter; and 3) species are less vulnerable to fire when they are aquatic (i.e., watercress snail), especially during hibernation.

Nekola (2002) reports that prescribed fire has been shown to substantially reduce the abundance of land snails, including *E. alderi*, and cause the local extirpation of land snail species in upland and lowland grassland habitats. He further suggests that burn intervals be at least 15 years and recommends that other methods of removing woody and invasive plants be used that preserve organic litter layers at sites with land snails (Nekola 2002). Research of the results of the 2002 forest fire in the central grasslands of the United States (in the states of Wisconsin, Iowa and Minnesota), led to 44% of land mollusk species there experiencing population declines. The situation was dramatic for snails as they underwent the most severe declines due to the fire having destroyed all plant waste (Santos et. al 2009). More research on the effects of prescribed burning on rare/remnant-dependent species is necessary, especially in the prairie fen wetlands in the Great Lake States. From other geographic areas there appears to be widespread consensus that it is important to leave unburned "refugia" to allow for faunal recolonization in the event of local extirpation related to fire (Roloff and Doran 2010).

INSECTS

Phenology Information

Dates used for life stage categories should be viewed as approximate and have been gleaned from a variety of literature, mostly distilled thorough the MNFI's Species Explorer website available at: (http://mnfi.anr.msu.edu/explorer/search.cfm), detailed species abstracts where available (http://mnfi.anr.msu.edu/pub/abstracts.cfm), and field data provided in the MNFI Biotics database with specific reference to adult activity dates. The information used to determine egg, larval/nymph, pupal, and adult stage in this table was limited for some species and often times widely overlapping or over simplified. For example, male adults of the angular spittlebug can be found in the late summer from August to October. Adult females can be found from late April through early November. Insect life stage phenologies can also vary due to annual weather fluctuations. We suggest managers use caution when interpreting this table and take local conditions into account. We indicated the timing for four broad insect life stage categories: 1) eggs (E); 2) larval/nymphal (L) or (N); 3) pupal stage (P); and 4) adult (A).

Fire Vulnerability

Insects may be vulnerable to fire in any of these life stages and to what degree depends largely upon individual species' life stage at time of ignition, behavior, and species specific dispersal capabilities. There is a lack of published information specific to many of the rare/remnant-dependent species listed in the table. Given this lack of information, we made several assumptions when building this table: 1) insects are vulnerable to fire in any life stage that occurs mainly on the vegetation or in the duff layer; 2) insects are highly vulnerable during the least mobile stages such as when eggs, pupae, larvae, or nymphs; 3) species that utilize food plants that occur in wet or damp microhabitats are less likely impacted by fire (i.e., spartina moth, angular spittlebug); and 4) species are not vulnerable to fire when they are aquatic (i.e., gray petaltail, Cantrall's bog beetle) or when pupating below the soil surface (Papaipema moths).

It is also important to remember while some species could be negatively impacted during the season when the fire occurs, there could very well be benefits during subsequent breeding seasons due to improved habitat or host plant conditions. More research on the effects of prescribed burning on rare/remnant-dependent species is necessary, especially in the prairie fen wetlands in the Great Lake States. From other geographic areas there appears to be widespread consensus that it is important to leave unburned "refugia" to allow for faunal recolonization in the event of local extirpation related to fire (Roloff and Doran 2010).

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Make Your Own Herbicide Wand

Appendix A-2: Directions to Make your own Herbicide Wand

(From the Global Invasive Species Team website: http://www.invasive.org/gist/tools/wandinst.html)

Parts Required

Unless otherwise specified, all the parts are 1 inch diameter PVC fittings.
2--threaded female caps
1--3/4-inch unthreaded female cap
4--male couplings, threaded on the male end
1--45 degree elbow coupling, unthreaded
1--ball valve, threaded on both female ends
1--pipe piece 12 to 15 inches long
2--pipe pieces 1 inch long
1--heavy duty ("cellulose") sponge 2 x 4 x 1.5 inches
4--1.25 inch rubber lavatory gaskets (see construction hints, below)

Tools/Materials Required

PVC purple primer and cement
PVC pipe cutters or hacksaw
Coarse file for PVC
Drill with 1/16 inch and 3/4 inch bits
Ruler
Scissors (to cut sponge)

Assembly Instructions

Construction hints: When buying parts for the wand, remember that the wand has four threaded joins which are hand-tightened. Lavatory gaskets ensure the fits are leak proof. When selecting gaskets, try them out on the PVC connectors before you use them. You may need to double up gaskets to make a tight seal. Gaskets with too large of an inner diameter may leak, too. In general, refer to the construction schematics on our web site if you are unclear on any of the instructions.

