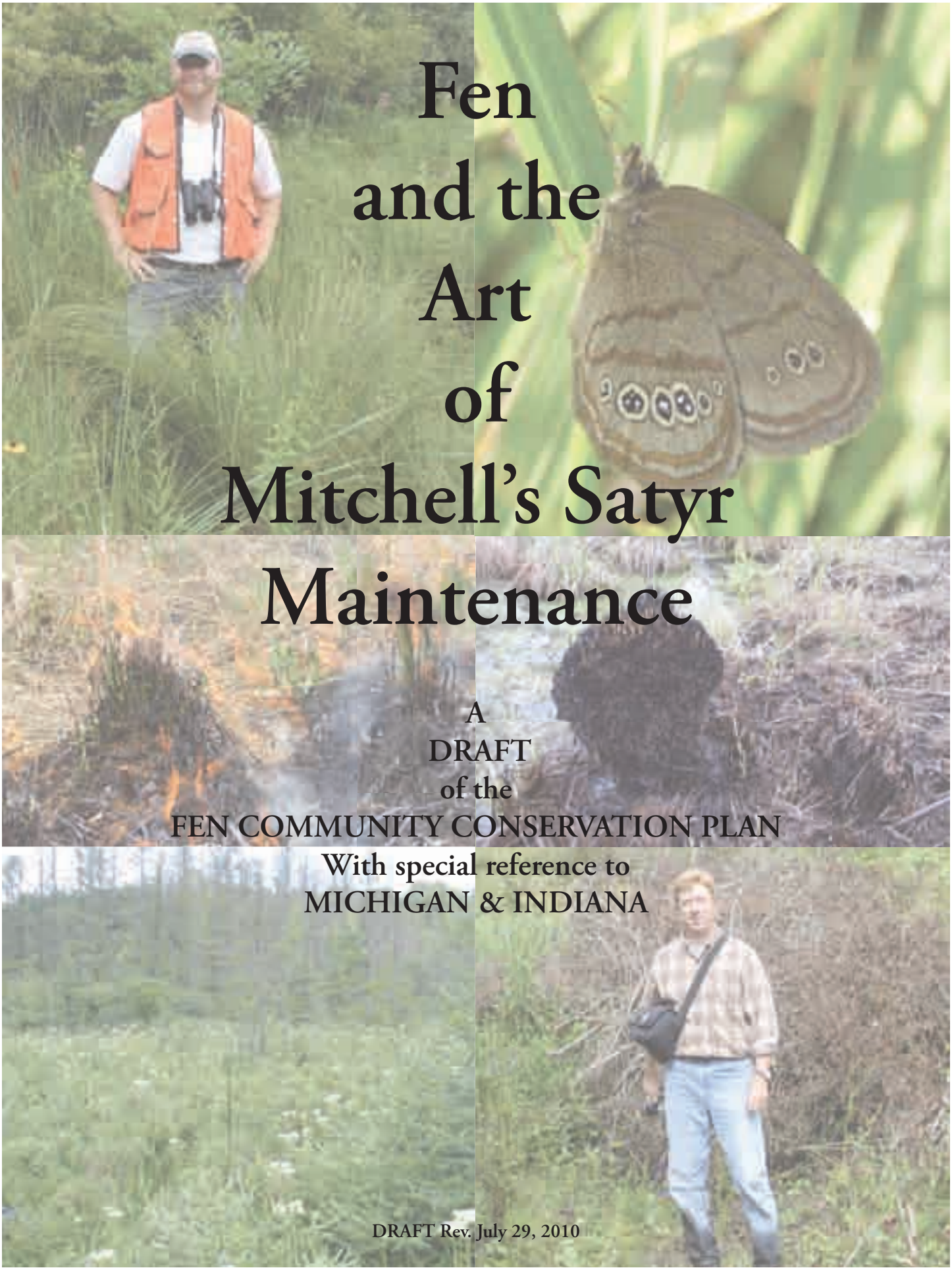

Fen and the Art of Mitchell's Satyr Maintenance

A
DRAFT
of the
FEN COMMUNITY CONSERVATION PLAN
With special reference to
MICHIGAN & INDIANA

DRAFT Rev. July 29, 2010

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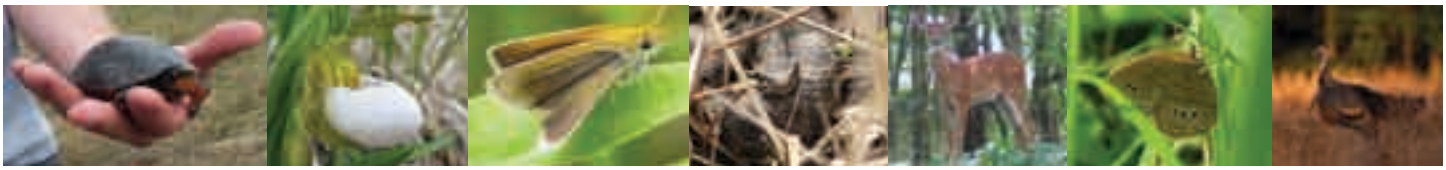

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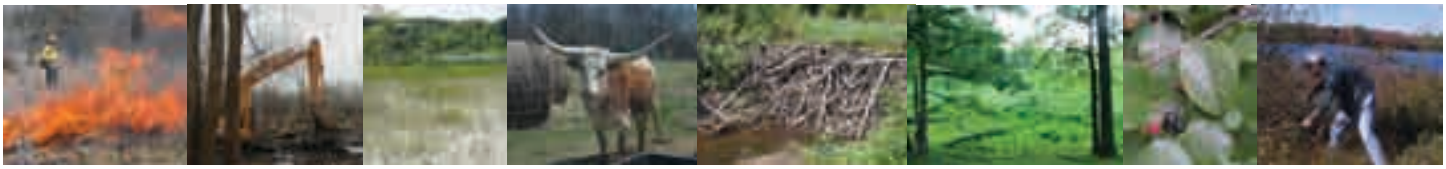

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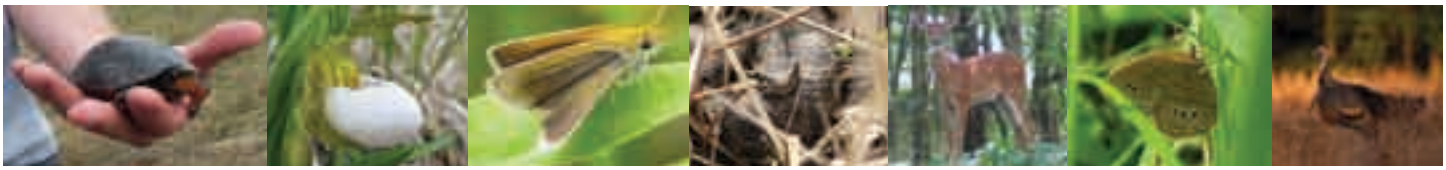

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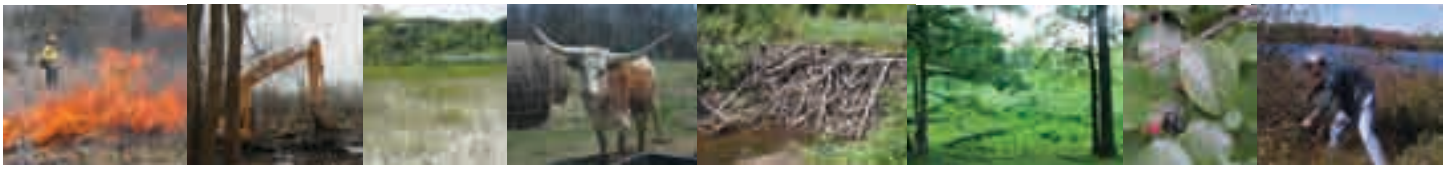


Introduction

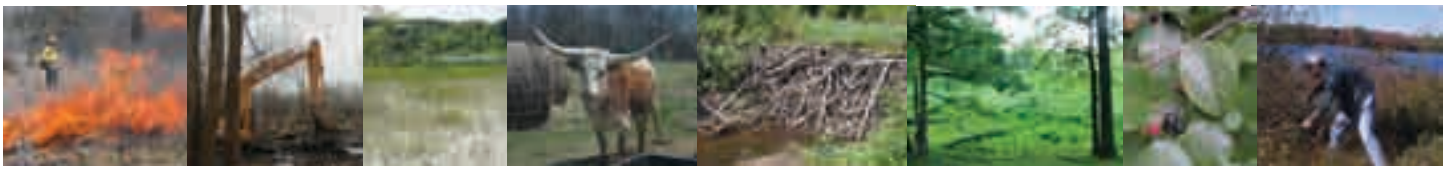
1. Introduction

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 Habitat Conservation Plan (HCP; Appendix A). The HCP outlines measures to avoid, minimize and mitigate take of the federally endangered Mitchell's satyr butterfly (*Neonympha mitchellii mitchellii*) during management activities in occupied habitat, as 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; the HCP ensures that associated management activities will not jeopardize local Mitchell's satyr 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. 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.

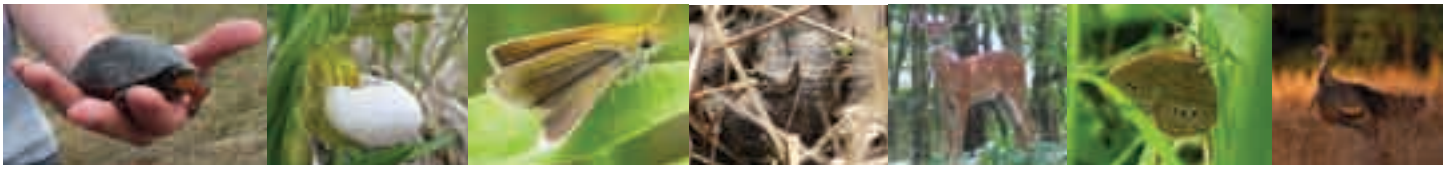
This plan is focused on what NatureServe (2008) defines as a North-Central Interior Shrub-Graminoid Alkaline Fen: a "fen system… found in the glaciated portions of the Midwest and southern Canada. Examples of this system can be located on level to sloping seepage areas, in pitted outwash or in kettle lakes associated with kettle-kame-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 shrubs with a fairly continuous sphagnum moss layer. 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 (Figure 1). Other types of fen occur both north and south of this zone.

Groundwater conservation is the key to fen conservation.

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 2.4.1) 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).

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

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



Overview

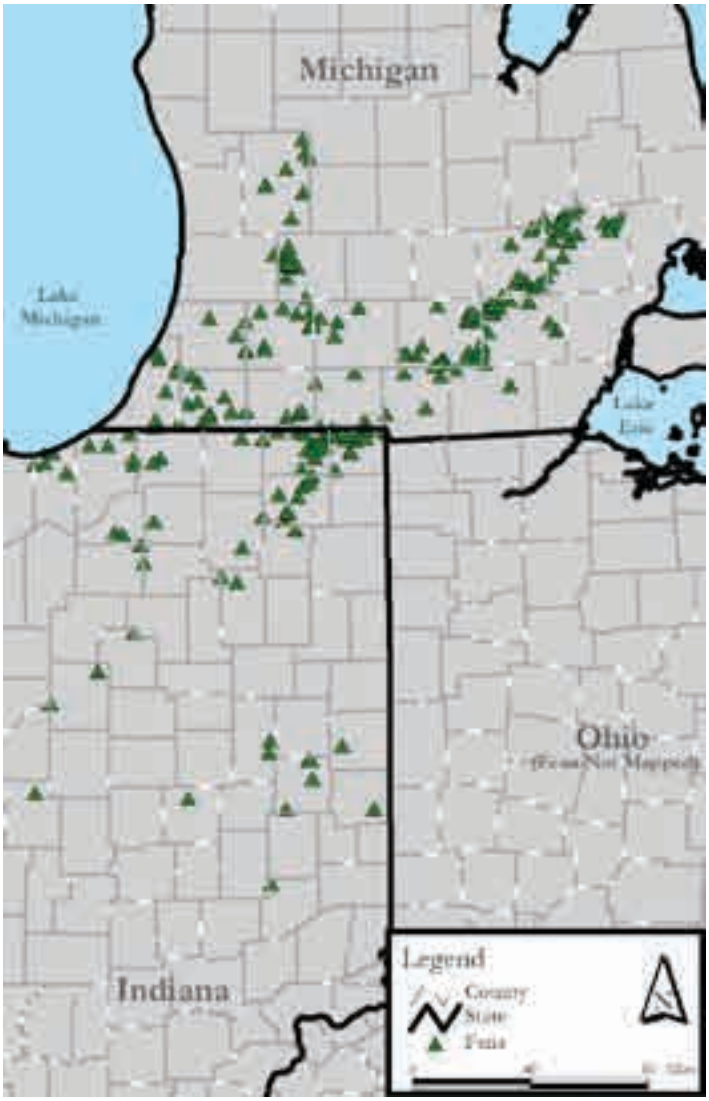


Figure 2. Fens occur in specific bands with rolling topography and coarse soils

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. 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.

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 dependant 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 2). 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

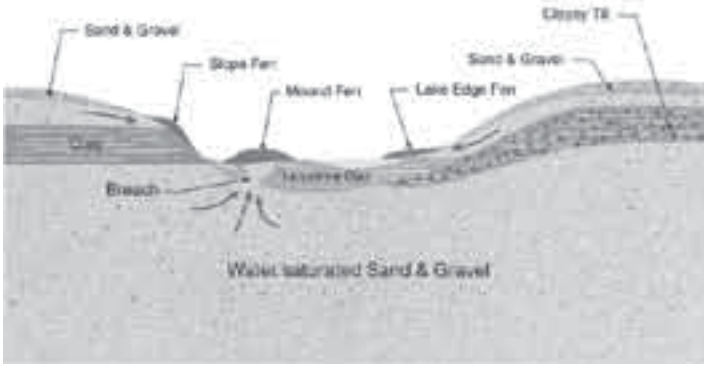
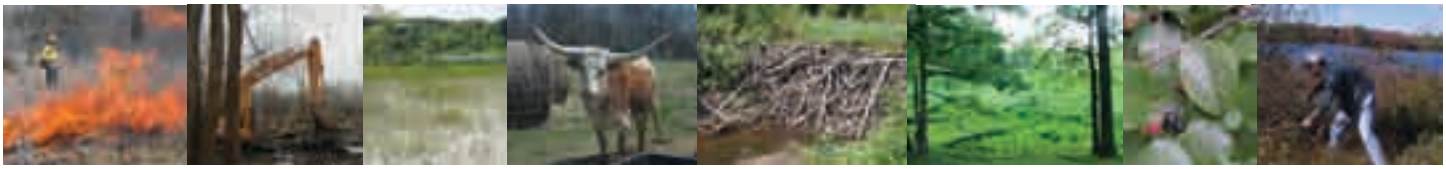


Figure 3. Different types of prairie fen occur in different parts of the landscape



Overview

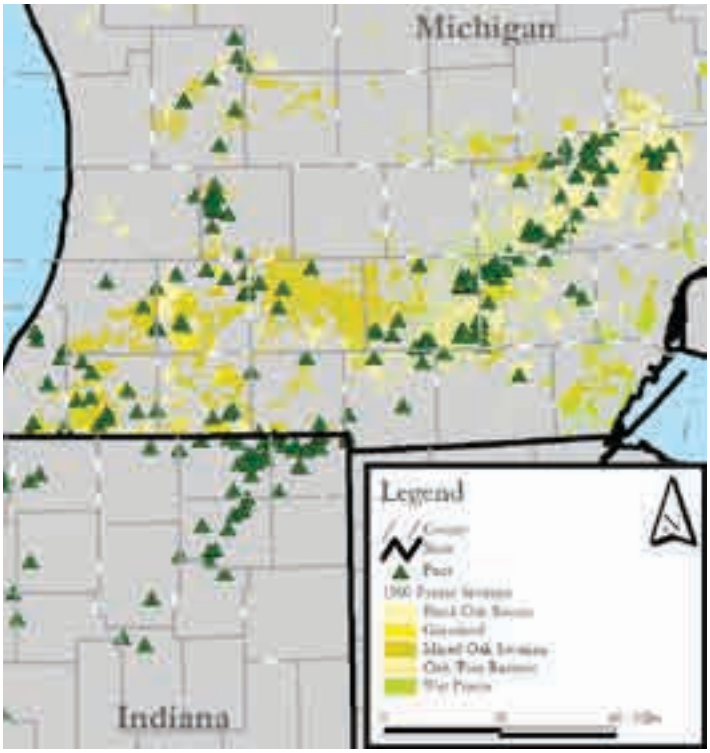


Figure 4. Prior to landscape changes associated with European American settlement, fens were often found in association with oak savannas and other fire dependent communities

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.

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 dependant 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. 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.

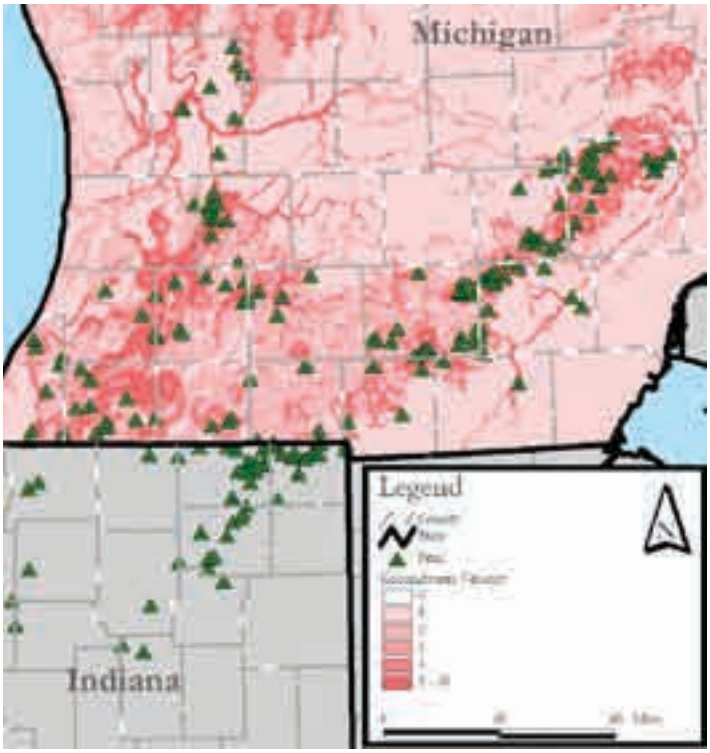
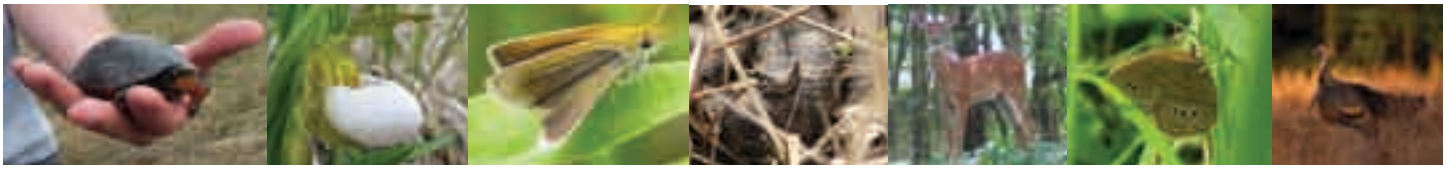


Figure 5. Fens are associated with high velocity groundwater, as predicted from the "Darcy model" for Michigan..



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).

2.3.3 Microclimate

Fens have a microclimate that sets them apart from the surrounding landscape. Prairie fens consistently have a higher humidity than the surrounding landscape. 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.

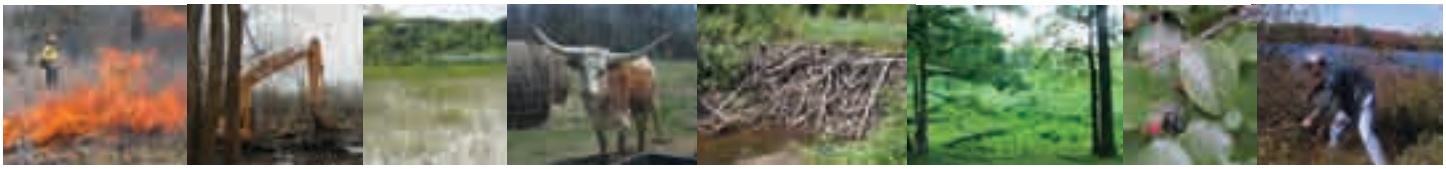
2.3.4 Microtopography

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 3). 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 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 presettlement 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.

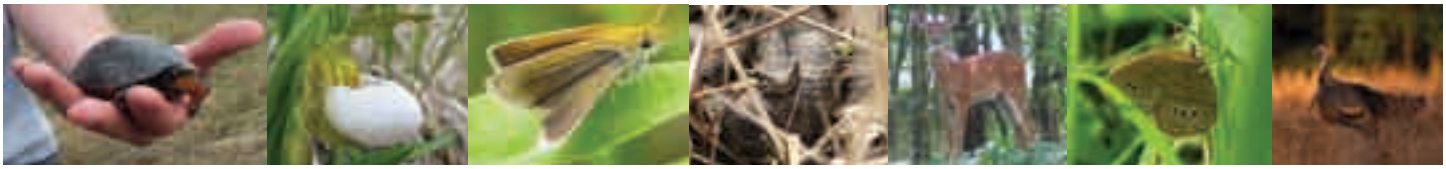
Fire has profound effects on many ecological services, including vegetation structure, plant diversity, predator/prey dynamics, herbivory, plant reproduction, and nutrient cycling (Whelan 1995). As one of the oldest ecosystem management tools, humans have created a large store of applied knowledge in applying fire to achieve specific fire effects. Scientific literature (Whelan 1995, Panzer 2002, Andrew and Leach 2006, Middleton et al 2006b, Langford et al. 2007). Management guidance (Anderson et al. 2001, O'Connor 2007) on the specific effects of different fires abounds. 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.

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

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. 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.

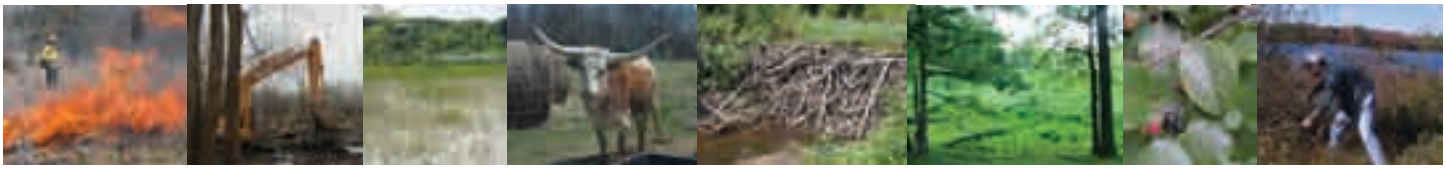
Contemporary beaver activity is more closely associated with prairie fens. Many fens now exist in landscapes with little or no fire management. Large, level areas that might have been used by beavers in the past have now largely been converted to other land uses, most notably urban development and agriculture. 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.

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



Overview

Table 1. State listed plants of prairie fens in Michigan and Indiana. Threatened and endangered plants are protected; staterare, 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	

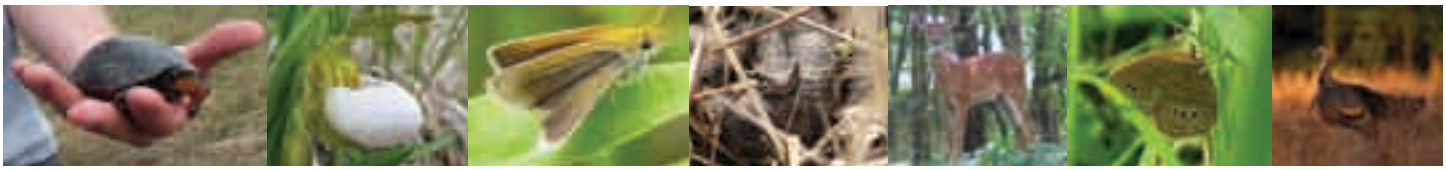
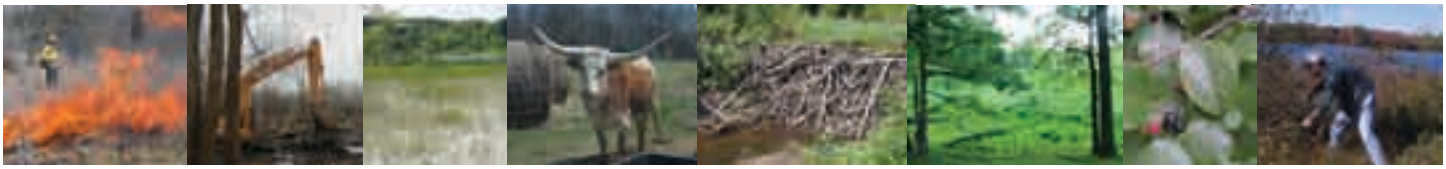


Table 1 continued.			
Common name	Scientific name	IN Status	MI Status
Leiberg's witchgrass	*Panicum leibergii*	State threatened	State threatened
Wild sweet William	*Phlox maculate*		State threatened
Leafy white orchis	*Platanthera dilatata*	State endangered	
Leafy northern green orchis	*Platanthera hyperborean*	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



Overview

Table 2. State listed animals of prairie fens in Michigan and Indiana. Threatened and endangered animals are protected; staterare, 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 leafhop-	*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

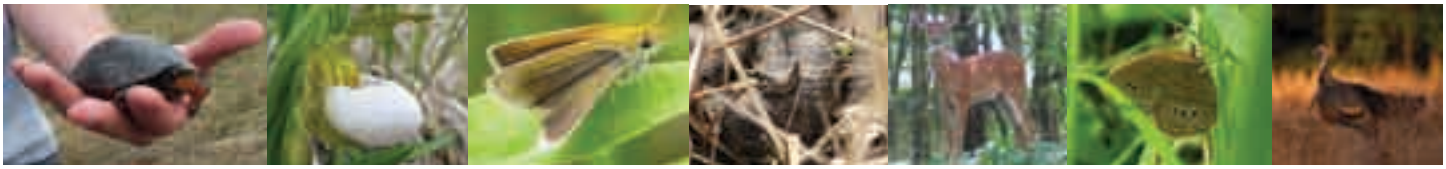


Table 2 continued.			
Common name	Scientific name	IN Status	MI Status
Pitcher window moth	*Exyra rolandiana*	State endangered	
Marsh fern moth	*Fagitana littera*	State threatened	
Leafhopper	*Flexamia delongi*		Special concern
Huron river leafhopper	*Flexamia huroni*		State threatened
Indiangrass flexamia	*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
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	

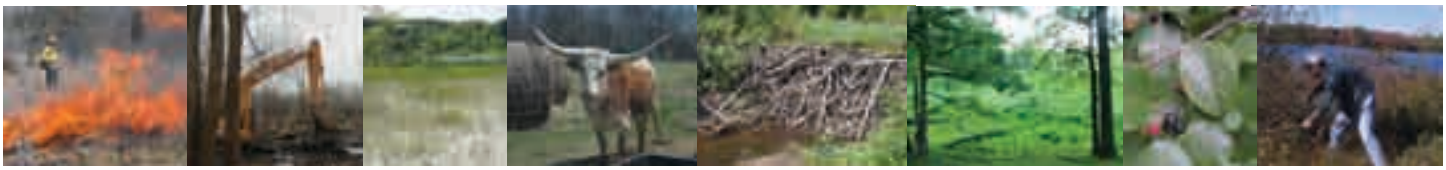


Table 2 continued.			
Common name	Scientific name	IN Status	MI Status
Mitchell's satyr	*Neonympha mitchellii mitchellii*	Federal endangered	Federal endangered
Poweshiek skipper	*Oarisma poweshiek*	State extirpated	State threatened
Elegant prominent	*Odontosia elegans*	State rare	
Tamarack tree cricket	*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

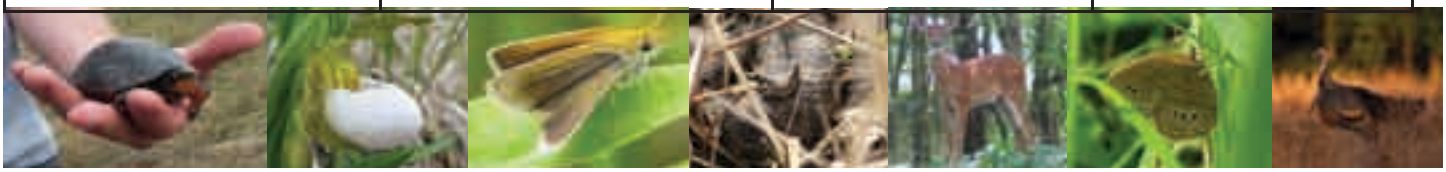


Figure 7. The soft ground of fens is inappropriate for livestock grazing. Fens already damaged by livestock grazing can be grazed lightly in late summer or fall to manage woody vegetation and invasive species.

