

Mitchell's Satyr Butterfly

Neonympha mitchellii mitchellii

Recovery Plan



U.S. Department of the Interior
Fish and Wildlife Service



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RECOVERY PLAN FOR MITCHELL'S SATYR BUTTERFLY
Neonympha mitchellii mitchellii French
(Lepidoptera: Nymphalidae: Satyrinae)

April 1998

Prepared by

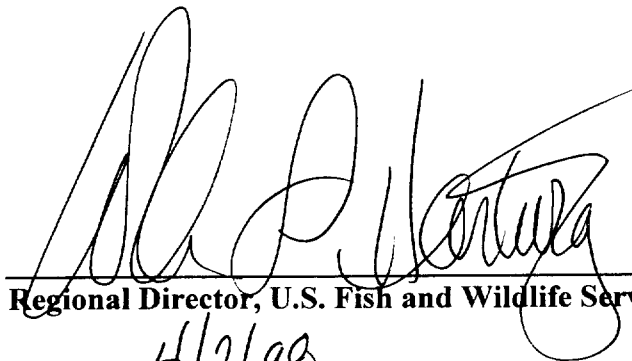
The Mitchell's Satyr Butterfly Recovery Team

for

Region 3

**U.S. Fish and Wildlife Service
Ft. Snelling, Minnesota**

Approved by:



Regional Director, U.S. Fish and Wildlife Service

Date:

4/2/98

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EXECUTIVE SUMMARY

Current Status: The species is listed as endangered. Of the 30+ historical populations known, 15 extant populations are known from Michigan (13) and Indiana (2). The species is considered to be extirpated from Ohio, New Jersey and Maryland (if it actually occurred in that state).

Habitat Requirements and Limiting Factors: Mitchell's satyr habitat is best characterized as a sedge-dominated fen community. Occupied fens are located in a small region of southern Michigan and northern Indiana. Habitat loss and the disruption of ecological processes which create and maintain habitat are the probable cause of this decline. Continued habitat loss and disruption of ecological processes are the primary threats to surviving populations.

Recovery Objective: The primary objective of the recovery program is to remove the Mitchell's satyr butterfly from the List of Endangered and Threatened Wildlife and Plants by: (1) achieving a well-distributed increase in numbers; and (2) providing for long-term habitat protection.

Recovery Criteria: Reclassification from endangered to threatened: when 16 geographically distinct, viable populations or metapopulations are established or discovered range wide. These will include, at a minimum, 12 populations or metapopulations in southern Michigan, two in Indiana, one in Ohio, and one metapopulation in New Jersey. At least 50 percent of these sites will be protected and managed to maintain Mitchell's satyr habitat by federal or state agencies or by private conservation organizations. Delisting: when nine additional, for a total of 25, geographically distinct, viable populations or metapopulations are established or discovered range wide and remain viable for five consecutive years following reclassification. A minimum of 15 sites must be protected and managed to maintain Mitchell's satyr habitat by state or federal agencies or by private conservation organizations before delisting will be considered.

Actions Needed:

1. Monitor existing and survey for additional populations of Mitchell's satyr.
2. Establish a research program to determine the ecological requirements and life history of Mitchell's satyr. Lack of information about life history traits, ecological requirements, and the response of the habitat to potential management practices are a major hindrance toward the recovery of this species.
3. Develop and implement protection strategies for Mitchell's satyr. Many of the best populations are vulnerable to land use practices on private and public lands.
4. Develop an outreach program to keep local communities informed of the butterfly's status.
5. Develop and implement a strategy for reestablishing populations of Mitchell's satyr through its historical range. This will include management of habitat as well as establishment of a rearing facility to provide butterflies for introduction into the wild.

Estimated cost of recovery for FY 1998-2007 (in \$1000s): details are found in the Implementation Schedule.

<u>Year</u>	<u>Task 1</u>	<u>Task 2</u>	<u>Task 3*</u>	<u>Task 4</u>	<u>Task 5</u>	<u>Total</u>
1998	13	12	34	5	0	64
1999	13	26	36.5	5	6	86.5
2000	10	26	51.5	8	45	140.5
2001	10	20	52	10	45	137
2002	10	15	52	10	45	132
2003	10	15	52	10	45	132
2004	10	0	52	10	45	117
2005	10	0	37	10	45	102
2006	10	0	37	10	45	102
2007	10	0	37	10	45	102
TOTALS	106	114	441	88	366	1115

* These totals do not reflect additional costs for habitat acquisition due to the uncertainty of land prices.

Date of Recovery: Delisting could occur in 2007, if recovery criteria are met.

DISCLAIMER

Recovery plans delineate reasonable actions which are believed to be required to recover and/or protect listed species. Plans published by the U.S. Fish and Wildlife Service are sometimes prepared with the assistance of recovery teams, contractors, state agencies, and other affected and interested parties. Recovery teams serve as independent advisors to the Service. Plans are reviewed by the public and submitted to additional peer review before they are adopted by the Service. Objectives of the plan will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not obligate other parties to undertake specific tasks and may not represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than the U.S. Fish and Wildlife Service. They represent the official position of the U.S. Fish and Wildlife Service **only** after they have been signed by the Regional Director as **approved**. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

By approving this document, the Regional Director certifies that the data used in its development represents the best scientific and commercial data available at the time it was written. Copies of all documents reviewed in development of the plan are available in the administrative record, located at the East Lansing Field Office.

Literature Citations should read as follows:

U.S. Fish and Wildlife Service, 1997. Recovery Plan for Mitchell's Satyr Butterfly (*Neonympha mitchellii mitchellii* French). Ft. Snelling, MN. viii+71 pp.

Additional copies may be obtained from:

Fish and Wildlife Reference Service
5430 Grosvenor Lane, Suite 110
Bethesda, Maryland 20184

800-582-3421 or 301-492-6403
fwrs@mail.fws.gov
<http://www.fws.gov/search/fwrefser.html>

The fee varies depending on the number of pages of the Plan.

ACKNOWLEDGMENTS

This recovery plan was prepared by Dr. John Shuey, Indiana Chapter of The Nature Conservancy (TNC), for the U.S. Fish and Wildlife Service (USFWS) with input from the Mitchell's satyr butterfly Recovery Team on a preliminary draft of this document. Final edits and word processing on the plan were completed by Mr. Mark Hodgkins, Mr. Mike DeCapita, and Ms. Sally Hopp of the USFWS-East Lansing, Michigan, Field Office. Dr. Shuey gathered the regional information included in this text from a variety of sources, most importantly the professionals with actual experience and insights into the ecology of Mitchell's satyr. The following individuals provided information from their region: Mogens Nielsen, Michigan State University, Department of Entomology, and Christopher Clampitt, The Nature Conservancy, Michigan Chapter, for localities and insights into habitat requirements; Nora Murdock, USFWS-Asheville Field Office, North Carolina, biology of *Neonympha mitchellii francisci*; Tom Breden, New Jersey Natural Heritage Program, New Jersey habitats; David Iftner, Lepidopterists Society, New Jersey historical records and habitat information; Steve Hall, North Carolina Natural Heritage Program, habitat requirements and population structure of *N. m. francisci*; Heather Ericson, University of Washington, Seattle, for insights into succession of abandoned beaver (*Castor pallux*) ponds in Wisconsin; Don Hey, Director of Wetland Research, Inc., Chicago, Illinois, for insights into the beaver as a landscape force; Paul Opler, National Biological Survey, Fort Collins, Colorado, for background on the Maryland records of Mitchell's satyr; and, John Peacock, retired, U.S. Forest Service, Ohio, for discussions of the population structure of this insect. Special thanks to the Natural Heritage Programs in Indiana, Michigan, Ohio, and New Jersey for their close cooperation in gathering background information included in this recovery plan.

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I. INTRODUCTION

The Mitchell's satyr butterfly, *Neonympha mitchellii mitchellii* French (Lepidoptera: Nymphalidae: Satyrinae), was given short-term protection under the Endangered Species Act of 1973, as amended, on June 25, 1991, when the U.S. Fish and Wildlife Service (Service) published an emergency rule (DOI 1991a) to list the butterfly as an endangered species. The emergency rule provided Federal protection to Mitchell's satyr butterfly (hereinafter referred to as Mitchell's satyr) for 240 days, during which time the Service initiated the normal listing process to ensure long-term protection for the butterfly. On September 11, 1991, the Service proposed the Mitchell's satyr for listing as an endangered species (DOI 1991b). On May 20, 1992, the Service published a final rule listing Mitchell's satyr as an endangered species (DOI 1992). Critical habitat has not been designated for this species.

Of the 30+ historical populations known, only 15 known extant, isolated populations remain in southwestern Michigan (13) and northern Indiana (2). The species is considered extirpated from Ohio, New Jersey, and perhaps Maryland.

A. Description

Mitchell's satyr is a medium-sized butterfly and is a typical member of the Satyrinae, a subfamily of Nymphalidae, which includes about 43 species of pearly eyes, satyrs, and wood nymphs in North America¹. Male forewing length ranges between 1.6-1.8 cm (0.6-0.7 in), females between 1.8-2.1 cm (0.7-0.8 in) (Opler and Krizek 1984). Although the dorsal (upper) wings are essentially unmarked and dark warm-brown in color, the ventral (lower) wing pattern may show through the thinly scaled dorsal wing surfaces. The ventral wing ground color is also dark warm-brown. Two conspicuous pattern elements characterize the ventral wing surfaces. The first is a linear series of four to five sub-marginal ocelli (eye-spots) on both the forewings and hindwings. The second is a pair of orange lines which encircle the ocelli rows on both wings.

As with most satyrines, the expression of the ocelli is variable, and they tend to be larger and more conspicuous in females. Parshall and Kral (1989) claimed the butterfly exhibited sexual dimorphism in the number of forewing ocelli, with males typically having four (range 2-4) and females having six (range 5-6). However, field observations of copulating pairs of Mitchell's satyr by M. Rabe (Michigan Natural Features Inventory, Lansing, pers. comm.) indicate that the variability in number of ocelli observed among and between the sexes renders this characteristic unreliable for determining sex in the field.

Mitchell's satyr is superficially similar to several species with which it occurs in Indiana, Michigan and Ohio. Two species of *Satyroides*, the Appalachian eyed brown (*Satyroides appalachia*) and the eyed brown (*S. eurydice*), both have a similar series of ventral ocelli (see

¹The use of the subfamily Satyrinae within the family Nymphalidae is recognized by Scott (1986), Opler and Malikul (1992), and others. However, many lepidopterists give full family status to this subfamily, i.e., Satyridae. In either case, the correct scientific name for the species would be *Neonympha mitchellii mitchellii* French (1889).

Opler and Malikul 1992 for illustrations). However, both these species can be separated by their larger size, which averages 50 percent greater, and their much lighter ground color (almost tan). The little wood satyr (*Megisto cymela*) is also frequently encountered along the edges of wetlands which support Mitchell's satyr. The little wood satyr is approximately the same size as Mitchell's satyr, but has ocelli on both the ventral and dorsal wing surfaces, and the ventral ground color is lighter, tending to warm-tan. A color plate (Plate 36) in Iftner et al. (1992) shows all of the satyrid (satyrine) species which occur in the fens in the states which are likely to support Mitchell's satyr. Older, worn specimens of Mitchell's satyr found late in the season may be lighter in color than fresh ones, making it more likely to confuse with other species. Researchers may want to use other characteristics to confirm their identifications (M. Rabe, pers. comm.). In New Jersey, the Georgia satyr (*Neonympha areolata septentrionalis*) may also be confused with Mitchell's satyr. However, the known and predicted ranges of these species do not overlap (Iftner and Wright 1996; D. Iftner, Lepidopterists Society, Sparta, New Jersey, pers. comm.), and the Georgia satyr butterfly is not in the fens of northern New Jersey.

Mitchell's satyr is easily identified in the field by a combination of size, pattern and flight characteristics. In the field, Mitchell's satyr's dark brown color and small size set it apart from all other species, and experienced personnel (with good vision) can accurately identify the butterfly from up to 20 m (65 ft). If closer examination is required to separate this species from the little wood satyr, the dark brown color, the absence of ocelli on the dorsal wing surfaces and the band of ocelli on the ventral wings will easily identify Mitchell's satyr. These characteristics can be seen easily in flight or by waiting for the satyr to settle. Netting Mitchell's satyr is not required for accurate field identification. In flight, experienced observers will readily observe the weak flight characteristics of Mitchell's satyr relative to the other potentially confusing species. The Appalachian eyed brown and the eyed brown fly moderately rapidly and tend to be very erratic in flight. The little wood satyr has a bouncing flight that is more energetic than Mitchell's satyr. In contrast to the other species, Mitchell's satyr has a slow bobbing flight pattern as it flies through, rather than over, sedges and brush. Mitchell's satyr covers ground very slowly, and observers can catch up with flying individuals by walking at a normal pace. In addition, Mitchell's satyr generally does not fly far before settling. However, this flight pattern may also vary slightly. Some have observed Mitchell's satyr sunning/resting about 3 m (10 ft) above the ground and traveling up to 200 m (650 ft) before settling (M. Rabe, pers. comm.).

The early stages of the butterfly were described in detail by McAlpine et al. (1960) and are typical of the family. Mature larvae are pale green with pale, lateral stripes. As is typical of satyrines, the tail is bifurcate. The pupae are also pale green, and are suspended by a posterior cremaster 5-8 cm (2-3 in) above the ground. Little is known about Mitchell's satyr development in the wild (M. Rabe, pers. comm.).

B. Distribution

Although isolated populations of this species are known from northern New Jersey, northeastern Ohio, and perhaps Maryland, the majority of population sites are clustered in southern Michigan and adjacent northern Indiana (Fig. 1). An additional subspecies, the St. Francis satyr (*Neonympha mitchellii francisci* Parshall and Kral), is known from North Carolina.

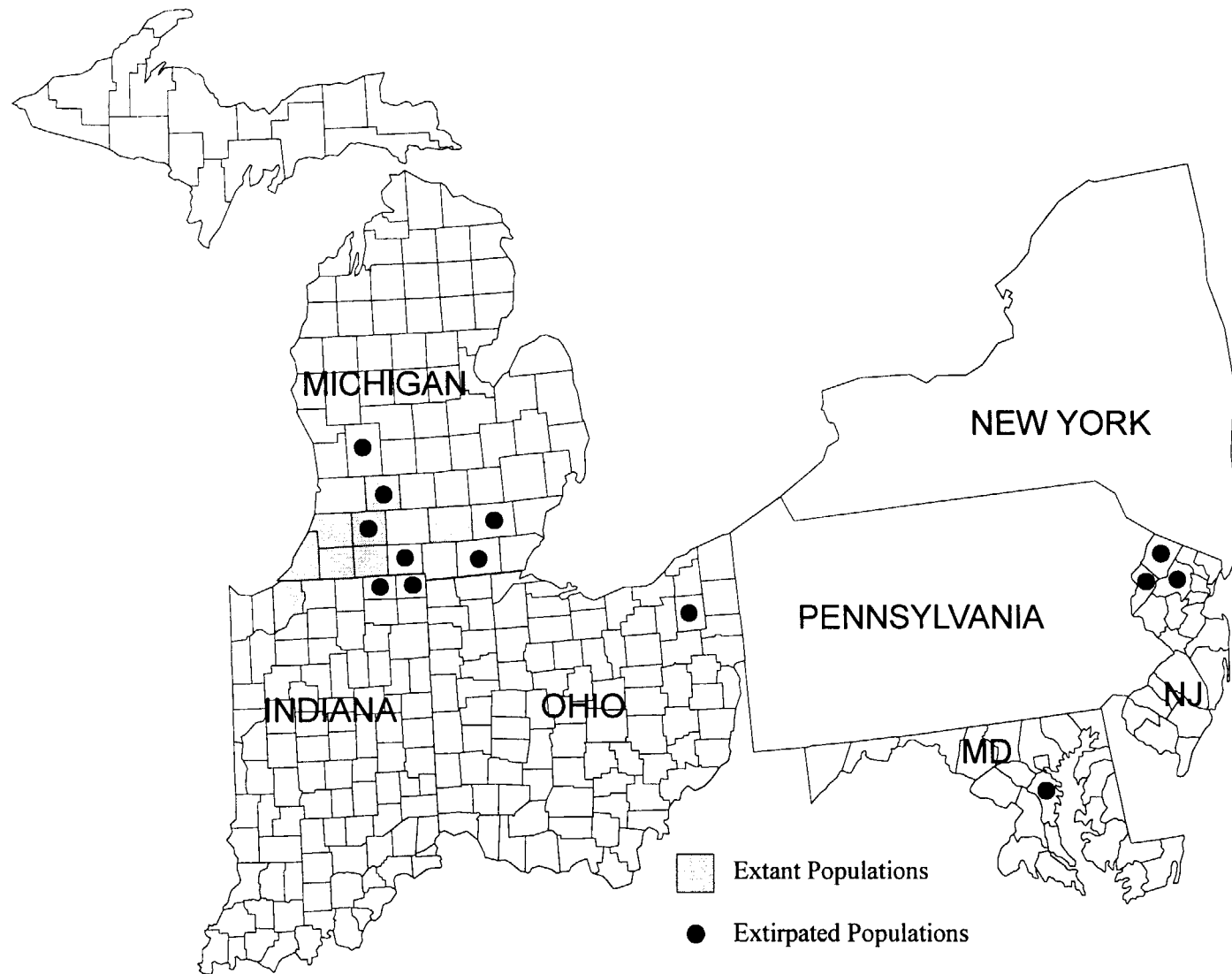


Figure 1. The current and historical range of *Neonympha mitchellii mitchellii* French (Modified from Wilsmann and Schwietzer, 1991)

Extant populations of Mitchell's satyr are known from only Michigan and Indiana. The following paragraphs detail the historical and present distribution of the subspecies in each state. Table 1 provides an overview of historical and extant populations in Michigan, Indiana, Ohio, Maryland, and New Jersey.

