Development of a Multi-State Mitchell's Satyr Habitat Conservation Plan: Michigan Portion
2009 Annual Report

Prepared by:
Daria A. Hyde, Bradford S. Slaughter, David L. Cuthrell, Helen D. Enander, Yu Man Lee,
Michael R. Penskar, Barbara J. Barton, Michael A. Kost,
Michael A. Sanders, Peter J. Badra and Michael J. Monfils

Michigan Natural Features Inventory
P.O. Box 30444
Lansing, MI 48909-7944

For:
MDNR Wildlife Division, Stevens T. Mason Building
P.O. Box 30444, Lansing, MI 48909-7944

December 14, 2009

Report Number 2009-18

Cover photos: Mike Sanders (MNFI) taking notes after using a sweep net to sample the vegetation for insects, Kalamazoo County, August 2009, David L. Cuthrell. **Lower inset:** Mitchell's satyr at Cass County Southwest Prairie Fen, 2008, Bradford S. Slaughter.

Recommended Citation: Hyde, D. A., B. S. Slaughter, D. L. Cuthrell, H. D. Enander, Y. Lee, M. R. Penskar, B. J. Barton, M. A. Kost, M. A. Sanders, P. J. Badra, and M. J. Monfils, 2009. Development of a Multi-State Mitchell's Satyr Habitat Conservation Plan: Michigan Portion - 2009 Annual Report. Report number MNFI 2009-18. Report to MDNR, Wildlife Division, Lansing, MI. 75 pages + appendices.

Table of Contents

List of Tables

List of Figures

Introduction

The Mitchell's satyr butterfly (*Neonympha mitchellii mitchellii*) is a rare butterfly species whose worldwide distribution is restricted to Michigan and Indiana. It is currently only known from 16 sites in southern Lower Michigan and 1 site in northern Indiana, although it has potential to occur at two additional sites in Michigan as the status at these sites in uncertain. This species is currently listed as endangered in Michigan and Indiana, and was federally listed as endangered in 1992. Sites that continue to support the Mitchell's satyr contain peat soil with carbonate rich groundwater seeps and are most often dominated by narrow leaved sedges with scattered tamarack and poison sumac. Habitat ranges along a continuum from open fen, wet prairie, prairie fen, and sedge meadow to shrub-carr and tamarack savanna. It appears that the Mitchell's satyr occupies areas in these fen communities where woody and herbaceous vegetation occur as a mosaic.

To reclassify to federal threatened status, 16 geographically distinct populations or meta-populations must be established range wide, including 12 in Michigan; to de-list, nine more populations must be established. These populations must remain viable for five consecutive years following reclassification, which will require a valid, repeatable monitoring protocol. At least 15 of the 25 recovered populations also must be protected and managed for the benefit of this species (U.S. Fish and Wildlife Service 1997). Currently, only nine occupied sites in Michigan and Indiana are considered to have potential to contain viable populations. Satyrs at the remaining sites either occur in much lower numbers or the amount of suitable habitat is limited in size. All but two of the known satyr sites occur on private land. In addition, some sites are threatened by development, making their long-term viability uncertain.

Michigan Natural Features Inventory (MNFI) is working with the Michigan and Indiana Department of Natural Resources to develop a multi-state HCP to assist in the recovery of Mitchell's satyr habitat. MNFI has committed to specific objectives that will support this effort. This report summarizes the work completed during the past three years and highlights relevant findings. Objectives for this project are listed below.

Project Objectives

Objective 1. Baseline Surveys
Objective 2. Inventories and modeling
Objective 3. Outreach
Objective 4. Plan writing and NEPA compliance

Literature Cited

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

Results of Baseline Surveys

Survey Protocol Modifications

Introduction

Determining the most appropriate survey protocol for documenting rare insects and then standardizing surveys so that data from these surveys is most useful has always been a challenge. Meaningful data is required for monitoring populations and documenting trends. These data can be useful for analyzing habitat use as well the potential impacts of various activities taking place both in the fens and in the surrounding landscape.

History

The Mitchell's Satyr Working Group met on 24 May 1997 to discuss monitoring needs for the satyr. At that time it was agreed that conducting Pollard transects during the satyr flight period was the preferred method for monitoring this species (Pollard and Yates, 1993). The group also discussed a variety of factors that likely affect the number of adults seen during a Pollard walk and recognized the need to evaluate these factors. A Mitchell's satyr monitoring form was developed to document these factors as well as to record observations of satyrs and other butterflies. The group also identified priority sites where monitoring activities would be initiated. Monitoring was conducted at these sites in 1997, and 1998. On 24 February 1999, Working Group members agreed to re-evaluate the effectiveness of Pollard counts and to consider using a different technique, potentially a timed area search (meander survey). Members agree to do both a Pollard count and timed area search at several sites in 1999 to evaluate the effectiveness of the Pollards and develop an index relating satyr numbers to the Pollard counts.

On 19 January 2000, the Working Group determined that it was most effective to conduct timed-meander surveys and that it was important to conduct these surveys at occupied sites on more than one occasion during the field season to more successfully monitor these populations. It was decided that visiting sites three times during the flight period and conducting timed meander surveys would provide valuable data on the distribution and number of butterflies and would help determine long-term site viability as well as reflect the impacts of various management activities.

Protocols were revised again in 2007 (See Appendix A) to incorporate the use of GPS technology to record locations of satyrs as well as the track or path taken during the survey. We are then able to import the point location and track data into a GIS project for each site, so that we can determine the portion of habitat surveyed and document areas that are occupied by the Mitchell's satyr in any given year. Surveyors are instructed to record this data on the Mitchell's satyr survey form so that this information can be analyzed (See Appendix B). Thus we can compare site occupancy between years at any given site, and analyze the potential impacts of various management prescriptions as well as other activities taking place on the landscape. If these protocols are followed, we can compute a value for the number of satyrs' seen-per number of surveyors-per hour using the highest count taken during the flight period. Using the highest count increases the likelihood that the count taken closest to the peak of the flight is used. In addition, the goal of this revised protocol is to try to standardize survey data further by only recording the time spent looking for satyrs in suitable or potential habitat as well as defining the appropriate distance between surveyors as they meander through suitable habitat.

Discussion

Collecting data from occupied satyr sites in a standardized manner remains problematic for a number of reasons. Given the short flight period, it is not possible for the same team of people to survey all of the occupied sites at the peak of the flight each year. We rely on the effort of a variety of trained staff and volunteers from many organizations to conduct satyr surveys. Despite

our best efforts at standardizing how counts are conducted, variability of detection among different surveyors is a reality. Limited resources does not always support enough staff hours to conduct an adequate number of site visits to insure that the survey is conducted close to the peak of the flight. Thus it is difficult to make meaningful comparisons of satyr counts between years at the same site, if there is variability in whether surveys are conducted close to the peak of the flight. In addition, some surveyors have experienced technical difficulties with the GPS equipment and data has not always been collected in an optimal manner. Problems such as insufficient satellite strength during certain times of the day, confusion by the surveyor on the correct manner for saving points and tracks on different GPS devices, and loss of data can compromise survey results. Given the heterogeneous nature of most of the occupied satyr sites, some surveyors have found it challenging to determine when they are in suitable habitat, and so leave the track turned on during the entire survey. This results in a larger value for the "time" portion of the equation (# satyrs/#surveyors/hour) which leads to a smaller overall value. Finally, incomplete recording of data and submission of the data forms remains problematic.

Recommendations

It is essential that we continue to collect meaningful survey data so that we can monitor Mitchell satyr populations, document population trends and study the response of satyr populations to fen management activities and land use change in the surrounding landscape. The current survey protocol is ideal but may not always be practical when staff resources are limited. It is suggested that if three site visits are not possible in any given year that surveyors attempt to visit the site at least once during the peak of the flight. If the surveyors document good numbers of satyrs (using previous year's data as a reference) then a second or third visit may not be necessary. If satyrs are only found in low numbers then returning for a second or third visit is suggested in order to insure that sufficient attempts were made to time the survey near the peak of the flight. Continued training of staff and volunteers on the identification of Mitchell's satyr and their habitat, use of GPS equipment and accurate collection of relevant data on survey forms is also encouraged.

Literature Cited

Pollard, E. and T.J. Yates. 1993. Monitoring Butterflies for Ecology and Conservation. Chapman and Hall. London

Timed-Meander Visual Surveys

Introduction

Mitchell's satyr survey data from 2007 through 2009 in Michigan is presented below. In addition, summary statistics and figures from the past ten years of satyr surveys are provided in Tables 1 and 2 and Figure 1 and 2 at the end of this section.

2007 Results

In 2007 **Mitchell's satyrs were reconfirmed at 16 sites** in Barry, Berrien, Branch, Cass, Jackson, Kalamazoo, St. Joseph, Van Buren and Washtenaw counties by surveyors from MNFI and a variety of other partners. MNFI conducted multiple surveys (2-3 visits) at 12 known satyr sites (large habitat complexes with multiple landowners) in 6 southern Michigan counties. MNFI also conducted de novo surveys at one site in Jackson Co. and at 2 historical sites in Lenawee and Kalamazoo counties, but did not find the satyr. MDNR (Wildlife Biologists and LIP Program Biologists) conducted or assisted with surveys at 9 sites and denovo surveys at 1 site in Jackson County. Southwest Michigan Land Conservancy (SWMLC) conducted multiple surveys (2 visits) at 6 known satyr sites in 4 southern Michigan counties and de novo surveys at one site in Berrien Co., one site in Barry/Calhoun Co. and one site in Van Buren Co. but did not find any new populations. The Nature Conservancy (TNC) conducted surveys at 2 known satyr sites in Berrien and Cass Counties. Finally, Michigan State University staff assisted with surveys at 1 site in Jackson County

In 2007, **Mitchell's satyrs had the potential to be extant at 3 additional sites** where satyrs were last observed in 2006 in St. Joseph Co., in 2003 in Kalamazoo Co. and in 1993 in Van Buren Co. (permission to survey has been denied by landowner at this site). **Satyrs are believed to be extirpated at 5 sites** in Cass, Kalamazoo (2 sites), Lenawee and Washtenaw counties (last observed in 1993, 1956, 1978, 1980 and 1950's respectively).

2008 Results

In 2008 **Mitchell's satyrs were documented at 15 sites** in Barry, Berrien, Branch, Cass, Jackson, Kalamazoo, St. Joseph, Van Buren and Washtenaw counties by surveyors from MNFI and a variety of other partners. MNFI conducted multiple surveys (2 visits) at 14 known satyr sites in 6 southern Michigan counties. MNFI conducted de novo surveys at 3 sites and extended the range of the satyr at Grand River fen by finding a satyr on a tract south of the known population. MDNR conducted or assisted with surveys at 5 sites and denovo surveys at 1 site in Jackson Co. SWMLC conducted multiple surveys (2 visits) at 1 satyr site in Van Buren county. TNC conducted surveys at 1 site in Cass County. In addition, an MSU doctoral student collected wing clippings from satyrs at 12 sites for the purpose of doing a genetic study.

Satyrs are likely extant at one site in Berrien County (last observed in 2007). **Satyrs have potential to be extant at 2 additional sites** last observed in St. Joseph County in 2007 and in 1993 in Van Buren Co. (permission to survey has been denied by landowner at this site). **Satyrs are believed to be extirpated at 6 sites** in Cass, Kalamazoo (3 sites), Lenawee and Washtenaw counties (last observed in 1993, 2003,1956, 1978, 1980 and 1950's respectively).