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.

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.

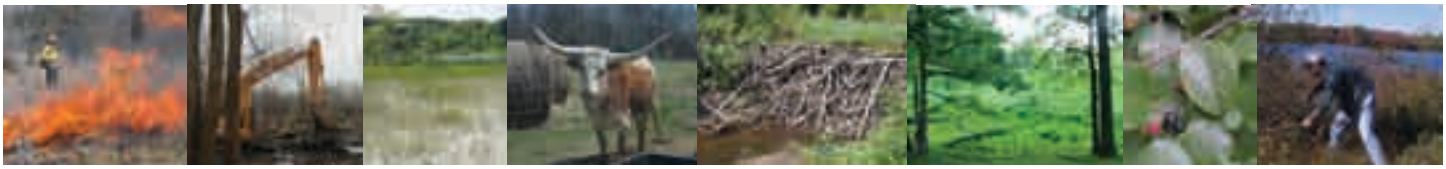
Disease outbreaks and the open canopy also cause a significant build-up of fine and coarse fuels. Disease outbreaks probably interacted with periodic fire to lengthen the time that particular areas remained open prairie fen. The interaction may have competitively favored tamarack over red maple (*Acer 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 (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) (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 a short-term plans. However, these threats provide an important context to realistic

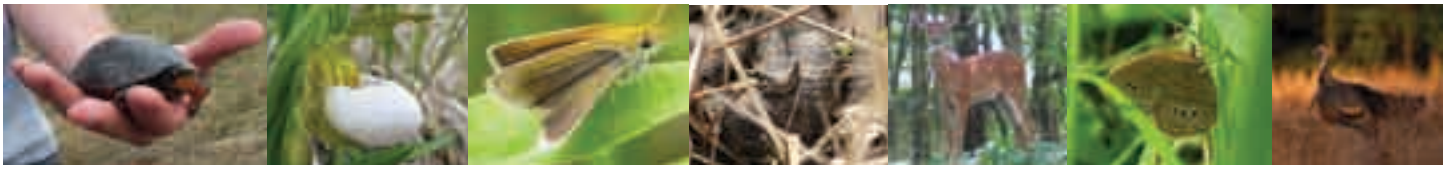


Figure 9. Because of their small size, lack of open water, and lack of surface water input, fens are poorly protected from draining and development protection, especially under federal wetland regulations.

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.

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

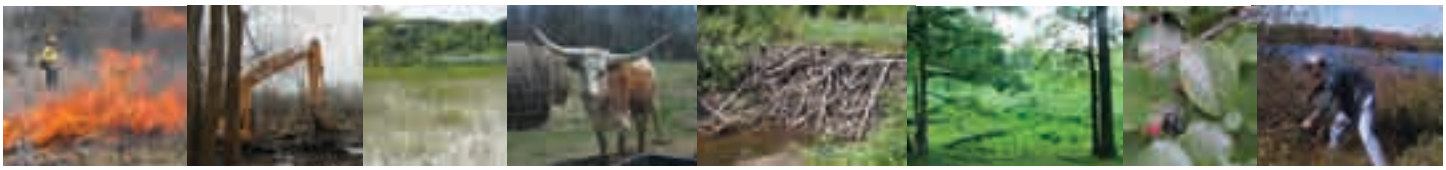
The vast majority of citizens in Michigan and Indiana could draw a forest or a prairie by the time they are in grade school. Most adults would be challenged to provide even a rough sketch of a "fen." Those who have encountered fens often have a negative experience; either because they encounter poison 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.

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. 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 parts of 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 dependant 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 dependant 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.

3.1.3 Climate change

Human-induced climate change is recognized to

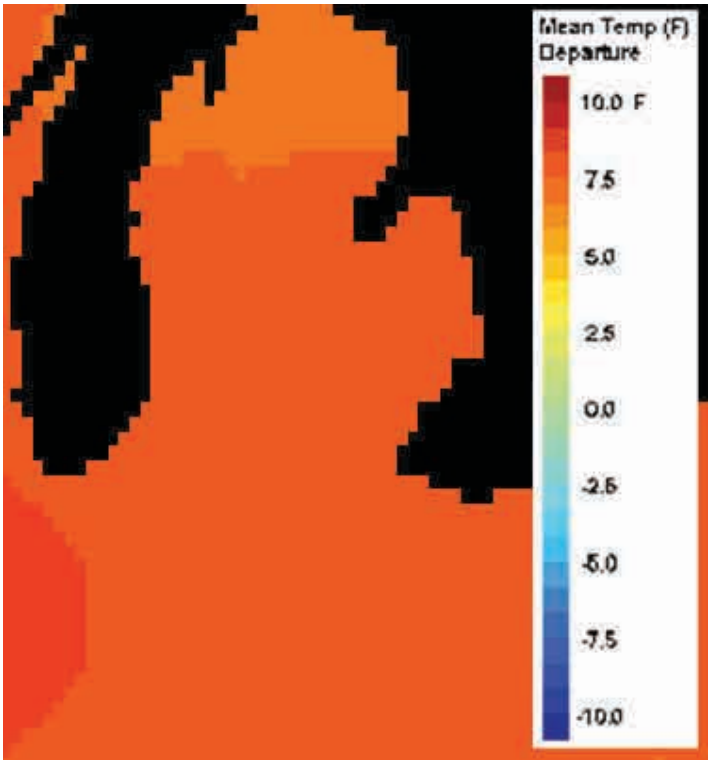
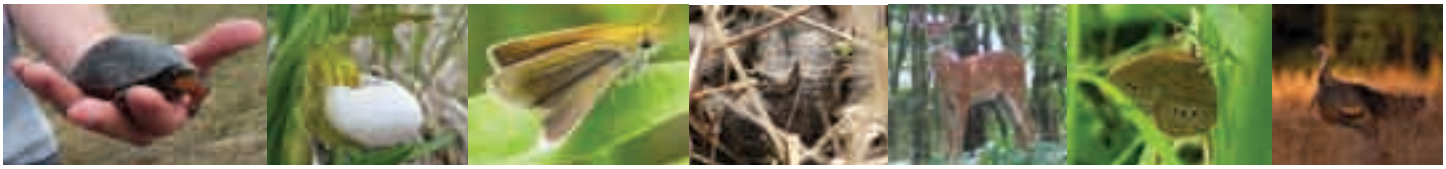


Figure 8. Predicted temperature change by 2080. This prediciton is from the median model. Half of all models predicted greater temperature change, half predicted less extreme change. All models predicted an increase in temperature. Map created by The Nature Conservancy's Climate Wizard.



Threats

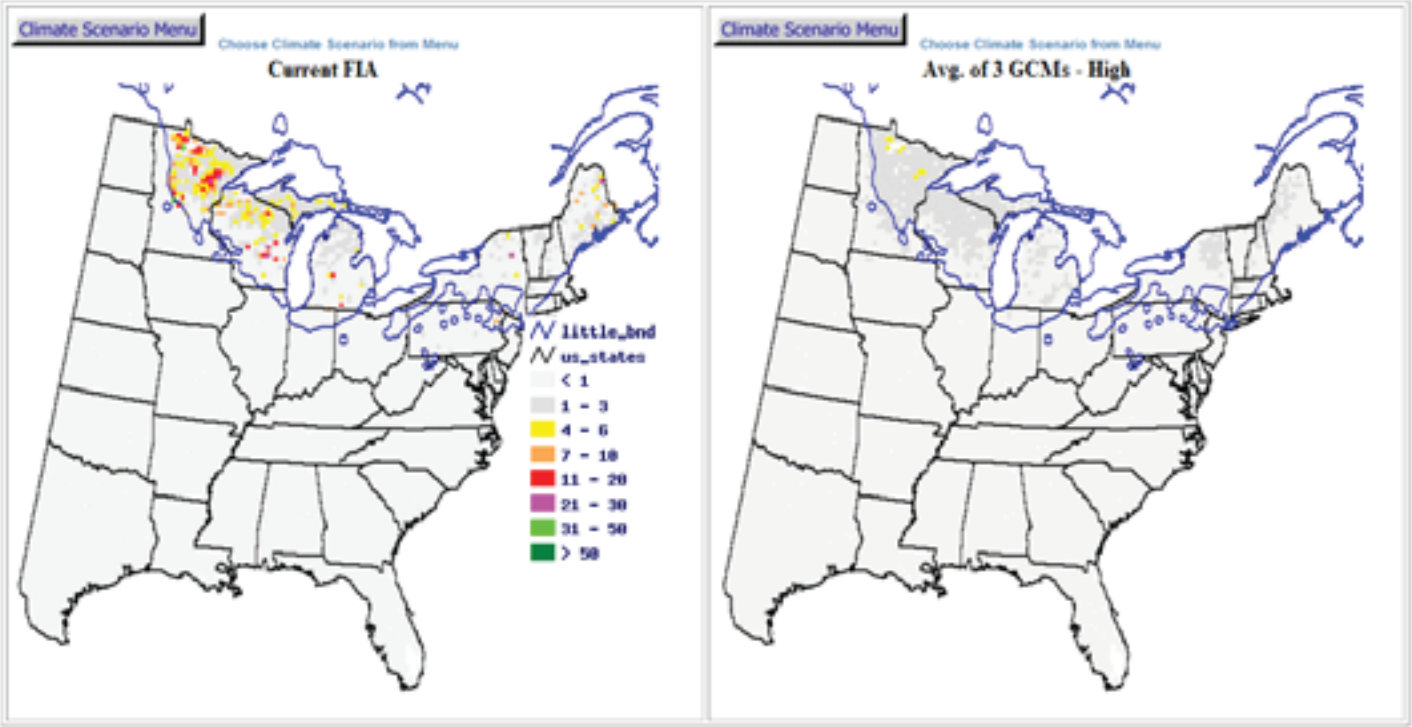


Figure 10. Current (laft) and predicted future (right) climate envelopes for tamarack, an important tree species often found in prairie fens. Although coarse analyses such as these are grim for many fen species, groundwater may preserve suitable microclimates in fens, independent of changing air temperatures.

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). Impacts to biodiversity are predicted to be most severe:

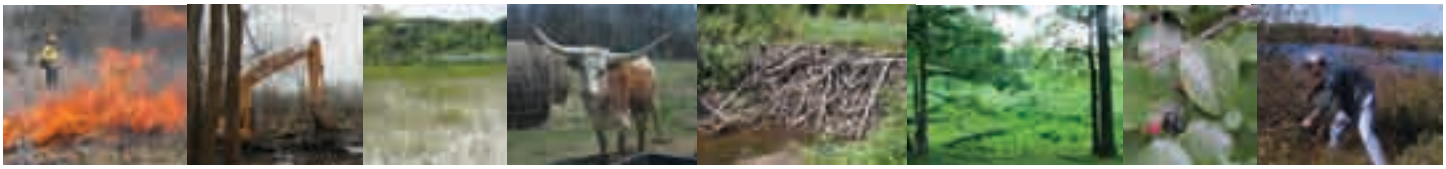
1) in regions where climate changes more than the global average,
2) on species with limited distributions, or
3) on species with limited abilities to disperse.

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 can not 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.

While overall precipitation is predicted to increase



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

slightly, the increase is expected to occur during the season 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 4). 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

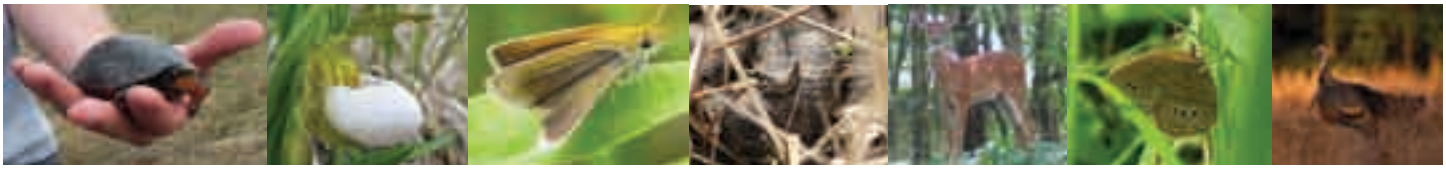
Fens exist as relatively nutrient poor wetlands with a constantly high water table. Changes in the quantity, seasonality, or chemistry of water entering and flowing through fens is a major threat to these ecological communities.

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.

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

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



and 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 microtopography unique to fens (Figure 5). 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.

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.

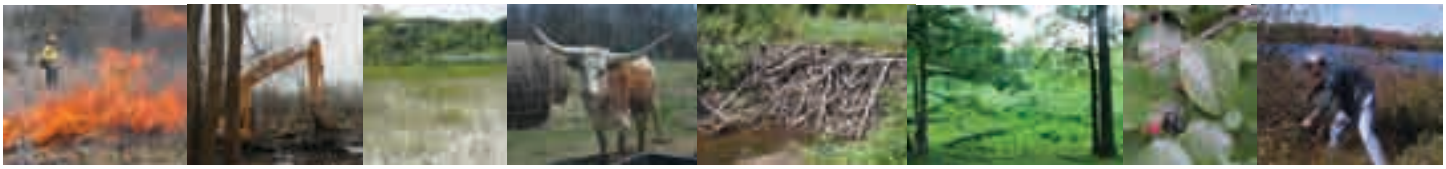
Another potential source of sediments is the forested hillsides surrounding the fen. Fens are often surrounded by steep bluffs of glacial deposit, which usually consist of gravel, sand, or other coarse sediment. Historically, these coarse deposits would have been drought and fire prone, and the vegetation 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 run-off 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. Even small changes to the water quality and nutrient availability in prairie fens can have profound negative consequences for the fen itself. The prairie 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



Threats

Figure 12. Many species within prairie fens react positively certain disturbance regimes, such as fire.

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.

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

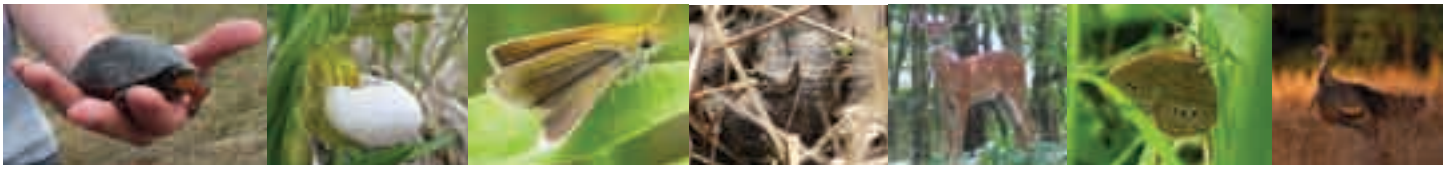
Direct mortality of rare animals from prescribed fire is a concern to many conservationists, who worry that aggressive use of prescribed fire may act more as a conservation threat than conservation strategy. Fire effects on rare species are sometimes negative (Panzer 2003, Durblan 2006, Swengel and Swengel 2007), sometimes neutral (Andrew and Leach 2006) and sometimes positive (Panzer 2002, Pickens and Root 2009). 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*).

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 dependant on large, vertebrate grazers, such as bison and elk?



Threats

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).

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

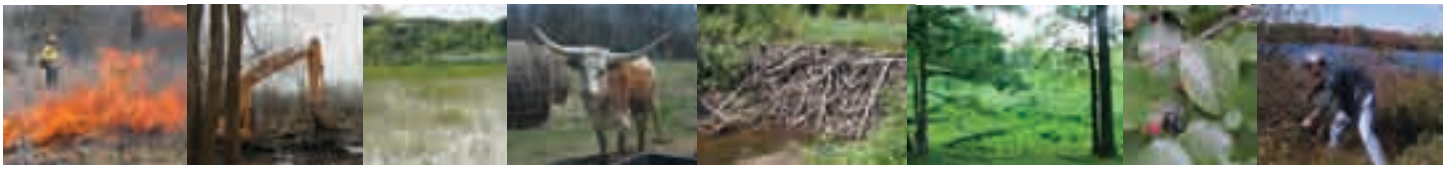
Livestock should not be used as a management tool in fens without a documented history of grazing. Grazing damages fens. However, once grazing has occurred, the damage is done. Ceasing grazing (at a low to moderate animal stocking density) then becomes a conservation threat, unless considerable resources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

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.

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

Figure 15. Fens can often be burned when burning adjacent uplands, such as this oak savanna



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 over-abundant 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

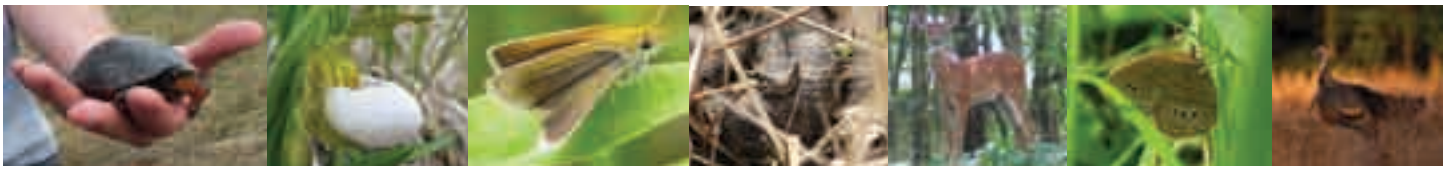
Invasive species cause significant economic and environmental damage in the United State and around the world. Non-native invasive species cause an estimated $120 billion dollars in economic losses in the United States, annually (Pimental et al. 2005). These economic damages include decreased crop yields, 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

Figure 13. Care must be exercised in using fire within fen ecosystems. Some species of fens are sensitive to fire, especially at certain times of the year.

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, CO_2 fertilization, and historic use as pasture for livestock (Bedford and Godwin



Focus on Invasive Plants

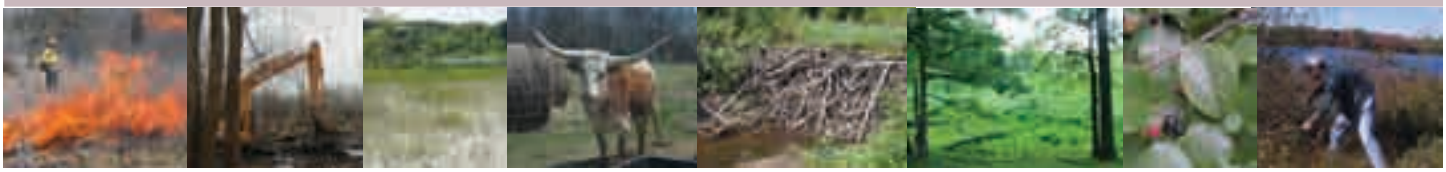
Eurasian buckthorns
(Rhamnus cathartica and R. fragula)

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 cat-tail
(Typha augustifolia) 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.**



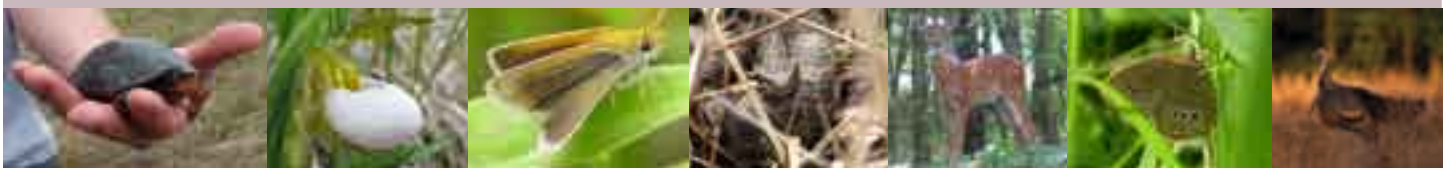
Focus on Invasive Plants

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

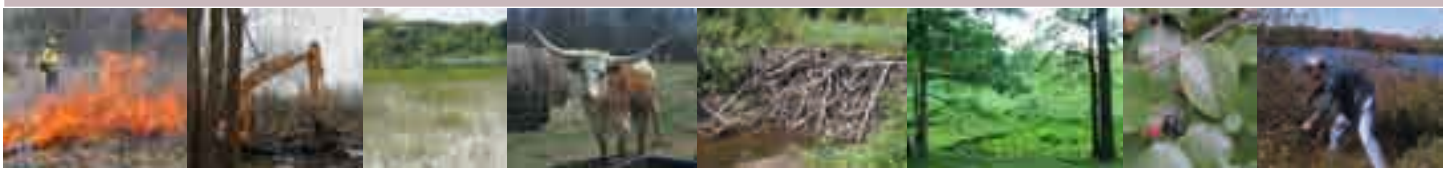
Japanese knotweed (Polygonum cuspidatum)

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)

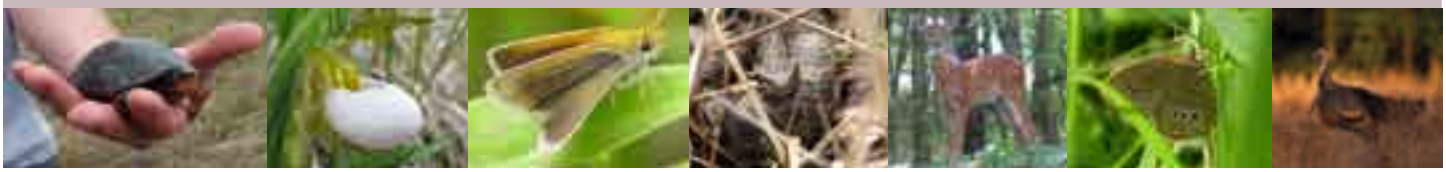
Japanese barberry is a widely planted ornamental shrub. Birds and small mammals spread the berries to natural areas. The ecology of barberry invasions is similar to buckthorn. The barberry vegetation shades nearby vegetation and adds nitrogen to the soil, thus decreasing plant diversity and fuel for 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 autralis)

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.

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). 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.

Although they can invade relatively pristine high-quality fens, invasive species are more often a symptom of a deeper problem in the community. These deeper problems in the community are largely addressed in other sections of the plan, and include sedimentation, septic discharge from adjacent development, road salts, agricultural run-off, climate change, CO_2 fertilization, fire suppression, altered hydrology, drying, intermittent flooding, incompatible recreation, or habitat fragmentation. If possible, management should be directed not only toward the invaders, but also the reason for the invasion. In many cases, the reason for the invasion cannot be easily changed (e.g., a paved road through the fen that continues to alter hydrology). In these cases, invasive species management will not be a one-time solution, but will require long-term management to preserve the fen community.

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.

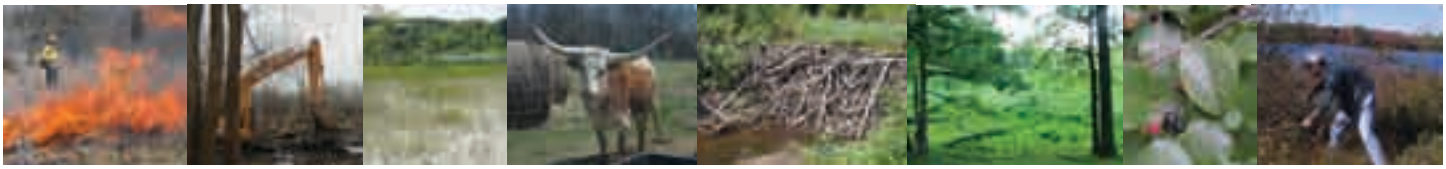
Off-Road Vehicles (ORVs)

ORVs are designed to serve as all terrain vehicles, are usually 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.