A) Making the main reservoir: Cement a male threaded coupling onto each end of the 12-15 inch pipe. Place a rubber gasket on one end, followed by a female threaded cap. With the rubber gasket in place, the fit should be leakproof when hand-tightened to a snug fit.

B) Making the sponge reservoir: Depending upon the details of the way your PVC fittings were molded, you may have to innovate to complete this part of the construction. Read this section completely before proceeding! First, cut the end off the 3/4 inch PVC cap, and drill two holes (1/16 inch) in it. The cap should look like a large shirt-button. The cap should slide snugly into the unthreaded end of a threaded male coupling (you may need to file it a little). Cement it in place as far inside the male coupling as you can. Use a 1 inch length of pipe to cement the male coupling to the 45 degree elbow coupling. Use another 1 inch length of pipe to cement the other end of the 45 degree elbow to a male coupling.

C) Making the sponge tip: Drill a 3/4 inch diameter hole into a threaded female cap. Make a sponge tip by cutting a square or columnar chunk out of a heavy-duty sponge. A tip 1 inch in diameter and 1.5 inches long should fit snugly in the hole. A metal pipe with sharpened ends can be used to cut out sponge tips. Cut out several, you will need them.

D) Completing the wand: Using gaskets, screw the sponge tip to the end of the sponge reservoir nearest the 3/4 inch drip hole disk. Screw the other end into the ball valve. Screw the main reservoir into the other side of the ball valve.

Make Your Own Herbicide Wand

How To Use the Wand

With ball valve in the closed position, pour the herbicide mix into the main reservoir and replace the fill-cap on the wand. Open the ball valve slightly to let herbicide enter the sponge reservoir. (You may need to loosen the fill-cap to let air into the main reservoir.) Once the sponge tip begins to saturate, close the ball valve (and if necessary, retighten the fill cap). Only a light touch of the saturated sponge tip is needed to apply herbicide to a cut-stump. Open the ball valve when more herbicide is needed in the sponge tip.

Helpful Hints

(by the wand's inventor, Jack McGowan-Stinski, TNC MI)

1) During colder weather the ball valve may have to be left open to allow enough herbicide to saturate the sponge. Drip holes also can be made larger if faster herbicide flow is desired.

2) Do not allow left-over herbicide mix to remain in the reservoir in extreme temperatures.

3) Always clear drip holes of residue before using the applicator. A paper clip works well for cleaning out residues.

4) When the sponge becomes worn, replace it (recommended after every work day at a minimum).

5) When using the applicator during freezing conditions, duct tape a disposable chemical hand warmer around the section with the drip hole disk to reduce the chance of drip holes freezing shut.

6) Use a herbicide dye to check for leaks, monitor applications, and identify any exposure to the person using the applicator.

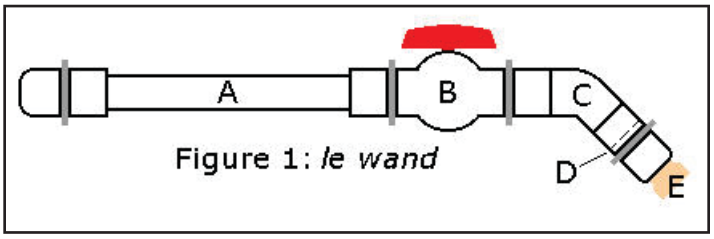

Figure 1: *le wand*

-Barry Rice, TNC/GIST, May 2000; revised March 2001
http://www.invasive.org/gist/tools/wand.html

Appendix A-3: Methods and Guidelines for Assessing Restoration Progress in Prairie Fens Using Coarse-Level Metrics

Douglas R. Pearsall and Steven S. Woods, The Nature Conservancy in Michigan, September, 2006 (updated January, 2008)