2009 Results

In 2009 **Mitchell's satyrs were reconfirmed at 14 sites in** Barry, Berrien, Branch, Cass, Jackson, Kalamazoo, Van Buren and Washtenaw counties by surveyors from MNFI and a variety of other partners. MNFI conducted surveys (1-2 visits) at 7 known satyr sites in 5 southern Michigan counties. MNFI conducted a survey at a historical site in Kalamazoo County but did not

find the satyr. MDNR conducted a survey at 5 known satyrs sites in Barry and Jackson counties. SWMLC conducted a survey at 2 sites in Branch and Van Buren counties. TNC conducted a survey at one site in Cass County. In addition, an MSU doctoral student continued his genetic study by collecting wing clippings from satyrs at specific sites.

Satyrs are likely extant at 2 sites (confirmed in 2008 and 2007) in St. Joseph and Berrien counties. **Satyrs have potential to be extant at 2 additional sites** last observed in 2007 in St. Joseph County and in 1993 in Van Buren Co. (permission to survey has been denied by landowner at this site). **Satyrs are believed to be extirpated at 6 sites** in Cass, Kalamazoo (3 sites), Lenawee and Washtenaw counties (last observed in 2003, 1993, 1956, 1978, 1980 and 1950's respectively).

Satyr Site History

A value was calculated for each site surveyed from 2000 to 2009.by dividing the highest number of Mitchell's satyr recorded per year at each site by the number of surveyors per hour. These values are shown in Table 1. It is important to remember that there are many variables which would impact these values including the time of year surveyed, number and experience of the surveyors, time spent in potential habitat at a site, and the size of the site surveyed. For this reason these values are of limited importance but can suggest trends on a very coarse level.

Graphical depiction of survey results

Values calculated for eighteen satyr sites were graphed to depict potential site trends over a ten year period (See Figure 1.). At many sites it is typical to see variation over the years, with some sites sharing the peaks and lows in the same year. It is possible that environmental variables such as winter snow cover, spring cold snaps and summer thunderstorms could impact populations within the state or within a region within the same year. At sites that are thought to have become extinct it is easy to see that once a population falls to a critical low level, that it rarely recovers. Some values stand out as being outside what would be expected compared to values for previus year. For example, the value calculated for Berrien County North is quite high in 2009. This is likely due to the fact that only one surveyor conducted the survey from the boardwalk available at this small site in only 30 minutes during the peak of the flight and counted 40 satyrs. In previous years at least 2 surveyors spent a longer time off the boardwalk meandering through the habitat. Thus the value for this site is quite high in comparison to other years or at other sites where more than one surveyor spent a longer time in a larger habitat complex documenting satyrs. Again, these graphs may suggest potential trends but it is important to remember that there are numerous variables which can affect these values.

Trends and Threats to satyr populations

Table 2. depicts trends and potential viability at 24 current or historical Mitchell's satyr sites. The first and last observed dates are shown as well as the current and previous element occurrence ranks for each site. Element occurrence ranks (with guidance from NatureServe) incorporate a number of variables including number of Mitchell's satyrs documented, the size of occupied habitat, metapopulation dynamics, and perceived threats to the habitat. Over the past seven years the rank at 7 sites improved, the rank at 9 sites declined, and the rank at 8 sites stayed the same.

Eight sites are considered likely viable (those with a rank of C or higher), **3 sites are considered potentially viable** (those with a CD rank), **7 sites are considered nonviable** (those with a rank of D) and **6 sites are considered historical** (those with a rank of H). There is one site ranked "F" (failed to find) where we have been unable to gain permission to access the site to determine if the site is still occupied. It is unlikely that this site is extant, but without a survey, it is not yet considered historical. Figure 2. depicts the distribution of satyr sites by last observed date.

The factors most likely responsible for the declining ranks and potential viability at satyr sites include inbreeding depression due to isolation of satyr sites and decreased habitat suitability due the impact of altered hydrology (digging of pond and wells, road construction, and nutrification from agriculture and septic fields) with resulting invasion by native and nonnative plants.

Much remains to be accomplished in order to meet the recovery criteria of 16 geographically distinct, viable populations or metapopulations (12 in southern Michigan) in order to reclassify the Mitchell's satyr from endangered to threatened. Further results from the recent genetic studies from wing samples collected at Michigan satyr sites will assist in guiding the actions and determining priorities for the Mitchell's satyr working group in the years ahead. Stewardship of satyrs sites as well as at potential reintroduction sites to ameliorate threats by MDNR and land conservancies is critical. Continued monitoring of satyr populations at known sites, at least every other year, is important to determine site viability and to determine as best as possible the response of satyr populations to site management as well as changes on the landscape.

Number of satyrs observed at occupied sites 2000-2009

DO NOT DISTRIBUTE:CONFIDENTIAL

Table 1. Results of Mitchell's Satyr timed-meander surveys at occupied sites during 2000-2009. Bolded numbers indicate the greatest number of satyrs seen during one visit, followed by the number of surveyors and time (hr) spent surveying. The number of satyrs observed per surveyor per hour is provided in parentheses. Numbers followed by an asterisk (*) indicate that not all of the occupied habitat was surveyed. Dashes (-) are used for years during which surveys were not done because the site was not yet known. No survey indicates lack of permission or resources.

Official Name	EO #	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Barry Co. S.	.007	**15**/1/3 (5.0)	**14**/3/0.5 (9.3)	**8**/1/0.5* (16.0)	**6**/1/1 (6.0)	**19**/2/2 (4.8)	**69**/4/1 (17.3)	**24**/3/0.65 (12.3)	**37**/3/1.5 (8.2)	**18**/4/1 (4.5)	**8**/2/1 (4.0)
Barry Co. SW.	.005	**8**/2/0.75 (5.3)	**4**/3/0.25 (5.3)	**8**/1/0.5* (16.0)	**1**/2/1 (0.5)	**3**/2/2 (0.8)	**16**/2/1 (8.0)	**7**/6/1.5 (0.8)	**8**/3/2.15 (1.2)	**13**/4/2 (1.6)	**1**/3/2 (0.2)
Berrien Co. S.	.022	transect data	**34**/3/0.75 (15.1)	**6**/2/2* (1.5)	**7**/2/0.75 (4.7)	**15**/2/2 (3.8)	**7**/3/?	**35**/3/0.5* (23.3)	**8**/3/1 (2.7)	no survey	no survey
Berrien Co. N.	.009	transect data	**32**/4/1 (8.0)	**60**/2/1.5 (20.0)	**28**/2/0.5 (28.0)	**10**/2/2 (2.5)	**19**/6/4.5 (0.7)	**31**/2/1.5 (10.3)	**39**/2/1 (19.5)	**40**/1/0.5 (80.0)	**16**/2/1.13 (7.1)
Berrien Co. E.	.025	**-**	**-**	**8**	no survey	**15**/2/2 (3.8)	**10**/5/0.5 (4.0)	**19**/2/1.2 (7.9)	**16**/2/0.5 (16.0)	**13**/3/1.25 (3.5)	**6**/2/0.5 (6.0)
Branch Co. Site	.016	**147**/2/4.75 (15.5)	**103**/2/3.75 (13.7)	**110**/1-2/4.25 (17.3)	**130**/2/5 (13.0)	**74**/2/2 (18.5)	**160**/3/6 (8.9)	**382*** **marked** pop. est. 700-approx. 2/3 habitat	**143**/4/3* no survey on NW prop. (11.9)	**142**/3/3/ no survey SWMLC parcel/ NW prop (15.8)	**49**/3/5.5 (late in flight) (3.0)
Cass Co. SW.	.021	**86**/2-3/4.25 (8.1)	**77**/2-4/?	**57**/2/3* (9.5)	**47**/2/3 (7.8)	**90**/2/4 (11.3)	**75**/3/2.75 (9.1)	**58**/2/3 (9.7)	**24**/2/?*	**56**/3/2.75 (6.8)	no survey
Cass Co. E.	.001	**24**/2/3 (4.0)	**7**/1/1* (7.0)	**14**/2/2 (3.5)	no survey	**11**/2/3 (1.8)	**8**/2/2 (2.0)	**12**/2/1.5* Private parcel. No survey TNC preserve. (4.0)	**34**/2/3 on private parcel. **15**/3/1.5 on TNC (4.4)	**10**/2/1.5**:** Private parcel, **20**/3/1 on TNC (4.8)	**19**/3/2 TNC **4**/3/1 Private parcel. (2.6)
Cass Co. NW.	.008	no survey	**0**	**0**	**0**	**0**	no survey	no survey	no survey	no survey	no survey
Cass Co. SE.	.026	**-**	**-**	**-**	**-**		**10**/3/1.5 (2.2)	**26**/2/3.25* (4.0)	**13**/2/1 (6.5)	**32**/3/4 (2.7)	**35**/2/2.75 (6.4)
Jackson Co. W.	.002	**14**/1/0.5 (28.0)	no survey	no survey	no survey	no survey	**11**/4/2 (1.4)	**2**/4/1.3 (0.4)	**1**/5/0.5 (0.4)	**2**/2/1.5 (0.7)	**1**/2/1 (0.5)
Jackson Co. E.	.012	**26**/1/7 (3.7)	no survey	no survey	no survey	**10**/2/2 (2.5)	**18**/2/3 (3.0)	**38**/4/1.5 (6.3)	**31**/2/1 (15.5)	**16**/2/1 (8.0)	**8**/2/1 (4.0)

Number of satyrs observed at occupied sites 2000-2009

DO NOT DISTRIBUTE:CONFIDENTIAL

Official Name	EO #	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Jackson Co. Cen.	.003	**15**/1/3.5 (4.3)	**24**/1/2.5 (9.6)	**58**/2/2.5 (11.6)	MRR est- **1106**	MRR est- **1106**	MRR est- **1200**	**29**/1/1.25* on Private parcel (W tract) only (23.2)	MRR est- **~3000** **1**/2/3 :Private parcel (M tract)	**39**/3/1** Private parcel (W) and County prop. only. (13.0)	W-creek **91**/2/4.5 E-creek **149**/3/2.5, Weaver- **8**/2/1 (12.4)
Kalamazoo Co. W.	.018	**17**/2/2 (4.3)	**10**/3/2.75 (1.2)	**4**/2/1.75 (1.1)	**8**/2/2.5 (1.6)	**4**/2/1.5 (1.3)	**5**/1/2 (2.5)	**8**/4/0.25* (8.0)	**1**/2/2 (0.3)	**12**/2/4 (1.5)	**6**/2/2 (1.5)
Kalamazoo Co. N.	.020	**8**/2/2.5 (1.6)	**3**/2/0.5* (3.0)	**1**/2/0.25* (2.0)	**2**/2/2 (0.5)	**0**/2/0.5 (0.0)	**0**/1/0.5 (0.0)	**0**/2/2.5 (0.0)	**0**/2/1 (0.0)	**0**/2/1 (0.0)	None found on (T) parcel, no survey on (B) parcel
St. Joseph Co. W.	.006	**15**/1/3.75 (4.0)	**10**/3/3.5 (1.0)	**23**/2/2.5 (4.6)	**17**/3/2 (2.8)	**15**/2/2 (3.8)	**28**/3/1.75 (5.3)	**7**/2/2* (1.8)	**1**/1/1 (1.0)	**0**/2/1 (0.0)	**0**/2/1.5 (0.0)
St. Joseph Co. E.	.010	**6**/2/2.5 (1.2)	**2**/2/1.5* (0.7)	**8**/1/1.25 (6.4)	**0**/1/1 (0.0)	**8**/3/3 (0.9)	**1**/2/4.5 (0.1)	**3**/2/2.25 (0.7)	**6**/4/3 (0.5)	**3**/2/1.15 (1.3)	No MS on (B) parcel, permission denied on (F) parcel (occupied)
Van Buren Co. NW.	.013	**11**/1/0.5 (7.3)	**12**/2/0.5 (12.0)	**18**/2/2 (4.5)	**9**/2/1.75 (2.6)	**42**/3/3.5 (4.0)	**121**/5/3.5 (6.9)	**71**/2/2.15 (16.5)	**78**/4/2 (9.8)	**35**/2/2.15* (8.1)	**35**/2/2.5* (7.0)
Van Buren Co. Site	.015	no survey	no survey	no survey	no survey	no survey	no survey	no survey	no survey	no survey	no survey
Washtenaw Co. W.	.011	**16**/2/1.25 (6.4)	**6**/1/0.5 (12.0)	**12**/2/2 (3.0)	**32**/3/2 (5.3)	MRR- **32 captured**	**39**/6/3 (2.2)	**81*** **marked** in study area; approx. 2/3 of habitat	**47**/3/2 (7.8)	**58*** marked in study area: approx 2/3 of habitat	**48**/2/4 (6.0)

* Not all occupied habitat was surveyed.