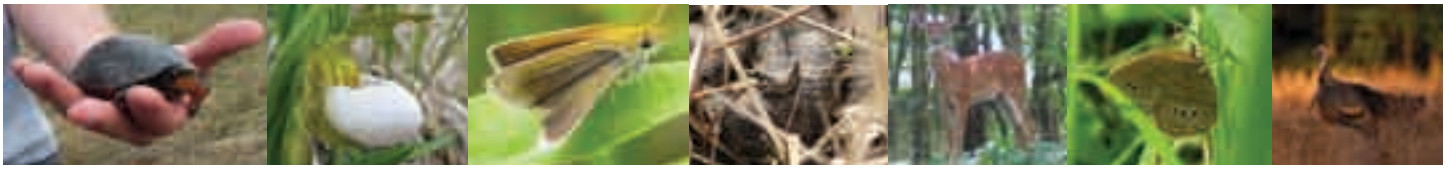
3.3.3 Extinction and extirpation

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, 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.)

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 (see Figure 5) 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.

Figure 14. The swamp metalmark is one of many rare species that occur in prairie fens.



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 bring browsing pressure down 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

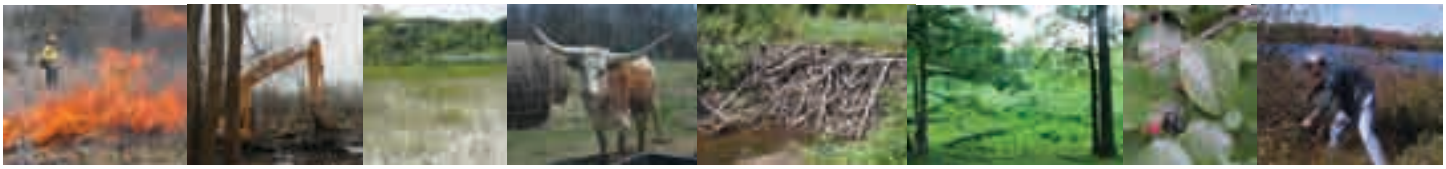
4.3.3 Manage motorized and equine recreation activities to avoid impacts prairie fens

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.



Conservation Strategies

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 and need to develop a level of trust with organizations and agencies before feeling comfortable staff or conservation partners.

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 (Appendix A) will allow state agencies in Indiana and Michigan to seek grant funds to protect lands to conserve Mitchell's satyr 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 (1610 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.

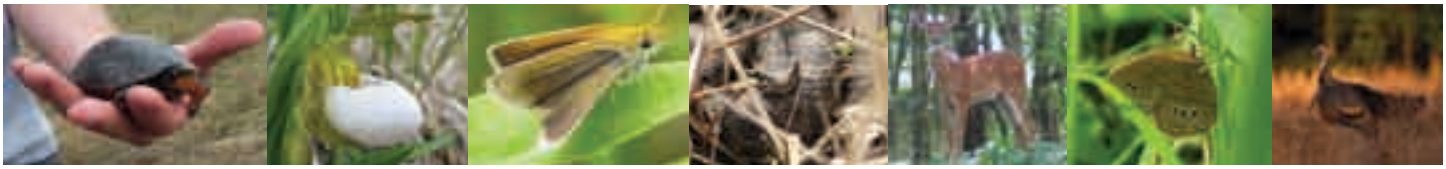
Until recently, land and conservation easement acquisition has focused on protecting parts of fens. Upland properties surrounding fens have been a lower priority. However, given threats to water quality and the important effects of habitat matrix on the fen itself (Cozzi et al. 2008), equal priority 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

Almost no fens currently 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 maintain 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 specifically 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.

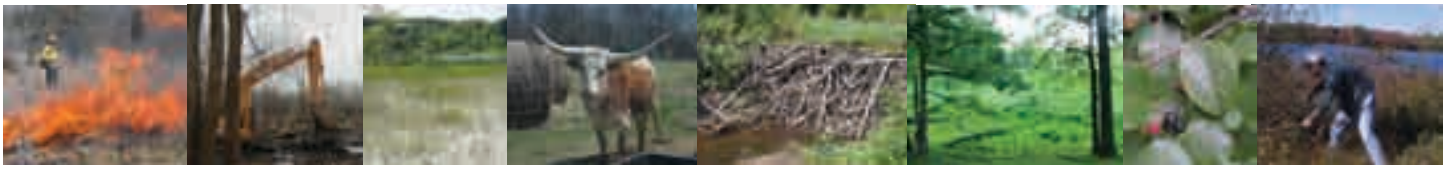
5.3 Incorporate predicted climate change into conservation planning for prairie fens

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

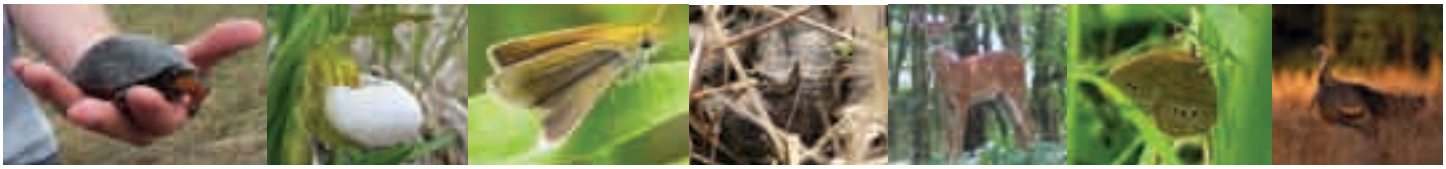
Some traits to evaluate include geographic breadth (widely distributed or localized and endemic), placement in context of range (north end of range or south end), dispersal ability (coefficient of conservatism in plants?), population size, and habitat fragmentation.

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 Mitchell's satyr 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

Figure 16. 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.



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 impact disproportionately 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.

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

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.

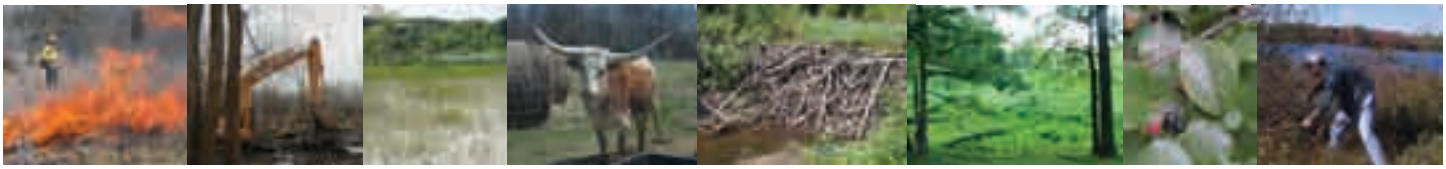
5.4.1 Identify and protect regions of critical groundwater recharge around fens

Fens exist where significant amounts of groundwater is 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 surround 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 activities 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 cat-tail 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.

Figure 18. Marls flats, seeps, springs, and small headwater streams create a natural patchiness to prairie fen burns. Prescibed burn plans should explicitly recommend patchiness

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 and the Environment (DNRE). 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.

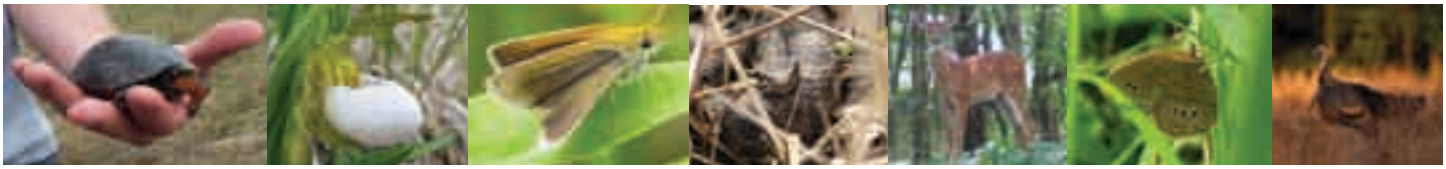


Figure 19. Crayfish burrows or "chimneys" are often found in uplands adjacent to fens. These are often used a hiberancula for rare snakes, and should be burned rarely and with extreme caution.

Cat-tails (*Typha* spp.) can tolerate higher salt concentrations than many plants native to prairie fens. In fens in northeastern Illinois, cat-tail 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, cat-tail monocultures are often adjacent to roads or septic systems (Hoving, personal communication.) While treatment of cat-tails 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 initiative and private lands programs.

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

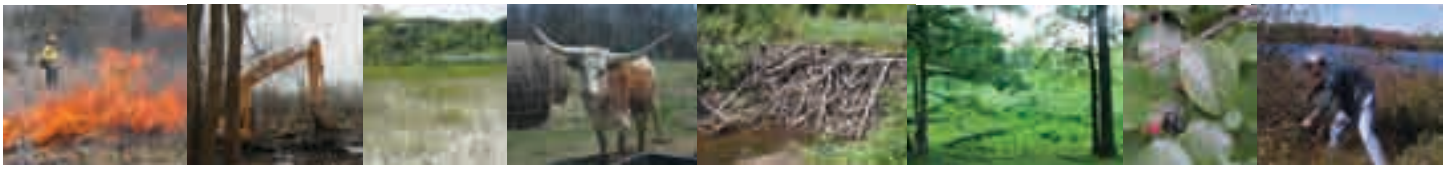
- atmospheric deposition from power plants, heavy industry, and agriculture,
- septic systems discharging adjacent to fens
- animal waste from livestock operations near fens
- fertilizer and sediments from agricultural fields near fens
- fertilizer and sediments from urban/suburban lawns near fens

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

Figure 20. Many species, such as this box turtle, are insensitive to fire during some seasons and extremely sensitive during other seasons.



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 6). 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.

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

Michigan Natural Resources Conservation Service
517) 324-5270

Michigan Farm Service Agency
(517)324-5110

Michigan DNRE (517) 373-1263

Figure 21. The landscape context of a fen is important. Both surface water and groundwater inputs should be considered.

Figure 22. 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).

USFWS Partners for Fish and Wildlife
517-351-6236

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 should refer to Appendix A, the Mitchell's satyr 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;

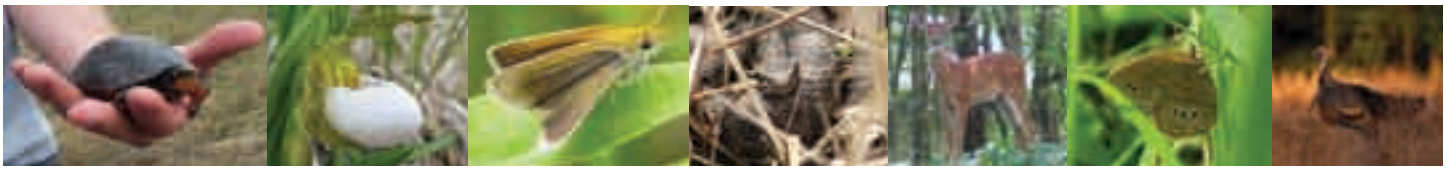


Figure 23. Because fens are small and difficult to access with mechanized equipment, management often occurs at a small scale.

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.

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) (Table 5). 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.

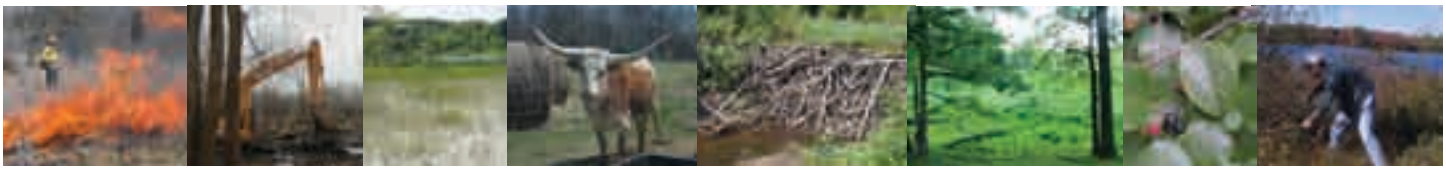
The management of ecological communities can be counter intuitive to those focused on the conservation of specific rare species. Managers must often employ tools that kill individuals for the long term benefit of rare species. The ecosystem manager's goal may be very different from those who would like 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-dependant 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-drive 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.

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 on-going, 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 5.5 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. An herbicide wand (Appendix B) 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.

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 to 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).

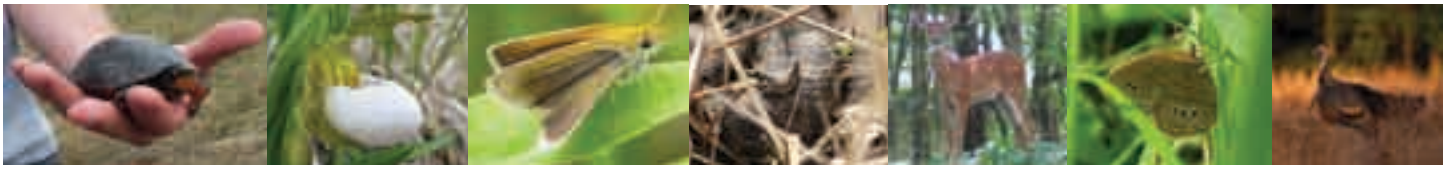
Grazing is a viable and valuable management tool for those fens already degraded by grazing. However, because grazing has negative effects, it should only be used when other management techniques (fire, shrub control, herbicide, etc.) are not available. Grazing a degraded fen is preferable to no management,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

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 encourgaed 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



Focus on Prescribed Fire

Wetlands can be burned, and fire is often a valuable management tool. Consider there general 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.

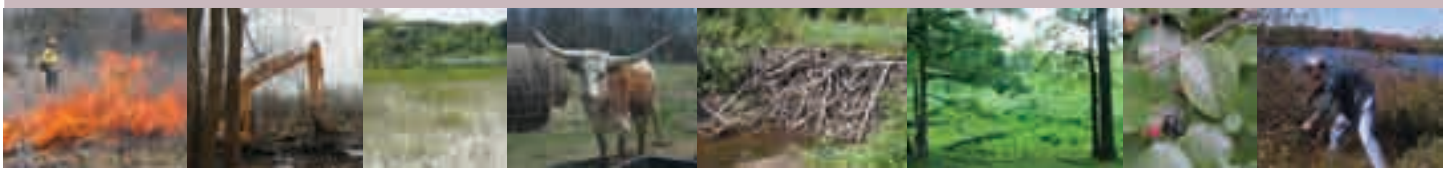
1, Avoid soil disturbance in fens or adjacent wetlands. Use natural burn breaks (streams, shrub-carr, etc) or existing features (roads, trails, etc.) wherever possible (Figures 24 and 25).

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.

Figure 24. 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.

- 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.
- 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 timing burns and the effect of that timing on biodiversity, and not entirely on convenience for recreational activity, wildfire activity, or ease of predicting fire weather.
- 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, for example:
    - 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 sensitive to fire in most seasons and most 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



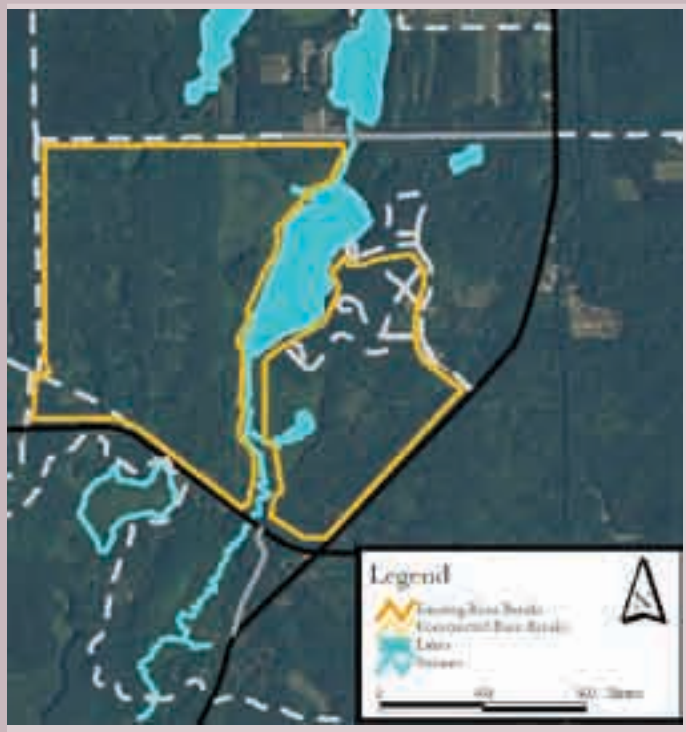


Figure 25. The use of existing burn breaks has the added advantage of restoring adjacent upland communities, such as 400 acres of degraded oak savanna around this small prairie fen

accelerate the break down of fuel in their immediate vicinity, effectively creating their own burn break.

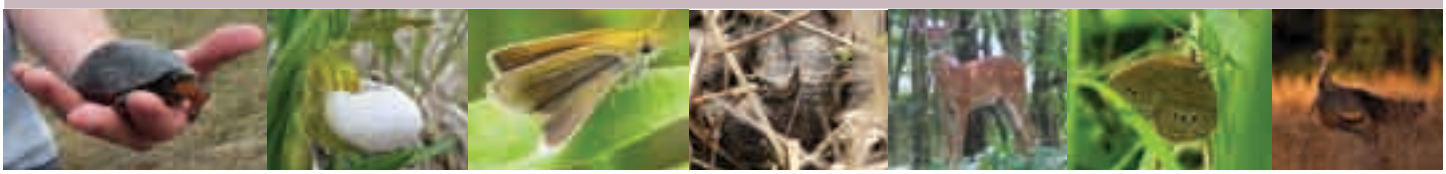
- Fire provides a nutrient pulse to the soil, which can cause an increase in herbaceous invasive plants, especially cat-tails (*Typha* spp.) If water quality is degraded in the fen, the nutrient pulse may make the invasive plant problem worse.
- Targeted chemical or mechanical control of herbaceous plants during the growing season immediately after a burn is highly recommended for all fen burns.

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)
   - 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 and that are suspected to be sensitive to fire, most fires should occur only during the dormant season. 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

Figure 26. 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



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).

- To avoid or minimize take, land managers working in habitat occupied by Mitchell's satyr butterflies must abide by Appendix A, the Mitchell's satyr HCP, for management restrictions. These restrictions constitute the terms of an Incidental Take Permit.

Fire Sensitivity and the Phenologies 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 an 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 Appendix E.

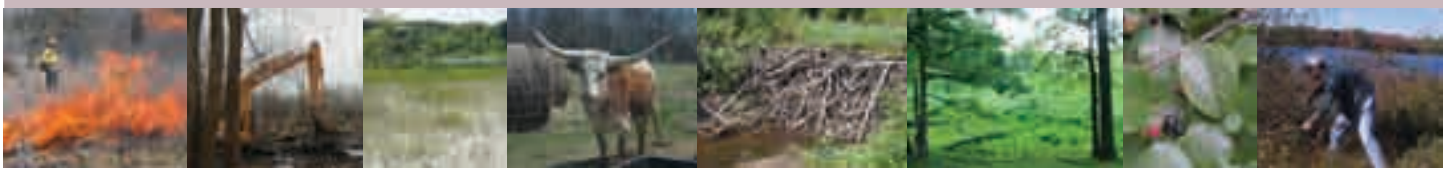
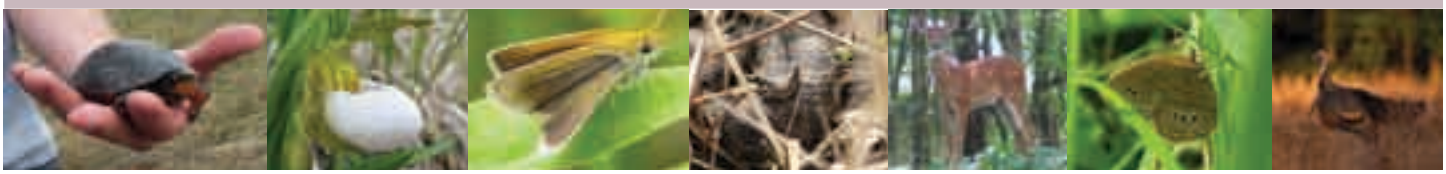


Table 3. Hypothesized plant sensitivity to fire based on life history and phenology. Only short-term acute sensitivities to individuals are considered in this table. Sensitivity also varies from species to species, by fire intensity and ignition pattern, and according to time scales considered.

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 *Filipendula rubra*			D			E	FL		FR	SD	SD	D



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

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
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

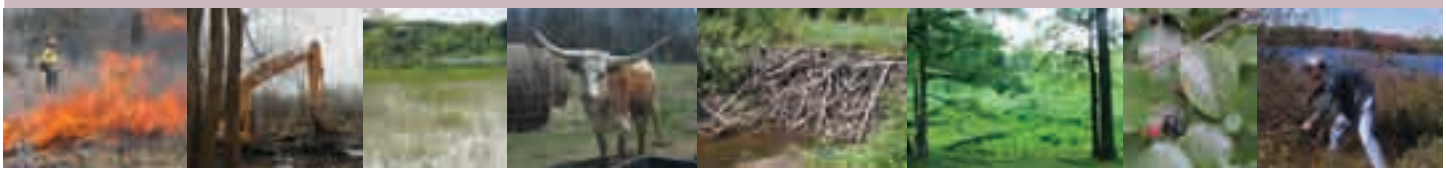
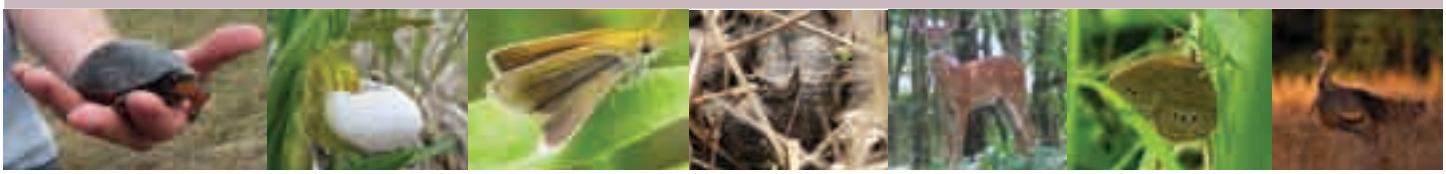


Table 4. Hypothesized animal sensitivity to fire based on life history and phenology. Only short-term acute sensitivities to individuals are considered in this table. Sensitivity also varies from species to species, by fire intensity and ignition pattern, and according to time scales considered.

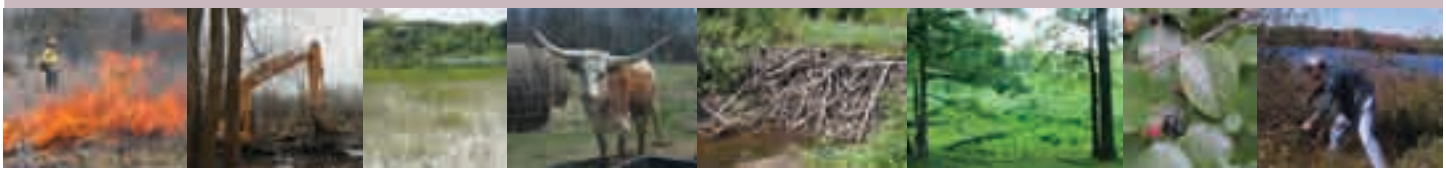
BIRDS	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Ground- nesting												
American bittern *Botaurus lentiginosus*				A	N	NY	Y		P			
American woodcock *Solopax minor*			A	AN N	NY	Y			P			
Blue-winged teal *Anas discors*				A	N	NY	Y		P			
Blue-winged warbler *Vermivora pinus*					A N	NY Y		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	DEC
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	HT
Spotted turtle *Clemmys guttata*		HA		BA		NT	E	E/M	M	A	HA	



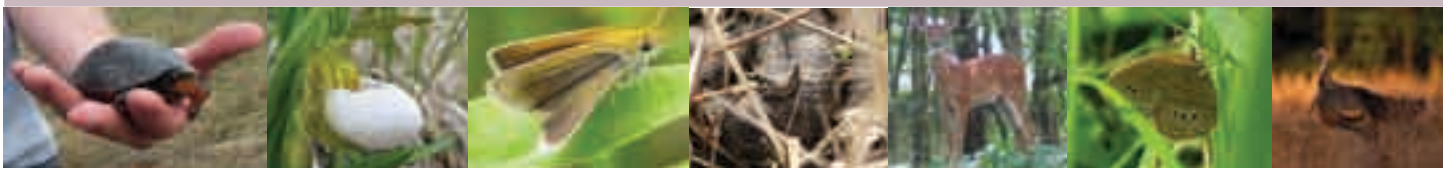
Animal Species Phenology and Fire Sensitivity

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
HERPETOFAUNA Continued												
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	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Butterflies and Moths												
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 *Claephelis mutica*				L		P	A	E		L		



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 *Synaptomys cooperi*		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

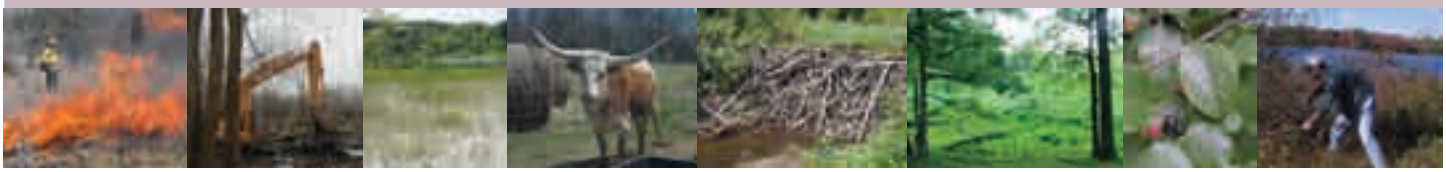
Hibernation H
Active A

Insect Phenology

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

Mammal Phenology

Breeding/Nesting B



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.

Tamarack trees are an important part of the prairie fen community. Many plants and insects (including the Mitchell's satyr butterfly) 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 cat-tail 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).

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. 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.

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,

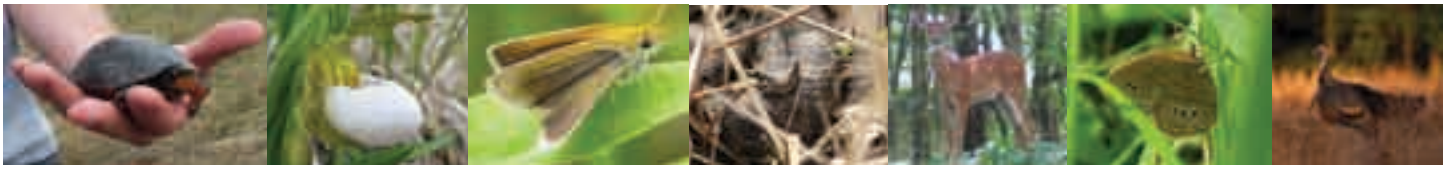


Figure 26. Prairie fens occurred in landscapes that burned on a regular basis. The high loads of fine fuels in fens would have been suceptible to fire as well. Today, fire is a useful tool to manage woody succession in fens.

it is important that outreach materials reach 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 Mitchell's satyr should refer to the Mitchell's satyr 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 Department of Fish and Game 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.