Introduction

Prairie fens in southern Lower Michigan and northern Indiana have long been a focus of conservation efforts. Most, if not all, of these fens suffer from altered hydrology, altered fire regime, and invasive species, and significant resources have been invested in restoring and maintaining fens by public agencies and private organizations. While restoration techniques have improved and there is some monitoring being carried out in individual fens, monitoring procedures have generally required botanical expertise and more time and resources than managers have to spend on monitoring. Additionally, there has been no consistent monitoring of the progress of restoration across multiple fens. Given that there are roughly 130 prairie fens in southern Michigan and tens more in northern Indiana, at least 20% of which are being actively managed, implementation of consistent measures of restoration progress in multiple managed fens would provide a valuable index of the status of fens in this part of their range.

The Nature Conservancy in Michigan has developed a set of coarse-level metrics to provide a relatively quick and inexpensive means to track the progress of restoration in prairie fens. Assessment of these metrics requires basic understanding of the ecology of fens and the behavior of fire in fens, but does not require extensive botanical expertise. They are designed so that land managers and stewards can evaluate them without relying on external botanists or ecological consultants. We first conceived and applied them in 2004 at Ives Road Fen Preserve and have since refined them and applied them also at Grand River Fen Preserve. Initially there were three metrics (percentage cover of native species, percentage cover of herbaceous species, and percent of a management unit that would carry a prescribed fire), but based on discussions in a field workshop with partners in August, 2006, we added a fourth metric: percentage cover of woody plants. This fourth metric recognizes that herbaceous and woody plants can occupy the same area (i.e., there are multiple structural layers) and that the total cover of the two can exceed 100 percent. For consistency, it was agreed that woody and herbaceous plant cover should be evaluated independently. A fifth metric, percentage cover of non-native plants was added in 2008. As with herbaceous and woody plants, the coverages of native and non-native plants are not entirely dependent and the total coverage can exceed 100 percent.

General Methods

1. Divide managed area into management units (see more detailed discussion below).

2. Walk through each management unit and perform visual assessment of each of the coarse-level metrics. It is recommended that the assessments be performed by at least two people familiar with fen ecology and fire management. Because these estimates are subjective, there will be variation among surveyors. The effects of variation can be diminished by taking the average value of two or more estimates.

3. Record each individual estimate on field data sheet and calculate the average value—this average should be used as the estimate for the individual management unit.

4. Determine values for each metric for the entire preserve or managed area using the estimates for each management unit.

a. First, calculate the area of each management unit and determine proportional area of each management unit.

b. Second, calculate weighted value for each metric in each management unit by multiplying the estimated values by the proportional area.

c. Lastly, determine the sum of all weighted values f or each metric across all management units.

5. Establish a system of categories for rating each metric for a given ecosystem (prairie fen, shrub fen, grassland, savanna, tamarack swamp, etc…). The Conservancy typically uses the categories of Poor, Fair, Good, and Very Good when rating an indicator of viability of a natural community or a population. Therefore, we have determined thresholds for each of these categories for each of the metrics as applied to prairie fens (Attachment B). These thresholds are designed to reflect ranges that are considered meaningful with respect to restoration progress in fens and would not apply well to most upland systems or wetlands characterized by more woody vegetation.

Guidelines for Field Estimates

1. Ensure visual access to entire unit or at least to areas that are representative of all portions of the unit.

2. Evaluate each metric independently, i.e., percentage cover of herbaceous species should include plants that occur underneath woody plants. Total percentage cover of herbaceous and woody plant will often exceed 100%.

3. Consider even low shrubs, such as shrubby cinquefoil (Dasiphora fruticosa), as woody species.

4. The percentage of a management unit that will carry a prescribed fire should be evaluated under the assumption that internal ignition will be used when necessary. Isolated patches of flammable fuels should be included in the total percentage, but areas of homogeneously thin fuels that would not carry a fire should not be included.

Establishing Management Units

Management units can be defined based on natural ecosystem boundaries or on imposed boundaries such as trails or burn breaks. Boundaries of disturbed areas, such as a ditched or plowed area, or of dense clumps of invasive species can also be used to define management units. It is recommended that management units be relatively uniform in vegetation composition and structure, and that a goal (or desired future condition) for the unit be clearly articulated. Examples of desired future condition include prairie fen, shrub fen, tamarack swamp, and hardwood swamp, and the metrics described here may be applied differently, or not at all, in units having a goal other than prairie fen.