Michigan Natural Features Inventory- (Daria Hyde)- 11/30/2009

Table 2: History of Mitchell's Satyr Sites

Official Site Name	First Obs.	Last Obs.	Current Rank 2009	Previous Rank-2005	Previous Rank 2002	Direction	Viable 2009
Jackson Co. Central	1974	2009	AB	AB	C	pos	Y
Branch Co. Site	1965	2009	B	B	C	pos	Y
Van Buren Co. NW	1999	2009	BC	BC	CD	pos	Y
Barry Co. South	1974	2009	C	C	CD	pos	Y
Washtenaw Co. West	1952	2009	C	C	D	pos	Y
Berrien Co. North	1986	2009	C	C	C	neutral	Y
Cass Co. SW	1987	2009	C	C	C	neutral	Y
Cass Co. Southeast	2005	2009	C	CD	not known previously	pos	Y
Jackson Co. East	1996	2009	CD	CD	D	pos	?
Berrien Co. East	2002	2009	CD	CD	not known previously	neutral	?
Cass Co. East	1889	2009	CD	CD	C	neg	?
Kalamazoo Co. West	1974	2009	D	D	D	neutral	N
Jackson Co. West	1980	2009	D	D	D	neutral	N
Barry Co. SW	1965	2009	D	CD	D	neutral	N
Berrien Co. South	1987	2007	D	CD	C	neg	N
St. Joseph Co. East	1996	2008	D	D	CD	neg	N
Van Buren Co. Site	1984	1993	D (not surveyed since 1993- unlikely to occur)	D	D	neutral	N
St. Joseph Co. West	1952	2007	F	C	CD	neg	N
Kalamazoo Co. North	1973	2003	H	F	D	neg	N
Cass Co. Northwest	1979	1993	H	H	F	neg	H
Lenawee County Site	1965	1980	H	H	F	neg	H
Kalamazoo Co. East	1978	1978	H	H	F	neg	H
Kalamazoo Co. NE	1956	1956	H	H	H	neutral	H
Washtenaw Co. East	1931	1931	H	H	H	neutral	H

F= Failed to find, H= Historical

Sites highlighted in yellow- likely viable (8)

Sites highlighted in green- potentially viable (3)

Sites highlighted in blue- non viable (7)

Sites highlighted in orange- historical (6)

Sites with pink highlight-rank improved (7)

Sites with grey highlight-rank declined (8)

MNFI- updated 11-11-09

Results of Timed-Meander Mitchell's Satyr Surveys 2000 – 2009

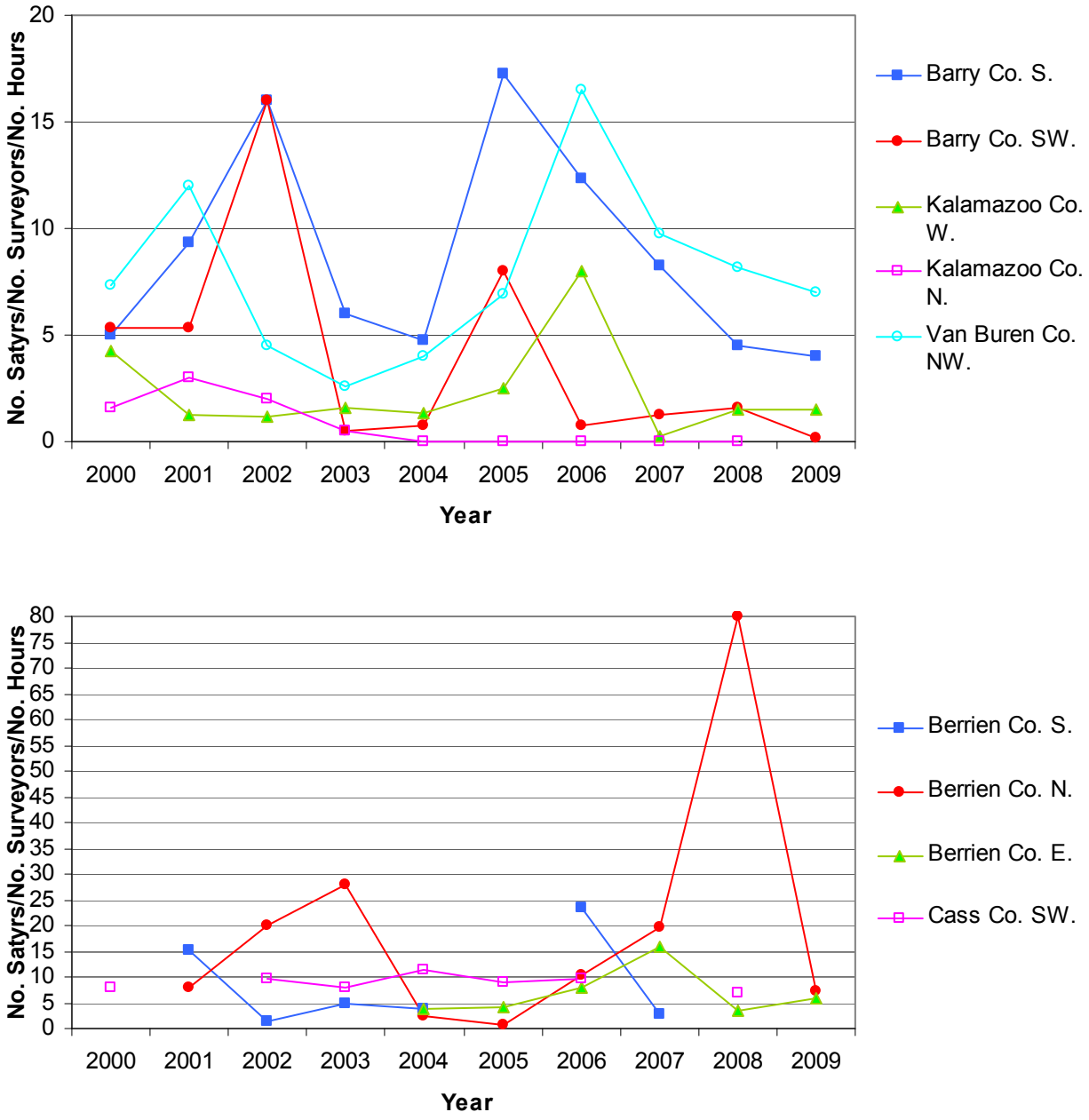


Figure 1. Average number of Mitchell's Satyrs observed (per surveyor per hour) during timed-meander surveys of known sites in southern Michigan during 2000-2009. Mean abundance was calculated based on the maximum number of individuals observed at a site within a given year. Gaps in survey data indicate years during which no surveys were done or more intensive mark-recapture studies were conducted.

Results of Timed-Meander Mitchell's Satyr Surveys 2000 – 2009

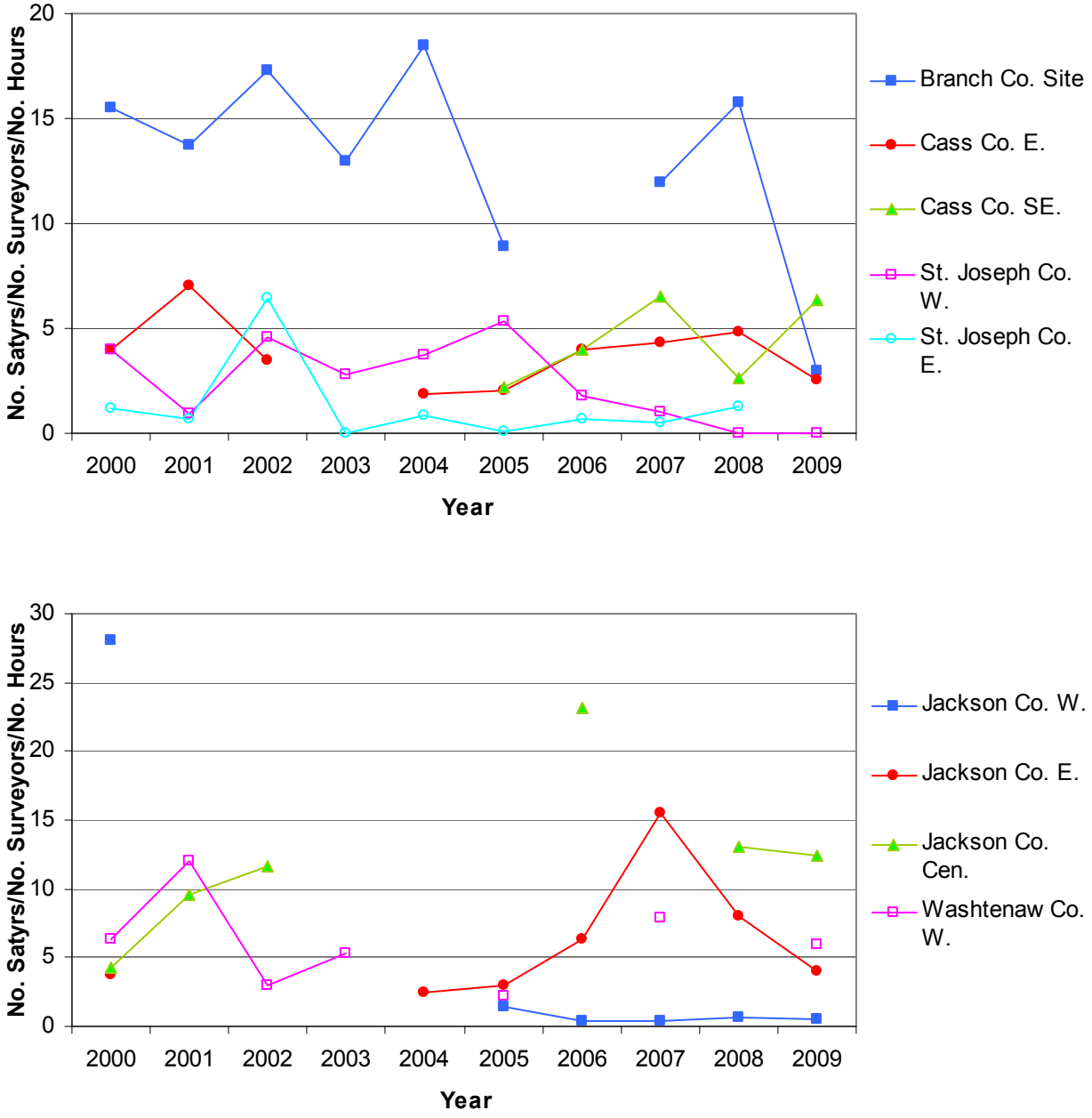


Figure 1 continued. Average number of Mitchell's Satyrs observed (per surveyor per hour) during timed-meander surveys of known sites in southern Michigan during 2000-2009. Mean abundance was calculated based on the maximum number of individuals observed at a site within a given year. Gaps in survey data indicate years during which no surveys were done or more intensive mark-recapture studies were conducted.