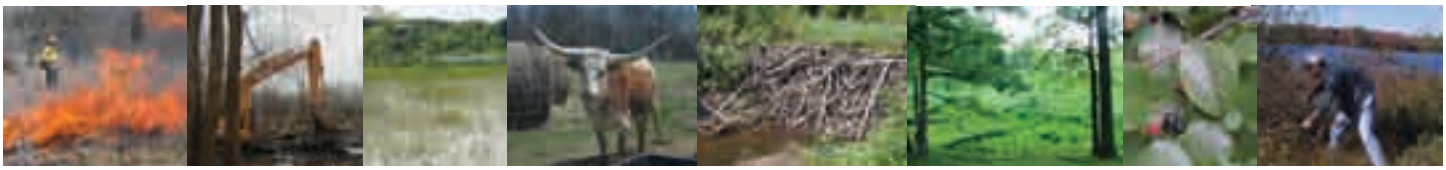
Invasive Plants of the Upper Midwest (Czarapata 2005) provides a good overview of specific invasive plants across the geographic range of the prairie fen. The book contains many useful pictures of ecologically significant invasive species, and gives much useful information on control techniques.

The Michigan Natural Features Inventory is in the process of creating a handbook *Guide to the Invasive Plant Species of Michigan* (Borland et al. i*n press*). The handbook is geared toward identification. It contains succinct information on management, but does not have detailed information on treatment, herbicides, etc.

The website for the *TNC Global Invasive Species Initiative* (The Nature Conservancy 2008) is another excellent resource for managers. The geographic scope of this resource is large, but the Management Library section does allow managers to search by species. The species accounts are long and exhaustive. The detailed information on management techniques and the ecological effects of herbicides in the Weed Control Methods Handbook (Tu et al. 2001) is especially handy.

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 reflected 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 and Landis, unpublished report)
- and conservation threats (has the original reason that satyrs disappeared been fixed at this site?)

5.10.3 Prioritize components and areas for species reintroduction.

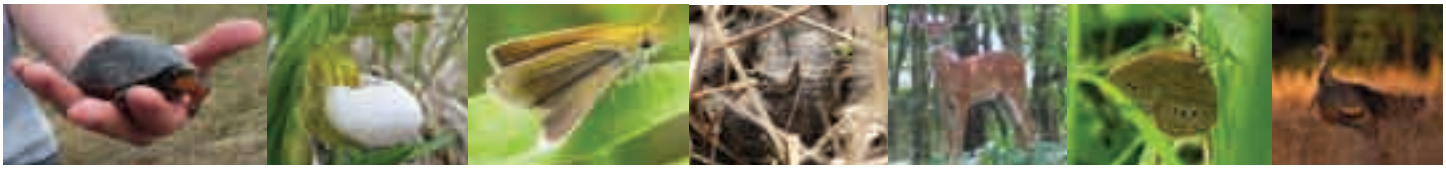
What are the most appropriate areas for introduction? Is the site owned by a public entity or conservation organization?

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



Monitoring

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 disproportional number of rare plant and animal species. Both the status of the community and populations of rare species within the 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 Mitchell's satyr butterfly. Recently, community level protocols have been developed specifically for prairie fens (Pearsall and Woods 2006 in Appendix C, 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. Landowner Incentive Program 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.

There is still much that we do not know. Which changes in hydrology affect Mitchell's satyr, and why? What level of grazing can keep a degraded fen from becoming a shrub-carr or invasive monoculture? Are there management techniques that are more efficient (less time or money for the same or better ecological outcome)? Can the community be conserved without the responsible use of prescribed fire? Can all species be conserved with the responsible use of prescribed fire? How much is too much or too little of any management tool (fire, herbicide, mowing, grazing)?

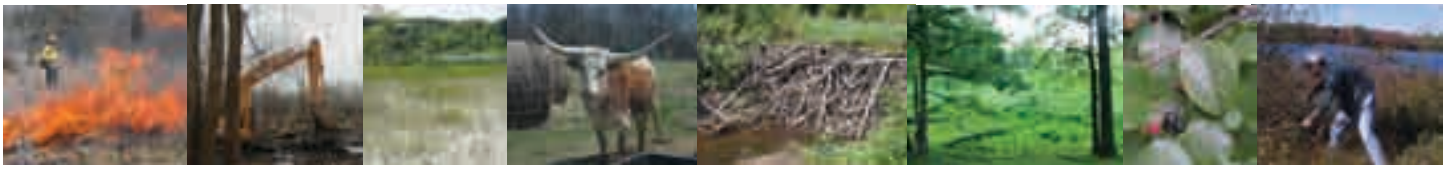
The challenges for the future are to mentor and train younger managers while at the same time quantifying and documenting the results of our management. This will ensure that future fen managers are building on our hard-earned knowledge and not repeating our past mistakes.

6.3 Adaptive Management

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 resprouts 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 resprouted and stem density increased. In another small fen, annually repeated 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 DNRE has developed a community-based monitoring strategy (Pearsall and Woods 2006) that is relatively simple, with only three metrics to estimate per management unit of fen (Appendix C).

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.

6.3.2 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 working 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 on 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 land 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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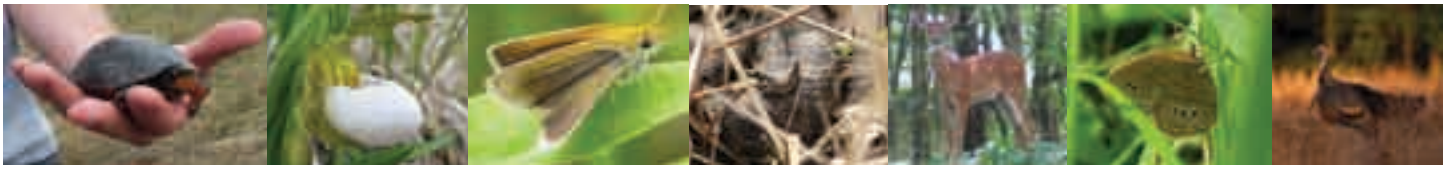

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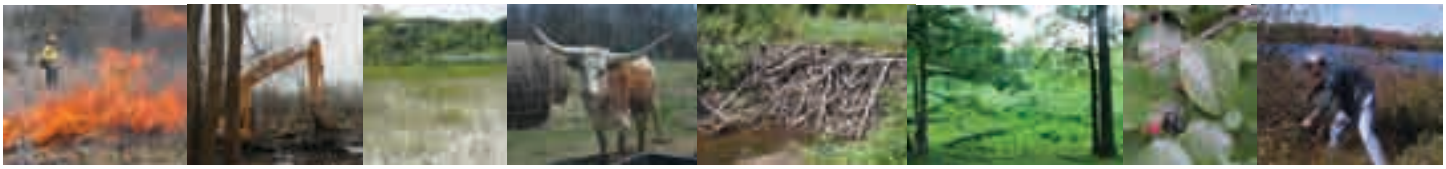

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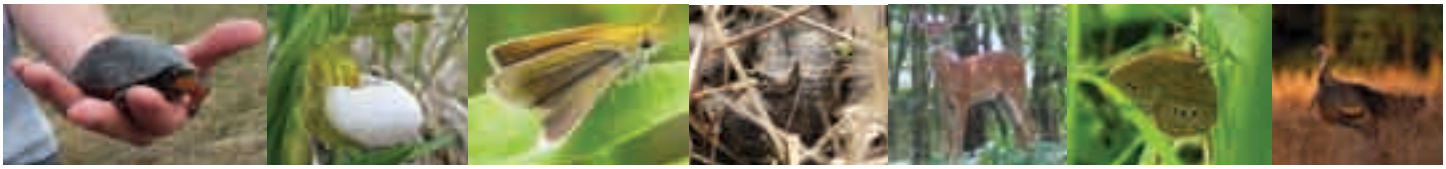

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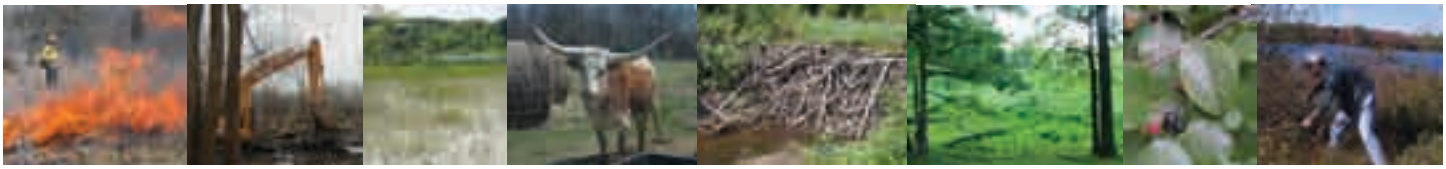

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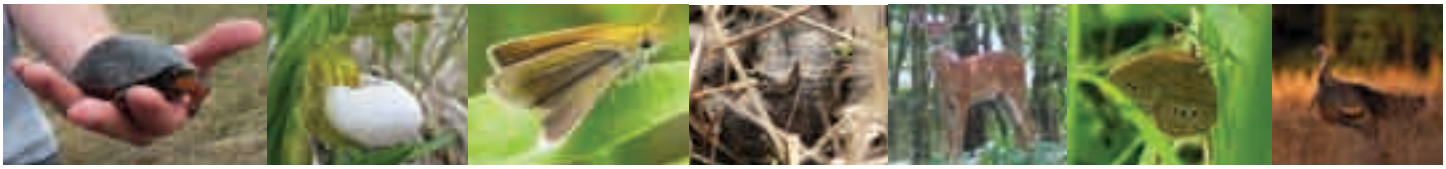

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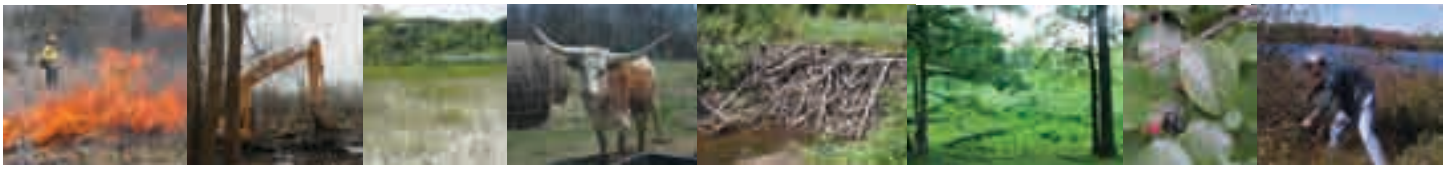

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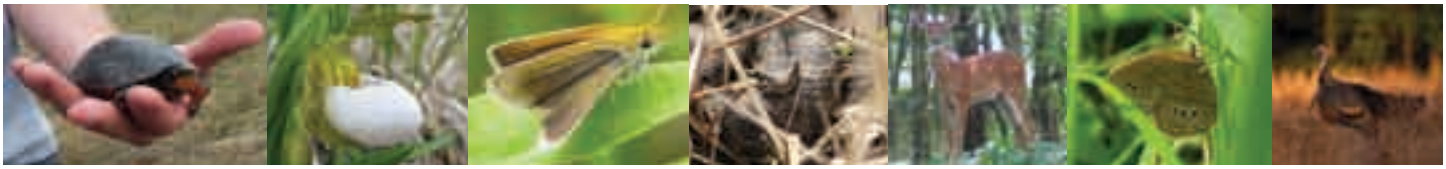
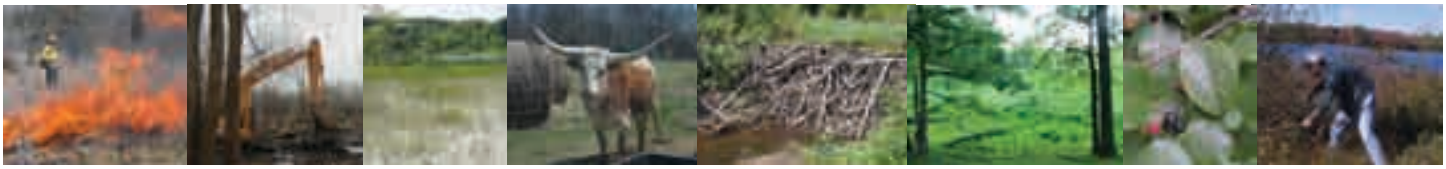


"Other people can talk about how to expand the destiny of mankind. I just want to talk about how to fix a motorcycle. I think that what I have to say has more lasting value."
— Robert M. Pirsig in *Zen and the Art of Motorcycle Maintenance*



APPENDIX A: Two-State HABITAT CONSERVATION PLAN for the MITCHELL'S SATYR BUTTERFLY

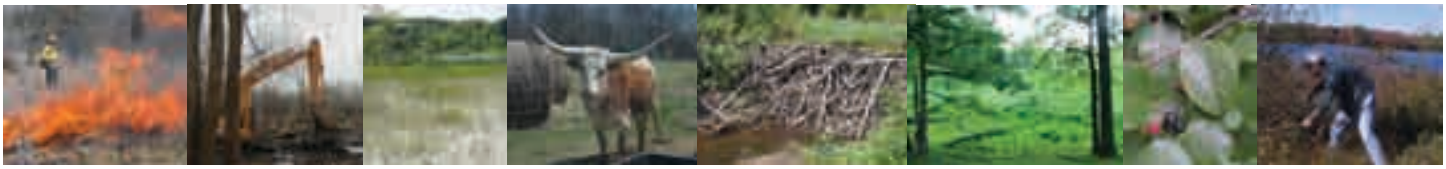
A1. Introduction

A1.1 Purpose

The federally endangered Mitchell's satyr butterfly (*Neonympha mitchellii mitchellii*) is one of the most imperiled butterflies in North America. Once distributed across at least five states, only 17 populations remain in Michigan and Indiana. At the initiation of this Plan there were 19 populations.

The Mitchell's satyr butterfly is on the Michigan DNRE list of "featured species," which is analagous to "focal species" within the US Fish and Wildlife Strategic Habitat Conservation (SHC) approach. Just as SHC uses specific species to focus and monitor habitat activities, the featured species approach is a way to focus and measure state habitat initiatives that may have broader goals. In this particular context, prairie fens are a conservation target for a partnership of agencies and organizations in Michigan and Indiana. The plan for fens is in the preceeding Fen Conservation Plan (FCP). This Appendix comprises the Habitat Conservation Plan (HCP) for habitat occupied by the Mitchell's satyr butterfly (hereafter "satyr"). This HCP has been written to outline how and where activities outlined in the Fen Conservation Plan must be applied to ensure the survival of populations of satyrs. The satyr occurs primarily on private land. This HCP applies only to non-federal lands occupied by satyrs in Michigan and Indiana. **It is hoped that this structure of a broader community or landscape plan with a focused featured species plan can be a model for efforts to consider multiple levels of conservation targets simultaneously.**

All fens in Michigan and Indiana have been altered, either through altered 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 butterflies, are susceptible to vegetation changes that endanger the native fen biota. Modern satyr habitat requires management; without management satyr habitat will become non-habitat: either closed canopy shrub-carr or monocultures of hybrid cat-tail (*Typha x glauca*) and other non-native invasive species. This HCP is written to avoid, minimize and mitigate take of satyr and other species that could be caused by much-needed management activities in occupied satyr habitat. This HCP supports the issuance of an incidental take



permit (ITP) pursuant to section 10(a)(1)(B) of the Federal Endangered Species Act of 1973, as amended (87 Stat 884, 16 U.S.C. § 1531 et seq.; ESA).

A1.2 Background

The historical distribution and abundance of satyr are difficult to reconstruct. They are now restricted to less than two dozen fens in southern Michigan and northern Indiana. Historical records for Mitchell's satyr occur from fens in Wisconsin (C. Hamm, personal communication), Ohio, New Jersey, and possibly Maryland (McAlpine et al.1960, USFWS 1998). A close relative, the St. Francis satyr (*Neonympha mitchellii francisci*) occurs in sedge meadows in North Carolina. Research continues regarding the status of recently discovered populations of *Neonympha mitchellii* in Alabama and Mississippi (C. Hamm, personal communication).

Satyr populations were once larger and less fragmented than they are today, although the extent of loss is a matter of some speculation. At a minimum, satyr habitat has disappeared as wetlands were drained for agriculture or urban development. Indiana and Michigan have lost 86% and 50% of their original wetlands, respectively (Dahl 1990). In addition, beaver meadows are far less common than they once were, and *Neonympha mitchellii* in Gulf Coast states have been observed using ephemeral beaver meadows extensively (C. Hamm, personal communication). In southern Michigan Hubbard estimated that beaver meadows and ponds comprised 20% of the entire landscape (Whitney 1994). Finally, large landscape fires burned across much of the Midwest where prairies and savannas were common (Nuzzo 1986, Whitney 1994, Albert 1995). These fires would have burned through wetlands as well as uplands, which would have maintained many wetlands in a semi-open stage. For these reasons, the semi-open grass and sedge wetlands that are habitat for Mitchell's satyr butterflies were likely much more extensive and continuous prior to European-American settlement.

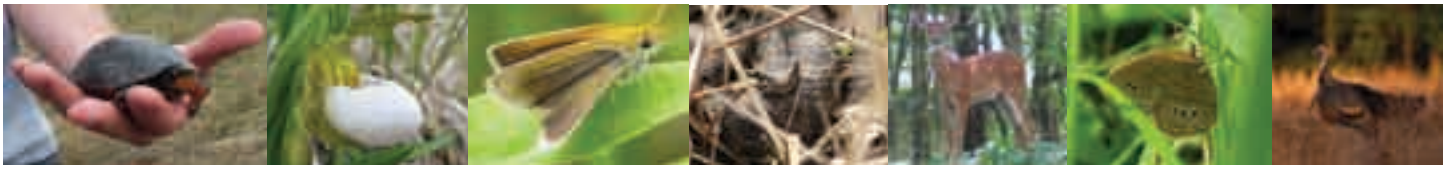
Draining, fragmentation, water pollution, beaver extirpation, and fire exclusion have changed the landscape in southern Michigan and Indiana. Healthy wetlands in a matrix of healthy prairie and savanna uplands are nearly extinct. The wetlands that persist have higher nutrient loads, more sediments, altered hydrology, invasive species, and more woody vegetation. They occur in the context of forested or agricultural landscapes where fire is no longer a natural process. Fires that do occur are limited almost entirely to the dormant season.

Mitchell's satyr occur at 19 sites, spread across 517 acres of prairie fen in Michigan and Indiana. In 2009 a total of 484 butterflies were seen for 82 person hours of timed meander searches. At some sites the number of butterflies was as low as zero butterflies per person-hour or as high as 12 butterflies per person-hour. Since listing in 1998, 4 new sites have been discovered (in Berrien, St. Joseph, Cass and Jackson Counties in Michigan). As of 2009, satyrs were not detected at 4 sites where they occurred in 1998.

Two sites (approx. 50 acres) occur entirely on state land in Michigan. One site occurs on a mix of jurisdictions, including state, township, and private land. The rest of the sites occur entirely on private lands. Of the 19 sites, 12 are partially protected by state agencies or other conservation organizations. Five populations are entirely protected. Management to reduce woody species and non-native invasive species has occurred at most sites with funds from private landowners, conservation organizations, State Wildlife Grants, Michigan DNRE Landowner Incentive Program, USFWS Section 6 Cooperative Endangered Species Conservation Fund, and USFWS Private Stewardship Grants Program.

This management has occurred under consultation via Section 7 and under Section 10(a)(1)(B). The approach has been piecemeal. Without LIP to enter into Section 7 consultation on behalf of private landowners, permitting would be intimidating for private landowners wishing to do needed management in habitat occupied by the Mitchell's satyr butterfly. LIP is no longer funded at the federal level, and a more unified and coordinated approach is needed to write an HCP in pursuance of an Incidental Take Permit (ITP) for management actions in occupied habitat.

In the absence of a comprehensive HCP and associated ITP, land managers and landowners would need to obtain incidental-take authorization on an individual, project-specific basis to legally conduct the activities listed below. This situation would result in a patchwork of projects conducted with little or no coordinated planning or consideration of range-wide impacts to satyrs and other associate species of concern. By contrast, projects implemented under this HCP will be authorized by a single ITP. Projects will be



implemented according to consistent conditions, and HCP management partners will coordinate management activities and benefit from predictable regulatory approaches. This HCP will help evaluate and minimize the cumulative adverse impacts of individual projects to particular satyr populations.

A1.3 Permit Duration

The desired term of the ITP is 25 years. If recovery requires more time than currently anticipated, the Michigan DNRE may apply for extension of the ITP.

A1.4 Regulatory/Legal Framework

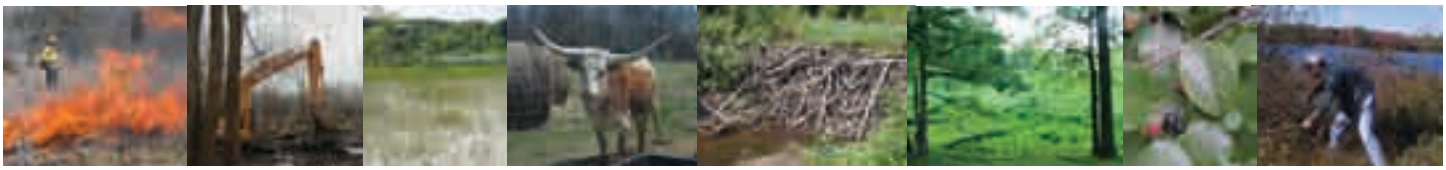
The Mitchell's satyr butterfly is listed as an endangered species under authority of the federal ESA. Take of endangered species is restricted by section 9 of the ESA. Under the ESA, 'take' means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect a federally listed threatened or endangered species or to attempt to engage in any such conduct. Satyrs require sedges and grasses with scattered trees and shrubs, a type of wetland savanna (USFWS 1998), and management needed to maintain these habitats may result in take of individuals. The take restriction limits the options available to manage habitat in areas occupied by Mitchell's satyr butterflies.

Under certain circumstances, however, section 10 of the ESA allows exceptions from the restriction on take. An ITP under section 10(a)(1)(B) allows incidental take associated with otherwise lawful activities. An HCP, intended to minimize and mitigate take authorized by an ITP, must be submitted with the permit application. By law, the U.S. Fish and Wildlife Service (USFWS) can not issue a permit that would jeopardize the continued existence of a listed species. In consultation with the USFWS, the Michigan DNRE identified an ITP as the most appropriate regulatory instrument to facilitate conservation of occupied satyr habitat in Indiana and Michigan.

Activities conducted under this HCP also must comply with State law. Similar to the ESA, the Michigan Endangered Species Protection Law (Public Act 451 of 1994, Part 365) prohibits take of State endangered and threatened species, including Mitchell's satyr butterflies. However, section 36504 of the law allows the Michigan DNRE to "establish programs . . . as are considered necessary for the management of endangered or threatened species." The same section continues: "In implementing the programs authorized by this section, the [Michigan DNRE] may enter into cooperative agreements with Federal and State agencies, political subdivisions of the State, or with private persons for the administration and management of any area or program established under this section . . ." Given these provisions, the conservation and partnering activities outlined in this HCP are consistent with this law.

Mitchell's satyr butterfly is listed as endangered on the official list of rare, threatened and endangered insects in Indiana. However, only vertebrates, mollusks and crustaceans classified as endangered in Indiana are protected from taking pursuant to the Nongame and Endangered Species Act of 1973 (IC 14-22-34). Therefore, management authority for insects in Indiana comes from general authority by the state

Figure A1. Nineteen Mitchell's satyr butterfly populations are widely scattered among 10 counties in Indiana and Michigan.



to manage wildlife resources.

A1.5 Area To Be Covered by Permit

The area covered under the HCP potentially includes all occupied habitat for the Mitchell's satyr butterfly in Michigan and Indiana. Currently, 504 acres are occupied habitat in Michigan and 13 acres are occupied habitat in Indiana. The average size of occupied habitat patches is 28 acres, the median size is 14 acres (i.e., half of all populations occur on sites that are under 14 acres in size). The Mitchell's satyr butterfly is known to occur in the following counties: Barry, Berrien, Branch, Cass, Jackson, Kalamazoo, St. Joseph, Van Buren, and Washtenaw in Michigan and Lagrange in Indiana (Figure 8).

A1.6 Species To Be Covered by Permit

The DNRE requests an ITP that authorizes take of the Mitchell's satyr butterfly in Michigan and Indiana. The Mitchell's satyr butterfly is listed as endangered at both the federal level and within Michigan and Indiana. Other species addressed by the HCP, but for whom an ITP is not sought, are discussed in Section A6.

Figure A2. The Mitchell's satyr butterfly is a gorgeous, chocolate brown with a distinctive linear pattern of eye spots and a slow bobbing flight.

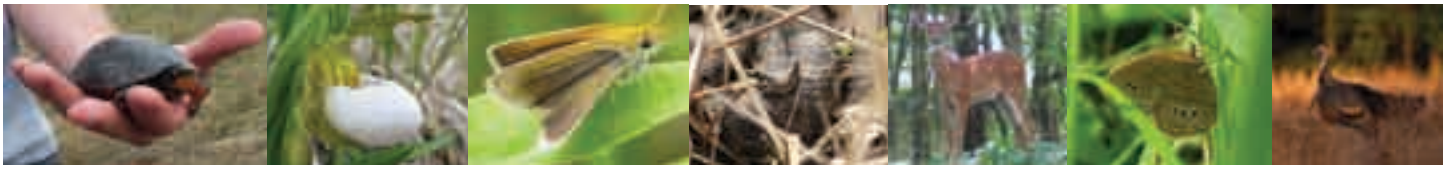
A2. Mitchell's Satyr Biology and Status

A2.1 Physical Description

The Mitchell's satyr butterfly (Figure 9) is a medium-size, chocolate brown butterfly. Adult wingspan is approximately 4 cm (1.5 – 1.75 inches). The Mitchell's satyr butterfly is superficially similar to other satyrs, browns, and pearly-eyes (subfamily Satyrinae), and adults can be distinguished by their size, color, and pattern of spots (ocelli) on the bottom (ventral) side of the wings. Larvae (caterpillars) are very small, green, and highly cryptic (Figure 10).