Supplies and Equipment

This approach requires little equipment, but the following items are helpful.

- GPS unit (both for mapping unit boundaries and then relocating boundaries during field surveys)
- Aerial photographs depicting management unit boundaries.

Appendix A-4: Techniques and timing to manage some common invasive exotic plants.

Invasive Species Control Techniques & Timing

F = **F**ire; p-**p**rescribed burn, t-propane **t**orch
C = **C**hemical; b-**b**loody glove, c-**c**ut & paint, d-**d**rill & fill, f-**f**oliar, g-**g**irdle & paint
M = **M**anual; b-cut at **b**ase, h-**h**and pull, s-cut below **s**oil level

Scientific Name	**Common Name**	**Jan**	**Feb**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept**	**Oct**	**Nov**	**Dec**
Acer platanoides	Norway maple	Ccdg	Ccdg	F	F		Ccdg	Ccdg	Ccdg	Ccdg	Ccdg	Ccdg	Ccdg
Ailanthus altissima	Tree of heaven	Ccdg	Ccdg				Ccdg	Ccdg	Ccdg	Ccdg	Ccdg	Ccdg	Ccdg
Alliaria petiolata	Garlic mustard	Cf	Cf	Cf	Mh	Mh	Mh					Cf	Cf
Alnus glutinosa	Black alder	Ccdg	Ccdg				Ccdg	Ccdg	Ccdg	Ccdg	Ccdg	Ccdg	Ccdg
Berberis spp.	Barberry	Cc	Cc	Fp	Fp, Mh	Mh	Mh, Cc	Mh, Cc	Mh, Cc	Mh, Cc	Mh, Cc	Mh, Cc	Cc
Bromus inermis	Smooth brome grass					Fp, Cf	Cf	Cf					
Butomus umbellatus	Flowering-rush												
Cardamine impatiens	Bitter cress				Mh, Cc	Mh, Cc							
Celastrus orbiculata	Oriental bittersweet	Cc	Cc				Ccf	Ccf	Ccf	Ccf	Cc	Cc	Cc
Centaurea maculosa	Spotted knapweed	Cf	Cf	Fp	Fp	Cf	Cbf, Mhs	Cbf, Mhs	Cbf, Mhs	Cf, Mhs	Cf, Mhs		
Cirsium arvense	Canada thistle						Msh, Cf	Msh, Cf	Msh, Cf	Msh, Cf			
Convallaria majalis	Lily-of-the-valley						Cf	Cf	Cf	Cf			
Coronilla varia	Crown vetch				Cf	Cf	Cf						
Eichhornia crassipes	Water-haycinth						Cf	Cf	Cf				
Elaeagnus umbellata	Autumn olive	Cc	Cc				Cc	Cc	Cc	Cc	Cc	Cc	Cc
Euphorbia esula	Leafy spurge						Cf			Cf			
Gypsophila spp.	Baby's breath						Ms	Ms	Ms	Ms			
Heracleum mantegazzianum	Giant hogweed				Ms	Ms	Ms	Ms	Ms				
Hesperis matronalis	Dame's rocket				Mh	Mh	Mh						
Ligustrum vulgare	Privet	Cc	Cc	Fp	Fp		Cc	Cc	Cc	Cc	Cc	Cc	Cc
Lonicera spp.	Bush honeysuckle	Cc	Cc	Fp	Fp		Cc, Mh	Cc, Mh	Cc, Mh	Cc, Mh	Cc, Mh	Cc, Mh	Cc
Lonicera japonica	Japanese honeysuckle					Cf, Ft	Cf, Ft	Cf, Ft					
Lysimachia nummularia	Moneywort												
Lythrum salicaria	Purple loosestrife						Cbcf	Cbcf	Cbc				
Melilotus alba	White sweet-clover				Fp		Mb	Mh	Mh				
Melilotus officinalis	Yellow sweet-clover				Fp		Mb	Mh	Mh				
Myriophyllum spicatum	Eurasian water milfoil												
Pastinaca sativa	Wild parsnip				Ms	Ms	Ms	Ms	Ms				
Phalaris arundinacea	Reed canary grass					Cf, Fp	Ccf	Ccf	Ccf				
Phragmites australis	Giant reed								Cbf	Cbf	Cbf		
Polygonum cuspidatum	Japanese knotweed					Cf	Cf	Cf	Cf	Cf			
Polygonum perfoliatum	Mile-a-minute weed												
Rhamnus cathartica	Common buckthorn	Cc	Cc	Fp	Fp		Cc	Cc	Cc	Cc	Cc	Cc	Cc
Rhamnus frangula	Glossy buckthorn	Cc	Cc				Cc	Cc	Cc	Cc	Cc	Cc	Cc
Rhodotypos scandens	Black jetbead	Cc	Cc	Fp	Fp		Cc	Cc	Cc	Cc	Cc	Cc	Cc
Robinia pseudoacacia	Black locust	Cdg	Cdg				Cdg	Cdg	Cdg	Cdg	Cdg	Cdg	Cdg
Rosa multiflora	Multiflora rose	Cc	Cc	Fp	Fp		Cc	Cc	Cc	Cc	Cc	Cc	Cc
Saponaria officinalis	Bouncing bet (soapwort)						Cbf	Cbf	Cbf				
Typha angustifolia	Narrow-leaved cat-tail						Cbcf	Cbcf	Cbcf	Cbcf			
Vinca minor	Periwinkle	Cf	Cf	Cf	Cf							Cf	Cf
Vincetoxicum spp.	Black swallow-wort					Cbf	Cbf	Cbf	Cbf	Cbf	Cbf		