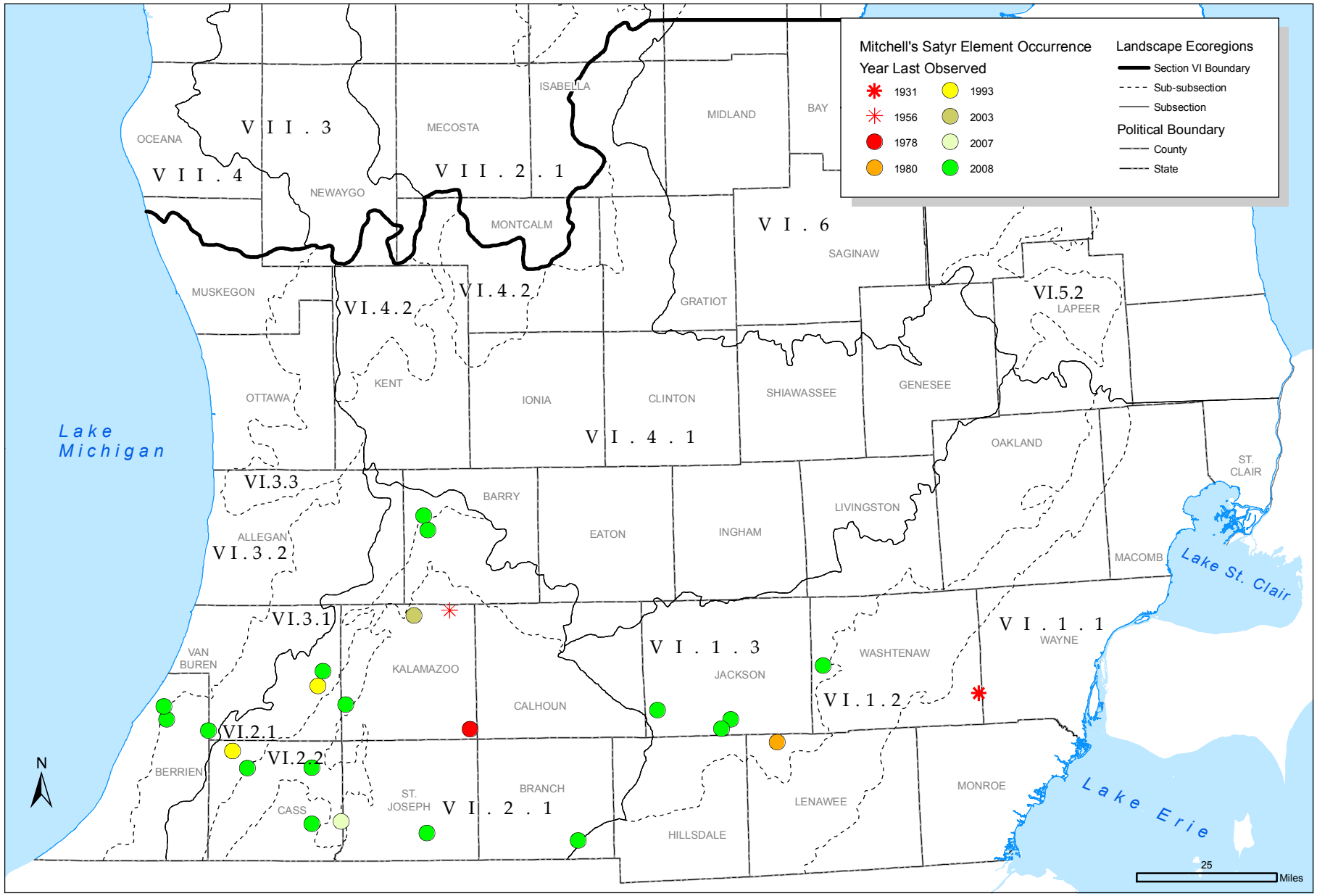


Figure 2. Distribution of Mitchell's satyr by last observed date

Summary of Research: 2006-2009

Introduction

A number of research projects were designed to address key needs identified by the Mitchell's satyr working group and that were consistent with recommendations included in the Mitchell's satyr recovery plan. Some of these needs include: a greater understanding of satyr biology and ecology, a more thorough understanding of satyr populations and a better understanding of effective management for both the Mitchell's satyr and other rare fen species.

Two research projects were initiated in 2006; 1) to monitor the population at the Branch County site through the use of a mark-release-recapture study (MRR), and 2) to study the effect of habitat clearing on Mitchell's satyr movement and distribution at the Washtenaw County West site using MRR. A summary of the results of research conducted in 2006 (drawn from the original reports) is provided below and the full report of this work can be found in Appendix C.

Four research projects were undertaken in 2007; 1) a MRR study to monitor the population at the Jackson County Central site, 2) a study to determine the correlation between timed meander transect data and MRR population estimates at Jackson County Central, 3) an attempt to direct oviposition in 32 enclosures as part of a study on the effects of fire on satyr emergence at Jackson County Central and 4) a study to identify Mitchell's satyr larval food plants by staff from The Toledo Zoo. A summary of the results of research conducted in 2007 (drawn from the original reports) is provided below and the full reports of this work can be found in Appendix D.

Three research projects were conducted in 2008; 1) continued study of the effect of habitat clearing on Mitchell's satyr movement and distribution at the Washtenaw County West site, 2) continued study of the effects of fire on satyr emergence at the Jackson County Central site and 3) a continued satyr larval food plant study by staff from the Toledo Zoo. A summary of the results of research conducted in 2008 (drawn from the original reports) is provided below and the full reports of this work can be found in Appendix E.

The satyr larval food plant study was continued in 2009 by the staff of the Toledo Zoo. A summary of the results of research conducted from 2008-2009 (drawn from the original reports) is provided below and the full reports of this work can be found in Appendix F. and G.

2006 Mark-Release-Recapture Population Studies

Although MRR population studies can be extremely labor intensive, they still provide the best methods for determining butterfly movements, population estimates, and home range estimates. There is a great deal that remains to be learned about the basic life history of the Mitchell's satyr. It is important to gather this type of data so that land managers have sufficient knowledge in order to help to conserve this species.

1) MRR at the Branch County Site

A MRR study was conducted at the Branch County site between June 24 and July 5, 2006. Although the original intent of this study was to cover the entire site the study area boundaries were adjusted due to size and dense shrub cover. It is estimated that approximately 2/3 of the occupied habitat was included in this study. Areas of open meadow and shrub areas were surveyed on alternate days. A total of 382 individuals (229 males and 153 females) were marked and 31% of males and 18% of females were captured more than once. The mean daily population estimate for males was 173.20 and for females it was 111.86. Assuming an equal sex ratio, the maximum daily population estimate was 699.94. These population estimates only apply to the Mitchell's satyrs within the designated boundaries of the study area and not the entire fen. These results indicate that the Branch County Fen site is the second largest known population in Michigan, behind Jackson County Central Fen.

In this study it was found that habitat type had a significant effect on both sexes. A greater proportion of males were found in open meadow areas and females were more often found in shrubby areas. There was a significant effect of sex on distance traveled each day with males traveling greater distances than females. The median distance traveled per recapture event was 38.34 m for males and 17.37 m for females. Males had larger travel distances overall. The longest distances recorded between consecutive captures for males were 333.14 m for males and 162.74 m for females. Home ranges for both sexes were under 0.10 ha. It is difficult to explain why there was a difference in densities of male and female Mitchell's satyrs in shrub and open meadow areas. Females have been observed to lay their eggs in close proximity to trees and shrubs and may be seeking oviposition sites in the shrub areas. Yet it is assumed that males would also be found in the shrubby areas seeking mates. The Branch County site is the only place where MRR studies have been conducted with both habitat types, so additional research at other Mitchell's satyr sites having both habitat components may provide more insight into this behavior.

2) Effect of Habitat Clearing at the Washtenaw County West Site

The objective of this research was to study the effects of clearing on Mitchell's satyr movement and distribution. As with most occupied satyr sites, the Washtenaw County West site is succumbing to encroachment by woody vegetation. Three plots with two paired treatment blocks in each were designated in areas with high Mitchell's satyr densities. Each block was 50 m x 20 m and randomly assigned control or treatment status. Treatment was defined as complete clearing of shrubs and trees <6" dbh (diameter at breast height) using hand-held brush cutters. Larger trees were girdled with the exception of tamarack trees which were not treated. An herbicide was applied to cut stumps, and all brush was removed from the blocks and placed outside of the study area. These treatments took place in February and March of 2006.

Figure 3. Private landowner clearing shrubs on his property in a treatment block

A mark-release-recapture (MRR) study was conducted from June 22nd to July 10th 2006 for a total of 13 sampling days. Each plot was surveyed twice per sampling day by walking established linear transects approximately 3 meters apart. A total of 81 individuals (53 males and 28 females) were marked during the study with 53% percent of males and 64% of females captured more than once. The estimated mean daily

population size for males was 21.99 and for females 10.03. If an equal sex ratio is assumed, the maximum daily population estimate was 160.00. These estimates apply to plot areas only and not the entire fen. The majority of both males and females were recaptured within the same plots of their first capturesThe results of this study suggest that clearing had no effect on Mitchell's satyr distribution and dispersal. There are a number of factors that may have influenced these results including: 1) the size of the blocks, 2) small home range sizes, or 3) temporal effects. The combined median home range sizes for male and female Mitchell's satyrs were 0.065and 0.032 ha respectively, with 62% of individual home ranges less than 0.10 ha, the same size as the treatment blocks. It is interesting that 63% of Mitchell's satyrs were recaptured within the same 0.10 ha block. The fact that there were no statistical differences between movements into or out of the treatment blocks indicates clearing has not yet produced more favorable conditions for the satyrs. This study was conducted during the first growing season after the clearing and movement patterns may change as vegetation in the cleared blocks recovers over time.

The most optimal approach for studying the effectiveness of clearing to enhance habitat and increase Mitchell's satyr populations would be to conduct long-term studies that monitor vegetation changes as well as satyr movements and distribution. It is known from previous studies that the Mitchell's satyr is an edge species that also occupies shrub-carr areas within the fen habitat. A better understanding of the structural components and cover types favored by the butterfly may assist in determining the best characteristics for artificially created openings (edge shape, amount of woody vegetation, size). Since previous research has demonstrated that the majority of Mitchell's satyrs fly short distances, it is safe to speculate that new habitat would be colonized by only a few individuals each season. Consequently, the benefits of clearing for the Mitchell's satyr may not be realized for several years.