The Mitchell's satyr can be confused with several species in Michigan and Indiana (Figure 11), including the Appalachian eyed brown (*Satyrodes appalachia*) and eyed brown (*S. eurydice*). However, the Mitchell's satyr is smaller (by about 50%) and usually darker in color (brown, as opposed to tan). The spots are arranged differently, as well. The top-most spot on the hind wing is larger and further forward on the eyed-browns, compared to the Mitchell's satyr (USFWS 1998, Glassberg 1999). The little wood satyr (*Megisto cymela*) is similar to the Mitchell's satyr in size, but the wood satyr is lighter in color, has fewer and more uniform spots, and tends to fly further and faster than a Mitchell's satyr butterfly (USFWS 1998, Glassberg 1999).

The behavior of the Mitchell's satyr butterfly is also diagnostic. Like other satyrs and browns, the flight has been described as "bouncing" (McAlpine et al. 1960, USFWS 1998). However, the Mitchell's satyr flight is slower, and they tend to fly through vegetation, rather than over the top. They often (but not always) stop after a short flight.



A2.2 Habitat

In Michigan and Indiana, the Mitchell's satyr butterfly is found exclusively in fens and open parts of rich tamarack swamps. Satyrs are not found in all fens, and are not distributed throughout any one fen. Within a fen, satyrs occur near (within 3m, usually) of woody vegetation (Barton and Bach 2005). In more open fens, satyrs occur along the shrubby edge of the fen. In fens with more tamarack or other woody vegetation, satyrs are found in open, grassy lanes between lanes of trees and shrubs. In still other fens, satyrs are found among openings in rich tamarack swamps. Satyrs are rarely found in open fens without trees or tamarack swamps without openings. Similar to the federally endangered Karner Blue butterfly (*Lycadies melissa samuelis*), the ideal Mitchell's satyr butterfly habitat appears to be intermediate between a grass (or sedge) dominated prairie and a closed canopy forest. The Mitchell's satyr butterfly is found primarily in fen savanna, usually dominated by tamarack.

A common question with regard to habitat of rare species is, "What aspect of habitat causes this species to be rare?" Mitchell's satyr butterflies do not appear to be food limited. The food plants used by Mitchell's satyr larvae are relatively common in wetlands, and are not limited to fens (McAlpine et al. 1960).

The juxtaposition of food plants and places to lay eggs may be a limiting factor in fens. Larvae feed on sedges and grasses. Like upland savannas, sedges and grasses tend to out-compete wildflowers in open sun. Wildflowers and bare peat soil tend to predominate in closed-canopy swamps. The intermixing of graminoids and wildflowers at a scale that is meaningful to a 3 mm first instar larva occurs in savanna, where neither sedges/grasses nor wildflowers can predominate. Furthermore, regular fire favors short-statured wildflowers, which have difficulty competing under the shade of litter from the previous growing season. These short-statured wildflowers tend to be most abundant after a fire. A similar effect occurs after grazing, but grazing can seriously harm soil structure, nutrient dynamics, and introduce invasive plant species (see Section 3.2.3).

A2.3 Food Habits

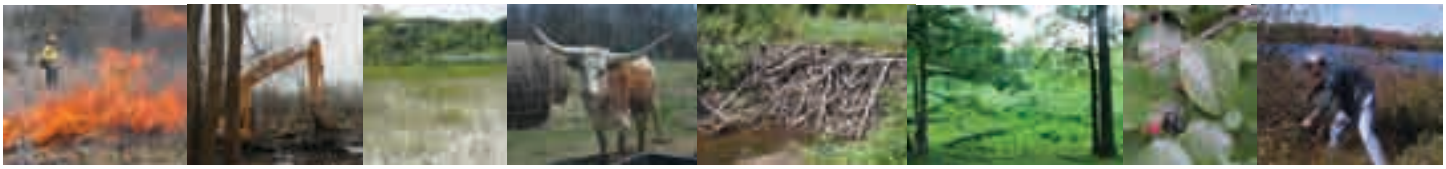
Mitchell's satyr larvae feed on a variety of sedges and grasses found in fens, sedge meadows, tamarack swamps, and other wetlands. Food preference trials for captive larvae have documented feeding on tussock sedge *Carex stricta*, bristly-stalked sedge *C. leptalia*, fowl bluegrass *Poa palustris*, and *Panicum* sp. (Tolson and Ellsworth, unpublished report). Adult butterflies are short-lived and are not known to regularly feed, although they have been observed nectaring on several occasions (D. Hyde., personal communication).

Some of the grasses and sedges used by larvae are limited to specific micro-habitats within the fen. *C. sterilis* occurs near seeps or areas with marl. Bristly-stalked sedge *C. leptalia* is most common under tamarack trees.

A2.4 Life Cycle

The Mitchell's satyr butterfly exists for 95% of its life cycle as a caterpillar or larva. Larvae hatch from eggs after 7-11 days, in July. They immediately move to a nearby food plant. First instar larvae are first 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 satyr overwinters as a fourth instar larvae on the leaves of tussock sedge. In the spring, the larvae continue eating and growing. In late-May to late-June, the larvae form a chrysalis about 40 cm (5- 68 cm) or 15 inches (2 – 27 inches) from the base of the plant (Tolson and Ellsworth, unpublished report). The chrysalis persists for 10 to 15 days (McAlpine et al. 1960). Adult butterflies emerge from mid-June to late July. Males emerge earlier than females (McAlpine et al. 1960, USFWS 1998). Adults are short-lived, do not usually feed, and exist primarily to mate, disperse, and lay eggs. Eggs are not usually laid on food plants. Instead, eggs are most often laid on wildflowers of very short stature. In captivity, eggs are most often laid on clearweed *Pilea pumila* (Tolson and Ellsworth, unpublished report).

A2.5 Dispersal



Mitchell's Satyr HCP

Mitchell's Satyr Butterfly

Slow bobbing flight is distinctive

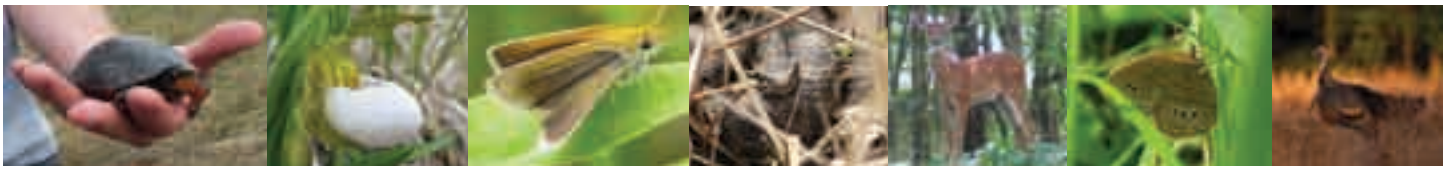
Frequent perching on vegetation is distinctive

Pattern of spots is unique

- Spots in linear line
- Larger spots on lower wing
- Number of spots varies

Color varies from brown (pictured) to dark brown

Size (1.5" to 1.75") is similar to other brown butterflies in fens



Mitchell's Satyr HCP

Eyed Brown or Appalachian Eyed Brown

Central large eye spot not in line with other marginal spots

Larger than Mitchell's satyr

Flights are longer and faster

Little Wood Satyr

Spots similar size, fewer than Mitchell's satyr

1.5" to 1.75"

Faster bobbing flight

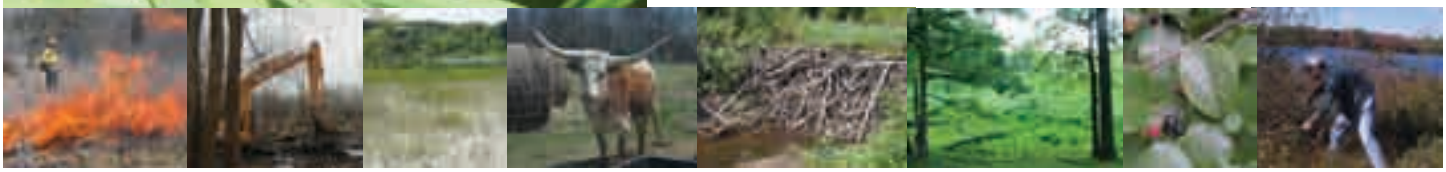
Very rarely ceases flight to perch on vegetation

Common Wood Nymph

Dark brown

Large eye spot on top wing

Often found in more wooded areas



All ecologically significant dispersal for the Mitchell's satyr occurs during a short period as adults. Adult Mitchell's satyr butterflies are weak fliers. In most contemporary landscapes, they are not capable of dispersal to unoccupied fens. In fens in Branch and Jackson Counties, the median daily movements were 32m for females and 56m for males. The maximum distances recorded in the study were 478m for females and 710m for males. The maximum distance ever recorded for a Mitchell's satyr dispersal is under 0.5 mile. Mitchell's satyr butterflies will disperse through forest and shrub-carr, but the degree to which woody vegetation acts as a barrier is unknown.

Clearing woody shrubs and trees in narrow lanes (15m - 30m) is an often recommended management strategy to promote dispersal between occupied openings within fen complexes (Hyde and Fuller, unpublished report). These corridors are often created along linear landscape features, usually streams. It is unclear whether satyrs disperse through these areas because they have an open vegetation structure or because they follow landscape features like streams.

Mitchell's satyr butterflies appear to colonize suitable fen within corridors after woody shrubs are removed. Thus, the corridors have the potential to connect previously disjunct sub-populations. Corridors provide habitat, and they have much edge between open fen and woody vegetation. However, corridors, especially narrow corridors, can revert to shrub-carr more quickly than restorations with less edge. Corridors can also provide substrate for invasive plants. Cutting and maintaining corridors is an expensive management tool, and the efficacy of corridors for movement or habitat and their ideal width are research needs.

A2.6 Distribution and Abundance

The Mitchell's satyr butterfly may be one of the world's rarest butterflies. Currently, 19 populations are known to exist in 10 counties (Figure 8). Of these, 18 populations occur in Michigan, and 16 occur on private land. Population sizes vary greatly. The largest population is found in south-central Michigan. The smallest populations occur in elsewhere southern Michigan where less than ten butterflies are seen in a given year. The butterflies often use only a portion of the fen, and several of these occupied areas are less than one hectare in size.

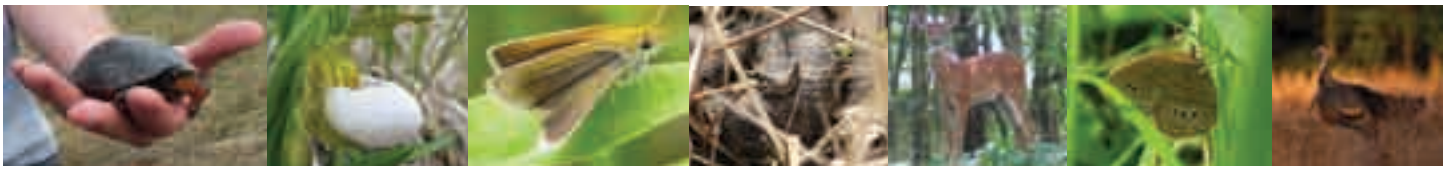
Figure A3. The Mitchell's satyr butterfly is one of America's most endangered butterflies.

In 2006, Indiana had two populations, in Lagrange and Laporte Counties. In 2007 and 2008, no butterflies were observed in Laporte County, and that population is assumed to be extirpated. Voucher specimens are known from a site in Steuben County, and although there is still suitable habitat, it has not been found there in recent decades. Historical records exist for populations in Ohio, New Jersey, and perhaps Maryland (McAlpine et al 1960, USFWS 1998). A historical record was recently discovered in the Field Museum in Chicago, with location information indicating a former population in Wisconsin. In recent years, populations of *Neonympha mitchellii* were discovered in Alabama and Mississippi, but it is unclear whether these are Mitchell's satyr, St. Fancis satyr, or another species altogether.

A3. Goals and Objectives

A3.1 Property Acquisition

Protect fens that are occupied, fens targeted for potential reintroduction, or critical uplands (adjacent



landscapes or groundwater recharge areas) through property acquisition.

Property acquisition of occupied habitats is an explicit criterion for recovery of the Mitchell's satyr butterfly (USFWS 1998). Currently, the Mitchell's satyr butterfly occurs overwhelmingly on lands that are not formally committed to conservation in perpetuity, and this constitutes a long-term threat to satyr habitat. The Recovery Plan for this species calls for state, federal or conservation organization ownership of 15 (60%) of at least 25 viable sites

A3.1. *Objective 1*: Protect occupied habitat within fens occupied by Mitchell's satyr butterflies in Michigan and Indiana by acquiring title, conservation easements, or assisting conservation partners to secure titles or conservation easements on these lands.

Figure A5. Groundwater in prairie fens is often so full of calcium and magnesium that it precipitates as "marl." Where they occur, marl flats are on of the more obvious features of prairie fens.

Figure A4. Mitchell's satyr butterfly habitat is prairie fens. They are most often found near shrubs, at the edges of openings. Scattered tamarack trees, poison sumac, and sedges are common in prairie fens.

A3.1 *Objective 2*: Acquire title or conservation easements on landscape connections between patches of occupied fen habitat to support dispersal among existing populations.

A3.1 *Objective 3*: Acquire title or conservation easements on fens with high potential for Mitchell's satyr butterfly reintroduction.

A3.2 Maintain existing processes and connectivity

Maintain fens and their landscape context in a condition and configuration necessary to sustain existing populations of Mitchell's satyr

Mitchell's satyr butterflies sometimes occur in fens, or portions of fens, that exhibit the biological diversity, vegetation structure, and ecological processes of a healthy fen. Processes, structure, and diversity are within the

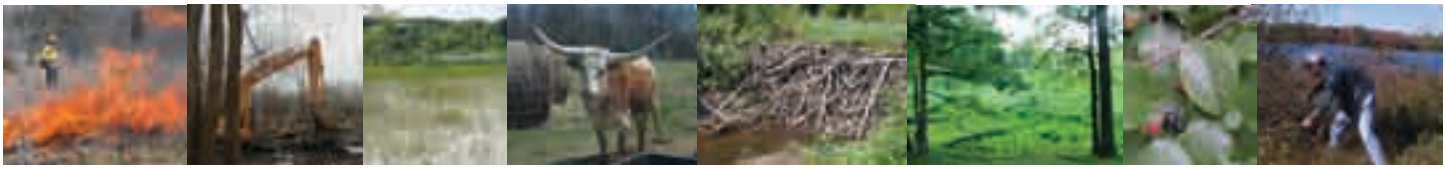


Figure A6. Mitchell's satyr spend 90% of their life sysle as larvae, eating a variety of sedges, especially tussock sedge Carex stricta.

historical range of variation for this system, and individual species are not threatened by habitat alterations. These fens will require a low level of management in order to intentionally perpetuate processes that create habitat for fen species, including the Mitchell's satyr butterfly. The maintenance of fens will require a balance of management sufficient to maintain tamarack savanna without extirpating Mitchell's satyr butterflies.

A3.2. Objective 1: Perpetuate ecological processes required to provide abiotic and biotic features required by Mitchell's satyr butterflies within fens.

A3.2. Objective 2: Maintain suitable dispersal habitat between patches of fen that are occupied by Mitchell's satyr butterflies to support dispersal among existing populations.

A3.2. Objective 3: Restore native vegetation in the uplands and non-fen wetlands within the surface or ground watershed of the fen, especially over critical groundwater recharge areas for occupied fens.

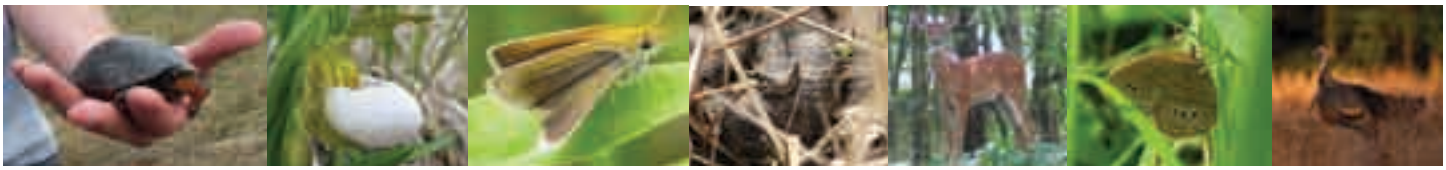
A3.3 Restore degraded processes and connectivity

Restore fens and their landscape context to a condition and configuration necessary to increase existing populations of Mitchell's satyr butterflies and associated fen species

Most fens on the landscape are currently degraded and will require restoration. Without restoration activities, Mitchell's satyr and associated rare plants and animals are likely to be extirpated from these fens. Restoration activities are more likely to cause short-term population declines in Mitchell's satyr and other sensitive species. Less restrictive criteria will be applied to restoration activities than maintenance activities because a) restoration activities are of shorter duration than maintenance activities, b) maintenance activity regimes are seldom adequate to restore habitat, and c) restrictions act as a disincentive to landowners who might restore habitat in fens.

Restoration activities are defined as management actions within fens (or portions of fens) that are 1) outside the historical range of variation for biological diversity,

Figure A7. Eggs are laid on low-stature broad-leaf vegetation. In many grassland ecosystems, this type of vegetation is favored by frequent disturbance, either from grazing or fire



vegetation structure, or ecological process; and 2) where the management objective is to return the diversity, structure, or process to within the historical range of variation.

A3.3. Objective 1: Manage fens to restore natural patterns of woody vegetation, graminoid vegetation, and forb vegetation, fuel continuity, and native vegetation necessary for Mitchell's satyr larvae and butterflies. Work with conservation partners to coordinate restoration on 23 additional fens.

A3.3. Objective 2: Restore or reintroduce ecological processes required to provide abiotic and biotic features required by the Mitchell's satyr butterfly.

A3.3. Objective 3: Create connectivity among occupied Mitchell's satyr habitats to support dispersal among existing populations and into newly restored habitat patches.

A3.3. Objective 4: Restore native vegetation in the uplands and non-fen wetlands within the surface or ground watershed of the fen, especially over critical groundwater recharge areas for occupied fens.

A3.4 Restore for reintroduction

Restore fens and landscape context to a condition and configuration necessary to allow future reintroduction of populations of Mitchell's satyr butterflies into currently unoccupied fens

Currently only 10% of fens in southern Michigan and northern Indiana are occupied by satyrs. We do not know how many historically had satyr. We do not know why some high-quality fens lack satyrs. Perhaps they lack some component of habitat, perhaps they were never colonized, or perhaps they have been extirpated from most fens. We do know that many fens had satyrs and now do not (e.g., the many fens mentioned in McAlpine et al. 1960). Recovery for this species will require reintroduction into at least six fens. Management should be initiated at 10 of the top 25 fens ranked highest by Rabe et al. (2002) or fens of similar quality, size, and landscape context. Maintaining these sites will ensure that reintroduction can occur at some future date. These restoration activities will require the least restrictions because take for Mitchell's satyr butterfly is not (yet) a concern at these sites.

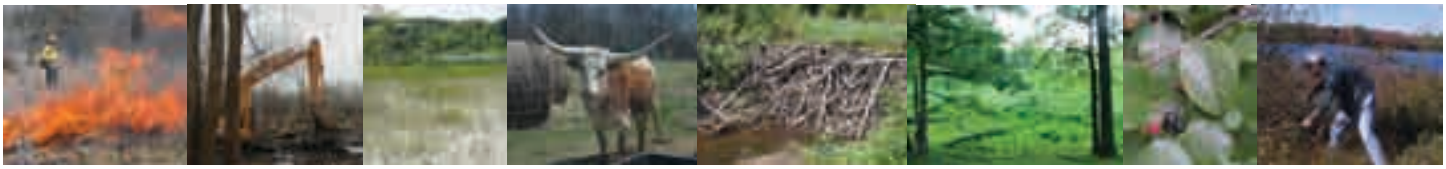
Because these activities have Mitchell's satyr habitat as a goal, they are covered in this Plan. However, we are not seeking an ITP for these activities. In the event that Mitchell's satyr are introduced into these habitats, and other permits and/or agreements are not negotiated to cover these populations (i.e., a Safe Harbor agreement or classification as nonessential experimental population), then the provisions of sections A5 will apply.

A3.4. Objective 1: Manage fens to restore natural patterns of woody vegetation, graminoid vegetation, and forb vegetation, fuel continuity, and native vegetation necessary for Mitchell's satyr larvae and butterflies.

A3.4. Objective 2: Restore or reintroduce ecological processes required to provide abiotic and biotic features required by Mitchell's satyr.

A3.4. Objective 3: Create connectivity among occupied Mitchell's satyr habitats to support dispersal among existing populations and into newly restored habitat patches.

A3.4. Objective 4: Restore native vegetation in the uplands and non-fen wetlands within the surface or ground watershed of the fen, especially over critical groundwater recharge areas for these fens.



A4. Project Description and Activities Covered under Permit

A4.1 Project Description

The project covered by this permit is limited to acquisition, restoration and maintenance of fens and associated landscapes. Unlike a similar HCP for the Karner Blue butterfly in Michigan, right of way maintenance and residential development are not covered by this project. Thus, this Plan is of more limited scope than the Michigan Statewide Karner Blue Butterfly HCP.

A4.2 Activities Covered by Permit

A4.2.1 Restore Hydrology

Most fens worldwide have altered hydrology (Amon et al. 2002). Both fens as a system (Bedford and Godwin 2003), and the Mitchell's satyr butterfly in particular, are sensitive to changes in the way groundwater flows through a fen. Restoring hydrology is a critical need in fens, especially when it has been significantly altered. However, in most cases, hydrology has been changed by expensive land use changes using heavy equipment. Removing berms, roads, wells, or ponds is extremely expensive, and often beyond the budget of most managers.

When hydrology cannot be restored, other on-going management can compensate for the altered hydrology. Much modern fen management is actually compensating for changes resulting from overgrazing and hydrological alterations. Increased use of fire, mowing, vegetation control, and (sometimes) grazing can compensate for drier conditions. In fens with highly altered hydrology, a balance between intensive management and accommodation for rare species may not be possible. These fens, and the species within them, are threatened by on-going altered hydrology.

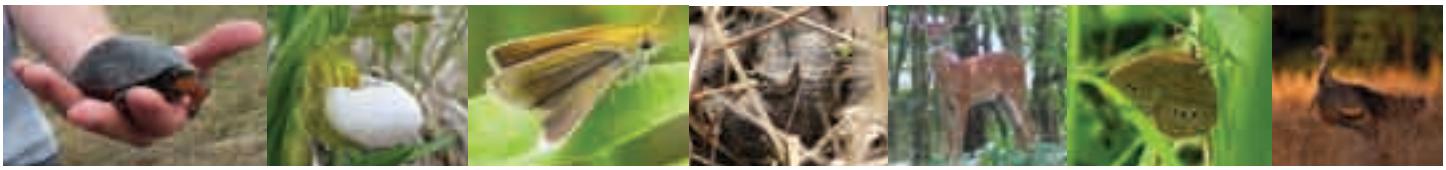
A4.2.2 Prescribed Burning

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

Landscape fires no longer occur in the fragmented landscape. Instead, prescribed fire is used as a management tool. 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, hydroaxing, 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 managers can "afford" when restoring fens. For these reasons, 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.

Research on the effects of fire on Mitchell's satyr larvae have been attempted, but the results were inconclusive (Barton 2008). Small areas of occupied habitat were recolonized following a prescribed burn at the largest satyr population in south-central Michigan. Similar anecdotal reports abound, both of negative and positive fire effects on insects. Scientific studies have been conducted, mostly in upland prairie systems. They reveal that fire can reduce butterfly abundance for the season immediately after the fire (Panzer 2002), but that butterfly diversity is higher on areas managed with fire, compared with grazing (Vogel et al. 2007). Butterfly populations persist in areas that are regularly burned if permanent non-fire refugia are established (Swengle and Swengle 2007). In situ survival and recolonization ensure that even rare invertebrates can persist as long as adjacent unburned refugia remain (Panzer 2003), but that one species, the Silphium borer moth (*Papaipema silphii*), which sometimes co-occurs with satyrs in fens, can persist when the entire occupied habitat is regularly burned (Andrew and Leach 2006). Fire has even been used successfully in small, isolated remnants that contain fire-sensitive invertebrates, as long as a year or more recovery time exists between fires



(Panzer 2002).

Like the vegetation of fens, the insect community is a mixture of prairie-adapted and wetland-adapted species. Thus, some species are likely to be sensitive to frequent or extensive fires. Swengle and Swengle (2007) recommend permanent refugia be established among burn units when managing areas with fire.

A4.2.3 Mowing/Hydroaxing

Altered hydrology causes fens to dry slightly, which allows woody vegetation to invade, thrive, and convert a tamarack savanna to a closed canopy forest or carr (i.e., shrub forest). Overgrazing causes surface peat to degrade from fibric peat, which conducts water, to sapric peat, which is a poorer conductor of water (Middleton 2002). Overgrazing also breaks apart the natural tussock microtopography of fens. These results of overgrazing allow woody vegetation to invade, thrive, and convert savanna to closed canopy shrub-carr or forest. Finally, some invasive shrubs, such as Eurasian buckthorns, will invade fens that have been less disturbed by grazing or hydrology. One step in setting back woody vegetation is to mow the 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 is used when fens freeze (if they freeze). Usually the softness of the ground prevents the use of wheeled or heavy tracked vehicles.

A4.2.4 Vegetation Removal

Both herbaceous and woody, native and exotic plants can be a significant management problem in fens. Usually 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*), reed grass (*Phragmites australis*), reed canary grass (*Phalaris arundinacea*), cattails (*Typha angustifolia*), and others. Removal of invasive plant species will be a large component of management activities at many sites.