1. Michigan

Mitchell's satyr is historically known from 11 counties in Michigan, and extant populations are known from seven of those. At least 22 sites supporting Mitchell's satyr have been reported, with 13 sites known to support extant populations. Several of these sites and many other potential habitats have been intensively surveyed in recent years as part of the effort to protect and conserve Mitchell's satyr (Wilsmann and Schweitzer 1991). Based on these surveys, it seems likely that additional sites will be found, although not many.

No single factor has been implicated in the decline of this species in Michigan. At least one wetland complex which supported this butterfly has been eliminated by urban growth (Wilsmann and Schweitzer 1991). In addition, it is difficult to locate wetlands in southern Michigan that have not been hydrologically altered in some manner by removal of forest cover from adjacent uplands, drain tiling of adjacent fields, and ditch or drain maintenance. These alterations can have subtle to profound effects in altering wetlands from their pre-settlement conditions. Sometimes alterations are difficult to nearly impossible to discern.

Several of the apparently extinct populations occupied wetland complexes which today seem to be relatively undisturbed hydrologically. In these cases, the suppression of natural disturbance regimes such as wildfire or flooding from beaver (*Castor pallux*) activity may have eliminated processes which maintain the open fen habitats required by this butterfly. Many of the fens known to support this butterfly were subject to grazing and winter haying, but several sites with extinct populations were also treated similarly. In the absence of natural disturbance regimes, suitable habitat for Mitchell's satyr may have contracted through succession to the point that populations of this insect could not persist. Several of the extant populations in Michigan may be currently approaching this situation.

Only two Michigan population sites received heavy annual pressure from collectors in recent years: Jackson County Central and Cass County East. Both of these sites are well known within the entomological community, and these sites received the brunt of both in-state and out-of-state collection pressure. Presumably viable² populations of Mitchell's satyr are present at both wetland complexes. Thus, collecting pressure alone can not be easily implicated in the recent extirpation (local extinction) of certain Michigan populations.

²Population viability has not been accurately defined to date and currently provides a source of much debate. A preliminary working definition, developed by Mitchell's satyr researchers, appears in section II Recovery - Objective and Criteria. This definition is subject to change as additional information becomes available.

Table 1. An overview of historical and extant Mitchell's satyr butterfly (*Neonympha mitchellii mitchellii*) populations

State	County	Site Name	Population Status	Population Health	Habitat Status/Ownership Pattern
IN	LaGrange	La Grange Co. East	extirpated?	-----	High quality, protected in part - Private/public ownership
IN	LaGrange	LaGrange Co. West	extant	-----	Possible rediscovery in 1996 - Portions are destroyed, 2 lake-side fens remain - Private ownership, The Nature Conservancy (TNC) Registry Site
IN	LaPorte	LaPorte Co. Site	extant	very good	Portions are destroyed, but remainder is very high quality - Private ownership (TNC Registry Site)
IN	Steuben	Steuben Co. Site	extirpated?	-----	High quality fen complex, IN-DNR protected, Public ownership
MD	An.Arundel	Fort Meade	extirpated	-----	No habitat present at this time
MI	Barry	Barry County North	extirpated	-----	Public ownership
MI	Barry	Barry County South	extant	poor	Threatened by woody succession - Public ownership
MI	Barry	Barry County Southwest	extirpated	-----	Wetlands degraded - Public ownership
MI	Berrien	Berrien Co. North	extant	very good	High quality habitat, protected by a nature center - Private ownership
MI	Berrien	Berrien Co. South	extant	very good	High quality habitat, forthcoming highway construction - Private/public (MDOT) ownership
MI	Branch	Branch Co. Site	extirpated	-----	Habitat quality poor - Private ownership
MI	Cass	Cass County Northwest	extant	good	Small area of fen remains, remainder is degraded wetland - Private ownership
MI	Cass	Cass County Southwest	extant	very good	High quality habitat, extensive TNC landowner contact - Private ownership

Table 1 (continued). An overview of historical and extant Mitchell's satyr butterfly (*Neonympha mitchellii mitchellii*) populations

State	County	Site Name	Population Status	Population Health	Habitat Status/Ownership Pattern
MI	Cass	Cass County East	extant	very good	High quality habitat, woody succession and beaver flooding, threatened by livestock - Private/limited TNC ownership
MI	Jackson	Jackson County East	extant	unknown	New in 1996, habitat quality to be determined - Private ownership
MI	Jackson	Jackson County Central	extant	very good	Very high quality habitat, extensive TNC landowner contact - Private ownership (TNC Registry Site, limited TNC ownership)
MI	Jackson	Jackson County West	extant	unknown	High quality habitat - Private ownership
MI	Kalamazoo	Kalamazoo Co. North	extirpated?	-----	Good quality habitat - Private ownership
MI	Kalamazoo	Kalamazoo Co. East	extirpated	-----	Poor quality habitat, degraded wetland - Private/public ownership
MI	Kalamazoo	Kalamazoo Co. West	extant	good	Extensive good quality habitat, but being developed - Private ownership
MI	Kent	Kent County Site	extirpated	-----	Destroyed by development
MI	Lenawee	Lenawee County Site	extirpated	-----	Poor quality habitat - Public ownership (Nearby high quality habitat exists on private land, TNC landowner contact)
MI	St. Joseph	St. Joseph County East	extant	unknown	New in 1996, habitat quality to be determined - Private ownership
MI	St. Joseph	St. Joseph County West	extant	very good	Portions of wetland degraded, several high quality areas persist - Private/public ownership
MI	Van Buren	Van Buren County Site	extant	poor	Good habitat - Private ownership

Table 1 (continued). An overview of historical and extant Mitchell's satyr butterfly (*Neonympha mitchellii mitchellii*) populations

State	County	Site Name	Population Status	Population Health	Habitat Status/Ownership Pattern
MI	Washtenaw	Washtenaw Co. East	extirpated	-----	Poor quality habitat, once farmed - Private ownership
MI	Washtenaw	Washtenaw Co. West	extirpated	-----	Poor quality habitat, currently being pastured - Private ownership
NJ	Morris	Morris County Site	extirpated	-----	Exact local unknown
NJ	Sussex	Sussex County Site	extirpated	-----	Quality habitats survive - Private/public ownership
NJ	Warren	Warren County Site	extirpated	-----	Quality habitats survive - Private/public ownership
NJ	Warren	exact locality unknown	extirpated	-----	Habitat quality unknown
OH	Portage	Portage County Site	extirpated	-----	Habitat largely destroyed on private lands, but high quality remnants remain on state nature preserves - Public/TNC/private ownership
OH	Seneca?	exact locality unknown	extirpated	-----	Habitat quality unknown, little potential habitat remains in county

To summarize, extirpation of some Mitchell's satyr populations in Michigan have coincided with wetland drainage and the elimination of disturbance regimes (e.g., wild fires and hydrologic fluctuations).

Recent surveys indicate there are six high quality Mitchell's satyr sites in Michigan. These sites consistently support medium to high densities of adults, and seem to represent fen complexes which have adequate habitat to support viable populations of Mitchell's satyr into the foreseeable future. These sites include Berrien County South, Berrien County North, Cass County Southwest, Cass County East, Jackson County Central and St. Joseph County West.

Berrien County South is a moderately disturbed fen complex occupying a shallow but steep-sided valley with a creek (Rogers et al. 1992). Mitchell's satyr was found in almost every wetland habitat within this complex which supported the sedge *Carex stricta* Lam. (strict sedge, sometimes called common tussock sedge) in abundance.

Berrien County North is located approximately 6.4 km (4 mi) northwest of Berrien County South. The broad fen community which supports Mitchell's satyr lies along the Paw Paw River. The site is managed as a natural interpretive center for the general public.

Cass County Southwest is a privately owned site that is a typical fen community occupying a relatively narrow stream channel. It is located approximately 8 km (5 mi) southeast of a smaller Mitchell's satyr population at Cass County Northwest.

Cass County East is the type locality for Mitchell's satyr. This complex occupies a poorly drained pocket of glacial till, and is at best a weakly defined fen community within a small, open tamarack swamp. However, it contains ample Mitchell's satyr habitat and consistently supports a dense population. It is partly in conservation ownership by The Nature Conservancy (TNC).

Jackson County Central is a privately owned site that is considered to be one of the best fen complexes surviving in southern Michigan. At this site, Mitchell's satyr is found throughout a series of openings in tamarack forest and savanna communities.

St. Joseph County West is largely protected as a State Game Area, with the remainder in private ownership. Portions of the wetlands are degraded but several high quality areas persist.

Two new populations of Mitchell's satyr were found in Michigan during the 1996 field survey season: St. Joseph County East and Jackson County East. Population assessments and habitat descriptions are not yet completed. These will be included in future revisions of the Recovery Plan.

2. Indiana

In Indiana, a total of four or five sites are known to have supported Mitchell's satyr. Two sites still support Mitchell's satyr populations, the status of two other sites is unknown, and

location information in the literature on a possible additional site is too vague to pinpoint. Surveys of the area in 1986 found no Mitchell's satyrs.

The La Porte County site contains a recently discovered population. This wetland complex is partially protected by TNC, but the actual portion of the wetland complex which supports the butterfly is privately owned.

The LaGrange County West population was thought to have been recently extirpated, but a new population, found 0.4 km (0.25 mi) from this site in a 1996 survey, is a possibly rediscovery of that population. Additional surveys are needed to confirm its status. The LaGrange County West is/was the best known Indiana wetland supporting Mitchell's satyr. It is well known in the scientific and general literature and was heavily utilized by entomologists curious about the butterfly since the 1950s (Shull 1987). McAlpine et al. (1960), Price and Shull (1969), Shuey (1985, 1986) and Shull (1987) have documented the status of the LaGrange County West population. This site is privately owned but is a Nature Conservancy Registry site.

LaGrange County East, which is less than 16 km (10 mi) away from LaGrange County West, supported a small, recently discovered population within a designated state nature preserve located inside a state fish and wildlife area. The exact current status of this population is not known but is suspected to be extirpated.

Steuben County site is an extensive fen complex covering several hundred acres. Homer Price, a northwestern Ohio naturalist, collected a pair of specimens from here in 1960. The fens are in excellent condition and are largely protected by a Wetland Conservation Area. Recent efforts (Martin 1987; Shuey 1986) to locate Mitchell's satyr here have been unsuccessful. However, it is possible that the butterfly is still present but was overlooked because the wetland is so large relative to the butterfly's typical localized distribution.

A possible additional historical site was reported as occurring in northeast Steuben County (Badger 1958). Martin (1987) interpreted the vague location description to a possible modern location. Wetlands including fens occur in a band and extend west in patchwork form along a creek which flows into the Steuben County Site. Roads and railroads, likely access points for Badger, intersect these wetlands at three points. Shuey (1986) surveyed the eastern portion of this area without discovering Mitchell's satyr. However, some nearby wetlands have not been searched for this butterfly. Some of these wetlands have been heavily disturbed and/or drained and are probably not suitable habitat today.

Martin (1987) surveyed 28 fens in northern Indiana for the presence of Mitchell's satyr but only found Mitchell's satyr at two sites. Because of personnel limitations, large complexes such as the Steuben County site could not be completely surveyed. Some sites, especially sedge meadows, which seemingly contain suitable habitat for the butterfly were not surveyed. Wilsman and Schweitzer (1991) summarize Martin's findings.

3. Ohio

One, possibly two population sites have been reported from Ohio. The primary site, located in Portage County, Ohio, was disjunct from all other known population sites and is approximately 200 km (125 mi) from the nearest known site in Michigan. Mitchell's satyr has not been reliably recorded from Ohio since Pallister's (1927) original report, although there is a reported capture from June 19, 1950 (McAlpine et al. 1960). This mid-June date, although plausible, is outside of the typical flight period of the butterfly, and no voucher specimen could be located despite an intensive search of all known private and public collections of Ohio butterflies (Iftner et al. 1992).

Portage County Fen is part of a large fen complex that originally covered several hundred acres. The fen was partially drained and converted to agricultural production by the 1950s. Today, much of this agricultural land has regrown into sedge meadow. Two portions of the Portage County Fen complex retain their natural conditions, and are preserved as two state nature preserves. Other fen remnants still occur in the surrounding countryside.

Between 1984 and 1986, a number of likely fen habitats in Portage County, including the remnants of the Portage County Fen, were surveyed for the presence of this species (Shuey et al. 1987a; Shuey et al. 1987b). Mitchell's satyr was not encountered during these surveys. This survey included most but not all the likely sites which might still support this butterfly.

A potential second population was reported by Henninger (1910), who included the Georgia satyr butterfly in a list of Seneca County butterflies. Henninger did not collect the single specimen personally, and rightfully doubted the presence of the Georgia satyr butterfly in Ohio. However, in north-central Ohio, there are only two potential species likely to be confused with the Georgia satyr butterfly: the little wood satyr and Mitchell's satyr (Iftner et al. 1992). The little wood satyr is common throughout Ohio and should have been well known to any collector during the early 1900s. Seneca County is located in north-central Ohio, approximately half way between Portage County and the nearest sites supporting Mitchell's satyr in Michigan and Indiana. Seneca County at one time had numerous wetlands including at least one extensive prairie fen complex (Andreas and Knoop 1992). All of the wetlands in Seneca County that may have once supported Mitchell's satyr have been extensively degraded, and most have been eliminated.

4. New Jersey

Two well known sites within Sussex (Rutkowski 1966), and Warren Counties supported this species in the recent past. The confirmed sites are both fens located in areas of limestone bedrock within the same watershed. Mitchell's satyr was collected to extirpation at these sites and was subsequently reranked to State Historic status by the New Jersey Heritage Program in 1989 (Schweitzer 1989).

A possible additional historical locality, the Morris County site, was reported by Pallister (1927) who mentioned a specimen collected July 10, 1890, by Charles W. Johnson, a very respected entomologist. The vague locality data reflects the norm for that period, and could easily refer to almost any locality within 16-32 km (10-20 mi) of the Morris County site,

including the Sussex or Warren County populations. Schweitzer (1996) argues that evidence supports the likelihood that the Johnson specimen is from a population separate from the Sussex or Warren County populations. However, no extant fens occur at this location now. The specimen existed until 1989, but has since been destroyed by dermestid beetles (Dermestidae)(Schweitzer 1996).

The occurrence of a fourth extinct population has been suggested which occurred within the same drainage as the Sussex and Warren County populations, located somewhere between the two. Field work to verify the existence of fen habitat is in progress (Schweitzer 1996).

Fens are relatively rare in New Jersey, and known occurrences of this community type have been surveyed by experienced biologists for Mitchell's satyr (T. Breden, Coordinator, New Jersey Natural Heritage Program, Trenton, pers. comm.). However, at least one newly discovered fen complex has yet to be surveyed and other complexes likely exist.

5. Maryland

While serving their enlistment in 1944 and/or 1945, Clay Gifford and his brother collected Mitchell's satyr from a "military marsh" near the railroad yard at Ft. Meade, Maryland (P. Opler, U.S. Geological Survey, pers. comm.). The specimens were shipped home, but have since been destroyed and no specimen records survive today. Gifford was an experienced, expert amateur lepidopterist, familiar with both Mitchell's satyr and the Georgia satyr. However, because voucher specimens do not exist, and because suitable habitats are no longer evident near Ft. Meade, the validity of this report will always be questionable.

C. Habitat / Ecosystem

Nearly all published descriptions of Mitchell's satyr habitat requirements are inaccurate. Klots (1951), Howe (1975), Shull (1987), Opler and Krizek (1984) and Scott (1986) all report the habitat as shrubby bogs. McAlpine et al. (1960), while referring to the wetlands supporting this butterfly as "bogs", provide detailed botanical descriptions which very clearly describe the fens in which they encountered the species. Likewise, Pallister (1927) described the Ohio site as a dense tamarack swamp with abundant sedges.

Shuey (1985, 1986) partially rectified this nomenclature problem, classifying the habitats at five sites which support Mitchell's satyr as fens, specifically as bog fens (in the sense of Stuckey and Denny 1981). Bog fens are characterized as fen communities which contain a significant number of species of northern affinities, including conspicuous species such as *Larix laricina* (tamarack), *Toxicodendron vernix* (poison sumac), and *Sarracenia purpurea* (pitcher plant). Other conspicuous plant indicator species which are often present in Midwestern fens supporting this butterfly include *Potentilla fruticosa* (shrubby cinquefoil), and *Cornus stolonifera* (red-osier dogwood).

It is now evident that Mitchell's satyr habitats cannot be so neatly classified. Known habitats are all peatlands but range along a continuum from prairie/bog fen to sedge meadow/swamp. However, certain attributes at each site remain fairly constant. All historical and active habitats have a herbaceous community which is dominated by sedges, usually *Carex*

stricta, with scattered deciduous and/or coniferous trees, most often *L. laricina* or *Juniperus virginiana* (red cedar). It should be noted that a typical large fen complex is hardly a homogeneous system. For example, the Berrien County South site, Michigan, supports seven identifiable wetland communities (Rogers et al. 1992). These different communities represent the end result of dynamic processes such as the interplay between disturbance, groundwater discharge, and plant succession, which acts to produce a mosaic of habitat types within each wetland complex.