Temporal barriers where individuals arrive in newly created patches too late to reproduce, are important to consider when managing for the Mitchell's satyr. This situation could occur when females have oviposited all of their eggs before reaching the new patch, or when emigrating individuals arrive in a new patch at the end of their lifespan. Species that are short-lived and have limited dispersal capabilities (such as the Mitchell's satyr) would be affected by temporal barriers; new habitat patches must be located close enough to the resident colony that sufficient numbers of gravid females could reach the new habitat and deposit their eggs. This assumes that the quality of the newly created habitat meets the requirements of the species. Given our knowledge that the median distances moved by females is 31 m, new habitat patches should be created no further than 30 m from occupied habitat in order to support immigration into the new area. Future studies are needed to define habitat requirements and complete the life history description of the Mitchell's satyr. Concurrent research should focus on the effects of management (prescribed fire, clearing) on the Mitchell's satyr, and long term monitoring should be implemented to document the temporal effects with the goal of providing land managers information that can be used to prescribe the best management practices for conservation of the Mitchell's satyr.

2007 Mark Release Recapture Population Studies

1) MRR at the Jackson County Central Fen

Population estimates and vagility data for the Mitchell's satyr population at Jackson County Central (JCC) were first obtained in 2003 and again in 2005. Because this site is undergoing active management by The Nature Conservancy (TNC), long term monitoring of the population (every two years) was proposed in 2006 by members of the Mitchell's satyr working group to determine the effects of management on the population. Using MRR techniques, it is possible to analyze changes in distribution and population levels over time. The information gathered can be useful in developing management plans for this and other sites.

The MRR study included fourteen sample days from June 22 to July 9, 2007. The majority of individuals were captured only once. There were 897 satyrs marked with an average recapture rate of 20%. The maximum daily population estimate for both sexes combined was 3020. If one assumes a 50/50 sex ratio, the maximum daily population estimate calculated was 3668 individuals. These estimates are larger than those from prior studies at this site.

In the eastern fen at the JCC site, 35males were marked (four recaptures) and 35 females (one recapture) with none found moving between fens. Conducting MRR studies in the eastern fen provided the opportunity for researchers to document whether movement was occurring between two closely situated fens and whether there is a functioning metapopulation at this fen complex. Unfortunately, the size of the field crew limited the amount of sampling that was possible in the eastern fen. It is recommended that in the future, increasing field crew numbers would facilitate daily MRR activities which would cover both sites in their entirety. Documenting satyr movement between sub-populations will help determine whether Mitchell's satyrs travel through unsuitable habitat between these two fens. This information is important to conservation efforts, which includes the acquisition of nearby occupied habitats.

2007 Timed- Meander Survey Correlation to MRR

2) Timed Meander/Population Estimate Correlation at Jackson County Central
The objective of this study was to produce a mathematical model to estimate population size based on Timed Meander (TM) survey data by conducting a TM survey during a MRR at Jackson County Central (JCC). The study was conducted in the northern 2/3 of the JCC fen on the east side of the creek with seven TM surveys occurring. MRR activities were conducted over the entire JCC site throughout the flight period of the satyr. MRR data from within the TM survey area was extracted using ArcView 3.2. Program Jolly was used to estimate population size and Pearson's test was conducted to determine whether population estimates or number of satyr handled during the MRR could be correlated with TM counts. Our objective was to develop a model that would allow the estimation of population size based on TM counts alone. Pearson's correlation test showed no correlation between the TM survey data and the population estimates; however the results are suspect because of low sample sizes. Additionally, population estimate data were not normally distributed and contained an outlier (sample period 2), further invalidating the test. Larger sample sizes would increase the validity of the data. It is recommended that next time a MRR study is conducted at a Mitchell's satyr site that TM surveys are coordinated at the same time (with the goal of a larger sample size) to build on this study.

Impacts of Fire on Satyr Survival - 2007 Research

3) Directed Oviposition-Fire Study
The two primary methods of enlarging and enhancing satyr habitat are mechanical/manual shrub removal and prescribed fire but these methods may may also have negative effects on larval survival. If larvae are above ground and not in the duff, fire could have serious consequences, depending on the intensity and coverage. There is a critical need to understand the effects of prescribed fire on Mitchell's satyr survival and population dynamics. The study attempted to document the effects of prescribed fire on larval survival and adult emergence.

On June 29th; 8 females were place in net enclosures attached over sedge tussocks to concentrate oviposition as part of the study of prescribed fire on satyr emergence. The females were checked several hours later and found perched at the top of the enclosures. They were removed 48 hours later on July 2nd per study protocol. During this process two of the females could not be located and it is not known whether they were eaten by predators or escaped (unlikely). One female was released unharmed, one female was dead and four others were injured and could not fly. Before removing the above females,

eight additional females were captured and were placed in enclosures. After discovering the injuries in the first set of eight, the study was terminated due to unacceptable risk to the satyrs. An attempt was made to release the newly captured eight individuals approximately 1 hour after capture. Two of the females were injured while held in the enclosures. The remaining six were unharmed and released.

Because research on the effects of fire on satyr survival is considered a top priority by the Mitchell's satyr Working Group it was recommended that the study should be repeated during the 2008 field season with new enclosures and an experimental prescribed burn done in the spring of 2009. It was recommended that the enclosures be redesigned, providing structures that are stable with no folds, corners, or other "hiding places" that could trap the satyrs and result in fatal injuries.

2008 Mark Release Recapture Population Studies

1) Effect of Habitat Clearing at the Washtenaw County West Site
A MRR study was conducted from July 1- July 14, 2008 for a total of nine sampling days at the Washtenaw County West Site to continue the research that was initiated at this site in 2006. Each plot was surveyed by two individuals walking linear transects approximately 3 meters apart. A total of 58 individuals were marked (37 males and 21 females) with only 4 recaptures (all males). Given the low number of recaptures it was not possible to calculate a population estimate. Wing conditions of the satyrs at the end of the study were still fresh to slightly worn, which is highly unusual as previous MRR's showed wing wear at the end of the flight periods to be mostly worn to well-worn. This suggests that the flight period was interrupted, perhaps due to severe weather or some other unknown circumstance. Several severe thunderstorms occurred during the flight period, which may have resulted in premature satyr mortality before their wings would have worn out naturally. Severe storms are common at the Jackson County Central site during the latter part of the flight period and are thought to hasten the end of the flight No conclusions could be drawn from the data regarding preference for treatment versus control plots due to the low number of recaptures.

While data collection did not provide sufficient data to analyze movement between control and treatment plots, it is recommended that MRR studies be continued every two years to capture trends in population size and to characterize the temporal changes in habitat. Butterfly populations are known to fluctuate annually and thus a long-term monitoring study is warranted to assess both the health of the population and the effects of the treatment (clearing) on satyr movements. It was noted during this study that a number of invasive plant species are taking hold in the study plots. These include Russian olive *(Elaeagnus angustifolia),* cattails *(Typha spp.),* phragmites *(Phragmites australis),* and reed canary grass *(Phalaris arnndinacea).* It is recommended that management action be undertaken to remove invasives before the habitat becomes unsuitable for the satyrs. The study plots were created in the center of known "hotspots" for Mitchell's satyrs, and the degradation of these areas may result in their extirpation.

Impacts of Fire on Satyr Survival- 2008 Research

2) Directed Oviposition-Fire Study
This study, first initiated in 2007, was repeated with modifications to the design of the enclosures to prevent mortality and injury to the satyrs. In June of 2008, four blocks with two paired plots (treatment and control were designated in the fen and flags were placed on appropriate sedge tussocks to indicate enclosure locations. On June 8, 2008, 10 females were captured and eight were placed in the enclosures and two in rearing cages provided by the Toledo Zoo. The rearing cages were to be used as backup enclosures should the newly designed enclosures not function properly. On June 10, 2008, 16 females

were captured and placed in enclosures. During the removal of females from eight enclosures and two cages on June 8, two satyrs were found dead with evidence of predation and two satyrs were missing from the cages and presumed predated upon. During removal of females from 16 enclosures on June 12, seven were missing and presumed predated upon, one was found in spider's web (wing only), and one was alive but had broken forewing and was unable to fly. This satyr was left on site with the hopes that she would continue to lay eggs. Due to the high level of mortality the study was terminated.

Research on the effects of fire on satyr survival is considered a top priority by the Mitchell's satyr Working Group, yet non-lethal methods of testing this are not yet realized. Given the reported locations of larvae during hibernation, there can be little doubt that some mortality occurs during fire. The question of how many larvae perish has yet to be answered. The Mitchell's Satyr Working Group should continue to generate ideas on methodology that would test the effects of fire without causing unnecessary mortality to the individual satyrs used in these experiments.

Food Plant Preferences Study 2007-2009

One of the most important tasks of a habitat conservation plan is determining which habitat attributes contribute to the successful retention or colonization of Mitchell's satyr in any given fen. Critical tasks include determination of which species of wetland grasses and sedges are utilized by early-instar larvae as host plants. Although Mitchell's satyr often occurs in sedge meadows and fens dominated by the tussock sedge, Carex stricta, and some larvae unequivocally feed on C. stricta, anecdotal reports, older publications, and some of the grey literature all report that Mitchell's satyr early-instar larvae feed on a variety of grasses and sedges. Efforts to define the range of larval host plants used by N. mitchelli began in 2006 as a cooperative effort between the Michigan Natural Features Inventory and The Toledo Zoo.

Potential host plants were selected and collected by Daria Hyde and Michael Penskar of the Michigan Natural Features Inventory with assistance from Peter J. Tolson, Candee L. Ellsworth of The Toledo Zoo, Michael DeCapita of the USFWS, and Todd Hogrefe of the Michigan Department of Natural Resources within the Barry State Game Area. The first collections were made on June 22, 2006 and included *C. leptalea, C. sterilis, Eleocharis elliptica, Panicum* sp., and *Poa palustris*. *Carex stricta* has been under cultivation at the Zoo since 2003. Additional collections were made on June 6, 2007 at the Lost Nation State Game Area and included *Carex buxbaumi, C. flava, C. lasiocarpa, C. prairea, C. tetanica*, and *Rhynchospora capillacea*.

2007 Food Plant Study

2007 Methods - Captive bred Mitchell's satyr larvae were obtained by a second generation breeding of adults produced from conservation breedings in 2005 and 2006. No eggs were collected from the wild in 2007. Plants to be tested for larval feeding were planted in 50 cm x 65 cm poly tubs in a four-plant species grid surrounding a central area containing newly-oviposited *N. m. mitchelli* eggs on small plants that were used by captive-bred females for oviposition. These plants were primarily *Pilea pumila* and *Viola nephrophylla*. Newly hatched larvae needed to travel approximately 5 cm on bare soil to reach any of the potential host plants. *Carex stricta* was always offered as one of the four plant species available to the larvae. Four replicates of each experimental setup were produced.

The first Mitchell's satyr eggs were detected on June 28, 2007. Oviposition continued through July 5, 2007. The breeding group was estimated to consist of 12 males and six females. Butterflies were not dissected to determine sex and all were kept in the breeding cage until death. Because adults were kept in a group, no egg totals were tabulated for individual females. A total of 309 eggs were discovered, but only 88 larvae were detected and subsequently used for the host plant selection experiments. Others may

have died without being detected. Several larvae in each group descended to the substrate from the oviposition plant after hatching, but remained on the substrate, apparently without attempting to feed. All of these larvae subsequently died.