Appendix A-5: Photo Credits

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upper right: Daniel Kennedy, Michigan Department of Natural Resources
remaining: Christopher Hoving, Michigan Department of Natural Resources

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Daniel Kennedy, Michigan Department of Natural Resources
David Cuthrell, Michigan Natural Features Inventory
Daniel Kennedy, Michigan Department of Natural Resources
Christopher Hoving, Michigan Department of Natural Resources
Daria Hyde, Michigan Natural Features Inventory
David Kenyon, Michigan Department of Natural Resources
Christopher Hoving, Michigan Department of Natural Resources
Todd Losee, Michigan Department of Environmental Quality
David Cuthrell, Michigan Natural Features Inventory
Daniel Kennedy, Michigan Department of Natural Resources
Michael Kost, Michigan Natural Features Inventory
Daria Hyde, Michigan Natural Features Inventory
Michael Kost, Michigan Natural Features Inventory
Ibid.

Fen Conservation Plan
Introduction: Christopher Hoving, Michigan Department of Natural Resources
Figure 1: Amon et al. 2002
Figure 2: Christopher Hoving, Michigan Department of Natural Resources
Figure 3: Amon et al. 2002
Figure 4: Christopher Hoving, Michigan Department of Natural Resources
Figure 5: Ibid
Figure 6: Michael Kost, Michigan Natural Features Inventory
Figure 7: David Kenyon, Michigan Department of Natural Resources
Figure 8. Todd Losee, Michigan Department of Environmental Quality
Figure 11. Ibid.
Figure 12: Peter Tolson, Toledo Zoo
Figure 13: Christopher Hoving, Michigan Department of Natural Resources
Figure 14. Daniel Kennedy, Michigan Department of Natural Resources

Focus on Invasive Plants Section
Buckthorn: Christopher Hoving, Michigan Department of Natural Resources
Narrow-leaf cat-tail: Rebecca K. Schillo, Michigan Natural Features Inventory
Reed Canary top: Chris Evans, River to River CWMA & Bugwood.org
Reed Canary, bottom: Jamie Nielsen, Univ. of Alaska, Fairbanks Cooperative Extension Service & Bugwood.org
Japanese Knotweed top: Tom Heutte, USDA Forest Service & Bugwood.org
Japanese Knotweed bottom: Ibid.
Purple Loosestrife: Michael Kost, Michigan Natural Features Inventory
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Figure 21: Ibid
Figure 22: Ibid
Figure 23: Ibid
Figure 24: Ibid
Figure 25. Ibid
Figure 26: Ibid.
Conclusion: Ibid