The specific habitat requirements for Mitchell's satyr seem to include structural components as well as the presence of suitable host plants. Other researchers in the Midwest have noted the close relationship between Mitchell's satyr and young *L. laricina* trees. Pallister (1927) noted that in the several hundred acre Portage County site, Ohio, Mitchell's satyr was limited to a small sedge meadow surrounded by *L. laricina*. Likewise, Badger (1958) and McAlpine et al. (1960) noted that within the fens in which they encountered the butterfly, it was most often found flying among open stands of *L. laricina*. At the LaGrange County West site, Indiana, Mitchell's satyr was found to fly along the edges of *Juniperus virginiana* and shrubs on the edge of a floating fen mat. Similarly, at the Berrien County South site, Michigan, Mitchell's satyr was most often encountered at the interface between the open sedge meadow and bordering dense stands of deciduous shrubs such as *Cornus stolonifera* or among scattered trees in a *Larix laricina* savanna area (Rogers et al. 1992). Breden (pers. comm.) reports that in New Jersey, the habitat was characterized as narrow calcareous stream-side sedge meadows bordered by *Juniperus virginiana* and dense shrubs.

The structural component of the habitat requirement of Mitchell's satyr is not unprecedented in wetland satyrines: the Appalachia eyed brown is found almost exclusively in shaded, scrubby wetland habitats while the closely related northern eyed brown is limited to open sedge meadows (Shapiro and Cardé 1970; Cardé et al. 1970; Shuey 1985). These two sister-species generally use the same *Carex* sp. host plants, but partition their habitats based upon habitat structure independently of *Carex* sp. distribution. D. Schweitzer (TNC, Port Norris, NJ, pers. comm. 1996) reports that in New Jersey, the Georgia satyr seldom occurs more than a few dozen meters from trees or tall shrubs, even in extensive, very open sedge meadows. He has observed adults resting in these shrubs near the trees. Mitchell's satyr too seems to use the interface between open sedge meadow and the shrubby edges of later successional habitats.

The fens which supported Mitchell's satyr in Michigan and Indiana may have been subjected to occasional wildfire. Nearly all of the historical sites in these two states occur in association with glacial outwash and moraine deposits, and soils on adjacent uplands are generally composed largely of sand. These glacial deposits supported upland communities such as oak barrens and oak woodlands, and remnants of these communities, can still be found in association with most sites today. Oak barrens and oak woodlands are fire maintained communities, and in the absence of wildfire generally convert through successional processes into more mesic oak forests (Curtis 1959). This evidence suggests that wildfires are required to maintain these upland habitats and may have swept through the adjacent wetland complexes which support(ed) Mitchell's satyr on a regular basis. It is less likely that the habitats which supported this butterfly in Ohio and New Jersey were subjected to wildfire. The surrounding uplands in these states are more mesic, and wildfire events were not a regular occurrence in these regions.

The following paragraphs briefly describe typical habitats which support or supported Mitchell's satyr in each state. The detail of these descriptions varies between states, and reflects differences in state by state documentation procedures rather than differences in understanding.

1. Michigan

In Michigan, three sites which support Mitchell's satyr have been relatively well studied. These sites demonstrate the range of wetland types known to support this butterfly.

Jackson County Central - Jackson County Central fen is a large 930 ha (2300 ac) wetland complex which includes approximately 62 ha (155 ac) of high quality prairie fen in several patches. The fens occupy a two-mile long glacial outwash channel which is the drainage basin of two converging creeks. The receiving creek is approximately 1-2 m (3-6 ft) wide and 0.6-1.2 m (2-4 ft) deep and has a thin sand-gravel substrate deposited over heavy muck. Adjacent uplands include fire-starved oak barrens and oak woodland remnants.

The open fen is associated with shrub carr and groves of tamarack and tamarack savanna. Although prairie fen was once extensive in the area, fragmentation and draining have reduced the amount of fen. Besides extensive prairie fen along the streams and ponds of the area, reconstruction of pre-settlement conditions indicate extensive dry or dry-mesic southern forest surrounding the prairie fen with the exception of oak barrens or savanna to the southwest. A small stand of southern swamp forest was located to the north (Ballard 1986a). Today, large stands of shrub carr are found along the creek in areas that were formerly prairie fen.

The dominant soil within the prairie fen and shrub carr is Edwards muck. This black, calcareous muck soil is typically underlain with marl. There is high water capacity and slow or ponded surface runoff. The water table is at or near the surface from September to June. Houghton muck is also found within the prairie fen although its occurrence is not as common. This soil is typically underlain by sand or loamy deposits (USDA 1981). In most of the open fen, the substrate is saturated by the active water flow. *Sphagnum* spp. (mosses), a common fen species, are found near the fork of the creek. Marl deposits are also found in areas along the creek and are characterized by short vegetation dominated by calciphilic Cyperaceae (sedge family). The creek branches into many rivulets which crisscross the fen and supply it with the characteristic free flow of alkaline water. Some areas of the fen are on perched slopes of 5-10 percent with rivulets at the base and seepage supplying the water farther up the slope (Ballard 1986b).

The majority of the open wetland is fen meadow and lies between the shrub carr concentrated along the creek and the shrub carr-tamarack border. The fen meadow is dominated in some areas by *C. stricta* and in others by grasses, notably *Muhlenbergia richardsonis* (mat muhly), both of which are accompanied by a rich assemblage of forbs and other grasses and sedges. Sedge flats are adjacent to the stream especially in areas free of shrub carr. Marl flats form the substrate for the flats which are dominated by low *Eleocharis* spp. (spike rush) and *Carex* spp. Shrub carr of *Cornus* spp. (dogwoods), *Salix* spp. (willows), and *T. vernix*, is scattered over the interior of the fen meadow but are concentrated primarily along the creek bed and lowest areas of crisscrossing rivulets, and around the perimeter of the whole drainage basin.

The uplands surrounding the outwash basin are level to gently rolling, mostly dissected outwash plain (Dorr and Eschman 1970) dominated in pre-settlement times by southern dry forest and oak barrens with prairie. Areas with well drained, coarse-textured sand and gravel substrate favored the proliferation of oak barrens or savanna with dry prairie. Pre Euro-American settlement survey notes indicate the existence of barrens or very open savannas principally to the south and west of the Jackson County East fen. The area northeast of the wetland, on an expanse of outwash plain composed mostly of sandy loams, evidently supported dry-mesic or mesic southern forest with a more closed canopy relative to the open canopy of the barrens or savanna with prairie landscape to the west or south. Prairie fen was a widespread feature in the fine-textured muck outwash channels and kettle lakes scattered over the local landscape. Dissected streams of seepage from the base of adjacent hills provided an active water supply, the alkalinity of which was strongly influenced by the calcareous till and limestone bedrock beneath it. Here the occasional fire suppressed shrubby and woody invasion to maintain the open aspect of the fens.

Mitchell's satyr is found primarily in the northern portion of the fen where tamarack savanna occurs. Forbs are an important component of this habitat and outnumber the sedges at a ratio of 2.56 to 1. The dominant forbs are *P. fruticosa*, *Solidago riddellii* (Riddell's goldenrod), and *Eupatorium maculatum* (spotted joe-pye weed). The dominant sedge is *Carex stricta*. *Carex aquatilis* (aquatic sedge) is also relatively common in these areas.

Cass County East - Cass County East is a 65 ha (160 ac) wetland complex. The area is a complex of shrub carr, sedge meadow, hardwood swamp, and tamarack swamp. Many streamlets traverse the central wetland. However, in the spring of 1996, this wetland was inundated as the result of a one meter (3 ft) tall beaver dam (C. Clampitt, The Nature Conservancy, Michigan Chapter, pers. comm.). The entire complex is surrounded by a mix of cultivated land and secondary forest. Xeric oak woodlands likely dominated these uplands. A hog farm is located on the southwest corner of the wetland and hogs may have access to some of the most productive habitats for Mitchell's satyr.

A comparison of pre Euro-American settlement conditions with current conditions at Cass County East indicates that wetlands cover approximately the same area today as they did in the past. At the time of Euro-American settlement, it appears that vegetation was composed of mesic southern forest and emergent marsh-relict conifer swamp complex. Mesic southern forest was composed of *Fagus grandifolia* (American beech), *Acer saccharum* (sugar maple), *Fraxinus americana* (white ash), and *Carya* spp. (hickory) dominated forest on moist sandy loams within moraines. Associated species included *Liriodendron tulipifera* (tulip poplar), *Prunus serotina* (black cherry), *Tilia americana* (basswood), *Ulmus americana* (American elm), *Juglans cinerea* (butternut), and *Quercus rubra* (red oak). The emergent marsh-relict conifer swamp was found in an irregular mosaic pattern. Distinctions between the two plant communities could not be made from the original land survey notes (Welton 1993). There are indications that shrub invasion has drastically altered the plant composition within the wetland. Descriptions of the wetland from the 1930s depict grassy strips within a dense tamarack swamp. There are indications that the area was grazed in 1935 to 1937 resulting in a decrease in woody vegetation, including *Larix laricina*, that recovered by the 1950s. During the 1930s, most of the larger *L. laricina* were dead, and growing among them was a dense stand of young *L. laricina* (McAlpine et al. 1960). Today, very little *L. laricina* remains in the vicinity of Mitchell's satyr habitat and,

if historic descriptions are accurate, *L. laricina* has decreased drastically since the 1950s, perhaps as a result of water level changes.

Soils within the wetland complex are primarily Houghton muck which typically has a water table at or near the soil surface from September through June. Soils on the slopes and uplands are Oshtemo sandy loam, Kalamazoo loam, and Spinks-Oshtemo complex (USDA 1991).

Although the site is calcareous, most of the usual fen species are absent. The tamarack swamp is dominated by *L. laricina*, *Acer rubrum* (red maple), *Betula alleghaniensis* (yellow birch), and *F. nigra* (black ash) (Mattei 1992). *Toxicodendron vernix* and *Cornus foemina* (gray dogwood) are dominant in the subcanopy. Sedge meadow areas are dominated by *Carex stricta* and *Aster puniceus* (swamp aster). Subdominant species include *Carex lacustris* (lakebank sedge), *Solidago uliginosa* (bog goldenrod), *Eupatorium perfoliatum* (common boneset), and *Eupatorium maculatum*. In some areas, *Phalaris arundinacea* (reed canary grass) forms dense monocultures. Shrub invasion into the sedge meadow where Mitchell's satyr is found could become a problem in the future. Already, dense shrub carr of *Cornus stolonifera* (red-osier dogwood), *C. amomum* (silky dogwood), and *C. foemina* (stiff dogwood), as well as *T. vernix*, can be found surrounding the main sedge meadow where Mitchell's satyr is found (Sferra and Darnell 1992). Past descriptions of this site make no mention of fire and it seems unlikely that any fires have occurred since at least 1930.

Berrien County South - Berrien County South is near the western limit of the range for Mitchell's satyr. The fen occupies a 1.5-3 km (1-2 mi) stretch of a creek floodplain, which flows through a relatively narrow valley cut through glacial till and outwash. The uplands surrounding Berrien County South likely supported oak barrens and open oak woodland communities during presettlement times, with several characteristic species persisting today. Degraded remnants of these fire-starved communities can be found directly adjacent to the wetland communities. The creek is 1-2 m (3-6 ft) across, and is sandy or mucky bottomed through most of the wetland.

Berrien County South is a complex of seven wetland communities, best described as a "prairie fen", although not a species-rich example of this community type in Michigan (Rogers et al. 1992). The area appears to have a complex disturbance history with lumbering and cattle grazing being most evident. Fence lines are evident throughout the fen, and grazing has probably structured the sedge meadow-shrub carr communities which dominate the wetland at the present time. Scattered throughout the length of the wetland are open fen communities, tamarack savanna, disturbed marsh and wet river bottom forest communities. The sedge meadow - shrub carr complex is dominated by sedges such as *Carex stricta* and *C. lacustris* with a shrub component of *Salix discolor* (pussy willow), *S. bebbiana* (Bebb willow), *S. eriocephala* (Missouri river willow), *Viburnum lentago* (nanny berry), *Cornus stolonifera* and *Rosa palustris* (swamp rose). The open fen communities are dominated by the same suite of *Carex* species, but shrubs such as *Cornus stolonifera* and *Salix* spp. account for only 40 percent of the cover in this community. The tamarack savanna is dominated by *L. laricina*, a sparse shrub layer composed of *Cornus stolonifera*, *Salix* spp. and *Rosa* spp. and a dense sedge layer composed mainly of *Carex lacustris* and *Carex stricta*.

Mitchell's satyr is distributed throughout the length of the wetland complex in a variety of community types (Rogers et al. 1992). Most of the sites where the butterfly occurs can be described as dense stands of *Carex stricta* associated with edges of dense shrubs. Often these sites are small openings within dense shrub carr. Other more open communities used by Mitchell's satyr include the rich fen communities and dense stands of *Typha* spp. (cattail) with scattered *Carex*.

2. Indiana

LaGrange County West presents a somewhat different aspect than the fens described from Michigan. This fen is fed by seeps which discharge from adjacent hillsides of glacial till into a nearby lake. The fen community occurs in a small protected embayment on the lake, and is very much a "quaking" community that seemingly floats on the lake surface. This fen supports concentric zones or communities that emanate from the hillside towards the open lake. Near the hillside, at the interface between upland and wetland, is a shrubby zone supporting abundant *Juniperus virginiana*, *Cornus stolonifera*, and *Salix* spp. with a dense sedge herbaceous layer. Slightly further into the wetland, these shrubs decrease in frequency, but *Toxicodendron vernix* becomes more abundant. These shrubby carr zones grow on firmly grounded peat, and range in width from approximately 2-6 m (6-20 ft), and Mitchell's satyr is found almost exclusively within this narrow band. Further towards the lake, the fen mat becomes less firmly grounded and the fen supports a more herbaceous community with conspicuous clumps of *Sarracenia purpurea* (pitcher plant), abundant *Potentilla fruticosa*, *Vaccinium* spp. (cranberry) and a wide variety of orchids. This portion of the fen does not support the dense stands of sedges that typically characterize Mitchell's satyr habitats, and the butterfly has not been sighted in the more open areas of the fen.

The southern portion of LaGrange County West at one time supported several additional pockets of fen habitat. A high quality fen community still occurs on the southwest portion of the lake, but an extensive complex of wetlands that once occupied the southern extreme of the lake basin has been mined and is now largely destroyed. Spoil piles from past dredging indicate that these wetlands were marly, and were likely to be botanically similar to the surviving fen known to support Mitchell's satyr. The mined areas are located approximately 200 m (656 ft) south of this fen, and were likely to have provided additional habitat for Mitchell's satyr.

The other three known Indiana fens which supported Mitchell's satyr are similar to the fens described in Michigan. All of these sites occur in areas of glacial deposits, mostly outwash deposits. The upland communities at these sites were dominated by xeric oak barrens and oak woodlands. Remnants of these communities are found in close association with all of the wetlands known to have supported Mitchell's satyr.

3. Ohio

The single documented habitat (Pallister 1927) in Ohio was Portage County, a fen complex of over 80 ha (200 ac) classified by Stuckey and Denny (1981) as a bog fen community. This site includes two state-owned natural areas, with some very high quality habitat protected. Pallister (1927) reported the habitat as a clearing containing "swamp grasses" (probably *Carex* spp.) surrounded by *L. laricina*. G. Denny (Division of Natural Areas and Preserves, Ohio

Department of Natural Resources, Columbus, pers. comm.) confirms that the dominant sedge in the high quality portions of the fen is *Carex stricta*. Other conspicuous elements include *P. fruticosa*, *Cornus stolonifera*, *Toxicodendron vernix*, and various *Salix* species. Collection records are detailed in Shuey et al. (1987a and 1987b) as well as Iftner et al. (1992). However, these old records do not estimate number of butterflies or the extent of habitat occupied.

Surviving remnants of the Portage County wetlands indicate that a well developed and complex fen community existed at one time. Surviving remnants include fen meadow, disturbed sedge meadow (*Carex lacustris* dominated), and tamarack savanna communities. This wetland was very likely similar to the more boreal portions of the complex now found at the Jackson County East fen in Michigan. The primary difference between these sites is the lack of a prairie influence within the Portage County wetlands.

4. New Jersey

The two known habitats which once supported Mitchell's satyr are very similar in appearance and vegetative structure. Located within a single watershed, both are typical fen complexes supporting such calciphiles as *P. fruticosa* and *Parnassia glauca* (waxy grass of Parnassus). Dense stands of the sedge *C. stricta* occur in openings along the spring runs which drain the groundwater discharge; *Juniperus virginiana* border the sedge meadows up-slope from these runs. *Acer rubrum* saplings are encroaching upon the more open sedge meadows. Calcareous fens are quite uncommon in New Jersey with less than 20 still in existence in 1989 (Schweitzer 1989).

Unlike many of the fens supporting Mitchell's satyr in the Midwest, fire is not a likely contributor to the dynamics of these fen communities (T. Breden, pers. comm.). Both fens are surrounded by mesic communities, which are not themselves fire adapted, nor are they likely to carry fire into the fen communities. However, they are subject to encroachment from *Acer rubrum* (T. Breden, pers. comm.), and some dynamic process such as hydrologic fluctuations or beaver disturbance may have functioned to periodically control woody invasion.