Monitoring- Satyr eggs were monitored twice per day for hatching and movement of the larvae to specific host plants. Individual larvae that had selected host plants were monitored at least daily until well into the 3rd instar, when they became sedentary and entered diapause. There was no attempt to avoid mortality when larvae chose a potential host plant. If a larva moved to a plant but did not feed, or fed sparingly, it was not transferred from the plant it originally selected to a more palatable species. Plant selections and perch heights were noted each day. Perch heights were measured to the nearest mm.

Host plant selection- Plant species included in the experiments included *C. stricta, C. tetanica, Panicum* sp. and *Rhyncospora capillacea.* In addition, a replicate of the host plant experiment from 2006 using two grasses was replicated in 2007. Species tested were *C. stricta, Panicum* sp. and *Poa palustris*. First instar larvae overwhelmingly tended to remain on the host plant selected until death or the 3rd instar. All larvae that initially selected *Carex tetanica* and *Rhyncospora capillacea* and remained on those species died. Feeding damage was evident on both species. As in 2006, the most movement occurred between *Carex stricta, Panicum sp*., and *Poa palustris.* By mid August most larvae had migrated to *C. stricta* to begin diapause.

2008 Food Plant Study

2008 Methods - The system was simplified by using 12" diameter Belvin bulb pans sparsely planted with the test grasses and sedges- to reduce spider predation. A plastic sleeve was installed around the plants and cap of chiffon fabric was placed over the top of the cylinder to increase ventilation. *Carex stricta* was always offered as one of the four plant species available to the larvae. Thirty eggs were collected on July 11, 2008 from four females at the Van Buren County NW site by Peter Tolson, Mitchell Magdich, and Candee Ellsworth of the Toledo Zoo and Nate Fuller of the Southwest Michigan Land Conservancy. Females were netted and placed overnight in a polyester-netted tub planted with *Carex* and forbs and were released unharmed. An additional four females were collected during a second visit to this site on July 21 and 22nd, 2008. One of the females was copulating, so the pair was gently released, along with the other three females, into a similar tub. When the tub was checked the next morning it was discovered that the male and one of the females was dead. This take equaled the maximum allowed by the Toledo Zoo's permit and the collection activities were terminated. The satyrs were not predated and exhibited no injuries.

Monitoring- Satyr eggs were monitored twice per day for hatching and movement of the larvae to specific host plants.

Host plant selection - In 2008 the species tested were *Carex buxbaumii*, *Carex lasiocarpa*, *Carex prairea*, and *Carex stricta*. The only Mitchell's satyr eggs collected were detected on July 11, 2008. Thirty eggs were discovered- 23 on the lower framing of the enclosure and seven on *Pilea pumila*. The eggs on the tub framing hatched overnight on July 19th and the larvae were recovered the next morning. Twenty-one larvae were detected and used for the subsequent host plant experiments. Three larvae descended to the substrate and died before selecting a host plant. This year was very unusual in that larvae were very vagile and moved from plant to plant very frequently, feeding on every plant provided. One striking difference between 2007 and 2008 was larval activity. In 2007 most larvae had ceased feeding and entered diapause by mid-August. In 2008 larvae were still active and feeding as late as September 12th.

2009 Food Plant Study

2009 Methods- Fifteen eggs were collected on July 8, 2009 from four females at the Van Buren County NW Site Lake by Peter Tolson, Mitchell Magdich, and Candee Ellsworth of the Toledo Zoo and Nate Fuller of the Southwest Michigan Land Conservancy. Females were netted and placed overnight in a polyester-netted tub planted with *Carex* and forbs and were released unharmed. The same 12" diameter Belvin bulb pans sparsely planted with the same test grasses and sedges that were used as in 2008 (*Carex buxbaumii, Carex lasiocarpa, Carex prairea,* and *Carex stricta)*. A plastic sleeve was installed around the plants and cap of chiffon fabric was placed over the top of the cylinder to increase ventilation. *Carex stricta* was always offered as one of the four plant species available to the larvae.

Monitoring- Satyr eggs were monitored twice per day for hatching and movement of the larvae to specific host plants.

Hatching 2009 - Of the fifteen eggs collected, partial hatching was observed on July17-18. Five eggs were infertile. Four larvae died attempting to hatch. Two larvae made it to the soil but died there almost immediately. The remaining four larvae were transferred to *C. stricta* but never fed and also died.

Discussion - Through the course of these experiments, the numbers of experimental subjects and replicates were limited by the numbers of larvae available either due to permit restrictions or the number of eggs laid by the captured females. With low numbers of eggs collected at the Van Buren County NW site is it speculated that this locality may be reproductively compromised. It is recommended that the USFWS permit be increased to allow for the take of 100 Neonympha eggs for the 2010 field season from a more robust population.

The research reconfirmed that 1st instar Mitchell's satyr larvae will select and feed upon several different grasses and sedges, not all of which can support successful development. Six species in the Carex family were identified which support normal development until the 3rd instar diapause in August including: *Carex- buxbaumii, lasiocarpa, leptalea, prairea, sterilis,* and *stricta*. In addition, two grasses- *Panicum amplicatum* and *Poa palustris* were found to support normal development. On the other hand all larvae that initially selected *Carex tetanica* and *Rhyncospora capillacea* and remained on those species died.

Feeding height data was also collected but is not intended to indicate plant palatability or preferred perch heights. These data reflect many observations of the same larvae over the course of the study, and simply give some indication of where the larvae are eating in the layer of grasses and sedges. No attempts were made to "rescue" larvae that had apparently made poor choices, as the goals was to determine if a particular potential host plant would support larval growth through the 3rd instar. Similarly, many larvae died on the substrate (soil, moss, or wood fragments) as they wandered about but did not climb on any of the available plants. No attempts were made to place these larvae on host plants, although larvae that were inadvertently brushed off the plants as observers were looking for them were replaced on their host plants.

Plant species used in the trials in both 2007 and 2008 were those that had transplanted most successfully after the collection and were numerous enough to make replicate tubs. For purposes of breeding Mitchell's satyr for future reintroduction at sites it is recommended to use species of plants that larvae preferred: *C. stricta, C. prairea,* and *Panicum amplicatum*. With the opening of a new $500,000 Butterfly Conservation Center at the Toledo Zoo in 2009, there is an even greater potential to aid in the efforts to reintroduce *N. m. mitchelli* at selected fens in Michigan and Indiana. This new facility resulted in a record number of Karner blue butterflies produced in 2009- 1538 butterflies, more than double the old record of the 756 adults produced in 2008.

Associated Plant and Animal Surveys 2007-2009

Introduction

Rather than following a single species management approach for the recovery of the Mitchell's satyr butterfly, it is preferred to take an ecosystem view and consider the prairie fen habitat in which this species lives along with other associated plant and animals as well as adjacent natural communities that border fens. This approach provides a more comprehensive understanding of Mitchell's satyr habitat and yields critical information that can inform management strategies that can benefit many fen species.

MNFI scientists conducted surveys for rare and potentially vulnerable plant and animal taxa at extant and historical Mitchell's satyr sites, known prairie fens and wetlands with potential fen habitat as well as in adjacent upland habitats such as oak barrens (Table 3.). Surveys for rare plants, insects, reptiles, amphibians, snails, mussels and crayfish were conducted at potential sites using methodology appropriate for the specific plant or animal taxa. Final analyses of snail, mussel and crayfish specimens have not been completed. The results of these analyses will be reported in the 2010 final report.

During 2007, surveys were conducted at 50 sites in 12 counties in southern Michigan for a total of 102 site visits. As a result of these surveys 18 new element occurrences (EOs) were confirmed including 5 plant and 13 insects. In addition, 33 EOs for 4 plants, 20 insects and 9 herps (amphibians or reptiles) were updated, including information about the size, extent and condition of the occurrence (Table 4.). In 2008, surveys for plants and animals were done at 37 sites in 14 counties for a total of 52 site visits. These surveys resulted in 22 new EOs including 3 plants and 19 insects. Seventeen EOs were updated, made up of 1 plant, 15 insects and 1 herp (Table 5.). Finally, in 2009, surveys were conducted at 44 sites in 12 counties for a total of 72 site visits. As a result of these surveys 11 new EOs were confirmed including 2 plants, 5 insects, 1 herp and 3 mussels. Thirty four EOs were updated consisting of 12 plants, 13 insects and 9 herps (See Table 6.).

Table 3. Summary of Plant and Animal Survey Effort and Results- 2007-2009

Year of Survey	Sites Surveyed	Site Visits	New EOs	Updated EOs
2007	50	102	18	33
2008	37	52	22	17
2009	44	72	11	34

The following sections provided a more detailed review of the methods, results and possible implications of these survey results. This information should be shared with land managers so that they can carefully consider the potential impacts of various management strategies on the plants and animals that make up the prairie fen community.

Table 4: 2007 Plant and Animal Survey Effort and Results

County	Survey Site Name	Survey Date	Surveyors	Plant and Animal Targets	Rare Plant and Animal Species Documented (updates in normal font new EOs in bold)
Allegan	Jackson Lake Fen (Ebersole)	09/06/2007	DC	Papaipema moths	
Barry	Bassett Lake Southwest/Barry SGA	06/01/2007	KK	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle	
		06/22/2007	KK	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle	
		07/05/2007	KK, NH	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle	
		08/14/2007	YL, KK	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle	
Barry	Stream between Basset Lake and Shaw Lake/Barry SGA	08/14/2007	YL, KK	Eastern Massasauga, Eastern Box Turtle	
Barry	Bowens Mill Road Fen/Barry SGA	06/01/2007	KK	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle	
		07/31/2007	DC	swamp metalmark, rare leafhoppers, spittlebugs	***Dorydiella kansana***
		08/02/2007	KK	Eastern Massasauga, Eastern Box Turtle, Blanding's Turtle	
Barry	Deep Lake Fen/Barry SGA	05/25/2007	KK	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle	
Barry	Deep Lake Fen Uplands/Barry SGA	08/13/2007	KK	Eastern Massasauga, Eastern Box Turtle	
Barry	Snow Lake/Barry SGA	08/13/2007	KK	Eastern Massasauga, Eastern Box Turtle	
Barry	Turner Creek /Barry SGA	05/25/2007	KK	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle	*Eastern Massasauga*
		07/30/2007	DC	swamp metalmark, rare leafhoppers, spittlebugs	*Lepyronia angulifera*
		08/13/2007	KK	Eastern Massasauga, Eastern Box Turtle	
		09/05/2007	DC	Papaipema moths	*Lepyronia angulifera*, ***Dorydiella kansana***
Berrien	Blue Creek Fen (TNC)	06/20/2007	KK	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle	
Berrien	Butternut Creek	05/24/2007	KK, NH	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle	*Eastern Box Turtle*
		06/05/2007	KK	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle	*Eastern Box Turtle*
		06/19/2007	YL, KK	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle	
		06/28/2007	YL, BY, CH	Mitchell's satyr, Eastern Massasauga, Eastern Box Turtle, Spotted Turtle	*Eastern Box Turtle*