Habitat Conservation Plan

Figure A1: Daniel Kennedy, Michigan Department of Natural Resources
Mitchell's Satyr Identification: Doug Landis, Michigan State University
Eyed Brown Identification: David Cuthrell, Michigan Natural Features Inventory
Little Wood Satyr Identification: Will Cook, Carolinanature.com
Common Wood Nymph Identification: David Cuthrell, Michigan Natural Features Inventory
Figure A2: Carrie Tansy, U.S. Fish and Wildlife Service
Figure A3: David Cuthrell, Michigan Natural Features Inventory
Figure A4: Peter Tolson, Toledo Zoo
Figure A5: Ibid
Figure A6: Rebecca Rogers, Michigan Natural Features Inventory
Figure A7: David Cuthrell, Michigan Natural Features Inventory
Figure A8: Ibid
Figure A9: Ibid
Figure A10: U.S. Fish and Wildlife Service
Figure A11: Rebecca Rogers, Michigan Natural Features Inventory
Figure A12: Christopher Hoving, Michigan Department of Natural Resources
Figure A13: Southwest Michigan Land Conservancy

"Other people can talk about how to expand the destiny of mankind. I just want to talk about how to fix a motorcycle. I think that what I have to say has more lasting value."
— Robert M. Pirsig in *Zen and the Art of Motorcycle Maintenance*

Appendix F.

Mitchell's Satyr (*Neonympha mitchellii*) Survey Protocol

MITCHELL'S SATYR (*NEONYMPHA MITCHELLII*) SURVEY PROTOCOL

Acceptable Survey Conditions
Surveys should not be conducted when the temperature is below 15° C (60° F), during rain, or when winds exceed 25 km/h (15 mph). When temperatures are 15 - 21° C (60 - 70° F), cloud cover should be ≤50% of the sky. There is no cloud cover restriction if the temperature is above 21° C (70° F). If weather conditions deteriorate during a survey, observers should terminate the survey and resurvey the entire site on a suitable day. Be sure to note that the survey was ended on the data form and record the final weather conditions.

Survey Area
Mitchell's satyr (MS) surveys will be conducted at prairie fens with recent/historical occurrences and sites containing potential habitats. All open portions (canopy cover of mature trees <25% and/or tall shrubs [>1.5 m] <50%) of each site should be surveyed. Portions of the study sites with the following conditions can be avoided: (1) woody vegetation greater than the above thresholds or (2) invasive plant species (e.g., *Typha* [cattails], *Phalaris arundinacea* [reed canary grass], *Lythrum salicaria* [purple loosestrife], *Phragmites australis* [common reed]) combined area cover >50%.

Timing
Surveys can be conducted between 10 AM and 7 PM (EDT).

Survey Methodology
***Visual survey*:** Whenever possible, surveys should be done using teams of two people working together. The survey will consist of a series of transects paralleling the outer boundary of the prairie fen (or particular patch within a large fen or complex). The first transect will begin 5 m inward from the outer edge of the prairie fen wetland or patch. The second transect will be located 10 m inward from the first transect. The two surveyors will slowly walk parallel to one another along the first two transects until the entire periphery of the site has been surveyed. Then two new transects will be started inward from the first two, and so on, until the entire wetland or patch is surveyed. If it is not possible to have two surveyors, one person can conduct surveys using the same approach by surveying all transects separated by 10 m.

Butterfly counts: Each surveyor will look for and count butterflies within area 5 m to either side of the transect, 5 m forward along the transect, and 5 m above the transect (imagine a 10 m x 5 m x 5 m, box-shaped, survey area). Surveyors should walk at a steady, slow speed of approximately 35 m/min. When MS fly ahead of the observer, they can be ignored if the surveyor is certain that the individual was already counted. If the observer is uncertain as to whether or not the individual was counted, it should be counted and considered a new individual. It will be important that team members communicate about MS moving between transects (e.g., individual counted by one team member that flies into the area being surveyed by the other team member).

***Waypoints*:** To facilitate an accurate count of MS and collection of geospatial information, a waypoint should be collected for each individual MS observed. For example, if five MS were seen in one area, five waypoints should be collected at the same location. Surveyors may need to move off of transects slightly to record waypoints. If you walk off of a transect to collect a waypoint, be sure to move back to the point where you left off before continuing on with the survey. The number observed should also be recorded on the data form (we suggest using "hash" marks) under the "total number detected" box.