D. Associated Species

In addition to Mitchell's satyr, the fen complexes which support this butterfly are home to a variety of additional rare and imperiled plants and animals. Fens in general support unique species associations, and because of the rarity of fens in some states (e.g., Ohio and New Jersey), many of the calciphiles restricted to these systems are state imperiled. Appendix 1 lists the occurrence of Federal and state threatened and endangered species in known extant and historical Mitchell's satyr population sites. This listing clearly demonstrates the positive impact that preserving and managing these fen complexes for biodiversity would have.

E. Life History and Ecology

Despite a few historical studies, the biology of Mitchell's satyr is poorly documented. Although Mitchell's satyr has not been observed ovipositing in nature, its hostplants are almost certainly sedges, and *C. stricta* is probably the primary hostplant. Three lines of evidence support *C. stricta* as the primary hostplant. First, McAlpine et al. (1960) obtained abundant eggs

from a female caged with *C. stricta* cuttings, however, host preference experiments were not conducted. Rogers et al. (1992) reared Mitchell's satyr under greenhouse conditions by caging adult females with potted *C. stricta*. Under these conditions, females oviposited and larvae easily completed development. No larvae were obtained from females caged under identical conditions over the coarser *C. lacustris*. Second, in the field, adult Mitchell's satyr are almost always found in close association with dense stands of *C. stricta*. There are no known exceptions to this association. Finally, butterflies in the subfamily Satyrinae often utilize hostplants which are ecological dominants, and populations of most habitat-restricted satyrines are almost always associated with dense stands of their hostplants. Examples from eastern North America include species in the genus *Satyrodes*, which are primarily limited to *Carex* sp. dominated habitats; the Creole pearly eye (*Enodia creola*) and the pearly eye (*E. portlandia*), which are always associated with dense stands of cane (*Arundinaria* spp.); and the Georgia satyr, which is always found in southern wetlands dominated by *Carex* spp. and other sedges. The strong association between Mitchell's satyr and *C. stricta* in the field is a good indication of the relationship between the butterfly and hostplant.

Mitchell's satyr is single brooded range wide. Adults fly in late June through mid July, and during normal years the peak flight occurs during the first two weeks of July. Figure 2 is a composite histogram of adult collection records from Michigan and Indiana. Figure 3 illustrates a composite histogram of adult capture records from the two historical sites in New Jersey. A similar histogram for Ohio can be found in Iftner et al. (1992). However, there are only two verifiable dates for Ohio Mitchell's satyr records: July 4 and July 10. Due to the sparse data, a histogram has not been included for Ohio. Note that despite year-to-year differences in seasonal phenology, the entire window of adult activity is a four week period. These histograms indicate that there may be a tendency for Michigan and Indiana populations to fly slightly earlier in the season than the populations in New Jersey. In a typical year, adults are active at a given site for two to three weeks. The species is protandrous, and males generally emerge a few days before the females. McAlpine et al. (1960) indicate that an adult female held in captivity lived for approximately one week.

Observations from 1994 (Shuey 1997) indicate that Mitchell's satyr behavior and activity are strongly influenced by ambient temperature and solar radiation. These butterflies are most active on warm (>26°C/80°F), overcast days. On such days, males are very active and patrol over and through sedges and shrubs, presumably in search of receptive females. Although undisturbed females seem reluctant to fly unless disturbed, under these conditions, females fly further and more rapidly than usual. When landing, both sexes settle near the tops of sedges and other plants, and tend to be very conspicuous when at rest. During warm but sunny conditions, Mitchell's satyr activity is sharply reduced. Both males and females are apt to fly only in response to disturbance. Flights tend to be short, and adults seek out shaded resting areas. Males favor perches under shrubs, where they seem to survey passing insects (again probably in search of receptive females). These males fly out to investigate passing butterflies, but return to the nearest shrub following investigatory behavior. Females are generally found resting low in the scattered shade of sedges. During hot (>32°C/90°F) and sunny days, there is often little evidence of Mitchell's satyr. The few adults seen have usually been flushed from shaded areas by researchers and quickly settle low in sedges or inside shrubs. Just the opposite happens during cool but sunny mornings: adults are generally found at the tops of sedge plants, basking in the sun to raise their body temperature during these periods.

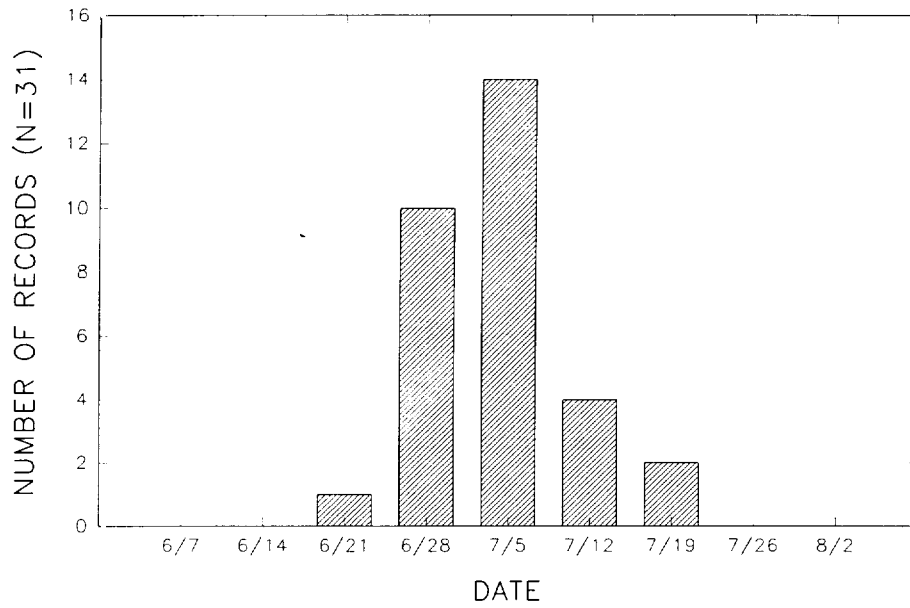


Figure 2. Temporal distribution of Mitchell's satyr (*Neonympha mitchellii mitchellii*) in Michigan and Indiana based on capture records

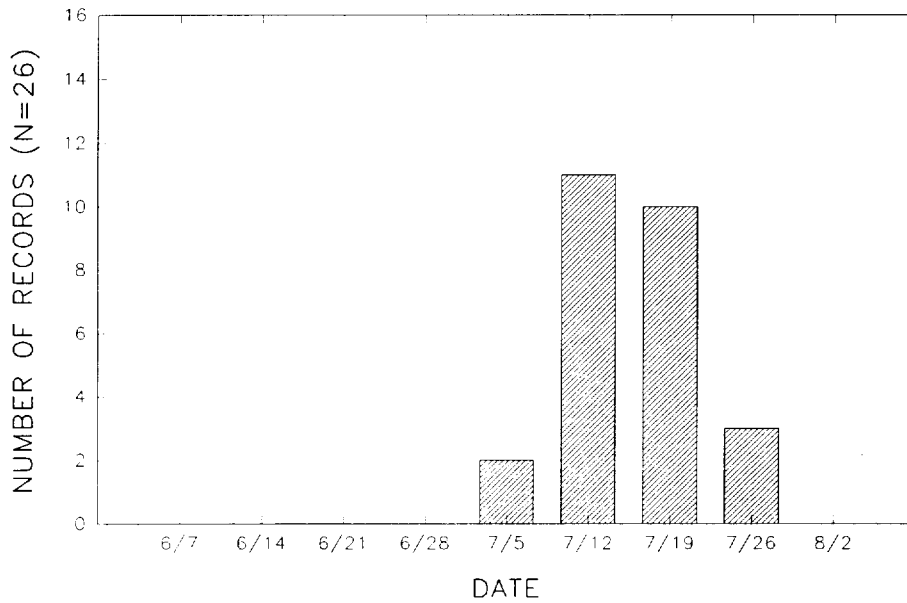


Figure 3. Temporal distribution of Mitchell's satyr (*Neonympha mitchellii mitchellii*) in New Jersey based on capture records

These observations indicate that Mitchell's satyr is strongly influenced by ambient temperature and thermal energy, and that this butterfly, like all insects, has little internal control over body temperature. However, the species seems to behaviorally thermoregulate by choosing favorable resting and flight areas. These behaviors can be generalized into simple 'rules' which predict and explain the butterfly's response to weather conditions.

- When ambient temperatures are cool, adults seek to increase their body temperatures using solar radiation. Adults are found basking under sunny conditions, and are inactive under overcast conditions.
- When ambient temperatures are optimal, solar radiation may increase body temperature above optimal. Under sunny conditions adults are active but usually found resting in shaded situations. If conditions are overcast, adults are very active and seldom settle for extended periods of time. This is true even during rainy days.
- On hot sunny days, adult activity is severely limited because optimal body temperature is easily surpassed. On sunny days, adult activity is severely reduced, and adults are found resting in dense shade. On hot, overcast days, adults are active but spend most of their time at rest.

Males employ a patrolling strategy to locate mates, and are often conspicuous as they fly through sedges and shrubs in search of females (Iftner et al. 1992). Female Mitchell's satyr are more sedentary than males, and are less frequently observed in the field. Females are generally sighted after being flushed from perches within dense stands of sedges. Females usually fly a short distance before settling back into the sedges. Despite the differences in observed sex ratios in the field, there is no evidence that true sex ratios differ significantly from 1:1.

During the flight period, which generally lasts only two weeks, the butterflies mate, lay eggs, and die. McAlpine et al. (1960) noted that under caged conditions, the eggs hatch within 7 to 11 days, and that larvae feed through the summer until reaching the fourth instar. Larvae then diapause in the fourth instar and resume feeding the following spring. However, this has not yet been confirmed under natural conditions.

Despite the absence of any evidence of a second generation under natural conditions, diapause is facultative in this subspecies and is apparently influenced by developmental temperature. Larvae reared in Ohio under greenhouse conditions of normal photoperiod but increased temperature developed directly into second generation adults which emerged in August-September (J. Shuey, unpub. data). This is consistent with observations of the single North Carolina site for this species, where St. Francis' satyr produces two broods each summer (Parshall and Kral 1989). As is the case with many insects, diapause is probably induced by a combination of photoperiod and temperature during a crucial larval period.

In older literature, Mitchell's satyr is usually reported as occurring at very high population densities (e.g., Pallister 1927; Badger 1958; McAlpine et al. 1960), but these population estimates are very suspect and cannot be used for direct comparison to current observations. However, it does seem likely that these authors were observing population densities that were considerably higher than those seen in more recent years. During 1981 to 1986, populations in

Michigan and Indiana were observed annually and appeared to remain stable but at relatively low densities, and on most occasions no more than five adult males were seen in flight at any moment (J. Shuey, unpub. data). These lower densities are corroborated by the range-wide survey observations at selected localities where typically less than 10 adults were seen per site visit (Wilsmann 1991; Martin 1987). These observations are consistent with Hall's (1993) observation of St. Francis' satyr populations in North Carolina. A single exception occurred in 1982 at Jackson County East, Michigan, where in limited areas, up to 15 adults could be seen simultaneously (J. Shuey, unpub. data). Surveys conducted in 1993 and 1994 indicate that populations were higher at several locations than had been observed in the recent past (J. Shuey, unpub. data).

Adult density fluctuations from year to year should be expected, and should not cause alarm as long as the microdistribution of each population within its habitats does not contract. If adult population density decreases in conjunction with a contraction of the microdistribution of the population, habitat suitability may be decreasing and habitat management may be warranted.

The population structure of Mitchell's satyr is seemingly very non-dynamic, in part because of this butterfly's strict reliance upon fens. Fens have two attributes that contribute to this. First, they are relatively stable systems that are resistant to short-term successional forces. Because fens are dependant upon the discharge of highly alkaline, nutrient-poor (usually low in nitrogen and sometimes phosphorus) groundwater, they are by nature harsh environments and are resistant to invasion from non-adapted species. Thus, community dynamics in fen communities are relatively slow. Some portions of the communities may be so resistant to invasion that they may have persisted relatively unchanged for hundreds of years, while others may require only periodic disturbance on the order of once every few decades. In the Midwest, fire is likely the most common source of periodic disturbance which "resets" fens to the early or mid successional stages required by Mitchell's satyr. Fluctuations in groundwater discharge rates may also hinder woody encroachment and maintain open fen meadows.

The second attribute of fens which may contribute to the sedentary population structure of Mitchell's satyr is the relative rarity of fens themselves. At the landscape scale, fens are often over-dispersed and several to many kilometers may separate suitable fen complexes. Thus, fens often function as isolated systems, with little or no opportunity for dispersal by animals, such as Mitchell's satyr, between systems.

Mitchell's satyr populations seemingly function as sedentary units, with little dispersal between sites, resulting in little or no colonization of unoccupied fens. It is likely that unoccupied but apparently suitable fens may have once supported Mitchell's satyr, but extirpation of isolated populations has decreased the number of populations surviving to historical times. Recolonization of isolated fens by such a weakly flying insect may have been uncommon in an unaltered landscape, and has become nearly impossible in today's landscape.

There is no reason to believe that females are incapable of colonizing recently unoccupied habitat patches within a fen complex. Many fen systems have undergone slow succession in the absence of recent disturbance so that suitable Mitchell's satyr habitats are distributed as small patches within a larger matrix of shrub carr or forested fen. Thus, management activities, either hand clearing or prescribed burning, could probably be used to create additional patches of

favorable habitat within fen complexes where Mitchell's satyr populations are restricted to small areas of pre-existing habitat.

The apparently sedentary population structure of Mitchell's satyr may be misleading. Currently, Mitchell's satyr occurs completely within the boundaries of the Wisconsinan glacial maximum (Pleistocene Epoch). During glacial maxima, populations of Mitchell's satyr occurred somewhere to the south of the glacial fronts. While the exact location and number of such refugia may never be known, based on paleoecological data (Pielou 1992), climates such as those which now occur in southern Michigan probably occurred at least 500 km (300 mi) south of the maxima. The simple fact that populations of Mitchell's satyr now occupy habitats exclusively in glaciated regions testifies to the potential metapopulation dynamics of the species. During the last glacial retreat, population(s) of Mitchell's satyr, "moved" northward in a very dynamic ecosystem march during which temperate species immigrated into the boreal regions to the north. This process can be imagined within the confines of stereotypical metapopulation dynamics: as new habitats became suitable, they were colonized by wandering female Mitchell's satyrs. That populations of Mitchell's satyr occur only in limited regions is also revealing. Southern populations that existed during the glacial maximum and intermediate populations located between the refugia and the current range of the species are extinct.

The second line of evidence supporting the potential for a dynamic metapopulation structure in Mitchell's satyr is the apparent dynamic nature of the populations of its southern sister taxon, St. Francis' satyr. This subspecies represents a southern population isolate that is well differentiated from the nominate subspecies. Given the morphological differentiation between these two series of populations (and the apparent lack of geographic variability between disjunct populations of Mitchell's satyr which range from New Jersey to northwest Indiana), it is unlikely that these two subspecies represent populations splintered by the Wisconsinan period, but more likely one of the earlier glacial cycles. Thus, while St. Francis' satyr may not represent the refugial stock from which Mitchell's satyr moved northward, it does represent the phylogenetic sister taxon to Mitchell's satyr: these two sets of populations, although somewhat divergent, are each other's closest relatives.

Based upon two field seasons of observations at Ft. Bragg, North Carolina, Hall (1993) depicts a very dynamic habitat structure for St. Francis' satyr. This single known metapopulation occupies an area of approximately 260 km² (100 mi²), primarily within early successional sedge glades, dominated in part by *Carex* sp. Some of these boggy glades are spring-fed, but unlike fens, they are quite acidic as well as very ephemeral. The glades succeed either to pocosin or swamp forest if not kept open by disturbance regimes that include beaver activity and fire.

S. Hall (1993; North Carolina Natural Heritage Program, Raleigh, pers. comm. 1994) feels that in North Carolina, the association between the ecological role of beavers and St. Francis' satyr was crucial. Through harvesting of trees and dam building, beavers created openings in an otherwise forested or scrubby landscape. When beaver ponds are abandoned, a large expanse of organic muck is exposed which is quickly colonized by sedges, wetland herbs, and mats of sphagnum. In the Carolina sandhills, beaver activity is probably the only natural mechanism that creates *Carex*-dominated sedge meadows. A sedge meadow will persist for approximately 5-10 years after a beaver pond is drained, but will rapidly succumb to succession.

Only further disturbance, such as fire or beaver impoundment can reset the community to the early successional community favored by St. Francis' satyr.

Following the elimination of beaver as a force in the landscape, the persistence of St. Francis' satyr at Ft. Bragg was probably the result of artillery practice. The best glade habitat is located within an artillery impact range which is exposed to scattered shell-ignited fires on an annual basis. This activity acted to maintain existing sedge meadows and even create small crater-rim stands of *Carex*. This area is recognized as the last "major refuge for many coastal plain species that have become endangered primarily through the loss of fire-maintained habitat" (Hall 1993). There is every reason to believe that St. Francis' satyr once occupied similar habitats throughout the Carolina sandhills region, but in the absence of both beaver- and fire-driven disturbance regimes, these populations did not survive to the present (although some isolated populations may survive undetected).