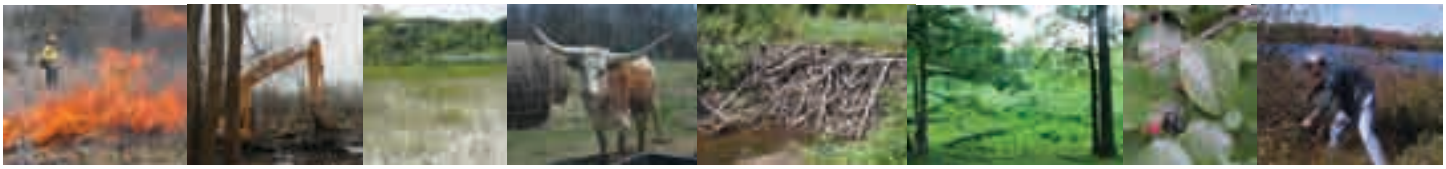
Activities may include the control of non-native vegetation through manual removal with hand tools or mechanical equipment. Mechanical vegetation removal is rarely effective when used alone, unless done during the earliest instars of the Mitchell's satyr butterfly (August). Thus, to avoid impacts to satyrs and other rare fen biota, manual removal is more often used in combination with herbicide and conducted during the dormant season.

Figure A8. Mitchell's satyr butterflies are often associated with fens, which have more diverse vegetation than sedge meadows. Fens are habitat to a variety of rare plants and animals, such as this special concern Prairie indian-plaintain (Calacia plantaginea).

Fire, mowing, and mechanical vegetation removal will stimulate some invasive plants. Most invasive plants can be controlled with appropriate herbicides used in appropriate ways. Because fens have extremely high plant diversity and many state listed plants, extreme care should be taken to minimize damage to native fen vegetation when treating invasives with chemicals.

A4.2.6 Biological Control

One reason often given for the ability of invasive exotic plants to create monocultures is enemy release. Because the plants are released from the pests and diseases of their native range, they 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.



Biological control for purple loosestrife has been initiated in one fen with what appears to be poor results. The biological control can take several years to produce results. However, since the initial release of beetles in 2004, the amount of loosestrife has increased in this fen. Grazing by livestock may be affecting the establishment of the biological control or spreading the loosestrife.

A4.2.7 Livestock Grazing

Grazing in fens by native vertebrates was likely uncommon prior to settlement (see Fen Conservation Plan, section 2.4.3.) After settlement grazing became common on the landscape, although livestock probably avoided the fen portion of their pastures throughout much of the season (Whitney 1994). Even moderate, seasonal grazing can damage tussock microtopography, change soil types, introduce invasives, and alter successional pathways away from savanna and toward closed canopy shrub carr or forest (Middleton 2002).

Once grazing has damaged a fen, 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 butterfly. Thus, grazing is a useful tool to manage the damage caused by grazing. Grazed fens from which livestock are removed will require significant resources to maintain the fen community.

A4.2.8 Seeding and Planting

Seeding and planting are rarely used within habitat used by Mitchell's satyr butterfly. The seedbank of peat wetlands is highly persistent, and will express itself when exposed to the right combinations of sunlight and water. However, it is possible that repeated broadcast spraying to control long-established monocultures of invasive exotic plants could exhaust the seedbank of a portion of a fen. In these situations it might become necessary to plant seeds, plants, or young trees.

A4.2.9 Treatment Combinations

Activities to maintain existing fens may use some of the above activities singly. However, most management will be targeted toward restoration activities. These activities will require combinations of activities, carefully planned to occur over multiple years.

A5. Measures to Minimize Adverse Impacts

A5.1 General

The following measures apply to all activities within habitat occupied by the Mitchell's satyr butterfly in Michigan and Indiana.

1. To minimize trampling of the habitat and inadvertent crushing of eggs or larvae, the number of people in areas of occupied habitat will be limited to no more than 10 individuals at any given time.
2. All activities in occupied habitat shall be conducted in a manner to minimize disturbance to satyr adults, pupae, larvae, eggs, and their habitat, by minimizing human movement and avoiding trampling of vegetation to the extent practical. People working in occupied habitat will use existing trails when available to minimize trampling.
3. People will travel through open fen >3m from woody vegetation when moving from one part of a fen to another to conduct activities. Individuals seeking adult Mitchell's satyr for surveys or research are exempt from this requirement.

A5.2 Restore Hydrology

Hydrological restorations outside occupied habitat can affect satyrs within occupied habitat

1. Restoring the flow of groundwater through the upper layers of peat is the highest priority.
2. Open ponds that cut springs before they reach the fen will be filled such that groundwater flows to the surface of the fen.

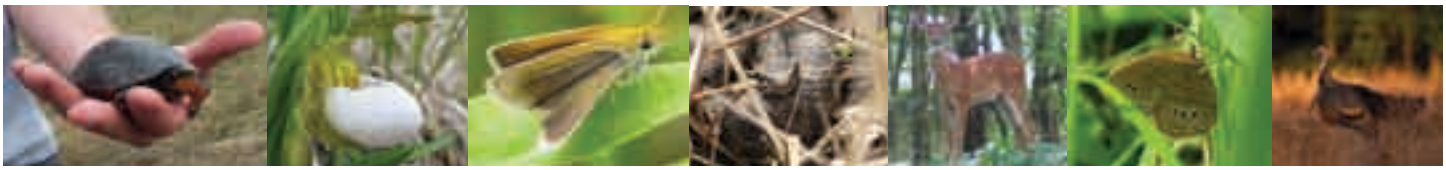


Figure A9. Immediately following a spring prescribed burn, much of the dead winter vegetation has turned to ash (above left). However, upon brushing the ash aside, one can find unburned duff (above left). A U.S. Fish and Wildlife Service biologist even found an invertebrate larva (species unknown) in the duff immediately after the burn pictured here (Carrie Tansy, personal communication).

3. Roads may be removed, but removal should be engineered such that groundwater can pass through the surface of the fen.
4. Plans to remove barriers to groundwater or surface water must explicitly detail the ways that water flow will be restored. Above-grade barriers (roads, berms, dams, etc.) will not be removed only to create a below-grade void (ditch, pond, etc.)
5. Occupied habitat will not be flooded, except for restoration purposes, and then no more than 1/3 of occupied habitat will be flooded at any one time
6. Hydrological restoration activities that would cause drying of the substrate during the month of July (to avoid impacting eggs) or during the dormant season (to avoid impacting hibernating satyrs or rattlesnakes) will be prohibited

A5.3 Prescribed Burning

1. All burns in habitat occupied by satyrs
    a. will use natural fire breaks where feasible and safe.
    d. will occur only in fens as consistent with the most recent version of the Mitchell's Satyr Recovery Plan.
2. Burns with any ignition by the burn crew anywhere within occupied habitat
    a. will burn no more than 1/3 of the occupied habitat
3. Burns with ignition entirely outside of the occupied habitat
    a. will have interior burn breaks (probably wet lines) to protect the highest concentrations of satyrs, based on survey data from previous years
    b. will have a plan with the goal of a patchy, mosaic burn without interior ignition within the fen

A5.4 Mowing/Hydroaxing

1. Mowing or hydroaxing is limited to no more than 1/3 of occupied habitat in any one year
2. Mowing or hydroaxing will occur only during the dormant season, when soil can support equipment
3. Mower or hydroax decks will be elevated such that sedge tussocks are not shortened or

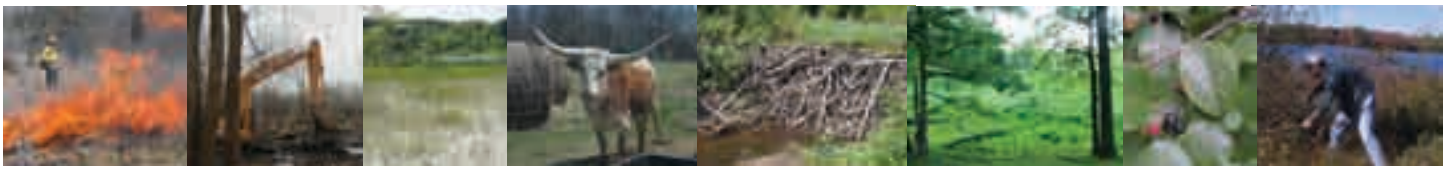


Figure A10. Vegetation removal is often necessary at prairie fens to restore the sedge and wildflower openings that Mitchell's satyr require. Directions on constructing PVC Herbicide Wands (pictured above) can be found in Appendix B.

damaged

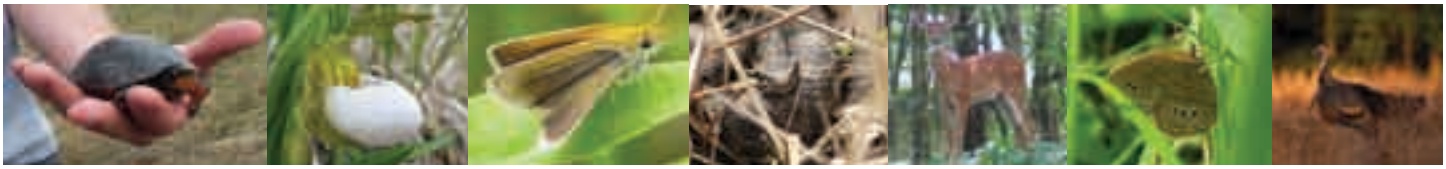
A5.5 Vegetation Removal

1. Vegetation may be managed or maintained in a manner designed to support a savanna and open fen complex, with openings dominated by *Carex stricta* and savanna interspersed with broad leaf plants of diverse heights. Satyrs prefer the edges of open fen habitat, and are also found associated with trees and shrubs within the fen.
2. Vegetation removal occurs at different intensities. For the purposes of this plan they are defined as vegetation removal without the aid of a wheeled or track vehicle.
   - Light management < 10 person-hours per acre per year
   - Moderate: > 10 person hours and < 100 person hours per acre
   - Intense: > 100 person hours per acre

   b. Light management is not restricted by area. This level of activity corresponds to monitoring for and treating scattered stems to keep an invasive from becoming established.

   c. Moderate management will not occur over more than 1/3 of the area in any one year period.

   d. Intense vegetation management will not occur over more than 1/3 of the area in any one year period.
3. Management that increases the amount of edge at sites is appropriate.
4. Cost-efficiency and potential take of satyrs should be considered explicitly when planning vegetation management. Methods that minimize cost or risk to satyrs are preferred, such as including satyr fens in larger habitat manipulations to reduce cost or choosing to manage during the dormant season to minimize take of satyr.
5. Herbicides must be approved for use over water and used according to label instructions.
6. Tamarack trees of any age should be protected within occupied habitat. Management should be consistent with encouraging a tamarack savanna. Adaptive management should be used to define the best disturbance regime to perpetuate tamarack at appropriate densities. The current disturbance regime in most occupied fens is too infrequent or conservative and is allowing red maple to regenerate under tamarack trees, which is a long term threat to the tamarack savanna.
7. Tamarack is not the only woody vegetation appropriate in a savanna. Poison sumac, spicebush, bog birch, willows, and scattered clumps of dogwood are appropriate. Restoration activities that clear all woody



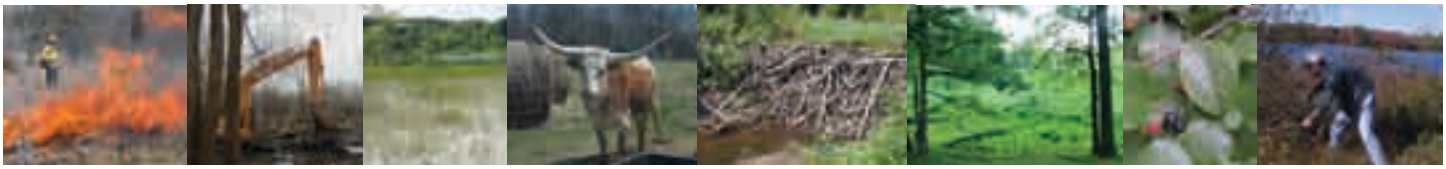
species are only appropriate for some parts of some fens. Other parts of the fen should be preserved in a partly wooded "savanna" structure with a diversity of canopy coverages at a fine spatial scale.

A5.6 Biological Control

1. Invasive plants are a significant threat to the fen habitat of Mitchell's satyr butterflies. Invasive plants are also a common manifestation of other threats, such as hydrology changes, water quality issues, or climate change. The resources available to manage invasive plants are limited, and the impacts of activities to control invasive plants are not negligible. For these reasons, biological control is a preferred management activity, despite the significant risks associated with this activity.
2. Biological controls to control any non-native invertebrate, will not be released within satyr habitat unless both of the following criteria are met:
   a. the invasive invertebrate to be controlled is determined to be a conservation threat to the population of Mitchell's satyr butterfly, and
   b. the USDA testing indicates no direct risk to Lepidoptera or to members of the subfamily Satyrinae
3. Biological control using native species and to control invertebrates (i.e., praying mantis releases) will not occur in satyr habitat
4. Any species native to Michigan or Indiana may be used as a biological control to control invasive plants. This does not extend to invasive insects.
5. Non-native species that have been approved by USDA after thorough testing to ensure host-specificity are also permitted, unless they feed on critical plant species (see A5.6.3 above.)
6. Sometimes biological controls are approved despite low levels of feeding on native plants. *Galuracella* beetles, for example, have been released to control purple loosestrife, but are known to feed on native loosestrife. The level of feeding on native loosestrife was low enough that the costs were determined to outweigh the benefits. However, this level of risk is not appropriate for plant species critical to the life cycle of Mitchell's satyr butterflies. Biological controls found to feed on plant species critical to satyrs for food or egg laying will not be released. These critical plant species include, but are not limited to *Carex stricta* and *Pilea pilosa*.
7. The restrictions on biological controls reflect the many unknowns related to their ecology and management. Much more is known about livestock, which are addressed in another section, and are not considered a biological control.

A5.7 Livestock Grazing

1. Mitchell's satyr butterflies can persist at relatively high densities in fens subject to moderate to light, seasonal grazing. While grazing may cause take of individual satyr larvae, through trampling or (accidental) ingestion, the net effect of grazing is to suppress shrubs and promote short stature broad-leaf plants. Grazing (at similar stocking density and seasonality) may continue in satyr habitat where it currently occurs.
2. Grazing may be initiated in fens that meet all of the following criteria:
   a. A history of grazing can be established.
   b. Stocking density and seasonality can be controlled at appropriate levels in mid to late summer.
   c. The fen is a low priority for manual and chemical vegetation control (i.e., available resources of time, people, and money are being spent at higher priority fens).



3. Grazing by livestock will not be initiated in satyr-occupied fens where a grazing history cannot be established, livestock cannot be managed, and where other management is a cost-effective option.

A5.8 Seeding and Planting

1. Seeding and planting should be done with seed collected in other parts of the same fen, or from another nearby fen (within 100 miles), or with local genotype seed (within 100 miles north/south or 200 miles east/west). Commercial, non-local seed may be used on plantings over 1 acre in size, but it is discouraged.
2. *Carex stricta* does not grow well from seed. Propagation is usually done vegetatively, and requires breaking apart existing clumps. *Carex stricta* clumps within occupied habitat will not be used as source material for plantings. It is recommended that source material come from degraded or non-viable wetlands, sedge meadows, or (least preferred) other fens.
3. Tamarack trees will be established only in areas that receive > 6 hours of sunlight per day.
4. Plantings and seed mixes should include significant amounts of short-statured plants, which should be planted in part sun (4-8 hours sunlight per day) or shade (< 4 hours sunlight). These are often found under and immediately north of existing trees or shrubs.

A5.10 Adaptive Management

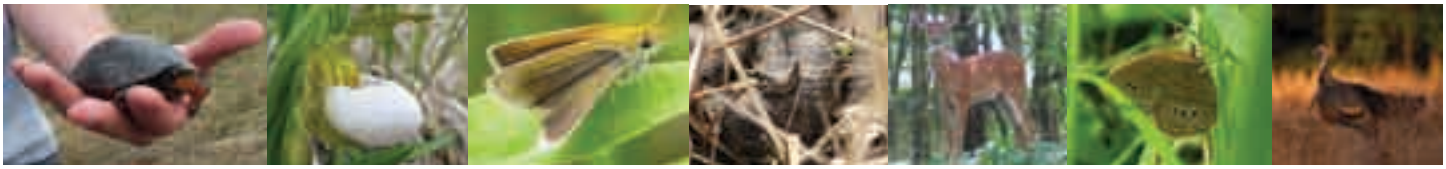
Adaptive management allows for changes in approaches or techniques based on new information. It evaluates the outcomes of implemented actions so that relative success can be documented and subsequent actions can be adapted for greater effectiveness. A successful adaptive management approach requires a clear statement of management goals and objectives so that a series of monitoring benchmarks can be developed accordingly (Noon 2003). Objectives should address the conservation target, the geographic area, the desired action, a measurable state or degree of change desired, and a time frame (Elzinga et al. 2001).

Because of their rarity, and unknown responses to certain management approaches, management within habitat occupied by satyr has been highly restricted. At most sites, no burning or flooding is allowed. Only 1/5 of large sites has been allowed under recent permits and consultations. This is far more restrictive than recovery plans for the federally threatened Karner Blue butterfly (USFWS 2003). Despite these restrictions and management outside occupied habitat, increasing numbers of populations have been disappearing in recent years.

These declines could be caused by a variety of factors, including the lack of management in occupied habitat. The positive links between satyr oviposition and short-stature forbs, and between short-stature forbs and management (Kost and De Steven 2009) suggests lack of management may be harming populations , especially small population of satyrs. Conversely, these declines may be attributed to other causes. Small sample sizes and butterfly mortality have stymied attempts to answer this question using tradition research.

In addition, certain invasive plants in fens are best managed using a series of coordinated management activites, including prescribed fire. Glossy buckthorn and reed canary grass in particular cannot be economically managed without prescribed fire.

For this reason we propose to burn up to 1/3 of sites, regardless of size, to assess the response of Mitchell's satyr to prescribed fire. If prescribed fire at 1/3 does cause declines, use of fire will be re-assessed in an adaptive management context. Conversely, if burning 1/3 of an area has no negative affect or has a positive effect at multiple sites, then burning might be considered over up to 1/2 of sites. Prescribed fire is a complex tool, and aspects such as burn completeness, vegetation affected, burn season, and ignition patterns



will similarly be addressed in an adaptive management context.

If nonessential experimental populations are established, these sites could be used in an adaptive management context to better understand the effects of prescribed fire. Experimental populations might be better candidates than nonviable sites for answering questions of the effect of patchy prescribed fire over 1/2 or greater parts of an occupied fen.

Adaptive maangement has the potential to answer important management questions regarding fire. However, a similar approach will need to be used in several other important habitat management tools, such as hydrologic manipulations, invasive species management, and biological control. Because grazing impacts appear to persist for several decades, grazing will only be considered in fens with a recent history of grazing.

A6. Potential Biological Impacts/ Take Assessment

A6.1 Direct Impacts

Based on recent surveys, the total geographic area occupied by Mitchell's satyr butterflies in Michigan and Indiana is 517 acres. Thus, the total impact in any one year is 171 acres or 1/3. In most years, we expect the impact to be less than 100 acres. Although the short-term take of individual satyrs is expected, the long-term impact to habitat for the species is expected to be positive.

A6.2 Indirect Impacts

The indirect impacts to satyr, SGCN, and the prairie fen community are expected to be positive, especially when considered over a multiple years. The impacts of no management, given the current landscape of fragmented, hydrologically-altered, and fire-suppressed wetlands, would be to allow most existing prairie fens to covert to shrub wetlands or monocultures of exotic plants. The status quo is a patchwork of moderately efficient and moderately coordinated management; the preferred approach would increase efficiency and coordination in existing management.

It would also allow managers to continue to work with private landowners under a formal programmatic agreement. Thus, the gains in habitat quality realized under past programs will be preserved and potentially improved upon.

The issuance of one ITP for Indiana and Michigan would streamline the permitting process for projects designed specifically for satyr conservation. This efficiency gain could then be applied to increased satyr conservation, fen conservation, or conservation of other endangered plants and wildlife. Thus, this HCP will have some indirect positive effects on the conservation of other SGCN.

This HCP and associated Fen Conservation Plan would redefine the conservation unit in satyr conservation as the groundwater-shed of the fen where the butterflies occur. Thus, it will foster and facilitate landscape-scale conservation for fens and associated ecological communities.

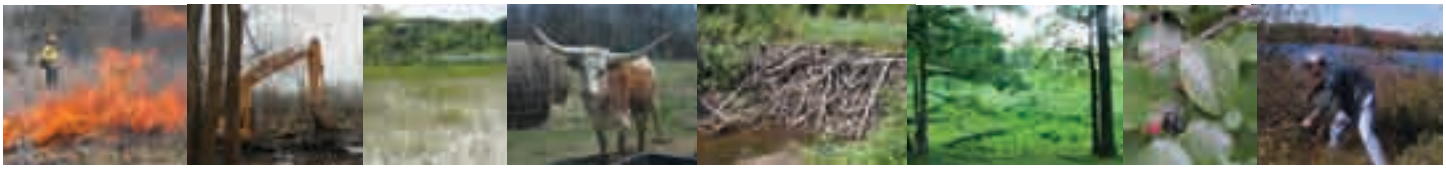
Finally, the HCP and FCP include explicit goals and objectives related to climate change. These will be some of the first examples of applied "climate change adaptation" in Michigan and Indiana. Although adaptation is only beginning to be addressed (USFWS 2008), this HCP and FCP could be useful examples that some level of planning is currently possible.

A6.3 Anticipated Take: Wildlife Species

A6.3.1 Mitchell's Satyr

Some habitat management prescriptions will result in the mortality of individual satyrs. For instance, a prescribed burn through an occupied area would destroy satyr juveniles or eggs. However, even within a burn unit, mortality may not be complete, because burn intensity tends to be uneven, especially in wetlands, and some juveniles or eggs at or near saturated peat may survive. Take of immature forms of insects (especially eggs) is difficult to quantify; therefore, take will be indirectly quantified as acres of occupied satyr habitat that could be impacted.

Based on known occurrences, habitat management could occur on approximately 517 acres of occupied satyr habitat. Habitat-management techniques that could result in



take will not be applied to more than 1/3 of any particular occupied habitat patch within a calendar year. Given these restrictions and based on the current amount of known occupied satyr habitat, take could occur on no more than 172 acres in any single calendar year. In practice, treating as many as 100 acres across 19 sites in a single calendar is unlikely. If reintroductions are successful, the number of acres could increase over 172, but not over 1/3 of the area occupied by this species in Indiana and Michigan.

A6.3.2 Other Federally Listed and Candidate Wildlife

Projects conducted under authority of the ITP will not take or otherwise adversely affect federally listed species other than satyr. Prior to implementation of any project, the potential presence of federally listed species will be evaluated.

The copperbelly water snake and Mitchell's satyr butterfly use similar habitats in southern Michigan and northern Indiana. However, the copperbelly water snake is more geographically restricted than the Mitchell's satyr. These two federally-listed species are not known to occur in the same counties in Michigan or Indiana. If conservation efforts are successful, these species could occur in the same wetland complexes, but not in the same parts of those complexes. The copperbelly water snake uses forested wetlands or forested parts of wetland complexes, whereas the satyrs would occur in the open or savanna parts of prairie fens.

The Indiana bat and Mitchell's satyr also co-occur in southern Michigan and northern Indiana. However, the management activities in the HCP are not expected to result in take of Indiana bat. Prairie fens are too wet to support the large diameter trees used by Indiana bats for roosting.

The eastern Massasauga rattlesnake is a federal candidate for listing. This snake occurs in prairie fens, and often occurs in fens that are also occupied by Mitchell's satyr butterflies. Both species are sensitive to hydrological alternations, invasions of exotic species, and successional change within prairie fens and the surrounding landscape. Thus, conservation actions in this HCP are expected to have a similarly beneficial effect on both satyrs and rattlesnakes.

A6.3.3 State-listed Wildlife

At least 75 wildlife species classified as threatened, endangered, or special concern/watch list under Indiana or Michigan law could occur in or near occupied satyr habitat (Table 2). Prior to implementation of any project under this HCP, the potential presence of these species will be evaluated based on review of the state's natural heritage data base, consideration of known species distributions, assessment of current habitat characteristics, and site surveys as necessary. If a State-listed species is determined to be present in a project area, proposed activities potentially resulting in take could proceed only if authorized under the provisions of state law applying to endangered species protection (Public Act 451 of 1994, Part 365).

Many state listed species that co-occur with the satyr are also dependent on prairie fens. These species face similar challenges to the satyr, and habitat conservation for satyrs is expected to contribute to the conservation of these species as well.

A6.4 Anticipated Impacts: Plants

A6.4.1 Federally Listed Plants

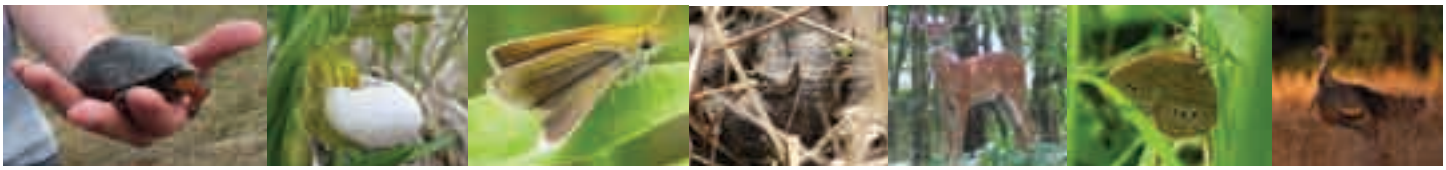
Prairie fens occupied by satyr have been thoroughly surveyed for endangered plants over many years. No federally listed plants are known to occur in prairie fens in Michigan.

A6.4.1 State-listed Plants

At least 47 Indiana or Michigan state-listed plants are known to occur in prairie fens (Table 1). The same protocol used for state-listed animals will also be used for state-listed plants. Like conservation benefits to state-listed animals, management activities envisioned under this HCP are expected to have a positive effect on the conservation of many state-listed plants.

A.6.5 Cumulative Impacts

The cumulative impact is the effect of the planned actions if repeated over a larger area or considered from the perspective of larger trends. The cumulative impacts of the actions in this HCP are explored in more detail in the main body of the Fen Conservation Plan. These effects are expected to be a modest and positive increase in the amount



and quality of fen conservation occurring in Michigan both in fens occupied by Mitchell's satyr (this HCP) and the cumulative effect of conservation in fens not occupied by satyrs.