Table 4: 2007 Plant and Animal Survey Effort and Results

County	Survey Site Name	Survey Date	Surveyors	Plant and Animal Targets	Rare Plant and Animal Species Documented (updates in normal font new EOs in bold)
		08/05/2007	DC	swamp metalmark, rare leafhoppers, spittlebugs	
Berrien	Butternut Creek (continued)	08/09/2007	KK	Eastern Massasauga, Eastern Box Turtle, Kirtland's Snake	
		05/23/2007	YL, KK, NH, LL	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle, prairie fen species and associated rare taxa of oak barrens in adjacent uplands	*Cypripedium candidum*
Cass	Cook Lake - Rudy Road Fen	08/05/2007	DC	swamp metalmark, rare leafhoppers, spittlebugs	***Prosapia ignipectus***
Cass	Lime Lake and vicinity (9 locations)	06/19/2007	YL, KK	Blanchard's Cricket Frog	
Cass	Priest Lake and vicinity (3 locations)	06/19/2007	YL, KK	Blanchard's Cricket Frog	
Cass	Skidmore Tract	07/27/2007	KK	swamp metalmark, rare leafhoppers, spittlebugs	
		05/24/2007	KK, NH	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle	*Eastern Box Turtle*
		06/06/2007	KK, BC	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle	
		06/19/2007	YL, KK	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle	
		07/04/2007	BY, DC	Mitchell's satyr	*Eastern Massasauga*
		08/09/2007	KK	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle	
Cass	Shavehead Lake	09/25/2007	YL, DC	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle	
Cass	Shavehead Lake and vicinity (9 locations)	06/19/2007	YL, KK	Blanchard's Cricket Frog	
Cass	Wakelee Fen (Tamarack Swamp)	07/27/2007	KK	swamp metalmark, rare leafhoppers, spittlebugs	
Hillsdale	Goose Creek Grasslands - MNA	07/15/2007	DC	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
		06/06/2007	MP, CE	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	*Cypripedium candidum*
Hillsdale	Lost Nation State Game Area	07/17/2007	DC, KK	Poweshiek skipper, swamp metalmark	*Calephelis mutica*
Jackson	Glenn Road Fen	08/07/2007	DC, MP	swamp metalmark, rare leafhoppers spittlebugs, prairie fen plants and associated rare taxa of oak barrens in adjacent rare uplands	

Table 4: 2007 Plant and Animal Survey Effort and Results

County	Survey Site Name	Survey Date	Surveyors	Plant and Animal Targets	Rare Plant and Animal Species Documented (updates in normal font new EOs in bold)
		05/31/2007	YL, KK	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle	
		07/11/2007	BB	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
		07/13/2007	DC, MP, RO, AF	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
		07/13/2007	MP, RO, DC, AF	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	***Muhlenbergia richardsonis, Geum virginianum***
		09/07/2007	DC	Papaipema moths	***Papaipema beeriana***
		09/07/2007	DC	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	*Muhlenbergia richardsonis*
Jackson	Grand River Fen	09/23/2007	DC	Papaipema moths	*Papaipema beeriana*
		07/26/2007	DC, MP	Swamp metalmark	
Jackson	Mt. Hope Road Fen	07/27/2007	DC, MP	Rare leafhoppers, spittlebugs	
		06/14/2007	KK	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle	
		07/13/2007	DC, MP, RO, AF	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	*Bessya bullii* on adjacent hillside prairie remnant
Jackson	Skiff Lake Fen	07/13/2007	DC, MP, RO, AF	Poweshiek skipper, swamp metalmark	
Jackson	Snyder Lake Fen West	07/12/2007	DC, KK, AF	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
Kalamazoo	Bear Creek - Fulton SGA	08/10/2007	KK	Eastern Massasauga, Eastern Box Turtle	
Kalamazoo	Bear Creek (private land N. of Fulton SGA)	08/10/2007	KK	Eastern Massasauga, Eastern Box Turtle	
Kalamazoo	Paw Paw Lake Fen - Boat launch	06/18/2007	KK, NH	Blanchard's Cricket Frog	*Blanchard's Cricket Frog*
		06/11/2007	KK	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle, Blanchard's Cricket Frog	*Blanchard's Cricket Frog*
		06/20/2007	KK	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Blanding's Turtle, Spotted Turtle, Blanchard's Cricket Frog	
		07/05/2007	KK	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Blanding's Turtle, Blanchard's Cricket Frog	
Kalamazoo	Paw Paw Lake Fen/Palmer Memorial Preserv (MNA)	08/03/2007	KK	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Blanding's Turtle, Blanchard's Cricket Frog	*Eastern Box Turtle, Blanchard's Cricket Frog*

Table 4: 2007 Plant and Animal Survey Effort and Results

County	Survey Site Name	Survey Date	Surveyors	Plant and Animal Targets	Rare Plant and Animal Species Documented (updates in normal font new EOs in bold)
Kalamazoo	Paw Paw Lake Fen/Palmer Memorial Preserv (MNA) (continued)	08/15/2007	YL, KK	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Blanding's Turtle, Blanchard's Cricket Frog	
		08/16/2007	NH	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Blanding's Turtle, Blanchard's Cricket Frog	
Kalamazoo	Springbrook Fen	08/15/2007	KK	Eastern Massasauga, Eastern Box Turtle, Blanding's Turtle	
Kalamazoo	Vanderbilt Fen - Gourdneck SGA	06/13/2007	KK	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle, Blanchard's Cricket Frog	*Eastern Box Turtle, Eastern Massasauga, Blanchard's Cricket Frog*
		06/18/2007	KK, NH	Blanchard's Cricket Frog	*Blanchard's Cricket Frog*
		08/16/2007	NH	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Blanding's Turtle, Blanchard's Cricket Frog	
Lenawee	Goose Creek Grasslands - MNA	07/01/2007	DC	Swamp metalmark	
Livingston	Bullard Lake	07/10/2007	RO, AF	Poweshiek skipper, swamp metalmark	
		07/26/2007	KK	swamp metalmark, rare leafhoppers, spittlebugs	
Livingston	Unadilla State Game Area	08/07/2007	DC, MP	swamp metalmark, rare leafhoppers, spittlebugs, prairie fen plants and associated rare taxa of oak barrens in adjacent rare uplands	
Oakland	Big Crotched Lake Fen	07/20/2007	DC, KK	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	***Muhlenbergia richardsonis***
		07/20/2007	DC, KK	Poweshiek skipper, swamp metalmark, rare leafhoppers, spittlebugs	***Prosapia ignipectus***
Oakland	Big Valley - MNA	07/10/2007	RO, AF	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
		07/25/2007	DC, KK	swamp metalmark, rare leafhoppers, spittlebugs	***Flexamia huroni, Prosapia ignipectus***
		09/18/2007	DC, DK	Papaipema moths	***Papaipema beeriana***
Oakland	Brandt Road Fen	07/09/2007	DC, KK	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
		09/24/2007	DC	Papaipema moths	
Oakland	Bridge Valley	07/09/2007	DC, RO, KK, DK, AF	Poweshiek skipper, swamp metalmark	
		07/26/2007	KK	swamp metalmark, rare leafhoppers spittlebugs	***Flexamia huroni***

Table 4: 2007 Plant and Animal Survey Effort and Results

County	Survey Site Name	Survey Date	Surveyors	Plant and Animal Targets	Rare Plant and Animal Species Documented (updates in normal font new EOs in bold)
Oakland	Golden Preserve	08/27/2007	DC	swamp metalmark, rare leafhoppers, spittlebugs, tree crickets	***Oecanthus laricis***
Oakland	Halsted Lake Fen	07/10/2007	DC, KK	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
Oakland	Long Lake Fen	07/10/2007	DC, KK	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
		07/11/2007	DC, KK	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
		07/20/2007	DC, KK	Poweshiek skipper, swamp metalmark, rare leafhoppers, spittlebugs	***Lepyronia angulifera***, *Prosapia ignipectus, Flexamia huroni*
		08/01/2007	KK, NH	Eastern Massasauga, Eastern Box Turtle, Blanding's Turtle	
		09/17/2007	DC, RO	Papaipema moths	
Oakland	Rattalee Lake Road	07/09/2007	DC,KK	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
		07/11/2007	DC, KK	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
		08/27/2007	DC	swamp metalmark, rare leafhoppers, spittlebugs, tree crickets	***Lepyronia angulifera***
Van Buren	Lime Lake Fen and vicinity (5 locations)	06/18/2007	KK, NH	Blanchard's Cricket Frog	
Van Buren	Paw Paw Conservation District and vicinity (4 locations)	06/18/2007	KK, NH	Blanchard's Cricket Frog	
Van Buren	Paw Paw Prairie Fen and vicinity (5 locations)	06/18/2007	KK, NH	Blanchard's Cricket Frog	
Washtenaw	Long Lake Fen	07/26/2007	DC, MP	Swamp metalmark	
		07/27/2007	MP, DC	Rare leafhoppers, spittlebugs	***Prosapia ignipectus***
		07/27/2007	MP, DC	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	***Sporobolus heterolepis***
Washtenaw	McLaughlin Lake fen - Waterloo RA	07/19/2007	DC, MP, MH	Poweshiek skipper, swamp metalmark, rare leafhoppers, spittlebugs, prairie fen plants and associated rare taxa of oak barrens in adjacent uplands	
Washtenaw	Mill Creek East	05/30/2007	YL, KK, DI	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle	
		06/20/2007	YL, BB, DK	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle	
		06/29/2007	YL, DK, TH	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle	
		07/10/2007	YL, KB	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Blanding's Turtle	

Table 4: 2007 Plant and Animal Survey Effort and Results

County	Survey Site Name	Survey Date	Surveyors	Plant and Animal Targets	Rare Plant and Animal Species Documented (updates in normal font new EOs in bold)
Washtenaw	Mill Creek East (continued)	08/17/2007	YL, DC	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle	
Washtenaw	Park Lyndon North	07/12/2007	DC, KK, AF	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
		07/19/2007	DC, MP, MH	Poweshiek skipper, swamp metalmark, rare leafhoppers, spittlebugs, prairie fen plants and associated rare taxa of oak barrens in adjacent uplands	*Lepyronia angulifera, Prosapia ignipectus*
Washtenaw	Whalen Lake	07/11/2007	DC, KK	Poweshiek skipper, swamp metalmark	
Washtenaw	Willis Road Fen	07/26/2007	DC, MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	***Sporobolus heterolepis***
		07/26/2007	DC, MP	swamp metalmark, rare leafhoppers, spittlebugs	
		09/20/2007	DC, KB	Papaipema moths	

12 Counties **50 sites visited** **102 visits** **18 new EOs (5 plants, 13 insects)**

33 updated Eos (4 plants, 20 insects, 9 herps)

Surveyors:

BB - Barbara Barton, MNFI
BC - Brad Cogdell, Land Manager/Volunteer
BY - Brad Yocum, MNDI Seasonal
CH - Chris Hoving, MDNR Wildlife Division
DC - David Cuthrell, MNFI
DI - Dick Irwin, Landowner/Volunteer
DK - Dan Kennedy, MDNR Wildlife Division
KB - Kim Borland, MNFI Seasonal
KK - Kile Kucher, MNFI Seasonal
LL - Larry Lyons, Volunteer
MH- Matt Heumann/Volunteer
MP- Mike Penskar, MNFI
NH - Nathan Herbert, MNFI Seasonal
RO- Ryan O'Connor, MNFI
TH - Todd Hogrefe, MDNR Wildlife Division (formerly)
YL - Yu Man Lee, MNFI