Extrapolating from Hall's observations of St. Francis' satyr, it is possible to imagine a habitat structure even more dynamic for Mitchell's satyr. Beavers were once a dominating landscape force throughout the Great Lakes Region, and evidence indicates that along typical streams, beaver dams occurred at 100-200 m (330-660 ft) intervals (D. Hey, Wetland Research Inc., Chicago, IL, pers. comm.). Also, research in progress indicates that in Wisconsin, drained beaver ponds often become *Carex*-dominated sedge meadows (H. Ericson, University of Washington, Seattle, pers. comm.). However, the exact fate of an abandoned pond is dependent upon a variety of factors, including local hydrology and soils. Unfortunately, Ericson's observations are from the extreme northern limit for *C. stricta*, and this sedge is rarely encountered in her study area.

If the pattern of community development within the range of Mitchell's satyr is similar to that of the sedge glades of the St. Francis' satyr, then it is likely that *C. stricta* would be one of the common sedges to colonize recently exposed pond bottoms. Unfortunately in the lower Great Lakes Region, beaver were rapidly reduced in numbers and eventually extirpated by extensive trapping by the mid-1600's (D. Hey, pers. comm.). If the habitats that develop over drained beaver ponds are exploitable habitat for Mitchell's satyr, it would be easy to imagine a very dynamic system in which the butterfly was a component of a fairly common, early successional community associated with recently drained ponds.

If this scenario is accurate, then the apparently sedentary nature of today's populations reflects more the lack of opportunity rather than ecological reality. With fens offering the only habitat available, and with recently drained beaver ponds an almost nonexistent entity in today's landscapes, populations of Mitchell's satyr have no options but to remain sedentary. Further, with few or no opportunities for successful emigration for approximately 300 generations, the genes which predispose a female to wander may now be reduced in frequency in many populations: females with a genetic predisposition to emigrate essentially commit suicide in today's landscape, removing their genes from the surviving pool. This phenomenon has been documented for butterflies in the sole surviving population of the swallowtail butterfly (*Papilio machaon*) in Great Britain, as well as in the monarch butterfly (*Danaus plexippus*) population that resides on the Bermuda Islands.

In this light, it is noteworthy that some Mitchell's satyr populations seem more sedentary than others. For example, at LaGrange West (Indiana-extirpated) and Cass County East (Michigan-extant), adults occupy(ied) a very small fraction of the seemingly suitable habitat. Both of these sites are small compact wetlands, and butterflies that wander quickly exit these fens. But even at small sites, the confinement of the butterfly to discrete fractions of the available habitats is curious. At other sites such as Berrien County South (Michigan) and LaPorte County Fen (Indiana), Mitchell's satyr is found in almost every habitat that seems appropriate. These two fens are more linear wetland complexes, and suitable habitats are arrayed along stream channels and adjacent seeps. It is conceivable that this wetland configuration provides dispersal opportunities to wandering females, thus potentially conserving the genetic predisposition for wandering.

F. Reason for Listing

Mitchell's satyr historically has always been a rare species and very selective in its habitats. Although it is likely to have been more widespread in the past, fewer than 30 historical populations or sites are known. Various factors have contributed to the decline of the species, and only 15 active populations are known today.

The primary threat to the continued survival of Mitchell's satyr is the loss and disruption of suitable fen habitats. Wetland alteration or complete draining has resulted in the loss of the single known Ohio population of the butterfly, and in the loss of populations at several sites in Michigan. Wetland alteration may also lead to nuisance plant invasions such as *Lythrum salicaria* (purple loosestrife), *Rhamnus cathartica* (common buckthorn), *R. frangula* (glossy buckthorn), and *Phragmites australis* (reed grass).

Complicating the loss of fen habitat for the species is the disruption of landscape-scale processes which may be crucial for the maintenance of habitat suitability and/or the creation of new habitats for Mitchell's satyr. Historical disturbance regimes such as wildfire, fluctuations in hydrologic regimes, and the flooding caused by beaver have all but been eliminated or modified throughout the range of Mitchell's satyr. Surviving populations now occupy highly isolated fens in which successional processes are slowed, but not eliminated by the discharge of calcium carbonate laden groundwater. Eventually, in the absence of some process which resets succession to an earlier stage, the surviving fen habitats will become increasingly unsuitable as habitat for Mitchell's satyr. As habitats become more isolated, dispersal between populations and suitable unoccupied habitats becomes increasingly unlikely, and the rate of extirpation outpaces the establishment of new populations. This may account for the disappearance of several historically known populations at pristine wetland sites.

Unlike most other species of Lepidoptera, Mitchell's satyr is potentially vulnerable to routine collecting. Anecdotal evidence exists for the elimination of the New Jersey Mitchell's satyr population due to overcollection. Commercial exploitation of Mitchell's satyr for the black market will likely continue as long as the monetary reward exceeds the perceived risk of knowingly violating federal and state laws. At a given site, commercial exploitation is likely to be short term but intense, with every marketable specimen encountered removed from the population. Depending upon the timing relative to the reproductive phenology of the butterfly, there may or may not be a significant lasting impact on local populations. Fear of detection may

deter repeated commercial exploitation at a given site, but there is no evidence of this. Sporadic collection may help dampen the impact by allowing time for populations to recover in subsequent years.

G. Conservation Measures

Conservation Measures are scientific studies, laws that provide protection, and other activities that affect the conservation of Mitchell's satyr.

1. Studies

In the past, seasonal field surveys were designed to assess the range-wide distribution of the butterfly. More currently, survey work in 1994 and 1995 assessed the distribution of Mitchell's satyr within large, defensible wetland complexes already known to support the species. This information will be used to assess the potential for preserving wetland systems which support or have the potential to support several independent sub-populations of the butterfly, and which are most likely to lessen the effects of habitat isolation on the population dynamics for the species. Surveys will be conducted at four such complexes in Michigan and two areas in Indiana. In New Jersey and Ohio, newly discovered and poorly known fens will continue to be surveyed for the presence of this butterfly.

A host plant affinity study was begun in 1993 by MNFI. Gravid females were confined in field cages placed over naturally growing sedges within one Mitchell's satyr site. Observations to date indicate that early instar larvae feed primarily upon newly sprouted sedges, either seedling or new root spouts (M. Rabe, pers. comm.). Observations also indicate that previously reported (McAlpine et al. 1960) life history traits, particularly population estimates, may be somewhat inaccurate, probably the result of McAlpine's artificial rearing conditions. This research continued through 1996 and may continue into the future.

In July, 1995, Dr. John Shuey (TNC, Indianapolis, IN) with the U.S. Fish and Wildlife Service Bloomington Indiana Field Office translocated eight pairs of Mitchell's satyr adults from one portion of the LaPorte County site to a location 3-5 km (2-3 mi) away within the same fen complex. The new location is owned by TNC. This site contains suitable habitat and is known not to have been previously occupied by the butterfly. No Mitchell's satyrs were observed during the 1996 or 1997 field seasons. Searches will continue into the future (J. Shuey, pers. comm.).

A University of Minnesota graduate student and Dr. Shuey began a life history study in June, 1997 at the Berrien County North and South sites. The study focuses on adult behavior, including oviposition behavior, and habitat use. Mark-release-recapture techniques were employed. Habitat analysis will begin in 1998. The Service's East Lansing Field Office is coordinating the project to assist MDOT in fulfilling their obligations under the April 1994 biological opinion (see 2. Federal Protections). When the life history study and habitat analysis are completed, a conservation plan for the site will be created, which will include management and monitoring plans. However, years of additional research in addition to trial and error management will be required to fully understand the Mitchell's satyr life history and how best to manage it.

2. Federal Protections

The Endangered Species Act of 1973, as amended (Act) provides multiple sections that promote conservation of Mitchell's satyr. Section 9 of the Act prohibits any person subject to the jurisdiction of the United States from harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collecting listed wildlife species. It is also unlawful to attempt such acts, solicit another to commit such acts, or cause such acts to be committed. Regulations implementing the Act (50 CFR 17.3) further define "harm" to include significant habitat modification or degradation that results in the killing or injury of wildlife by significantly impairing essential behavioral patterns including breeding, feeding, or sheltering. "Harass" means an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering.

Section 7 of the Act requires Federal agencies to consult with the Service prior to authorizing, funding, or carrying out activities that may affect listed species. Section 7 also requires that these agencies use their authorities to further the conservation of listed species. An example of a Federal activity that may affect Mitchell's satyr, thereby triggering Section 7(b) consultation, involves the proposed U.S. 31 freeway construction through the Berrien County South site, Michigan. A jeopardy Biological Opinion was rendered by the Service's East Lansing, Michigan Field Office, for that project, in April 1994.

The Biological Opinion determined that the proposed bridge could be built with agreed upon modifications designed to minimize impacts to Mitchell's satyr. However, it was also determined that threats to the butterfly remained and additional measures were needed to eliminate impacts. The Biological Opinion contained "reasonable and prudent alternatives" pursuant to 50 CFR 402.02. These are alternative actions to the proposed action, that (1) can be implemented in a manner consistent with the intended purpose of the action; (2) can be implemented consistent with the scope of the agency's legal authority and jurisdiction; (3) are economically and technologically feasible; and (4) would, in view of the Service, avoid the likelihood of jeopardizing the continued existence of listed species or result in the destruction or adverse modification of critical habitat. The reasonable and prudent alternatives section required the following actions:

- Life history, habitat investigations, and population structure of Mitchell's satyr at the Berrien County South site including studies to identify microhabitat components and estimate the type and frequency of past habitat disturbance events. The Michigan Department of Transportation (MDOT) is currently coordinating life history and habitat investigations.
- Acquisition and/or conservation easement protection of butterfly occupied habitat to ensure the likelihood of survival and recovery of Mitchell's satyr. This includes 15.6 ha (38.5 ac) of fen and adjoining upland habitat at the Berrien County South site and 486 - 567 ha (1200 - 1400 ac) of habitat at several key sites. Michigan TNC and MDOT have recently reached an agreement under which TNC will acquire key Mitchell's satyr habitat from willing sellers and manage it.

- Beneficial management of Mitchell's satyr habitat at the Berrien County South site and the Jackson County West site, to ensure the likelihood of survival. A private land conservancy is currently considering taking over ownership and management of the site.

Section 10 of the Act provides for permits that may be granted to authorize activities prohibited under Section 9, for scientific purposes or to enhance the propagation or survival of a listed species. Section 10 permits were granted in 1992 and 1994 for Mitchell's satyr abundance, distribution, and habitat use studies within the Berrien County South site and adjacent fen systems. Section 10 permits will likely be granted for some Recovery Activities listed in Section II B of this Plan. Also under Section 10, it is legal for employees or designated agents of certain Federal or State agencies to take listed species without a permit, if the action is necessary to aid sick, injured, or orphaned animals or to salvage or dispose of a dead specimen. Further, State conservation agencies and their designated agents have certain "take" authority for species listed as endangered if the species are covered by a Cooperative Agreement with the Service (see discussion of Section 6, below). Activities that may proceed are limited by regulation, but may include many recovery research projects that are identified in this plan. The limits on this authority are detailed in 50 CFR 17.21 (c)(5).

Section 10 of the Act allows permits to be issued for take on non-federal land where no federal action is involved that is "incidental to, and not the purpose of, carrying out an otherwise lawful activity" if the intent is not for research or recovery activities. An applicant for an incidental take permit must prepare a habitat conservation plan that specifies the impacts of the take, steps the applicant will take to minimize and mitigate the impacts, funding that will be available to implement these steps, alternative actions to the "take" that the applicant considered, and the reasons why such alternatives are not being utilized. No one has yet applied for a Section 10 incidental take permit for Mitchell's satyr under this program.

Section 6 of the Act provides for Cooperative Agreements between the Service and state agencies that have approved conservation programs for listed species. Currently, the Michigan Department of Natural Resources has an ongoing three year management, protection and recovery project for Mitchell's satyr. Identified objectives include surveys of fen complexes with known Mitchell's satyr populations to include all potential habitat occurring throughout the watershed, continue behavioral studies of larvae and adults initiated in 1993, and surveys of new areas with potential habitat.

3. State Protections

Mitchell's satyr was listed as a threatened species by the Michigan Department of Natural Resources in 1987. It was listed pursuant to Michigan's Endangered Species Act (PA 203 of 1974), now the Endangered Species Protection of the Natural Resources and Environmental Protection Act (Part 365 of Public Act 451 of 1994). The butterfly was elevated to endangered species status in 1991, coincident with its Federal listing. Part 303 of Public Act 451 also provides for the preservation, management, protection, and use of certain wetland habitats. The law lists habitat for threatened and endangered wildlife species as a criteria to be considered in the administration of the Public Act.

4. Interagency Measures

In September 1994, 14 Federal agencies, including the U.S. Fish and Wildlife Service, National Park Service, U.S. Coast Guard, U.S. Army Corps of Engineers, and the Department of Defense signed a Memorandum of Understanding affirming their commitments to carry out programs for the conservation of species listed under the Act and the ecosystems upon which they depend, including implementing appropriate recovery actions that are identified in recovery plans. No actions under this memorandum have been undertaken to date.

5. Conservation Organization Activities.

The Michigan Chapter of The Nature Conservancy has drafted protection and management plans for three of the five primary Mitchell's satyr sites in Michigan. Working from these plans, TNC has recently acquired a parcel in Hillsdale County and is discussing acquisition and other protection options with landowners at several key Mitchell's satyr sites. Through their landowner contact program, they are also educating neighbors of their preserves about the significance of these sites and helping them manage their lands in a compatible manner. The Michigan Chapter of TNC has also recently signed an agreement with the Michigan Department of Transportation under which TNC will acquire and manage Mitchell's satyr habitat as partial mitigation for the habitat lost through the construction of the US-31 freeway/bridge project in Berrien County.

H. Strategy of Recovery

Very little is understood about the ecological requirements, life history, and population structure of the Mitchell's satyr. A solid understanding of these basic parameters is required to fully protect the species from extinction. A research program that targets Mitchell's satyr and its supporting habitat is necessary. This information is required to implement protection and management activities to insure the long-term survival of this species. Without a better ecological understanding of Mitchell's satyr, protection efforts will remain in the realm of "best guesses" rather than the positive and confident efforts required for recovery of this insect.

Many of the more viable populations of this insect occur on private lands that are subject to potentially incompatible use. Habitats which support Mitchell's satyr must be protected. Protection of sites will be accomplished by a variety of voluntary programs. These include landowner agreements with private or governmental agencies, perpetual conservation easement purchase by a private or governmental agency, wetland easement under the Wetland Reserve Program and administered by the Natural Resource Conservation Service, or fee title purchase from willing sellers and ownership by a private conservation organization, state, or federal agency. The protection of habitat at the best remaining wetland complexes supporting Mitchell's satyr is a necessary step towards recovery of this species.

The identification of key population sites that are vulnerable to poaching is necessary. Each site would be evaluated on the size of occupied habitat, ease of access, potential for landowner/volunteer patrol, and enforcement. Protection of these key population sites during the flight season, on an "as needed" basis, is necessary.

Because so few viable populations of Mitchell's satyr are known, historical sites, when feasible, must be reestablished. Several historical sites once known to have supported this insect still provide seemingly suitable habitat. Conversely, many Michigan sites that are no longer extant no longer provide suitable habitat. Even if the historical habitat appears suitable, reintroduction potential would require some assessment of the causes that made the butterfly disappear in the first place. However, these assessments may be difficult, as addressed by MacKinnon and Albert (1996). They found that the extirpation of many historical populations is not directly linked to decline of currently presumed suitable habitat.

Likewise, many wetland complexes not previously known to have supported Mitchell's satyr but which occur within the historical range of the species may also provide suitable habitat. Such suitable but unoccupied habitats need to be identified and protected, and populations of Mitchell's satyr introduced to increase the total number of populations of this insect.

A successful introduction effort may require that a rearing facility for Mitchell's satyr be established to provide introduction livestock without depleting wild populations. Rearing facilities will require additional research on the best way to achieve results. One method is to "milk" a few females for as many eggs as possible and the offspring raised for release the next summer, a successful method for other satyrines (J. Shuey, pers. comm. 1996). A permanent rearing facility is discouraged due to the inherent problems with disease, inbreeding depression, biased survivorship and mating and the resulting shifts in genetic frequencies.

II. RECOVERY

A. Objective and Criteria

The objective of this recovery plan is to perpetuate viable populations of Mitchell's satyr throughout their former range thereby allowing reclassification, and ultimately removal, of this species from the Federal List of Endangered and Threatened Wildlife and Plants (50 CFR 17.11 and 17.12)

Mitchell's satyr may be considered for reclassification from endangered to threatened when 16 geographically distinct, viable populations or metapopulations are established or discovered range wide. These 16 populations, or metapopulations, will include, at a minimum, 12 in southern Michigan; two in Indiana; one in Ohio; and one in New Jersey. At least 50 percent of these sites will be protected and managed to maintain Mitchell's satyr habitat.

Delisting the species will be considered when nine additional, for a total of 25, geographically distinct, viable populations or metapopulations are established or discovered range wide and remain viable for five consecutive years following reclassification. A minimum of 15 of these sites will be protected and managed to maintain Mitchell's satyr habitat by state or federal agencies or by private conservation organizations before delisting will be considered.

A metapopulation can be defined as a patchwork of interacting populations (i.e. sub-populations) over a wide and heterogenous area of landscape. An accurate definition of a viable population is problematic due to limited life history information available. However, during a December, 1997 general coordination meeting between researchers involved with the Mitchell's

satyr, a decision was made that recent field research provided enough information to propose a preliminary working definition for viable population in the form of minimum performance standards. The researchers involved, some of whom are Recovery Team members, represented the U.S. Fish and Wildlife Service, Michigan and Indiana Chapters of The Nature Conservancy, and the Michigan Heritage Program (Michigan Natural Features Inventory). The resultant definition follows, with the understanding that it will be reviewed and revised pursuant to new information and input from experts.