A7. Monitoring and Reporting

Monitoring will be conducted to help evaluate satyr distribution and to assess the effects of HCP activities on satyr populations and habitat. Monitoring associated with specific projects will be funded by the management partners that conducted the treatments/disturbances. Monitoring will be conducted by qualified personnel, either by management-partner staff or contracted through other organizations. Monitoring will be conducted at sites following habitat management within habitat occupied by satyr or when activities outside occupied habitat are expected to affect hydrology within the occupied portion of the fen. Monitoring will be encouraged, but not mandatory, when management for satyr occurs near or adjacent to currently occupied habitat.

The objectives of management will be to:

1) assess the results of management; and
2) assess presence/absence of satyr before and after management.

A report of activities and monitoring results will be submitted to the USFWS by January 31 each year the ITP is in effect. At a minimum, the report will include a:

- summary of annual activities resulting in take of satyr, including acres treated/managed.
- summary of habitat monitoring conducted at treated/managed sites.
- summary of presence/absence and relative abundance surveys conducted at treated/managed sites.
- discussion of the effect of management on satyr populations at treated/managed sites.
- description of known and assumed take. Known take is take of satyr individuals that is directly observed; assumed take will be reported indirectly as area of occupied habitat treated/managed.

A8. Funding

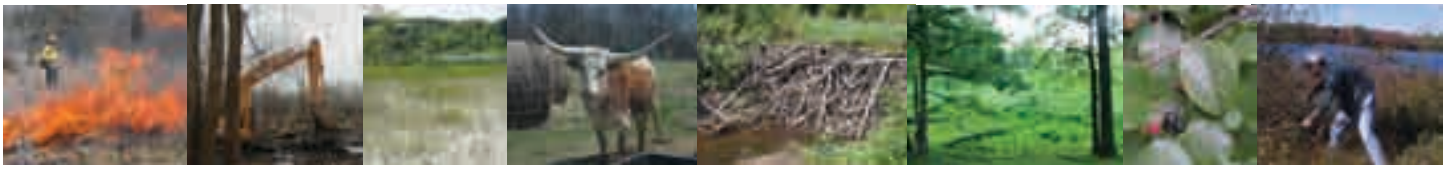
A8.1 Funding for HCP Administration

Administration of this HCP will be directed through the Michigan DNRE Wildlife Division, specifically the Natural Heritage Unit. This unit coordinates efforts related to endangered and threatened species and nongame programs. Administrative costs will be associated with activities such as planning of monitoring, evaluation of habitat treatments, reporting, auditing of Partnering Agreements, and modification of the HCP prompted by new information obtained through research and adaptive management. Annual program costs are expected to vary.

Administrative costs will be covered with funding provided to the Natural Heritage Unit in the Wildlife Division budget. The Wildlife Division has supported efforts related to threatened and endangered species since the mid 1950s. A formal endangered species program was initiated in the mid 1970s with the passage of State endangered species regulations. Efforts under this program have been funded by revenue sources such as Federal grants and revenue-matching projects, State income-tax check-offs, public donations, vehicle registration plates, and State restricted funds, where appropriate. Supported by this mix of funding sources, the Michigan DNRE has expended efforts on behalf of the Mitchell's satyr butterfly for many years. The Michigan DNRE will continue to provide funding necessary to perform the administrative tasks of this HCP.

A8.2 Funding for HCP Implementation

Management will be conducted on state land and on private land to maintain existing satyr habitat, to help ensure the long-term persistence of extant populations, and to manage sites for potential reintroductions. Management of fens on public and private lands has been increasing since the satyr was listed in 1992, and efforts have accelerated under the Michigan DNRE's Landowner Incentive Program (LIP). Current funding sources include federal matching funds, state restricted funds (where appropriate), and private matching funds. Continued management of prairie fens will be funded by a combination of these sources.



Partnering Agreements will be developed with management partners, both public and private. Management partners will provide funding for any management, maintenance, or monitoring that they conduct under this HCP. Partnering Agreements will include assurances of adequate funding.

A9. Alternatives

A9.1 Alternative A: Private Land and Protected Land HCP (Preferred)

The preferred alternative is the issuance of an ITP under section 10(a)1(B) of the Federal Endangered Species Act to authorize the take of endangered Mitchell's satyr butterfly on both unprotected private lands and protected lands, in accordance with this HCP. Protected lands are lands administered by either a state agency or a non-governmental organization with a conservation mission (e.g., States' DNR, The Nature Conservancy, local land conservancies, etc.) The range-wide HCP is designed to allow management to mimic natural disturbance processes to conserve fens while minimizing incidental taking of satyr that might occur during management. This alternative is preferred because it would standardize best management practices for fens, facilitate and encourage management in satyr occupied fens, and could apply to any fens where the species occurs and managers desire to conserve the satyr or the fen.

If funding and management change as recommended under the Prairie Fen Plan and HCP, populations of the Mitchell's satyr butterfly should remain stable or increase. Degradation of hydrology and plant communities will be arrested at some sites. These changes will be difficult to detect directly without expensive monitoring. Although imperceptible with relation to the human environment, the changes will be expressed through stable or improved status of the Mitchell's satyr butterfly and other sensitive fen species.

A9.2 Alternative B: Public-lands HCP

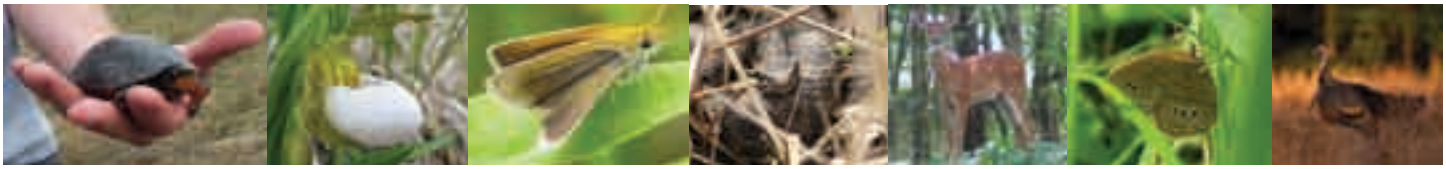
This alternative is similar to Alternative A in that it would require an ITP associated with an HCP. However, it would focus limited conservation time and money on protected lands. Often management of the fen through a private lands program precedes and lays the groundwork for future protection through land acquisition or conservation easements. Furthermore, some fens are well managed by knowledgeable landowners who are passionate about satyrs and their conservation. For these reasons, we felt that the HCP and ITP should leave open the option of working on currently "unprotected" fens.

A9.3 Alternative C: Status Quo or No New Action

The status quo alternative is not a no action alternative, but rather reflects what would happen if current actions continue without the federal action, in this case issuance of an ITP for satyrs throughout their range in Michigan and Indiana. Some management currently occurs at many satyr sites. This management often occurs outside occupied habitat in efforts to restore adjacent fen to suitable satyr habitat. Because many fens are small or occupied habitat is already degraded, management is also done in occupied habitat. This management results in incidental take, which is currently permitted on a site-by-site, project-by-project basis under section 7 consultation or 10(a)1(A) recovery permits. Because the Michigan DNRE and Indiana DNR both value fen conservation, this work would continue, but at lower efficiency and with poorer coordination among agencies. The quantity and quality of conservation would likely be lower under the status quo, compared to Alternatives A or B.

A10. HCP Implementation, Changed and Unforseen Circumstances

A10.1 HCP Implementation



The Michigan DNRE, as holder of the ITP, will implement this HCP at the administrative level in Michigan and as liaison for Indiana. The Natural Heritage Unit within the DNRE Wildlife Division will be responsible for overseeing this effort. Administrative activities will include planning of monitoring, evaluation of habitat treatments, reporting, auditing of Partnering Agreements, oversight of minimization measures, and modification of the HCP prompted by new information obtained through research and adaptive management. Wildlife Division field staff will be responsible for administering operational implementation of this HCP on State lands. Operational activities will include pre-treatment surveys, site assessments, habitat management, and habitat and population monitoring. Annual Wildlife Division work plans will help partition tasks necessary to achieve multi-year operational objectives.

Partnering Agreements will be developed between the Michigan DNRE and management partners, both public and private, to facilitate operational implementation of this HCP on non-State land. These agreements will translate strategic objectives into operational objectives for habitat on specific parcels. The Michigan DNRE will annually review the implementation of Partnering Agreements and will monitor adherence to Partnering Agreement conditions.

A10.2 Changed Circumstances

The Habitat Conservation Plan Assurances ("No Surprises") Rule (50 CFR Part 17.32(b)(5); 63 Federal Register 8859—February 23, 1998) provides regulatory assurances that, generally, no additional land-use restrictions with respect to species covered by an ITP will be required of a permit holder, even if changed or unforeseen circumstances arise after the permit is issued, provided the HCP is being properly implemented. "Changed circumstances" refers to "changes in circumstances affecting a species or geographic area covered by an HCP that can reasonably be anticipated by HCP developers and the USFWS and that can be planned for (e.g., the listing of a new species or a fire or other natural catastrophic event in areas prone to such events)" (50 CFR Part 17.3).

Changed circumstances relevant to this HCP might include events like species listing or delisting or the completion of research that suggests ways to improve management techniques. These changed circumstances would be addressed through the adaptive management process outlined in this HCP. If a modified approach would benefit satyrs, other species of concern, or associated habitats due to changed circumstances, the USFWS and the Michigan DNRE may agree to modify the HCP based on current conditions or new information (50 CFR Part 17.22(b)(5)).

A10.3 Unforeseen Circumstances

"Unforeseen circumstances" refers to "changes in circumstances affecting a species or geographic area covered by an HCP that could not reasonably have been anticipated by plan developers and the USFWS at the time of HCP negotiation and development, and that result in a substantial, adverse change in the status of the covered species" (50 CFR Part 17.3). Unforeseen circumstances relevant to this HCP might include the introduction of harmful diseases or additional exotic species that could have significant detrimental effects on satyr or other species of concern. Should the USFWS determine, based on considerations outlined in 50 CFR Part 17.22(b)(5)(iii)(c), that unforeseen circumstances have arisen during the permit term, the USFWS and the Michigan DNRE will consider potential measures to address the changed conditions.

A10.4 Other Measures as Required by the Director

An HCP Implementing Agreement between the Michigan DNRE and the USFWS is required prior to issuance of an ITP. This agreement is included in Appendix D.

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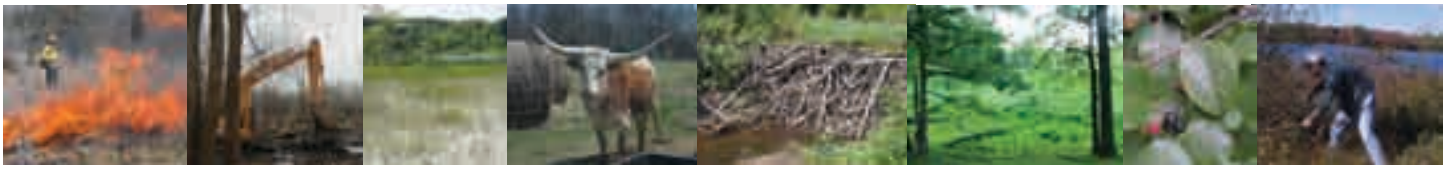

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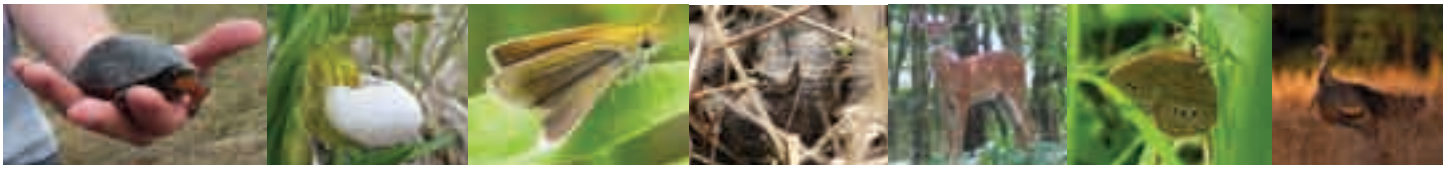


Appendix B: Directions to Make your own Herbicide Wand

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

B1. 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)

B2.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)

B3. 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.

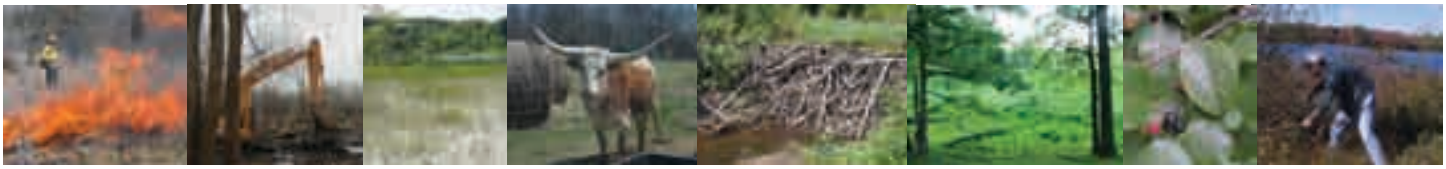
B) Making the sponge reservoir: Depending upon the details of the way your PVC fittings were molded, you may have to innovate to complete this part of the construction. Read this section completely before proceeding! First, cut the end off the 3/4 inch PVC cap, and drill two holes (1/16 inch) in it. 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.

B4. 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).

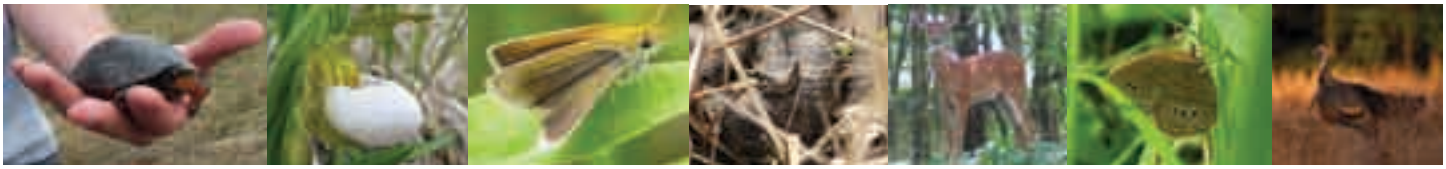


Only a light touch of the saturated sponge tip is needed to apply herbicide to a cut-stump. Open the ball valve when more herbicide is needed in the sponge tip.

B5. 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.



Appendix C: 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)

C1. Introduction

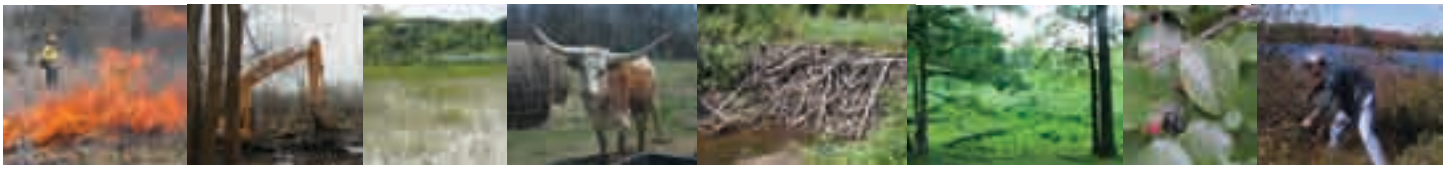
Prairie fens in southern Lower Michigan and northern Indiana have long been a focus of conservation efforts. Most, if not all, of these fens suffer from altered hydrology, altered fire regime, and invasive species, and significant resources have been invested in restoring and maintaining fens by public 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.

C2. 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 (Attachment A) 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 for 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.

C3. 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.

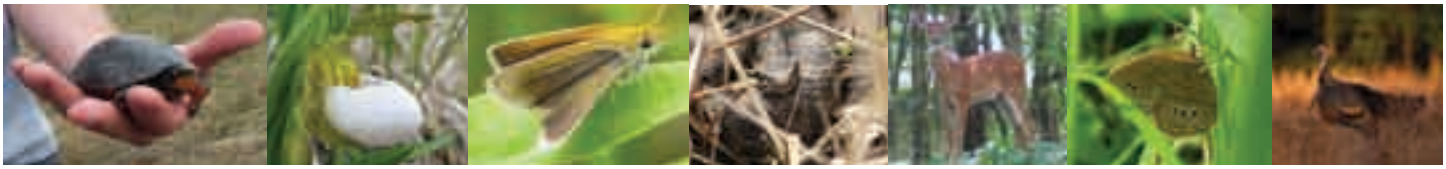
C4. Establishing Management Units

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.

C5. 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 D: Implementing Agreement

IMPLEMENTING AGREEMENT
by and between

U.S. FISH AND WILDLIFE SERVICE
and the
MICHIGAN DEPARTMENT OF NATURAL RESOURCES AND THE ENVIRONMENT

TO ESTABLISH A PROGRAM FOR HABITAT MANAGEMENT AND ECOSYSTEM RESTORATION WITHIN ALL HABITAT OCCUPIED BY THE MITCHELL'S SATYR BUTTERFLY IN MICHIGAN AND INDIANA.

This Implementing Agreement ("Agreement"), made and entered into as of the ___ day of _____, 201_, by and between the UNITED STATES FISH AND WILDLIFE SERVICE (FWS) and the MICHIGAN DEPARTMENT OF NATURAL RESOURCES AND THE ENVIRONMENT (DNRE), hereinafter collectively called the "Parties," defines the Parties' roles and responsibilities and provides a common understanding of action that will be undertaken to minimize and mitigate the effects on the Mitchell's satyr butterfly (satyrs, *Neonympha mitchellii mitchellii*) and unlisted species and their habitats of the proposed satyrs Habitat Management and Fen Restoration in Michigan and Indiana.

1.0 RECITALS

This Agreement is entered into with regard to the following facts:

WHEREAS, the federally endangered satyrs is currently known to occur across 9 counties in Michigan and 1 county in Indiana on public and private lands;

WHEREAS, the FWS has primary jurisdiction over the conservation, protection, restoration, enhancement and management of federally listed fish, wildlife, plants and their habitats, as necessary for biologically sustainable populations of those species to the extent set forth in the Federal Endangered Species Act of 1973, as amended (87 Stat 884, 16 U.S.C. § 1531 et seq.; ESA);

WHEREAS, the persistence of satyrs at most locations is dependent on disturbance (e.g., flooding, fire) to maintain early successional habitat, and the natural forms of these disturbances have largely been suppressed;

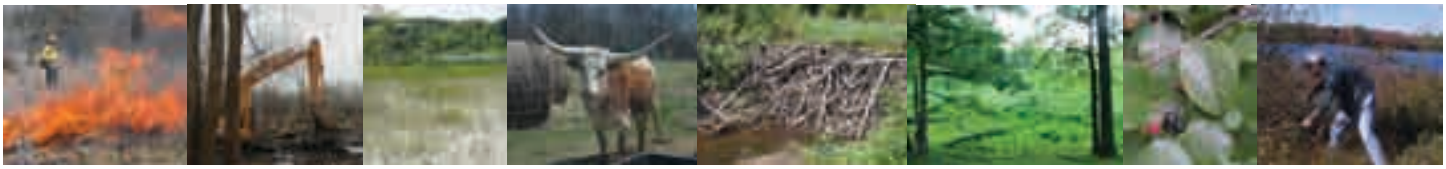
WHEREAS, the DNRE is responsible for the conservation, protection, and management of Michigan's wildlife resources, including implementation of the Michigan Endangered Species Protection Law (Public Act 451 of 1994, Part 365);

WHEREAS, the DNRE desires a process to allow management, to the extent possible, of occupied satyrs Habitat for the benefit of satyrs;

WHEREAS, the area covered by the HCP is comprised of all Occupied satyrs Habitat (including areas that become occupied in the future) within the entire States of Michigan and Indiana;

WHEREAS, the DNRE has developed a series of measures, described in the HCP, to avoid, minimize or mitigate, to the maximum extent practicable, the effects of take of satyrs incidental to satyrs Habitat Management and Fen Restoration in Michigan and Indiana; and,

WHEREAS, the DNRE, with technical assistance from the Service, has developed a series of measures, described in the Habitat Conservation Plan, to minimize and mitigate the effects of the proposed satyrs Habitat



Management and Fen Restoration upon the subject listed and unlisted species and their associated habitats; and,

THEREFORE, the Parties hereto do hereby understand and agree as follows:

2.0 DEFINITIONS

The following terms as used in this Agreement shall have the meanings set forth below:

2.1 The term "Permit" shall mean an incidental take permit issued by the Service[s] to the DNRE pursuant to Section 10(a)(1)(B) of the Endangered Species Act (ESA).

2.2 The term "Permit Area" shall mean the satyrs Habitat Management and Fen Restoration area consisting of approximately 500 acres occupied by satyrs, and where the DNRE or other Management Partner has the authority and ability to conduct management or restoration activities consistent with and approved under the terms of the HCP through Michigan and Indiana.

2.3 The term "Permittee" shall mean DNRE.

2.4 The term "Conservation Plan" shall mean the Habitat Conservation Plan prepared for the proposed satyrs Habitat Management and Fen Restoration in Michigan and Indiana.

2.5 The term "Plan Species" shall mean species adequately covered in the HCP and identified in Section 1.0 of this Agreement.

2.6 The term "unforeseen circumstances" means any significant, unanticipated adverse change in the status of species addressed under the HCP or in their habitats; or any significant unanticipated adverse change in impacts of the project or in other factors upon which the HCP is based. The term "unforeseen circumstances" as defined in this Agreement is intended to have the same meaning as "extraordinary circumstances" as used in the No Surprises policy.

3.0 HABITAT CONSERVATION PLAN

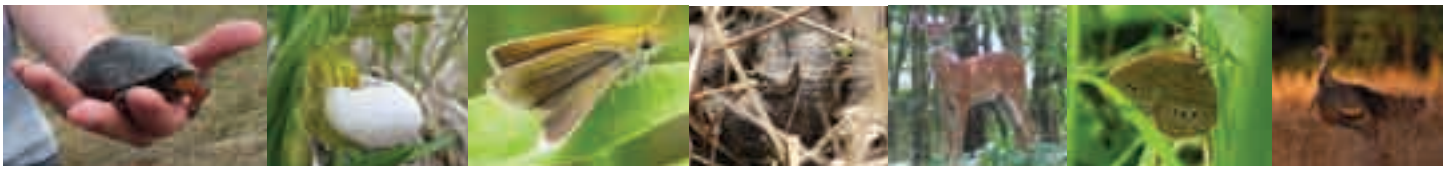
Pursuant to the provisions of Section 10(a)(1)(B) of the ESA, the DNRE, hereinafter referred to as "Permittee" has prepared a Habitat Conservation Plan (HCP) and submitted it to the Service with a request that the Service issue a Permit (Permit) to allow subject Plan species to be incidentally taken within the Permit Area as depicted and described in Figure [x] of the HCP. The HCP proposes guidelines to avoid, minimize and mitigate for take of satyrs to prevent adverse impacts on satyrs populations and their habitats and to allow for active management for the benefit of satyrs populations and their habitats.

4.0 INCORPORATION OF HCP

The HCP and each of its provisions are intended to be, and by this reference are, incorporated herein. In the event of any direct contradiction between the terms of this Agreement and the HCP, the terms of this Agreement shall control. In all other cases, the terms of this Agreement and the terms of the HCP shall be interpreted to be supplementary to each other.

5.0 LEGAL REQUIREMENTS

In order to fulfill the requirements that will allow the Service to issue the Permit, the HCP sets forth measures that are intended to ensure that any take occurring within the Permit Area will be incidental; that the impacts of the take will, to the maximum extent practicable, be minimized and mitigated; that procedures to deal with unforeseen circumstances will be provided; that adequate funding for the HCP will be



provided; and that the take will not appreciably reduce the likelihood of the survival and recovery of the Plan Species in the wild. It also includes measures that have been suggested by the Service as being necessary or appropriate for purposes of the HCP.

6.0 COOPERATIVE EFFORT

In order that each of the legal requirements as set forth in Paragraph 5.0 hereof are fulfilled, each of the Parties to this Agreement must perform certain specific tasks as more particularly set forth in the HCP. The HCP thus describes a cooperative program by Federal and State agencies and private interests to mitigate the effects of the proposed satyrs Habitat Management and Fen Restoration in Michigan and Indiana on the satyrs.

7.0 TERMS USED

Terms defined and utilized in the HCP and the ESA shall have the same meaning when utilized in this Agreement, except as specifically noted.

8.0 PURPOSES

The purposes of this Agreement are:

8.1 To ensure implementation of each of the terms of the HCP;

8.2 To describe remedies and recourse should any Party fail to perform its obligations, responsibilities, and tasks as set forth in this Agreement; and,

8.3 As stated in paragraph 12.3.a hereof, to provide assurances to the Permittee(s) and other non-Federal landowner(s) participating in the HCP that as long as the terms of the HCP and the Permit issued pursuant to the HCP and this Agreement are fully and faithfully performed, no additional mitigation will be required except as provided for in this Agreement or required by law.

9.0 TERM

9.1 Stated Term. This Agreement shall become effective on the date that the Service issues the Permit requested in the HCP and shall remain in full force and effect for a period of 20 years or until termination of the Permit, whichever occurs sooner.

10.0 FUNDING

10.1 The DNRE will provide such funds as may be necessary, to the extent practicable, to carry out the general administration of the HCP.

10.2 The DNRE shall be responsible for funding the necessary avoidance, minimization and mitigation measures as required under Section A5 of the HCP.

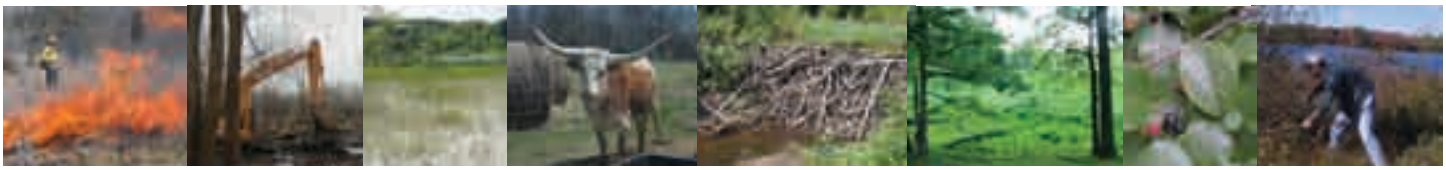
10.3 The DNRE shall be responsible for monitoring and reporting as required under Section A5.10 of the HCP.