***Mitchell's satyr observations*:** Record the number of MS detected by sex, activity and condition (i.e., wing wear) ranking. Using the same example of five individuals observed in one area, if two were male, two were female, and one the sex was uncertain, you would record those numbers in the appropriate boxes on the data form. The number of MS exhibiting particular behaviors or activities (e.g., flying, chasing, ovipositing) should be recorded on the data form in the same manner. We will rank the condition of MS according to the following 1 – 5 numeric scale presented by Watt et al. (1977): (1) freshly emerged, wings still damp; (2) wings and other cuticle dry and hard, no visible damage; (3) noticeable wear of scales from wings or body; (4) wings showing fraying or tearing in their cuticle; and (5) wings with extensive scale wear and cuticle damage. If no MS are observed during the survey of a site, write "None" in the box provided on the data form for "Total Number Detected."

Poweshiek skipperling Observations: If Poweshiek skipperling (*Oarisma poweshiek*) is detected during a survey, collect the same spatial, abundance, sex, and activity data in the same way as described above for MS. Be sure to denote waypoints used for Poweshiek skipperlings with a "P" (e.g., P01, P02, etc.), so they are not confused with MS points.

Survey tracks: Each surveyor should have a GPS unit and should record their survey route or transects using the tracking function. Set the GPS unit to collect your location along the track at 30 sec intervals. Once your track has been recorded during the first visit to a particular site, the tracking function can be turned off during the second visit and the same tracks can be followed during the second survey. It will be critical that each surveyor download their survey tracks at the end of the season as an ArcMap shapefile to facilitate surveying the same routes in future years. Use the following naming format when saving your survey tracks: year_observer last name_satyr_tracks (e.g., 2014_smith_satyr_tracks). Waypoints collected for Poweshiek skipperling locations should also be downloaded at the end of the season as a shapefile and named using a similar format: year_observer last name_poweshiek_locations (e.g., 2014_smith_poweshiek_locations).

Overall Butterfly Diversity: All butterfly species observed during MS surveys should be listed on the data form used for each site. Because estimating relative abundance would be difficult for multiple species and likely to distract observers from surveying for MS, observers should only note when the species of butterflies are seen and should not attempt to count species other than MS and Poweshiek skipperling. We have attached a list of butterfly species that could be encountered in prairie fens in Michigan.

Weather: At the start and end of the survey, record the temperature (°C), percent relative humidity, cloud cover (expressed as the % of sky occluded), and maximum wind speed (km/h). If a survey needs to be terminated because of poor weather conditions, collect that same weather information at the time the survey is ended.

Site characterization: Observers will collect general information about survey sites during each visit, such as potential threats and nectar sources. At least one representative photograph should be taken of each survey site. Record file identifiers of the photographs on the data form. Pesticide use on agricultural lands near occupied sites could pose a threat to MS survival, so we would like surveyors to record the nearest row crop field to the survey site using a GPS waypoint. Note the name of the waypoint and type of field (e.g., corn, soybean, wheat) on the data form.

Threats: Several potential threats to prairie fens and MS are listed on the data form. Place a check mark next to all those that apply to the survey site. Potential threats not listed can be added to the form under "Other" in the space provided. For invasive plant species, rank the abundance of those species observed as dominant (D), abundant (A), frequent (F), occasional (O), or rare (R) on the data form. Invasive species not listed can be added to the form under "Other." Below is more specific guidance on using the DAFOR scale.

<u>Dominant (D)</u>: In practice, the dominant ranking is rarely, if ever used. To be scored as D, a species would have to be the most common plant by far, covering over 75% of the wetland. If you are not sure if a species should be scored as D, then assign it a score of A.

<u>Abundant (A)</u>: Only use A if the species is common in many parts of the wetland. For most species, this would mean that there are thousands of individual plants present. At most sites, few species will be ranked as A. If you are unsure if a species should be scored as A or F, then give it a ranking of F.

<u>Frequent (F)</u>: Use F if you find a species at several places within the survey area and more than just a few individuals are present at each location. You could also use F if a plant species only occurs at one part of the site but is common at that location, with many individuals observed and a substantial area covered (e.g., between one eighth and one quarter of the site). If you are not sure if a species should be scored as F or O, then assign it a score of O.