A site must have the following four components to be considered a viable population:

- 1) A reasonable expectation of 300 individuals per brood, on average, for 5 of 7 years, with no fewer than 50 individuals on any given year, and a stable or increasing population.
- 2) A protected core of occupied habitat sufficiently large to allow for a mosaic of natural wetland vegetation types which are maintained by management or natural processes.
- 3) An adequate upland buffer of natural vegetation around the occupied core.
- 4) A landscape surrounding the core that maintains the quality and quantity of the groundwater feeding the wetland.

Each state in which the Mitchell's satyr occurs or had occurred needs to develop an internal plan for meeting their designated recovery goals so that a prioritized acquisition/protection plan, identification of restoration needs, partnerships and possible funding sources can be developed.

B. Step-down Outline

- 1.0 Mitchell's satyr surveys.
 - 1.1 Survey for previously unknown populations of Mitchell's satyr.
 - 1.2 Monitor extant populations and determine precise distribution of Mitchell's satyr at known population sites.
- 2.0 Research needs.
 - 2.1 Conduct cage studies of larval ecology.
 - 2.2 Quantify habitat requirements and use.
 - 2.3 Study response to habitat disturbance.
 - 2.4 Determine minimum population viability.
 - 2.5 Conduct captive rearing/reintroduction studies.
- 3.0 Protect all known occurrences, placing priority on achieving effective protection for the highest ranking occurrences and essential habitat.
 - 3.1 Identify populations vulnerable to poaching and provide protection during the flight season.

- 3.2 Protect essential habitats.
- 3.3 Provide and update current site occurrence information at least yearly.
 - 3.3.1 Provide current site occurrence information at least yearly to all appropriate departments and divisions of pertinent Federal, State, and local public agencies.
 - 3.3.2 Update U.S. Fish and Wildlife Service records.
 - 3.3.3 Update State Land and Water Management Division records.
 - 3.3.4 Update Michigan, Indiana, New Jersey, and Ohio Departments of Transportation rights-of-way records to ensure transfer of data to District Offices.
- 3.4 Develop habitat management plans.
- 3.5 Implement habitat management plans.
- 3.6 Develop written agreements and provide management plans for protection on public lands.
- 3.7 Promote protection of occurrences on privately owned land.
 - 3.7.1 Continue private landowner contact.
 - 3.7.2 Provide management guidelines to private landowners.
 - 3.7.3 Promote private landowner involvement in a registry program.
- 3.8 Promote development of local zoning ordinances favorable to the protection of Mitchell's satyr and its habitat if existing laws are inadequate.
- 3.9 Recommend and support sites for potential State Natural Area designation.
- 3.10 Encourage land acquisition.
- 4.0 Develop an outreach program.
- 5.0 Reintroduce into suitable but unoccupied habitats.
 - 5.1 Establish Mitchell's satyr breeding facilities.
 - 5.2 Reestablish historical populations.

C. Narrative Outline for Recovery Actions Addressing Threats

1.0 Mitchell's satyr surveys.

Although there has been a fair amount of effort expended searching for populations of Mitchell's satyr, (e.g., Wilsman and Schweitzer 1991), a lack of detailed information required to develop appropriate conservation and protection measures persists. Management activities which may improve habitat quality but which may have a short-term negative impact on Mitchell's satyr can not be safely implemented without this information. In addition, not all sites with the potential for supporting this butterfly have been surveyed. Before reintroduction of Mitchell's satyr in Ohio and New Jersey is attempted, more confidence that resident populations do not exist in these states is needed.

- 1.1 Survey for previously unknown populations of Mitchell's satyr. In Michigan and Indiana, additional potential habitats need to be searched to determine the number of populations in existence. Emphasis should be placed on seemingly pristine wetland complexes from which Mitchell's satyr is historically known, but for which no recent records exist. In addition, other wetlands within the known range of Mitchell's satyr need to be searched for its presence. In Ohio and New Jersey, and possibly Maryland, potential habitats near the known historical sites need to be searched for Mitchell's satyr. While the potential for rediscovery of the butterfly is minimal, the extirpation of this species needs to be documented as fully as possible before reintroduction attempts can proceed.

Historical site conditions can be assessed from maps depicting the presettlement vegetation as determined by interpretation of the General Land Office (GLO) survey notes (1816-1856). These were notes taken during the establishment of township, range, and section lines for the disposal of public lands under the *Act of May 18, 1796*, 1 Stat. 464, and subsequent legislation (Comer et al. 1995). Additional analysis with GLO on a range-wide assessment may help clarify the probability that a site was occupied by the Mitchell's satyr historically. This, with the addition of remote sensing data, will help guide survey activities and identify potential habitat/sites for acquisition and introduction.

- 1.2 Monitor extant populations and determine precise distribution of Mitchell's satyr at known population sites. Extant populations of Mitchell's satyr need to be monitored annually during the recovery process. Annual monitoring will provide the long-term data record required to assess recovery success and will be essential for evaluating the success or failure of implemented management plans at each population site. Further, the distribution of the Mitchell's satyr within occupied wetland complexes is unknown. Determination of within-site distribution will assist future monitoring efforts and provide other butterfly behavioral information necessary for formulating wetland management strategies discussed in research task 2.2-Quantify habitat requirements and use.

2.0 Research needs.

Our current understanding of the biology and ecology of Mitchell's satyr is inadequate to allow effective long-term protection measures to be implemented for this species. For example, the weight of evidence indicates that *C. stricta* is the primary hostplant in Michigan and Indiana, but this has not been verified. Furthermore, ongoing studies indicate that new seedlings and/or root sprouts may be crucial for early instar larvae. Before strategies can be developed to ensure the long-term survival of this butterfly, a better understanding of habitat requirements, larval ecology and wetland habitat dynamics as they relate to this species must be developed. Knowledge that is especially important for developing management strategies for the Mitchell's satyr includes the relationship between larval behavior, ecological requirements, and the effects of prescribed burning, flooding and/or other processes which maintain fens and sedge meadows. When we increase our understanding of these relationships, determining better criteria for minimum population viability should then be possible. Finally, research is needed to understand the

best methods to reintroduce the butterfly into suitable habitats by studying captive rearing methods.

2.1 Conduct cage studies of larval ecology. The only life history information available for Mitchell's satyr is derived from laboratory rearings using potted food plants. These observations provide no insights into larval ecology or behavior. Using field cages, detailed observations of larval behavior and ecology under nearly natural conditions can be obtained. These observations should illuminate life history traits such as oviposition substrates, hostplant use, feeding patterns, larval resting and diapause locations, rates of growth and development, and temporal site and microsite variations. More complete knowledge of larval ecology and behavior will help us refine habitat requirements and management strategies for the species.

2.2 Quantify habitat requirements and use. Seemingly suitable habitats are not occupied by Mitchell's satyr. A more detailed assessment of occupied and non-occupied habitat structure and plant species composition needs to be completed to determine the range of suitable habitats for this butterfly. Determination of within-site distribution, assessed during monitoring, would reveal dispersal trends and areas critical to reproduction. Mark-release-recapture studies would facilitate determination of annual adult density fluctuations and within-site dispersal. This information is essential to formulate management strategies for the protection and management of wetland complexes occupied by the Mitchell's satyr.

Also, an assessment of the causes that made the butterfly disappear at historical sites is needed. This study will provide the baseline data required for assessing the success of future habitat management activities, as well as provide insights into the suitability of sites contemplated for future reintroduction efforts.

2.3 Study response to habitat disturbance. Natural processes and disturbances may be essential for maintaining habitats for Mitchell's satyr. Research is needed to determine these natural disturbances and whether fire is among them. Some types of natural disturbance regimes may be lethal to some or all life stages of Mitchell's satyr and other rare and important associate fen species. Thus it is vital that their response to disturbance be fully understood before management plans incorporating disturbance at sites supporting this butterfly are implemented. These disturbance-management plans should be tested, monitored, and evaluated at unoccupied sites initially. If life stages of Mitchell's satyr or other important associate fen species could be negatively impacted by disturbance management activities, partial site-specific disturbance-management plans and intensive monitoring may be considered to assure that sufficient portions of suitable habitat remain undisturbed and available for these species. Finally, research should also focus on Mitchell's satyr's ability to disperse and reoccupy burned habitats. This is especially important since the current landscape often does not offer nearby sources for repopulating a burned site.

2.4 Determine minimum population viability. Determining a set of minimum population viability criteria will require the cooperative efforts of the Recovery

Team, the scientific community, and resource agencies. These criteria will likely include population size, habitat, and management/protection components. Knowing which populations are viable will allow for an accurate assessment of the species status and the ability to select appropriate management actions.

- 2.5 Conduct captive rearing/reintroduction studies. Studies are needed to determine criteria for selecting suitable reintroduction sites. If suitable sites exist, studies are needed to develop methods for rearing eggs, larvae, or adults for release into these habitats. Finally, studies are needed to determine appropriate methods for reintroductions that include seasonal timing and life stages.
- 3.0 Protect all known occurrences, placing priority on achieving effective protection for the highest ranking occurrences and essential habitat.

Strategies for the conservation of Mitchell's satyr occurrences should focus on the protection of essential habitat and the natural environmental processes that maintain it. These strategies involve a number of approaches, often in combination, to achieve as much protection as possible for the relatively few occurrences that exist. Protection should also include key buffer areas that enhance the integrity of occurrences as well as the immediate habitat of the species. Also, fragmentation of occurrences should be avoided. The protection of Mitchell's satyr and its habitat helps to ensure the protection of fen ecosystems which also supports several other rare plants and animals.

- 3.1 Identify sites vulnerable to poaching and provide protection during the flight season. Each site would be evaluated on the size of occupied habitat, ease of access, potential for landowner/volunteer patrol, and enforcement.
- 3.2 Protect essential habitats. Essential habitat is defined to mean areas that are presently occupied by Mitchell's satyr and have not undergone major alterations or successions, or areas that at one time contained the butterfly and can be utilized at some future time for reintroductions of the butterfly. Also, essential habitat that is subjected to disturbance, modification, destruction, or human activity might be expected to result in a further reduction in numbers of this species, or in a reduction in its potential for expansion or recovery.

Several fens which currently or historically supported Mitchell's satyr are already protected by State or private conservation organizations. However, several areas that have been determined to be essential for the species conservation are unprotected by conservation agreements, easements, or public ownership. For example, three of the four largest Mitchell's satyr populations (based on 1993 counts) are unprotected. At other sites, a portion of a wetland complex may be protected, but essential habitats for Mitchell's satyr may not be included within these protected lands.

Steps to enable permanent protection at the following primary Mitchell's satyr sites should be taken as soon as possible. Other, secondary priority sites

should also be protected as they become available. These sites will play a crucial role in the stabilization of precarious populations.

Michigan

Berrien County South - This site supports one of the largest known populations of Mitchell's satyr and is extremely vulnerable to the increasing urbanization of southwestern Michigan. A proposed four-lane state highway bridge may effectively bisect this elongated fen complex and Mitchell's satyr population. The preservation of this fen is crucial to decreasing the range-wide vulnerability of Mitchell's satyr.

Berrien County North - This site is managed as a natural interpretive center. It is important to insure that its management includes protection of fen communities and Mitchell's satyr habitat.

Jackson County East - This fen supports what was once one of the largest known populations of Mitchell's satyr. This is one of the most botanically diverse prairie fens in southern Michigan, and protection of this site will not only serve a key role in preserving Mitchell's satyr, but will provide protection of many other state and federal candidate species.

Cass County East - This area is the type locality for Mitchell's satyr and other Lepidoptera species, and supports one of the larger Mitchell's satyr populations known. Early in the 1994 flight season, up to eight males could be seen simultaneously in portions of this complex. Although TNC owns a portion of this complex, the most productive Mitchell's satyr habitat is privately owned and adjacent to a hog farm. Protection of this wetland complex is crucial for the recovery of Mitchell's satyr.

Cass County Southwest - This site supports one of the best Mitchell's satyr populations in Michigan but is not managed or protected from a biodiversity standpoint. In recent surveys, Mitchell's satyr was found in almost all areas with seemingly suitable habitat (M. Rabe, pers. comm.). The protection of this complex will add significantly to the range-wide stabilization of Mitchell's satyr.

St Joseph County Site - This wetland complex is largely protected as a state game area. However, essential habitats which support Mitchell's satyr are privately owned, and adjacent upland areas are rapidly being developed. These areas need to be protected before they are damaged by construction activities or by nutrient enrichment from septic drainage.

Indiana

LaPorte County Site - This area supports one of the largest and densest Mitchell's satyr populations known. The southern portion of this fen is partially protected by TNC, but this portion of the fen does not currently support the butterfly. The

northern portion of the fen is currently in private ownership, and should be protected. The protection of the entire fen complex including the northern and southern fens and adjacent buffers (as designed by Indiana Department of Natural Resources) will be vital for assuring the long-term viability of this Mitchell's satyr population.

LaGrange County West Site - This area supported the best known population of Mitchell's satyr in Indiana and is a key component in a proposed TNC ecosystem initiative designed primarily to protect a dense concentration of fens located along the Pigeon River. Protection of this site will help anchor the northern edge of the proposed Pigeon River Bioreserve, and after successful reintroduction, will serve as an important population site for Mitchell's satyr within this large-scale preserve system.

- 3.3 Provide and update current site occurrence information at least yearly. Land protection, the foundation of recovery efforts, is based on communication of occurrences and management information to Federal, State, and local government agencies and significant private landowners. Principal cooperators include: The U.S. Fish and Wildlife Service, the Michigan Department of Natural Resources, the Indiana Department of Natural Resource, the Ohio Department of Natural Resources, the New Jersey Department of Environmental Protection, the Michigan, Indiana, New Jersey, and Ohio Departments of Transportation, township and city governments, The Nature Conservancy, via the Michigan, Indiana, New Jersey, and Ohio Heritage field offices, and private landowners.
 - 3.3.1 Provide current site occurrence information at least yearly to all appropriate departments and divisions of pertinent Federal, State, and local public agencies. Distribute state Natural Heritage Program databases of Mitchell's satyr occurrences to all appropriate offices at least yearly so that land managers may use current information to make management decisions and anticipate and avoid actions that may adversely affect populations or essential habitat.
 - 3.3.2 Update U.S. Fish and Wildlife Service records. Update files of the Service's Regional offices yearly or more often, if possible, and distribute information to the Field Offices responsible for the occurrences. Consult these files when reviewing permit applications and during consultations with other Federal agencies.
 - 3.3.3 Update State Land and Water Management Division records. Update occurrence and management information yearly or more often if possible and consult during permit reviews.
 - 3.3.4 Update State Departments of Transportation rights-of-way records and ensure transfer of data to District Offices. Currently, only one Mitchell's satyr occurrence is within or along MDOT/IDOT right-of-ways. Still, this

information would be important to District Offices for future road planning so that impact can be avoided.

- 3.4 Develop habitat management plans. Management plans must detail the goals, tactics, and proposed management areas relative to occupied habitat. Most habitats will have to be actively managed to remain suitable for Mitchell's satyr. For example, in most Michigan and Indiana fens which support this butterfly, shrub encroachment is currently reducing available habitat. Other invasive, non-native species such as *Rhamnus frangula* (glossy buckthorn), *Lythrum salicaria* (purple loosestrife) and *Phragmites australis* (reed grass) also reduce available habitat for this butterfly and must also be aggressively managed. Site-specific management plans should be developed for each of the 15 Mitchell's satyr population that must be protected and managed to meet the delisting goal. These plans should clearly differentiate between short-term management activities designed to restore and enhance Mitchell's satyr habitat, and long-term activities which will be required for maintaining suitable habitat into the foreseeable future.

In developing management plans to control woody succession or invasive, non-native species, agencies must recognize potential negative impacts that these activities may have on Mitchell's satyr and other rare invertebrates limited to these habitats. For example, prescribed burning may produce direct mortality of immature stages (although it is not known whether this is true, a conservative approach must be followed at this time). Thus, nearby unburned, occupied habitat must exist from which Mitchell's satyr can repopulate recently managed areas. Herbicide treatments may likewise negatively impact this butterfly.

Most viable sites are where geologic conditions, such as ground water discharge, and/or streambank flooding, have maintained suitable habitat. Site management plans need to insure protection of these geologic processes, specifically, (1) ground water levels and flow gradients in the aquifers supporting the known and potentially viable ground-water supported sites and (2) water quality, specifically nutrient concentration within the aquifers. Also, it may be that the butterfly's habitat is defined, in part, by the timing and duration of seasonal flooding or surface saturation, particularly as these affect *C. stricta* and woody encroachment. A precise understanding of the hydrologic regime requirements are needed in order to formulate an appropriate management plan.

- 3.5 Implement habitat management plans. Because many Mitchell's satyr populations currently exist at very low densities and occupy very limited patches of habitat, aggressive but well planned management is crucial and should be implemented as quickly as possible, ideally by year three and continuing into perpetuity, as needed. Before management plans are implemented, they must be approved by the Service.
- 3.6 Develop written agreements and provide management plans for protection on public lands. Because Mitchell's satyr is a listed species, public agencies have a legal obligation to protect the species. To ensure a high level of protection now, as well as when and if the species is delisted, it is important to obtain written

commitments to protect the species and its habitat in perpetuity. This is especially important when public lands are managed for multiple purposes. Guiding the protection of occurrences on public lands by the preparation of specific management plans will best enable occurrences to be self-perpetuating. Prepare concise and understandable management plans for public agencies and government units, which often experience frequent personnel changes and need a familiar and consistent management policy. Many of the materials developed for private landowner contact (elaborated in section 3.7) can also be used to educate public land managers.