10.4 DNRE will provide such funds as may be necessary to carry out its obligations under the HCP. The Permittee should notify the Services, if the Permittee's funding resources have materially changed, including a discussion of the nature of the change, from the information provided in section A8 of the HCP.

11.0 RESPONSIBILITIES OF THE PARTIES

11.1 Responsibilities of the Permittee.

a. The HCP will be properly functioning if the terms of the Agreement have been or are being fully implemented.



b. The Permittee shall undertake all activities set forth in the HCP in order to meet the terms of the HCP and comply with the Permit, including adaptive management procedures described in subparagraph (c) below, if applicable.

c. Describe the adaptive management process agreed to by the parties to ensure the terms of the HCP are fully implemented, if applicable.

d. The Permittee shall submit an annual report describing its activities and an analysis of whether the terms of the HCP were met for the reporting period. The report shall provide all reasonably available data regarding the incidental take, and where requested by the Service, changes to the overall population of satyrs that occurred in the Permit area during the reporting period.

11.2 Responsibilities of the Service.

a. The USFWS will cooperate and provide, to the extent funding is available, guidance to the DNRE and Management Partners, and review of Partnering Agreements, site plans, and other consultation as detailed in the HCP.

b. Nothing in this Agreement shall require the USFWS to act in a manner contrary to the requirements of the Anti-Deficiency Act.

c. After issuance of the Permit, the Service shall monitor the implementation thereof, including each of the terms of this Agreement and the HCP in order to ensure compliance with the Permit, the HCP and this Agreement.

12.0 REMEDIES AND ENFORCEMENT

12.1 REMEDIES IN GENERAL

Except as set forth below, each Party shall have all remedies otherwise available to enforce the terms of this Agreement, the Permit, and the HCP, and to seek remedies for any breach hereof, subject to the following:

a. NO MONETARY DAMAGES

No Party shall be liable in damages to the any other Party or other person for any breach of this Agreement, any performance or failure to perform a mandatory or discretionary obligation imposed by this Agreement or any other cause of action arising from this Agreement. Notwithstanding the foregoing:

(1) Retain Liability

All Parties shall retain whatever liability they would possess for their present and future acts or failure to act without existence of this Agreement.

(2) Land Owner Liability

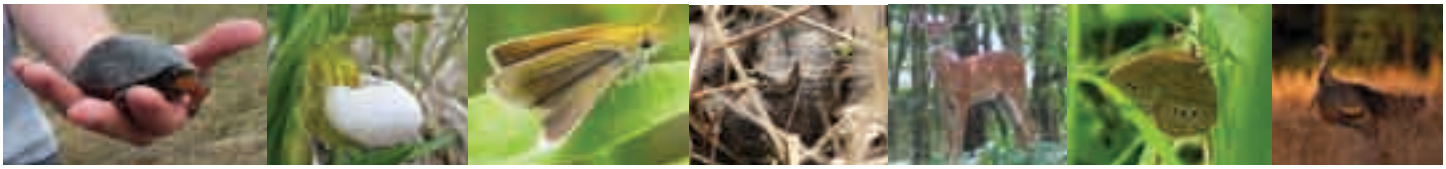
All Parties shall retain whatever liability they possess as an owner of interests in land.

(3) Responsibility of the United States

Nothing contained in this Agreement is intended to limit the authority of the United States government to seek civil or criminal penalties or otherwise fulfill its enforcement responsibilities under the ESA.

b. INJUNCTIVE AND TEMPORARY RELIEF

The Parties acknowledge that the Mitchell's satyr butterflies are unique and that their loss as species would result in irreparable damage to the environment and that therefore injunctive and temporary relief may be appropriate to ensure compliance with the terms of this



Agreement.

12.2 THE PERMIT

12.2.1 Permit suspension or revocation

12.2.1.1 Defaults

Any material breach or violation of this Agreement, the HCP, or the Permit shall be deemed a default under this Agreement.

12.2.1.2 Notice and opportunity to cure

On occurrence of a default by either Party, the non-defaulting Party may notify the defaulting Party in writing, describing the details of the default. The defaulting Party shall have 60 days to respond to or refute the allegation, to cure the default, or to commence to cure a default which cannot reasonably be cured within a 60-day time period, provided such cure is diligently pursued.

12.2.1.3 Ordinary remedies

After notice of and time to cure a default as provided above, the non-defaulting Parties shall have the right to revoke, terminate, or suspend the Permit or any other authorization to take satyrs issued pursuant to this agreement and the HCP, in conformance with the provisions of applicable law. Suspension, revocation, or termination of the Permit by the FWS shall occur in conformance with the provisions of 50 CFR 13.27-13.29.

12.2.1.4 Additional remedies of the FWS

A. Except as otherwise provided, the FWS shall have the right to suspend, revoke, or terminate the Permit or any other authorization to take satyrs issued pursuant to this Agreement and the HCP. Suspension, revocation, or termination of the Permit by the FWS shall occur in conformance with the provisions of 50 CFR 13.27-13.29.

B. Prior to taking action to suspend, revoke, or terminate the Permit, the FWS shall meet and confer with the DNRE to attempt to avoid this action.

C. The FWS shall not initiate an action to revoke any Permit on grounds which would constitute grounds for suspension, without first pursuing action to suspend the permit in accordance with 50 CFR 13.27. Any action by the USFWS to suspend the Permit shall be limited so as to address the specific action or inaction underlying the suspension, in order to minimize any impacts on the DNRE. Any take authorizations suspended or revoked shall be reinstated immediately upon cure of the default that led to the suspension or revocation.

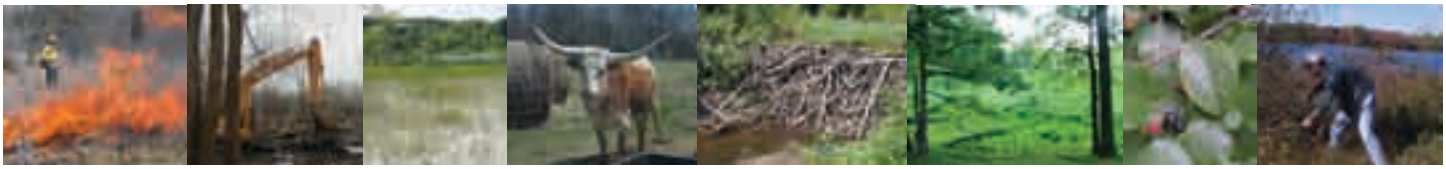
12.3 LIMITATIONS AND EXTENT OF ENFORCEABILITY

a. NO SURPRISES POLICY

Subject to the availability of appropriated funds as provided in Paragraph 14.6 hereof, and except as otherwise required by law, no further mitigation for the effects of the proposed satyrs Habitat Management and Fen Restoration in Michigan and Indiana upon the satyrs may be required from a Permittee who has otherwise abided by the terms of the HCP, except in the event of unforeseen circumstances; provided that any such additional mitigation may not require additional land use restrictions or financial compensation from the Permittee without his/her written consent.

b. PRIVATE PROPERTY RIGHTS AND LEGAL AUTHORITIES UNAFFECTED

Except as otherwise specifically provided herein, nothing in this Agreement shall be deemed to restrict the rights



of the Permittee to the use or development of those lands, or interests in lands, constituting the Permit Area; provided, that nothing in this Agreement shall absolve the Permittee from such other limitations as may apply to such lands, or interests in lands, under other laws of the United States and the States of Michigan and Indiana.

13.0 AMENDMENTS

13.1 Generally

Amendments to the HCP may be proposed by either Party. The Party proposing the amendment shall provide to the other Party a statement of the reasons for the amendment and an analysis of the effect of the amendment on satyrs and take authorizations.

13.2 Minor Amendments

Minor amendments to the HCP shall not require amendment of this Agreement or the Permit. The Parties will make every effort to review a proposed minor amendment, and approve or deny the proposed amendment within 90 days of receipt of a proposal, except where longer timelines are imposed by requirements of law. Minor amendments shall require the approval of both the FWS and DNRE. If the FWS determines within 90 days of receipt of a proposed minor amendment that the amendment should be treated as a standard amendment, the amendment will be addressed as described in paragraph 13.3, below.

13.3 Standard Amendments

A standard amendment is any proposed amendment that is not a minor amendment. Standard amendments to the HCP shall also require an amendment to this Agreement and the Permit. Following receipt of the proposed standard amendment, the FWS shall publish notice of the proposed amendment to the Permit in the Federal Register as required under ESA. The FWS shall use its best efforts to process the proposed amendment within 120 days of publication, except where longer periods are required by law.

14.0 MISCELLANEOUS PROVISIONS

14.1 NO PARTNERSHIP

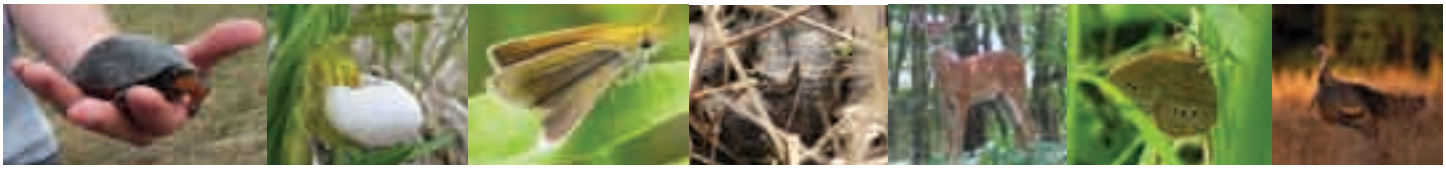
Except as otherwise expressly set forth herein, neither this Agreement nor the HCP shall make or be deemed to make any Party to this Agreement the agent for or the partner of any other Party.

14.2 SUCCESSORS AND ASSIGNS

This Agreement and each of its covenants and conditions shall be binding on and shall inure to the benefit of the Parties hereto and their respective successors and assigns.

14.3 NOTICE

Unless otherwise specifically provided herein, all notices, demands, and other communications given under the HCP and the Permit shall be in writing, shall be properly addressed to the Party to receive such notice at the address or addresses for such Party listed below, or to such other address or person as any Party may designate to the others for such purpose in the manner set forth in this subsection and shall be given or sent (1) Certified United States Mail, postage and fees prepaid, return receipt requested; (2) Federal Express, DHL, or United Parcel Service, charges prepaid or charged to sender's account; (3) personal delivery; or (4) facsimile, along with initiation on the same day of delivery by another means described in this subsection. Each such notice shall be deemed given when received by the addressee unless delivery of a properly sent notice is not made because: (1) acceptance of delivery is refused by addressee, (2) the addressee has moved without providing proper notice of such move, or (3)



the addressee is not open for business on the date of attempted delivery (unless such delivery is attempted on a Saturday, Sunday, or national holiday), in any of which events such notice shall be deemed given on the date of such attempted delivery. The addresses of the Parties for notices are as follows:

If to DNRE:

Department of Natural Resources and Environment
Wildlife Division
P.O. Box 30028
Lansing, Michigan 48909
Attention: Chief

If to USFWS:

U.S. Fish and Wildlife Service
Region 3 Office
Fort Snelling, Minnesota
Attention: Regional Director

14.4 ENTIRE AGREEMENT

This Agreement, together with the HCP and the Permit, constitutes the entire Agreement between the Parties. It supersedes any and all other Agreements, either oral or in writing among the Parties with respect to the subject matter hereof and contains all of the covenants and Agreements among them with respect to said matters, and each Party acknowledges that no representation, inducement, promise or Agreement, oral or otherwise, has been made by any other Party or anyone acting on behalf of any other Party that is not embodied herein.

14.5 ELECTED OFFICIALS NOT TO BENEFIT

No member of or delegate to Congress shall be entitled to any share or part of this Agreement, or to any benefit that may arise from it.

14.6 AVAILABILITY OF FUNDS

Implementation of this Agreement and the HCP by the Services is subject to the requirements of the Anti-Deficiency Act 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 money from the U.S. treasury. The parties acknowledge that the Services will not be required under this 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.

14.7 DUPLICATE ORIGINALS

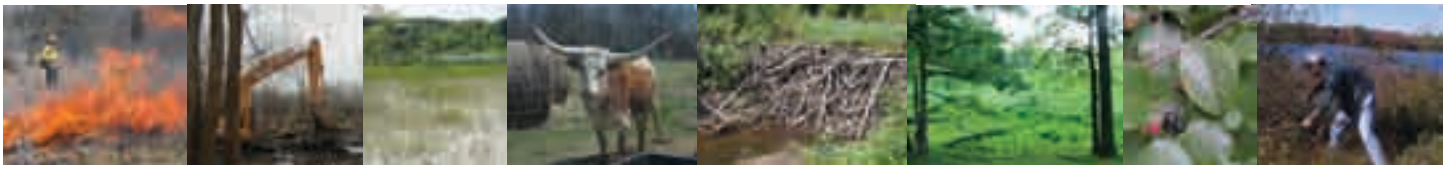
This Agreement may be executed in any number of duplicate originals. A complete original of this Agreement shall be maintained in the official records of each of the Parties hereto.

14.8 THIRD PARTY BENEFICIARIES

Without limiting the applicability of the rights granted to the public pursuant to the provisions of 16 U.S.C. § 1540(g), this Agreement shall not create any right or interest in the public, or any member thereof, as a third party beneficiary hereof, nor shall it authorize anyone not a Party to this Agreement to maintain a suit for personal injuries or property damages pursuant to the provisions of this Agreement. The duties, obligations, and responsibilities of the Parties to this Agreement with respect to third parties shall remain as imposed under existing Federal or State law.

14.9 RELATIONSHIP TO THE ESA AND OTHER AUTHORITIES

The terms of this Agreement shall be governed by and construed in accordance with the ESA and other applicable laws. In particular, nothing in this Agreement



is intended to limit the authority of the Service to seek penalties or otherwise fulfill its responsibilities under the ESA. Moreover, nothing in this Agreement is intended to limit or diminish the legal obligations and responsibilities of the Service as an agency of the Federal government.

14.10 REFERENCES TO REGULATIONS

Any reference in this Agreement, the HCP, or the Permit to any regulation or rule of the Service shall be deemed to be a reference to such regulation or rule in existence at the time an action is taken.

14.11 APPLICABLE LAWS

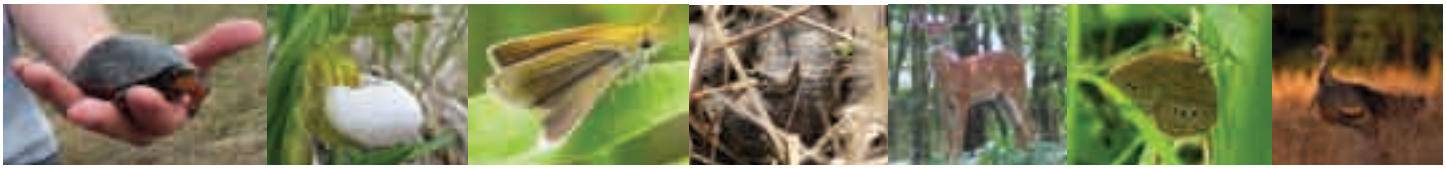
All activities undertaken pursuant to this Agreement, the HCP, or the Permit must be in compliance with all applicable State and Federal laws and regulations.

IN WITNESS WHEREOF, THE PARTIES HERETO have executed this Implementing Agreement to be in effect as of the date last signed below.

By:_____ Date:__
_____
Director
Department of Natural Resources
Lansing, MI

By:_____ Date:_
_____
Regional Director
US Fish and Wildlife Service
Region 3 Office
Fort Snelling, MN

DRAFT



Appendix E. Considerations and Caveats of the Fire and Species Phenology Tables

The tables on pages 46-52 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.

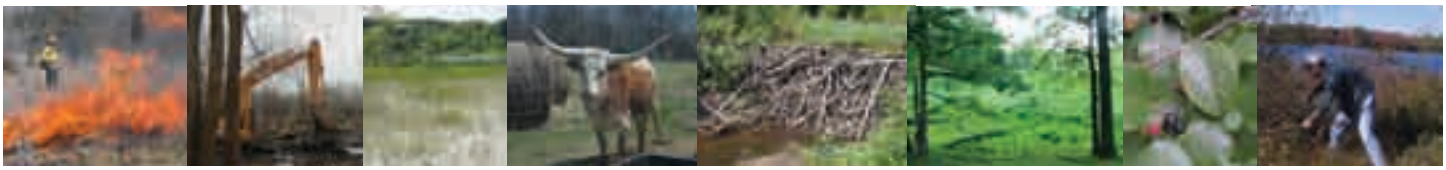
Monitoring is needed to better understand how to best use fire as a management tool. Resources should be prioritized to conduct monitoring of sites prior to prescribed burns so that managers have adequate information to consider including: 1) the presence of plants and animals that occur or have the 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://web4.msue.msu.edu/mnfi/explorer/index.cfm), detailed MNFI species abstracts where available (http://web4.msue.msu.edu/mnfi/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

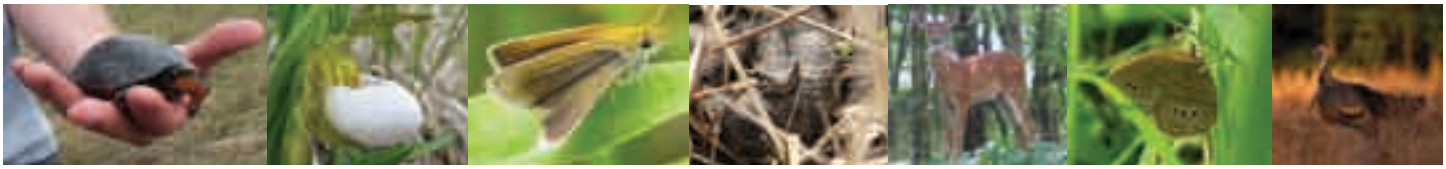
Phenology Information

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)

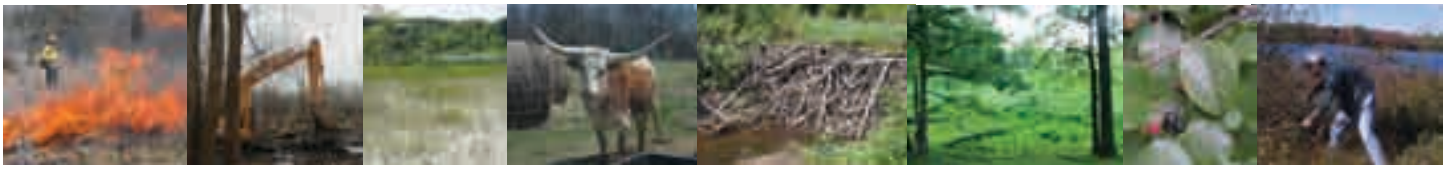
Phenology Information

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://web4.msue.msu.edu/mnfi/explorer/), detailed species abstracts when available (http://web4.msue.msu.edu/mnfi/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.

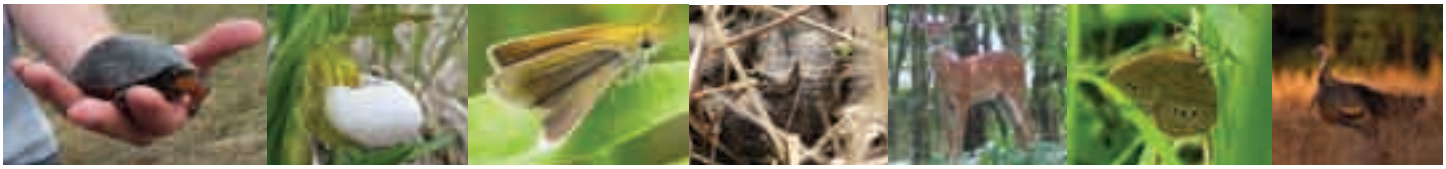
Herpetofaunal responses to prescribed fire are species specific, vary among habitats, and require further study (Russell et al. 1999, Pilliod et al. 2003). There is a lack of published information on the effects of fire specific to many of the rare species listed in the table. Given this lack of information, 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://web4.msue.msu.edu/mnfi/explorer/ detailed species abstracts where available (http://web4.msue.msu.edu/mnfi/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).

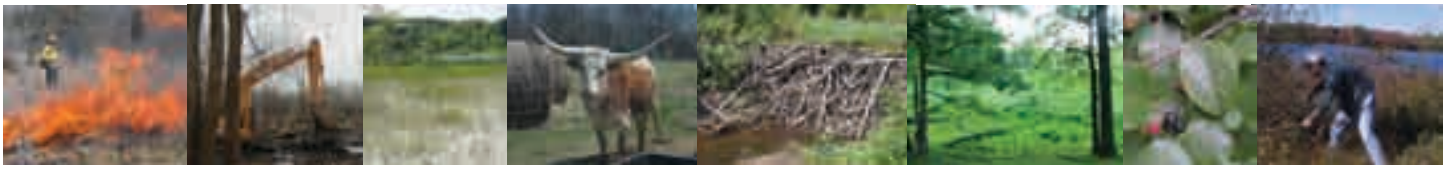
INSECTS

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://web4.msue.msu.edu/mnfi/explorer/ detailed species abstracts where available (http://web4.msue.msu.edu/mnfi/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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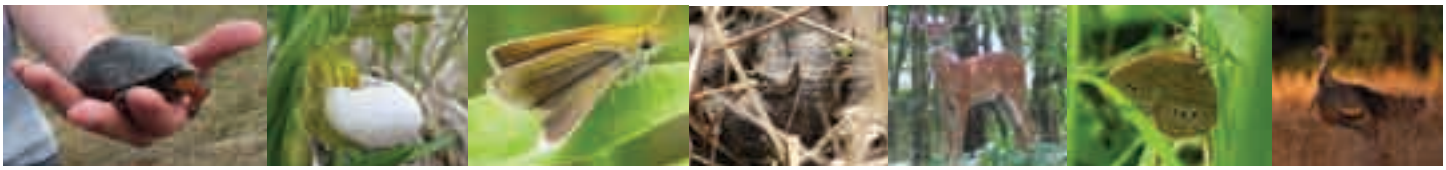

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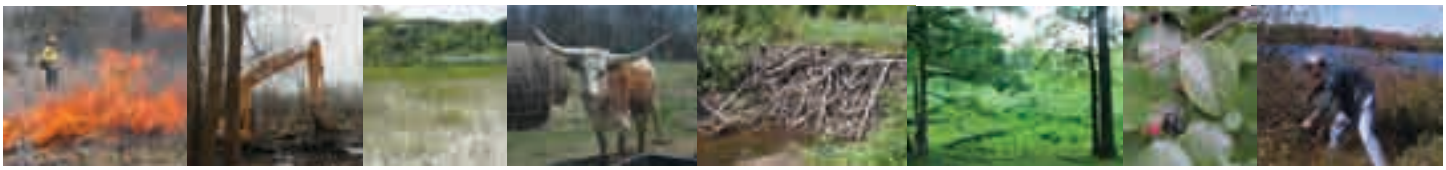
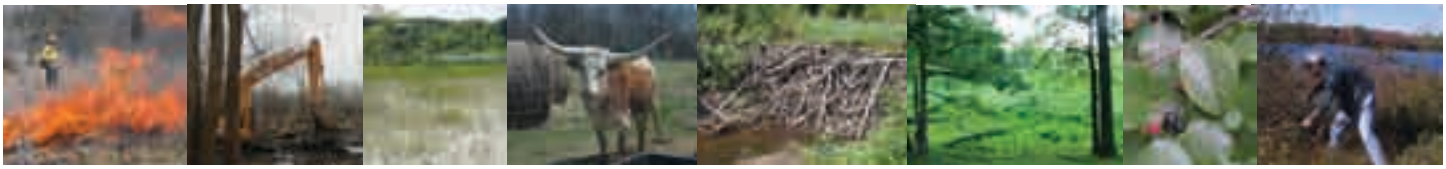


Appendix F. Techniques and timing to manage some common invasive exotic plants.

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		



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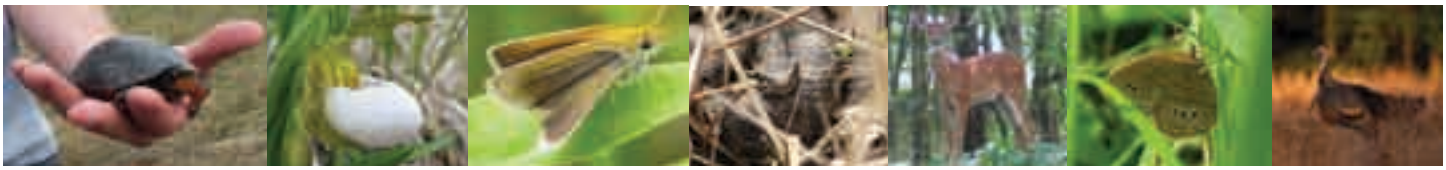

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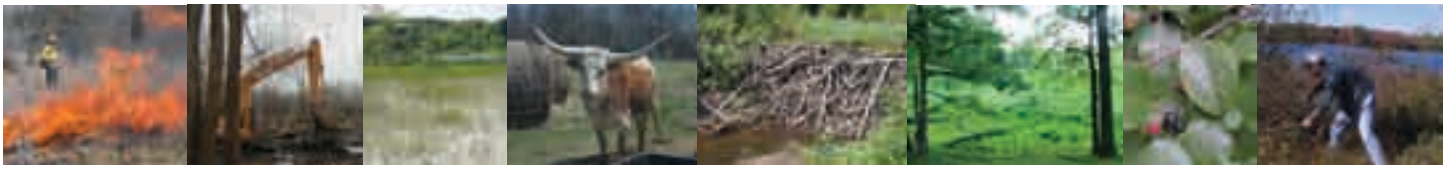
Figure 26: Christopher Hoving, Michigan Department of Natural Resources and Environment
Conclusion: Ibid.

Habitat Conservation Plan
Figure A2: Daniel Kennedy, Michigan Department of Natural Resources and Environment
Figure A3: Adrienne Bozic, Michigan Natural Features Inventory
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 A4: Carrie Tansy, USFWS
Figure A5: Christopher Hoving, Michigan Department of Natural Resources and Environment
Figure A6: Peter Tolson, Toledo Zoo
Figure A7: Ibid.
Figure A8: David Cuthrell, Michigan Natural Features Inventory
Figure A9: Christopher Hoving, Michigan Department of Natural Resources and Environment
Figure A10: Southwest Michigan Land Conservancy