<u>Occasional (O)</u>: Use O for species that occur in several places in the wetland, but whose populations are small at those locations. You could also use O for species that are common at one location but occupy a small area (e.g., less than one eighth of the site). If you are not sure if a species should be ranked as O or R, then give it a score of R.

<u>Rare (R)</u>: Use R for species that occur as a small number of individuals within the site. These individuals may be located in one place, or scattered over several locations within the wetland. If you are unsure if a species should be scored O or R, then assign it an R.

A list of possible nectar plant species for MS is provided on the data form. Rank the abundance of each available (i.e., flowering) nectar species observed at the site using the same DAFOR scale described above for invasive plant species. Nectar sources not on the list can be added in the blank boxes provided on the form.

Appendix 2. MICHIGAN NATURAL FEATURES INVENTORY – MITCHELL'S SATYR SURVEY

SITE INFORMATION			
SITE:	DATE:	VISIT (1 or 2):	OBSERVER:

	Time (24-hr)	Temperature (°C)	Relative Humidity (%)	Cloud Cover (%)	Wind Speed (km/h)
START					
END					

PHOTOGRAPH NAMES (minimum of 1 per site):				

NEAREST ROW CROP FIELD	Waypoint Name/ Coordinates:	Crop Type:

COMMENTS:

SATYR SURVEY INFORMATION		
TOTAL NUMBER DETECTED	NUMBER BY ACTIVITY	NUMBER BY WING WEAR (see below)
	Nectaring	1
	Flying	2
NUMBER BY SEX		
Male	Perched	3
Female	Copulating	4
Unknown	Ovipositing	5

BUTTERFLY DIVERSITY (LIST ALL SPECIES DETECTED BELOW)	

Appendix 2. MICHIGAN NATURAL FEATURES INVENTORY – MITCHELL'S SATYR SURVEY

POTENTIAL THREATS (CHECK ALL THAT APPLY)			
ALTERED HYRDROLOGY (ditching, tiles)		**INVASIVE PLANT SPECIES**	
LIVESTOCK GRAZING		**(rank abundance using DAFOR scale – see below)**	
ORV DAMAGE		***Lythrum salicaria* (purple loosestrife)**	
HUMAN DEVELOPMENT		***Typha* spp. (cattails)**	
SHRUB ENCROACHMENT		***Phalaris arundinacea* (reed canary grass)**	
ADJACENT AGRICULTURE		***Phragmites australis* (common reed)**	
OTHER		***Frangula alnus* (glossy buckthorn)**	
		Other	
NECTAR SOURCES (rank abundance using DAFOR scale – see below)			
***Rudbeckia hirta* (black-eyed Susan)**			
***Lobelia spicata* (pale spike lobelia)**			
***Triantha glutinosa* (sticky tofieldia)**			
***Galium boreale* (northern bedstraw)**			
***Apocynum cannabinum* (dogbane/indian-hemp)**			
***Anticlea elegans* (white camas)**			
***Pycnanthemum virginianum* (Virginia mountain mint)**			
***Asclepias incarnata* (swamp milkweed)**			
***Trifolium repens* (white clover)**			
***Lilium philadelphicum* (wood lily)**			

Butterfly Condition Ranking:

1: Freshly emerged, wings still damp.

2: Wings and other cuticle dry and hard, no visible damage.

3: Noticeable wear of scales from wings or body.

4: Wings showing fraying or tearing in their cuticle.

5: Wings with extensive scale wear and cuticle damage.

DAFOR Scale Descriptions:

Dominant (D): In practice, the dominant ranking is rarely, if ever used. To be scored as D, a species would have to be the most common plant by far, covering over 75% of the wetland.

Abundant (A): Only use A if the species is common in many parts of the wetland. For most species, this would mean that there are thousands of individual plants present. At most sites, few species will be ranked as A.

Frequent (F): Use F if you find a species at several places within the survey area and more than just a few individuals are present at each location. You could also use F if a plant species only occurs at one part of the site but is common at that location, with many individuals observed and a substantial area covered (e.g., between one eighth and one quarter of the site).

Occasional (O): Use O for species that occur in several places in the wetland, but whose populations are small at those locations. You could also use O for species that are common at one location but occupy a small area (e.g., less than one eighth of the site).

Rare (R): Use R for species that occur as a small number of individuals within the site. These individuals may be located in one place, or scattered over several locations within the wetland.