3.7 Promote protection of occurrences on privately owned land through an outreach program. Continue to notify private landowners and provide them with educational materials. This is essential to both the short and long-term conservation of Mitchell's satyr and can result in voluntary agreements to protect occurrences through a registry program. This has been an ongoing program through MNFI and Indiana Natural Heritage Program and will need to continue if new occurrences are discovered.

3.7.1 Continue private landowner contact. Communicate to all private landowners on whose property Mitchell's satyr occurs that a Federal and State endangered species occurs on their land. Landowner notification or contact is an immediate, short-term recovery action fundamental and precursory to long-term recovery efforts. Prepared educational materials would include the following: Information on the rarity of the species, an understandable and non-technical description and illustration of the butterfly, the species requirements to be self-sustaining, why the species is rare, and the value of protecting the species. Appraise landowners of the legal protection afforded by the Federal and State Endangered Species Acts. Notify adjacent landowners whose property provides contiguous and potential habitat so they will know not to engage in activities indirectly detrimental to the species. Transmit new information as it becomes available so that notification is a continuing process.

3.7.2 Provide management guidelines to private landowners. Provide landowners with specific instruction and guidelines for site management. Such guidelines are best prepared by the natural resource agency, such as State Natural Heritage Programs, and can be distributed with other prepared educational materials.

3.7.3 Promote private landowner involvement in a registry program. Encourage landowners to sign private registry agreements, which are non-legally binding contracts that are proactive alternatives and can provide significant protection for many occurrences. Registry can provide short-term protection and may ultimately lead to long-term protection through donation, legally binding conservation easements

(pursuant to State of Michigan Public Act 190 of 1980), Natural Area Designation, or purchase by a public agency.

- 3.7.4 Contact and inform local governments (counties, townships, etc.) to the presence of the Mitchell's satyr butterfly. Communicate to local governmental units the presence of the Mitchell's satyr within their jurisdiction and the legal protection afforded by Federal and State Endangered Species Acts. Provide prepared educational materials similar to that provided private landowners.
 - 3.8 Promote development of local zoning ordinances favorable to the protection of Mitchell's satyr and its habitat if existing laws are inadequate. If protection is inadequate within local governmental units, local zoning ordinances, such as those that protect natural features, may provide an additional measure of protection for several Mitchell's satyr occurrences.
 - 3.9 Recommend and support sites for potential State Natural Area designation. Work towards designation of areas as State Natural Areas as provided for by the Michigan Wilderness and Natural Areas Act (P.A. 241) or Indiana's equivalent. This provides a large measure of protection for appropriate public lands. Achieve long-term protection by eliminating or controlling activities (e.g., logging, certain types of recreation, and incompatible development) that would reduce the quality of the State Natural Area and adversely affect rare animal and plant species.
 - 3.10 Encourage land acquisition. Pursue land acquisition, from willing sellers, through Federal and State agencies and private conservation organizations such as TNC. The Natural Resources Land Trust Fund is a potential source of funding for the acquisition of public lands. Land acquisition can protect significant Mitchell's satyr occurrences and their habitats as well as preserve adjacent habitats that can buffer occurrences, or may eventually be colonized.
- 4.0 Develop an outreach program.

Outreach and protection activities are intimately linked. Outreach programs should be developed to reach beyond those not already covered by landowner contact programs. Outreach will help to build public support for Mitchell's satyr management efforts. This would be important if prescribed burning, or other disturbance management, was determined an important tool and needed to be used, especially in residential areas. Outreach methods could include use of the media to keep local communities informed of the butterfly's status, fact sheets and/or brochures distributed to the general public, table-top exhibits in community centers, post offices, highway rest areas, etc., and lesson plans distributed to schools within the butterfly's range.

Outreach programs should also be developed to address potential poaching problems by incorporating appropriate information into the above programs, and developing specific programs for special interest groups, clubs, symposia, and professional conferences.

5.0 Reintroduce into suitable but unoccupied habitats.

Reintroduction of Mitchell's satyr into suitable habitats throughout its historical range will be an important component of the recovery of this species. Some wetland habitats are currently being managed with disturbance processes intended to create approximations of pre-settlement ecosystem conditions. It is likely that populations of Mitchell's satyr occupied some of these habitats prior to the elimination of disturbance regimes. Now that these wetlands are being managed with occasional fire, Mitchell's satyr could be reintroduced into these sites, providing this has been determined to be appropriate. Reestablishing Mitchell's satyr populations in these habitats is a desirable and important step towards decreasing the species' vulnerability. This will be a crucial action in every state with historical populations of this butterfly.

Only a few populations now seem to reach high enough densities to serve as source populations for the establishment of laboratory stock for reintroduction. Whether Indiana or Michigan populations are used for reintroduction is probably of little consequence. Although not yet investigated, genetic variability is likely insignificant given the limited geographic area these populations occupy, and the relatively brief geological and evolutionary time they have existed.

Reestablishment in Ohio and New Jersey presents special problems. These areas are disjunct from the extant population centers in Michigan and Indiana, and there is a high probability that these populations were genetically adapted to unique environmental conditions. Thus, every effort should be made to locate extant, native populations in Ohio and New Jersey before reintroduction of Michigan and Indiana stock into Ohio and New Jersey is attempted.

- 5.1 Establish Mitchell's satyr breeding facilities. It seems likely that simple translocation of adult Mitchell's satyrs from existing populations to new or unoccupied sites will be infeasible. Most of the extant populations support densities that are too low to serve as the source of the large number of gravid females that would be required for simple translocation. Removal of 10-20 females from even the healthiest populations known is likely to have a significant impact in subsequent years. Therefore, it will be vital to develop an alternate source of individuals for reintroduction purposes. A facility for rearing Mitchell's satyr would provide stock for establishing new wild populations and enhancing existing wild populations without depleting wild populations.

Establishing a breeding facility may be accomplished by establishing a true laboratory culture or experimental population of Mitchell's satyr. Excess larvae, pupae, or adults could be culled from laboratory or experimental populations for introductions. However, establishing a true laboratory culture may be difficult and can result in selection for undesirable traits in the animals to be released. Preferably, a facility could be developed which carefully rears, on an annual basis, the offspring of a few wild-caught females for use in reintroductions. By removing as few as four wild females

annually, up to 400 larvae, pupae, or adults may be available for reintroduction to suitable habitats. By annually removing wild-caught females for egg production, problems which often develop in laboratory cultures such as inbreeding and genetic drift can be avoided. Further, with this approach the source stock for reintroductions and supplementation efforts can be changed annually to assure appropriate genetic sources for each effort.

The Ohio State University (University), in conjunction with the Ohio Department of Natural Resources, Division of Wildlife, has expressed an interest in developing methods and protocols for reintroducing Mitchell's satyr to historical population sites. The University has newly constructed, state-of-the-art rearing facilities available for use in this project. Furthermore, an ongoing multidisciplinary artificial wetland establishment program at the University will be available for this effort. This project is designed to assess the establishment of nearly natural communities, and already includes a native Lepidoptera component led by Dr. David Horn. The wetland may provide opportunities for establishing an experimental population for use as a source of individuals for reintroduction as well as providing a convenient opportunity to evaluate the feasibility of (re)establishing new populations.

Certain details of breeding facilities still need to be determined, such as whether breeding stock should include individuals from both Michigan and Indiana, or what stage of the life cycle should be released.

- 5.2 Reestablish historical populations. Once a source of larvae, pupae or adults is established, reintroduction within the historical range of Mitchell's satyr at protected sites should proceed. Although final decisions about reintroduction sites will have to be refined based upon the results of the studies outlined above, the generalized objectives of reintroductions by state should be as follows:

Michigan - Little is known about the current habitat suitability of formerly occupied sites in Michigan. Some of the wetland complexes have been altered through draining and filling, and are not suitable for reintroduction efforts, but other sites may still have suitable habitat. In addition to historical sites, there are many seemingly suitable wetland complexes within the southern Michigan range of Mitchell's satyr that may be potential sites for establishing new populations. Once Mitchell's satyr habitat requirements are better quantified, unoccupied wetland complexes should be identified as potential introduction sites for this species.

Indiana - Although only three or four specific historical and extant sites are known from northeast Indiana, LaGrange and Steuben Counties have many fens which were likely to have supported Mitchell's satyr in the past. The numerous fens in the Pigeon River State Game Area (LaGrange County) are

ideal sites for reintroduction. This area supports one of the densest assemblages of fens in the Midwest, and is an important area for establishing a network of Mitchell's satyr populations which may, in turn, allow the (re)establishment of an active metapopulation. The fens around the Steuben County site also supported Mitchell's satyr, and would be an ideal area in which to reestablish an array of occupied fens.

Ohio - Portions of the Portage County site are now state nature preserves. Additional fens in the immediate vicinity are also protected. Suitable habitats within these preserves should be identified for Mitchell's satyr reintroduction. In addition, Mud Lake State Nature Preserve in Williams County is a possible introduction site. Although not a historically known site for Mitchell's satyr, this fen is located a few kilometers east of the historical Steuben County site, Indiana. An introduced population at Mud Lake State Nature Preserve would help lessen the vulnerability of the Michigan and Indiana population core area.

New Jersey - Fens in Warren and Sussex Counties which supported or are near those which supported historical Mitchell's satyr populations are now protected by state and private organizations. These fen complexes are ideal sites for reintroduction efforts.

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III. IMPLEMENTATION SCHEDULE

The following Implementation Schedule outlines actions and estimated costs for the recovery program of Mitchell's satyr over the next three years. This process will be reviewed every three years until the recovery objective is met. Therefore, priorities and tasks may change in the future. Tasks are presented in order of priority.

A. Key to Priority Descriptions in Column 1

Task priorities are set according to the following standards:

- Priority 1: Those actions that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.
- Priority 2: Those actions that must be taken to prevent a significant decline in species population, or some other significant negative impact short of extinction.
- Priority 3: All other actions necessary to provide for full recovery of the species.

B. Key to Agency Designations in Column 4 and 5

FY	Fiscal Year
INDR	Indiana Department of Natural Resources
INHP	Indiana Natural Heritage Program
MDNR	Michigan Department of Natural Resources
NJDEP	New Jersey Department of Environmental Protection
NJNHP	New Jersey Natural Heritage Program
ODNR	Ohio Department of Natural Resources
OLS	Ohio Lepidopterist Society
ONHP	Ohio Natural Heritage Program
OSU	Ohio State University, Columbus
TNC	The Nature Conservancy
USFWS	U.S. Fish and Wildlife Service
Yrs	Years

C. Implementation Schedule. Mitchell's satyr butterfly (*Neonympha mitchellii mitchellii*) recovery actions

Priority /Task Description	Task Number	Duration	Responsible Agency		Cost Estimates (\$000)			FY 4 - 10	Comments
			USFWS	Other	FY 1	FY 2	FY 3		
1 Survey for new populations	1.1	Annually							
Michigan				MDNR/TNC	3	3	3	21	
Indiana				IDNR/TNC	2	2	2	14	Tasks 1.1, 1.2 and 2.1 are highly interrelated and must be performed concurrently by coordinated teams.
Ohio				ODNR/OLS	2	2			
New Jersey				NJDEP	2	2	1	7	
1 Monitor extant populations	1.2	Annually							
Michigan				MDNR/TNC	2	2	2	14	(see comment above)
Indiana				IDNR/TNC	2	2	2	14	
1 Conduct studies of larval ecology	2.1	Yrs 1-3							
Michigan				MDNR/TNC	2	2	2		(see comment above)
Indiana				IDNR/TNC	2	2	2		
1 Protect populations vulnerable poaching	3.1	Annually	USFWS	MDNR	5	5	5	35	
				IDNR	2	2	2	14	
1 Provide current site occurrence info at least yearly to agencies	3.3.1 to 3.3.4	Annually	USFWS	MNFI/INHP/ NJNHP/ONHP	2	2	2	14	
2 Quantify habitat requirements/use	2.2	Yrs 1-4							
Michigan				MDNR/TNC	5	5	5	5	
Indiana				IDNR/TNC	3	3	3	3	

C. Implementation Schedule (continued). Mitchell's satyr butterfly (*Neonympha mitchellii mitchellii*) recovery actions

Priority /Task Description	Task Number	Duration	Responsible Agency		Cost Estimates (\$000)				Comments
			USFWS	Other	FY 1	FY 2	FY 3	FY 4 - 10	
2 Study habitat disturbance response	2.3	Yrs 2-6							To coincide with task 2.2
Michigan				MDNR/TNC		5	5	15	
Indiana				IDNR/TNC		4	4	12	
2 Determine population viability	2.4	Yr 3	USFWS		TBD	TBD	TBD	TBD	TBD = To Be Determined
Michigan				MDNR/TNC	TBD	TBD	TBD	TBD	
Indiana				IDNR/TNC	TBD	TBD	TBD	TBD	
Ohio				ODNR/TNC	TBD	TBD	TBD	TBD	
New Jersey				NJDEP/TNC	TBD	TBD	TBD	TBD	
2 Protect essential habitats	3.2	Yrs 1-5							
Michigan			USFWS	MDNR/TNC	TBD	TBD	TBD	TBD	TBD = To Be Determined- Costs for land acquisition can not be predicted and are therefore not included in the long range budget
Berrien Co. South					TBD	TBD	TBD	TBD	
Jackson Co. East					TBD	TBD	TBD	TBD	
St. Joseph County site					TBD	TBD	TBD	TBD	
St. Joseph County site					TBD	TBD	TBD	TBD	
Cass Co. East & Southwest					TBD	TBD	TBD	TBD	
Indiana			USFWS	IDNR/TNC	TBD	TBD	TBD	TBD	
LaPorte Co. site					TBD	TBD	TBD	TBD	
LaGrange Co. West					TBD	TBD	TBD	TBD	

C. Implementation Schedule (continued). Mitchell's satyr butterfly (*Neonympha mitchellii mitchellii*) recovery actions

Priority /Task Description	Task Number	Duration	Responsible Agency		Cost Estimates (\$000)				Comments
			USFWS	Other	FY 1	FY 2	FY 3	FY 4 - 10	
2 Develop habitat management plans	3.4	Yrs 1-3							
Michigan			USFWS	MDNR/TNC	1	0.5	0.5		
Indiana			USFWS	IDNR/TNC	1	0.5	0.5		
Ohio			USFWS	ODNR/TNC		0.5	0.5		
New Jersey			USFWS	NJDEP/TNC		0.5	0.5		
2 Implement habitat management plans	3.5	Year 3 - ongoing							
Michigan			USFWS	MDNR/TNC			6	42	
Indiana			USFWS	IDNR/TNC			3	21	
Ohio			USFWS	ODNR/TNC			3	21	
New Jersey			USFWS	NJDEP/TNC			3	21	
2 Develop agreements for protection on public lands	3.6	Yrs 1-3							
Michigan			USFWS	MDNR/TNC	3	2	2		
Indiana			USFWS	IDNR/TNC	3	2	2		
2 Promote protection of occurrences on private land	3.7.1 to 3.7.4	ongoing		MDNR/TNC	6	6	6	42	
2 Develop outreach program	4.0	ongoing		MNFI/INHP	5	5	8	70	
3 Conduct captive rearing studies	2.5	Yrs 2-6	USFWS	MDNR		5	5	15	
3 Promote local zoning	3.8	ongoing		MDNR/IDNR	1	0.5	0.5	4	

C. Implementation Schedule (continued). Mitchell's satyr butterfly (*Neonympha mitchellii mitchellii*) recovery actions

Priority /Task Description	Task Number	Duration	Responsible Agency		Cost Estimates (\$000)				Comments
			USFWS	Other	FY 1	FY 2	FY 3	FY 4 - 10	
3 Support Natural Area designation	3.9	ongoing		MDNR/MNFI	5	10	10	70	
3 Encourage land acquisition	3.10	ongoing		TNC/INHP	5	5	5	35	
3 Establish breeding facility	5.1	Yrs 1-10	USFWS	ODNR/OSU	0	6	6	42	ODNR/OSU have expressed interest in breeding facility and have potential funding
3 Reestablish historical populations	5.2	Yrs 3-10	USFWS				10	70	
Michigan				MDNR			10	70	Except for Michigan, costs should decrease incrementally with time- Michigan costs will hold steady because of the number of sites where reintroduction is desirable
Indiana				IDNR			7	49	
Ohio				ODNR			5	35	
New Jersey				NJDEP			7	49	

VI. APPENDICES

Appendix A. An annotated listing of Federal and state imperiled species known to occur within fen complexes serving as extant or historical Mitchell's satyr (*Neonympha mitchellii mitchellii*) population sites. State status is presented only if the species is known to occur within a Mitchell's satyr wetland complex (several species presented here are imperiled in states but do not co-occur with Mitchell's satyr)

Species Name	Common Name	Federal Status	G Rank	Michigan Status	Indiana Status	Ohio Status	New Jersey Status
Plants							
<i>Andromeda glaucophylla</i>	bog rosemary		G5T5				E
<i>Angelica venenosa</i>	hairy angelica		G5	SC			
<i>Arenaria stricta</i>	Michaux's stitchwort		G5		R		
<i>Arisaema stewardsonii</i>	swamp Jack-in-the-pulpit		G?			P	
<i>Aster borealis</i>	rushlike aster		G5		R		
<i>Betula pumila</i>	swamp birch		G5				SC
<i>Berula erecta</i>	cut-leaved water-parsnip		G4G5	T			
<i>Cacalia plantaginea</i>	prairie Indian-plantain		G4G5	T			
<i>Calamagrostis stricta</i>	narrow-leaved reedgrass		G4	T			
<i>Carex aquatilis</i>	aquatic sedge		G5				E
<i>Carex buxbaumii</i>	Buxbaum's sedge		G5				SC
<i>Carex bebbii</i>	Bebb's sedge		G5			T	
<i>Carex conoidea</i>	field sedge		G4			T	
<i>Carex diandra</i>	small paniced sedge		G5			P	
<i>Carex flava</i>	yellow sedge		G5		T	P	
<i>Carex sartwellii</i>	Sartwell's sedge		G4			T	
<i>Carex sterilis</i>	fen sedge		G4			P	SC

Appendix A (continued). An annotated listing of Federal and state imperiled species known to occur within fen complexes serving as extant or historical Mitchell's satyr (*Neonympha mitchellii mitchellii*) population sites. State status is presented only if the species is known to occur within a Mitchell's satyr wetland complex (several species presented here are imperiled in states but do not co-occur with Mitchell's satyr)

Species Name	Common Name	Federal Status	G Rank	Michigan Status	Indiana Status	Ohio Status	New Jersey Status
<u>Plants (continued)</u>							
<i>Carex utriculata</i>	beaked sedge		G5			P	
<i>Cornus canadensis</i>	bunchberry		G5			T	
<i>Cypripedium calceolus</i> var. <i>parviflorum</i>	small yellow ladies slipper		G5Q		R	E	
<i>Cypripedium candidum</i>	white lady-slipper		G4	T	R		
<i>Cypripedium reginae</i>	showy ladies slipper		G4			T	
<i>Deschampsia cespitosa</i>	tufted hairgrass		G5		R		
<i>Deschampsia flexuosa</i>	crinkled hairgrass		G5			T	
<i>Drosera rotundifolia</i>	round-leaved sundew		G5			P	
<i>Epilobium strictum</i>	downy willow-herb		G5?				SC
<i>Epilobium leptophyllum</i>	linear-leaf willow-herb		G5				SC
<i>Eleocharis intermedia</i>	matted spikerush		G5			P	
<i>Elymus trachycaulus</i>	bearded wheat grass		G5T5			T	
<i>Eriophorum angustifolium</i>	narrow-leaved cottongrass		G5		R		
<i>Eriophorum gracile</i>	slender cottongrass		G5		T		
<i>Eriophorum viridi-carinatum</i>	green-keeled cottongrass		G5		R	P	
<i>Filipendula rubra</i>	queen of the prairie		G4G5				SC
<i>Galium labradoricum</i>	bog bedstraw		G5			E	E

Appendix A (continued). An annotated listing of Federal and state imperiled species known to occur within fen complexes serving as extant or historical Mitchell's satyr (*Neonympha mitchellii mitchellii*) population sites. State status is presented only if the species is known to occur within a Mitchell's satyr wetland complex (several species presented here are imperiled in states but do not co-occur with Mitchell's satyr)

Species Name	Common Name	Federal Status	G Rank	Michigan Status	Indiana Status	Ohio Status	New Jersey Status
<u>Plants (continued)</u>							
<i>Gentianopsis procera</i>	small fringed gentian		G5			P	
<i>Geum rivale</i>	water avens		G5			P	
<i>Glyceria grandis</i>	tall manna-grass		G5			P	
<i>Hydrocotyle americana</i>	American water-pennywort		G5			P	
<i>Larix laricina</i>	tamarack		G5			P	
<i>Melanthium virginicum</i>	bunchflower		G5			T	
<i>Muhlenbergia richardsonis</i>	mat muhly		G5				
<i>Muhlenbergia glomerata</i>	marsh muhly		G4				SC
<i>Myrica pennsylvanica</i>	bayberry		G5			E	
<i>Nemopanthus mucronatus</i>	catberry		G5			P	
<i>Panicum boreale</i>	northern witchgrass		G5		R		
<i>Panicum leibergii</i>	leiberg's panic-grass		G5	T			
<i>Platanthera clavellata</i>	green woodland orchid		G5			P	
<i>Platanthera hyperborea</i>	leafy northern green orchid		G5		T		
<i>Platanthera psycodes</i>	small purple fringed orchid		G5				SC
<i>Poa paludigena</i>	bog bluegrass		G3	T	WL		

Appendix A (continued). An annotated listing of Federal and state imperiled species known to occur within fen complexes serving as extant or historical Mitchell's satyr (*Neonympha mitchellii mitchellii*) population sites. State status is presented only if the species is known to occur within a Mitchell's satyr wetland complex (several species presented here are imperiled in states but do not co-occur with Mitchell's satyr)

Species Name	Common Name	Federal Status	G Rank	Michigan Status	Indiana Status	Ohio Status	New Jersey Status
<u>Plants (continued)</u>							
<i>Polemonium reptans</i>	Jacob's ladder or Greek-valerian		0	T			
<i>Potentilla palustris</i>	marsh fivefinger		G5			T	
<i>Prenanthes racemosa</i>	prairie rattlesnake-root		G5			P	
<i>Ribes hirtellum</i>	smooth gooseberry		G5		WL		SC
<i>Rosa setigera</i>	prairie rose		G5	SC			
<i>Rhynchospora alba</i>	white beak-rush		G5			P	
<i>Salix candida</i>	hoary willow		G5			T	
<i>Salix pedicellaris</i>	bog willow		G5				E
<i>Salix serissima</i>	autumn willow		G4			P	SC
<i>Sarracenia purpurea f. heterophylla</i>	pitcher plant, yellow		G5T2	T			
<i>Scleria verticillata</i>	low nut-rush		G4?			P	
<i>Silphium integrifolium</i>	rosinweed		G4G5	T			
<i>Sisyrinchium mucronatum</i>	narrow-leaved blue-eyed-grass		G5			E	
<i>Solidago ohioensis</i>	Ohio goldenrod		G4			P	
<i>Spiranthes romanzoffiana</i>	hooded ladies-tresses		G5		E		
<i>Spiranthes lucida</i>	ladies tresses		G5				SC

Appendix A (continued). An annotated listing of Federal and state imperiled species known to occur within fen complexes serving as extant or historical Mitchell's satyr (*Neonympha mitchellii mitchellii*) population sites. State status is presented only if the species is known to occur within a Mitchell's satyr wetland complex (several species presented here are imperiled in states but do not co-occur with Mitchell's satyr)

Species Name	Common Name	Federal Status	G Rank	Michigan Status	Indiana Status	Ohio Status	New Jersey Status
<u>Plants (continued)</u>							
<i>Stellaria crassifolia</i>	fleshy stitchwort		G4	T			
<i>Thuja occidentalis</i>	arbor vitae		G?				E
<i>Tofieldia glutinosa</i>	false asphodel		G5		R	P	
<i>Triglochin maritimaum</i>	arrow-grass		G5				E
<i>Triglochin palustre</i>	marsh arrow-grass		G5		T	P	
<i>Trisetum pensylvanicum</i>	swamp-oats		G4			P	
<i>Vaccinium macrocarpon</i>	large cranberry		G4			P	
<i>Valeriana edulis</i> var. <i>ciliata</i>	edible valerian		G4G5	T	E		
<i>Valeriana uliginosa</i>	bog valerian		G5		E		
<i>Viburnum opulus</i>	highbush-cranberry		G5T?		E	T	
<i>Zannichellia palustris</i>	hornedpondweed		G5		E		
<i>Zigadenus elegans</i> var. <i>glaucus</i>	wand-lily		G4?Q		R	P	
<u>Reptiles and Amphibians</u>							
<i>Clemmys guttata</i>	spotted turtle		G5	SC	T		
<i>Clemmys mulenbergia</i>	bog turtle	PT	--				E
<i>Sistrurus catenatus catenatus</i>	eastern massasauga		G3G4T3	SC	T	E	
<i>Nerodia erythrogaster neglecta</i>	copperbelly water snake	T	G5T2	E			

Appendix A (continued). An annotated listing of Federal and state imperiled species known to occur within fen complexes serving as extant or historical Mitchell's satyr (*Neonympha mitchellii mitchellii*) population sites. State status is presented only if the species is known to occur within a Mitchell's satyr wetland complex (several species presented here are imperiled in states but do not co-occur with Mitchell's satyr)

Species Name	Common Name	Federal Status	G Rank	Michigan Status	Indiana Status	Ohio Status	New Jersey Status
<u>Reptiles and Amphibians (continued)</u>							
<i>Terrapene c. carolina</i>	eastern box turtle		G5T5	SC			
<u>Birds</u>							
<i>Grus canadensis</i>	sandhill crane		G5		T		
<u>Insects</u>							
<i>Euphyes bimacula</i>	two-spotted skipper		G4			E	
<i>Euphyes dukesi</i>	Dukes' skipper		G3G4	T	R		
<i>Lepyronia angulifera</i>	angular spittlebug		G3	SC			
<i>Oarisma poweshiek</i>	Poweshiek skipper		G2G3	T			
<i>Oecanthus laricis</i>	tamarack tree cricket		G1G3	SC			
<i>Papaipema speciosissima</i>	regal fern borer		G4	SC			
<i>Papaipema silphii</i>	silphium borer moth		G3G4	T			
<i>Papaipema beeriana</i>	blazing star borer		G3	SC			
<i>Pieris napi</i>	mustard white		G5		R		
<i>Satyrodes appalachia</i>	Appalachian brown		G3		E		
<i>Speyeria idalia</i>	regal fritillary		G3	E			
<i>Tachopteryx thoreyi</i>	greyback		G4	T			

EXPLANATION OF ABBREVIATIONS USED IN APPENDIX A.

MI	Michigan
IN	Indiana
OH	Ohio
NJ	New Jersey

G Rank Global Rank, a convention devised by The Nature Conservancy national office that ranks species status throughout its entire world-wide range, based on number of extant occurrences and other factors.

G1	Critically imperiled globally because of extreme rarity (5 or fewer occurrences or very few remaining individuals) or because of some factor of its biology making it especially vulnerable to extinction (critically endangered throughout range).
G2	Imperiled globally because of rarity (6 to 20 occurrences or few remaining individuals) or because of other factors demonstrably making it vulnerable to extinction throughout its range (endangered throughout range).
G3	Either very rare and local throughout its range or found locally (even abundant at some of its locations) in a restricted range (e.g., a single western state, a physiographic region in the East) or because of other factors making it vulnerable to extinction throughout its range (20 to 100 occurrences).
G4	Widespread, abundant, and apparently secure globally, though it may be quite rare in parts of its range, especially at the periphery. Thus, element is of long-term concern (usually more than 100 occurrences).
G5	Demonstrably widespread, abundant, and secure globally, though it may be quite rare in parts of its range, especially at the periphery.
G?	Element is not yet ranked globally.
Q	Questionable taxonomy, numeric rank may change with taxonomy.
G#G#	A range between two or the numeric ranks. Denotes range of uncertainty about the exact rarity of the element.
G1G3	Occurrence uncertain but probably ranges between G1 and G3, probably 1-100 extant populations.
G2G3	Occurrence uncertain but probably ranges between G2 and G3, probably 6-100 extant populations.
G3G4	Occurrence uncertain but probably ranges between G3 and G4, probably 20 to more than 100 extant populations.
G4G5	Widespread, abundant, and apparently secure globally, though it may be quite rare in parts of its range, especially at the periphery, may or may not be of long term concern.

Subspecies and varieties are handled by giving a "subrank" to the global rank for the full species. A subrank consists of the letter "T" plus a number 1-5. The rules for assigning the second character are the same as the G ranking rules listed above, for example:

G3G4T3	Species occurrences uncertain, but probably range between G3 and G4, probably 20 to more than 100 extant populations, but the subspecies is either very rare and local throughout its range or found locally (e.g., a single western state, a physiographic region in the East) or because of other factors making it vulnerable to extinction throughout its range.
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E	Federal and/or State endangered species
T	Federal and/or State threatened species
P	Potentially state threatened species
PT	Federal Proposed as Threatened species
SC	State special concern species
SI	State special interest species
R	State rare species
WL	State watch list species (Indiana)

Appendix B. Principle Federal and State Laws Applicable to the Protection of *Neonympha mitchellii mitchellii* and its Habitat

Endangered Species Act of 1973, (16 U.S.C. 1531-1544), as amended. Regulations, in part, at 50 CFR 17 and 50 CFR 402.

Federal Water Pollution Control Act of 1948, (33 U.S.C. 1251-1376) as amended (“*Clean Water Act*”) Regulations at 33 CFR 320-338.

National Environmental Policy Act of 1969, U.S.C. 4321-4347, as amended.

Part 301, Inland Lakes and Streams Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451. MCL Sections 324.30101 to 324.30113

Part 303, Wetland Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451. MCL Sections 324.30301 to 324.30323.

Part 365, Endangered Species Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451. MCL Sections 324.36501 to 324.36507.

Part 17, Michigan Environmental Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451. MCL Sections 324.1701 to 324.1706.

Conservation and Historic Preservation Easement, of the Natural Resources and Environmental Protection act, 1994 PA 451. MCL Sections 324.2140 to 324.2144.

Appendix C. Comments to the Draft Technical /Agency Recovery Plan.

A notice of availability of the Draft Technical/Agency Recovery Plan (Draft Plan) for the Mitchell's satyr for review and comment was published in the Federal Register on March 27, 1996 (61[60]:13513-4). A 63-day comment period was provided. Approximately 90 Draft Plans were sent to affected agencies, institutions, and individuals. Draft Plans were provided to other parties upon request. A list of the recipients of the Draft Plan is in Appendix C. An asterisk (*) indicates those parties who submitted comments. Additionally, public notices announcing availability of the Draft Plan were published in the Herald Palladium (St. Joseph, Michigan), LaPorte Herald Argos (LaPorte, Indiana), Jackson Citizen Patriot (Jackson, Michigan), and the Chicago Tribune (Chicago, Illinois). These notices resulted in eight requests for copies of the Draft Plan.

Pursuant to section 3 of the Act (16 U.S.C. 1532), independent peer review were also solicited to review the Draft Plan. This is to ensure that reviews by recognized experts are incorporated into the review process of recovery plans developed in accordance with the requirements of the Act.

The Service received comments and suggestions from 16 reviewers, two of which were independent peer reviewers. Comments addressed a variety of format, content, and organization points of the Draft Plan. These comments were reviewed and incorporated, to the extent appropriate, into this document. Reviewer comment letters are available for viewing at the U.S. Fish and Wildlife Service, East Lansing Field Office, 2651 Coolidge Road, East Lansing, Michigan, 48823-6316.

Peer Review Comments

A summary of selected peer reviewer comments and how they were addressed follows.

Dr. Susan Harrison, University of California, Davis Dr. Harrison agrees with the Draft Plan's strong emphasis on protection and restoration of multiple units of habitat which is in line with current invertebrate conservation approaches. Dr. Harrison also agrees with the urgent need for more research to establish some basic facts about the biology and behavior of the Mitchell's satyr, especially specialized needs such as microhabitat requirements. However, she would add a detailed study of species interactions, such as disease, predation, and parasitism at all life stages of the butterfly, including overwintering larvae. Also, there is a need for quantitative information about natural mortality rates, especially at the overwintering stage. This would be critical to fully assess recovery actions, especially habitat management activities.

Response Action 2.1 - Conduct cage studies of larval ecology - will likely provide an opportunity to study species interactions and microhabitat characterization and possibly natural mortality rates.

Dr. Harrison believes the Draft Plan's discussion about beaver ponds doesn't seem consistent with the butterfly's habitat preference. Fens dominated by poison sumac and tamarack are quite different than the sedge meadows which develop during succession of beaver impoundments. She questions whether the discussion of beaver influence in the Draft Plan is

warranted. Dr. Harrison believes the Draft Plan is sound and well reasoned, and that the authors have clearly addressed important elements required for the conservation of the Mitchell's satyr.

Dr. David Braun, The Nature Conservancy, International Headquarters Dr. Braun believes that further research is needed to describe the climatic conditions necessary to support the Mitchell's satyr to distinguish whether climate has shaped the butterfly's historical distribution or a unique history of dispersion from late Pleistocene refuges.

Response Although haphazard dispersion probably played a role in the Mitchell's satyr distribution, not enough information is yet available to address climatic factors limiting the butterfly's distribution and why it is no longer located south of its historic range. Further research is needed.

Dr. Braun also identified two special threats warranting management consideration for the butterfly, specifically, protection of ground water levels and flow gradients in the aquifers supporting occupied habitat and protection of water quality, specifically nutrient concentrations in these same aquifers.

Response Action 3.4 - Develop habitat management plans - includes the need to insure that ground water levels, flow gradients, and water quality are maintained at viable Mitchell's satyr sites.

Appendix D. List of Reviewers

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ARW (Refuges)

ARW (Realty)

ALE (Law Enforcement)

APA (External Affairs)

U.S. Fish and Wildlife Service Washington Offices:

* Division of Endangered Species (Mail Stop 542 ARLSQ) - three copies

Office of Public Affairs (PA, 3447 MIB)

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