Table 5: 2008 Plant and Animal Survey Effort and Results

County	Survey Site Name	Survey Date	Surveyors	Plant and Animal Targets	Rare Plant and Animal Species Documented (updates in normal font new EOs in bold)
Barry	Bassett Lake Southwest/Barry SGA	05/20/2008	BB, HE	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle	
		09/08/2008	MS	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle	
Berrien	Butternut Creek	04/23/2008	YL, BB	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle	
		09/05/2008	DC, MS	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle	
Branch	Coldwater Lake Fen	08/27/2009	MP, DH, SW	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	
Cass	Shavehead Lake	05/23/2008	BB, BC	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle	
		09/19/2008	MS, BC	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle	
Calhoun	Mott Road Fen (Custer)	09/18/2008	DC	Papaipema moths	
Hillsdale	Goose Creek Grasslands - MNA	07/10/2008	DC	Poweshiek skipper	*Oarisma poweshiek*
Kent	Lamberton Lake Fen	08/27/2008	DC	Poweshiek skipper	***Oecanthus laricis, Lepyronia angulifera***
Jackson	Concord Lake Fen	05/09/2008	BB, DK	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle	
Jackson	Fowlkes Tract - TNC	08/18/2008	DC	Poweshiek skipper	
		09/23/2008	DC	Papaipema moths	***Papaipema beeriana***
Jackson	Grand River Fen	05/15/2008	BB	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle	
		09/10/2008	MS	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle	
		07/08/2008	DC, BS	Poweshiek skipper	*Oarisma poweshiek, Mitchell's satyr*
Jackson	Little Portage Lake North	05/22/2008	BS, MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	
Jackson	McCreedy Fen (MSU)	09/24/2008	DC, AF	Papaipema moths	
Jackson	Skiff Lake	06/06/2008	BB	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle	
Jackson	Willis Road Fen	09/25/2008	DC, MP, MM	Papaipema moths	
Kalamazoo	Paw Paw Lake Fen/Palmer Preserve (MNA)	05/08/2008	YL, BB	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle	*Blanchard's Cricket Frog*
		08/29/2008	DC, MS	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle	
Kalamazoo	Paw Paw Prairie Fen	08/29/2008	DC, MS, BS, SC	Rare leafhoppers, spittlebugs, tree crickets	***Lepyronia angulifera*, *Oecanthus laricis***

Table 5: 2008 Plant and Animal Survey Effort and Results

County	Survey Site Name	Survey Date	Surveyors	Plant and Animal Targets	Rare Plant and Animal Species Documented (updates in normal font new EOs in bold)
		05/08/2008	YL, BB	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle	
Kalamazoo	Vanderbilt Fen - Gourdneck SGA	09/05/2008	DC, MS	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle	
Kent	Lamberton Lake Fen	08/27/2008	DC	Poweshiek skipper	***Oecanthis laricis, Lepyronia angulifera***
Livingston	Bullard Lake - MNA	07/06/2008	DC	Poweshiek skipper	
Livingston	Fenton Road	07/06/2008	DC	Poweshiek skipper and prairie fen species and associated rare taxa of oak barrens in adjacent uplands	***Muhlenbergia richardsonis***
		07/01/2008	DC	Poweshiek skipper	*Oarisma poweshiek*
Oakland	Brandt Road Fen	09/26/2008	DC, MM	Papaipema moths	
Oakland	Big Valley - MNA	07/06/2008	DC	Poweshiek skipper	*Flexamia huroni, Prosapia ignipectus*
Oakland	Bridge Valley	07/04/2008	DC	Poweshiek skipper	*Flexamia huroni*
Oakland	Halsted Lake	07/04/2008	DC	Poweshiek skipper	*Oarisma poweshiek*
Oakland	Long Lake Fen (Eaton Road)	07/04/2008	DC	Poweshiek skipper	*Lepyronia angulifera, Prosapia ignipectus, Flexamia huroni*
				prairie fen species and associated rare taxa of oak barrens in adjacent uplands	***Muhlenbergia richardsonis***
Oakland	Rattalee Lake Road Fen - MNA	07/06/2009	DC	Poweshiek skipper	*Oarisma poweshiek*
		08/28/2008	DC, BS, NF, TB	Rare leafhoppers, spittlebugs, tree crickets	***Lepyronia angulifera, Lepyronia gibbosa, Oecanthus laricis***
Van Buren	Lime Lake	09/22/2008	DC, NF	Papaipema moths	
		08/28/2008	DC, NF	Rare leafhoppers, spittlebugs, tree crickets	***Oecanthus pini, Dorydiella kansana***
Van Buren	Jeptha Lake Fen	10/02/2008	DC	Papaipema moths	
Van Buren	Paw Paw Prairie Fen - TNC	10/07/2008	DC, YL	Papaipema moths	***Papaipema beeriana***
				prairie fen species and associated rare taxa of oak barrens in adjacent uplands	***Celtis tenuifolia***
Washtenaw	Green Lake Meadow	08/26/2008	DC, BS, MP	Rare leafhoppers, spittlebugs, tree crickets	***Oecanthus laricis***
Washtenaw	Green Lake West (pipeline prairie)	07/15/2008	MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	***Angelica venenosa***
		08/20/2008	MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	
Washtenaw	Hadley Road Fen	08/26/2008	DC, BS, MP	Rare leafhoppers, spittlebugs, tree crickets	***Oecanthus laricis***
Washtenaw	Hankerd Lake Fen	07/16/2008	MP	prairie fen species and associated rare taxa o oak barrens in adjacent uplands	

Table 5: 2008 Plant and Animal Survey Effort and Results

County	Survey Site Name	Survey Date	Surveyors	Plant and Animal Targets	Rare Plant and Animal Species Documented (updates in normal font new EOs in bold)
Washtenaw	Mill Creek East	04/24/2008	BB, DI	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle	
		09/02/2008	BB, MS	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle	
Washtenaw	Park Lyndon North	07/10/2008	DC	Poweshiek skipper, rare leafhoppers, spittlebugs	*Lepyronia angulifera, Prosapia ignipectus,* ***Oecanthus laricis, Dorydiella kansana***
		08/20/2008	DC	Rare leafhoppers, spittlebugs, tree crickets	*Dorydiella kansana, Lepyronia angulifera, Oecanthus laricis*
Washtenaw	Sullivan Lake Fen	08/19/2008	MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	
		08/26/2008	DC, BS, MP	Rare leafhoppers, spittlebugs, tree crickets, prairie fen plants and associated rare taxa of oak barrens in adjacent uplands	***Lepyronia angulifera, Dorydiella kansana***
Washtenaw	Willis Road Fen	09/25/2008	DC, MP, MM	prairie fen species and associated rare taxa o oak barrens in adjacent uplands	***Sporobolus heterolepis***

14 Counties **37 sites visited** **52 site visits** **23 New EOs (3 plants, 19 insects)**

17 Updated Eos (1 plant, 15 insects, 1 herp)

Surveyors:

AF-Anna Fiedler
BB - Barbara Barton, MNFI
BC - Brad Cogdell, Land Manager/Volunteer
BS- Brad Slaughter, MNFI
DC - David Cuthrell, MNFI
DH- Daria Hyde, MNFI
DI - Dick Irwin, Landowner/Volunteer
DK - Dan Kennedy, MDNR Wildlife Division
HE = Helen Enander, MNFI
MM- Michael Monfils, MNFI
MP= Mike Penskar, MNFI
MS = Mike Sanders, MNFI
NF -Nate Fuller, SWMLC
SW- Steve Woods, TNC
TB- Tyler Bassett
YL - Yu Man Lee, MNFI

Table 6: 2009 Plant and Animal Survey Effort and Results

County	Survey Site Name	Survey Date	Surveyors	Plant and Animal Targets	Rare Plant or Animal Species Documented (updates in normal font new EOs in bold)
		06/02/2009	YL, PB	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Land Snails, Aquatic Snails, Crayfish	
Barry	Bassett Lake Southwest/Barry SGA	11/08/2009	YL, KN	Kirtland's Snake	
Barry	Turner Creek/Barry SGA	06/02/2009	YL, PB	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Land Snails, Aquatic Snails, Crayfish	
Barry	Yankee Springs	08/06/2009	DC, BS, DK	Swamp metalmark	
				Eastern Massasauga, Eastern Box Turtle, Kirtland's Snake, Spotted Turtle, Land Snails, Aquatic snails, Crayfish	*Eastern Box Turtle*
		06/09/2009	YL, PB	Prairie fen species and associated rare taxa of oak barrens in adjacent uplands	*Cacalia plantaginea*
		07/03/2009	YL, JB	Mitchell's satyr, Eastern Massasauga, Eastern Box Turtle, Kirtland's Snake and prairie fen plants	***Eastern Massasauga***
Berrien	Butternut Creek	10/14/2009	YL	Eastern Massasauga, Kirtland's Snake	
			YL, PB, MP	Eastern Massasauga, Eastern Box Turtle, Kirtland's Snake, Spotted Turtle, Land Snails, Aquatic snails, Crayfish	*Eastern Box Turtle*
		06/03/2009	MP, YL, JB	Prairie fen species and associated rare taxa of oak barrens in adjacent uplands	*Cacalia plantaginea (2 locations) , Cypripedium candidum (2 locations) , Valeriana edulis var. ciliata*
Cass	Cook Lake-Rudy Road Fen (3 locations)	09/24/2009	DC	Papaipema moths	
			MP, MM, YL, JB, MH	Prairie fen species and associated rare taxa of oak barrens in adjacent uplands	***Plantanthera leucophaea***
Cass	Lagrange Valley Conservancy	07/07/2009	YL, MP, JB, MH	Mitchell's satyr, Eastern Massasauga, Eastern Box Turtle,	
		07/07/2009	YL, MP, JB, MC	Mitchell's satyr, Eastern Massasauga, Eastern Box Turtle,	
Cass	Lowe Foundation	07/07/2009	MP, MM, YL, JB	Prairie fen species and associated rare taxa of oak barrens in adjacent uplands	*Berula erecta*
Cass/ St. Joseph	Mill Creek West (Three Rivers SGA & private tract)	05/04/2009	YL, PB	Eastern Massasauga, Eastern Box Turtle, Blanding's Turtle, Spotted Turtle, Rare Mussels, Land Snails, Aquatic Snails, Crayfish	***Rainbow (mussel)***
Cass	Mill Creek West (private tract)	06/23/2009	BB, YL	Mitchell's satyr, Eastern Massasauga, Eastern Box Turtle	

Table 6: 2009 Plant and Animal Survey Effort and Results

County	Survey Site Name	Survey Date	Surveyors	Plant and Animal Targets	Rare Plant or Animal Species Documented (updates in normal font new EOs in bold)
Cass	Mill Creek West (private tract) continued	07/03/2009	YL, JB	Mitchell's satyr, Eastern Massasauga, Eastern Box Turtle	
		07/02/2009	YL, JB	Mitchell's satyr, Eastern Massasauga, Eastern Box Turtle	
Cass	Shavehead Lake	10/20/2009	YL	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle	
Hillsdale	Lost Nation SGA	08/03/2009	DC, BS, DK	Swamp metalmark	
				Prairie fen species and associated rare taxa of oak barrens in adjacent uplands	*Muhlenbergia richardsonis, Sporobolus heterolepis*
Jackson	Bayley's Fen	07/08/2009	DC, MP	Poweshiek skipper, swamp metalmark	
		06/11/2009	YL, PB	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle, Land Snails, Aquatic snails, Crayfish	
		07/03/2009	DC	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
		07/05/2009	DC	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek, Neonumpha m. mitchellii*
		07/08/2009	YL, HP, BB, TD, DM	Eastern Massasauga, Eastern Box Turtle, Micthell's satyr	
		07/11/2009	DC	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
		08/03/2009	DC, BS, DK	Swamp metalmark	
Jackson	Grand River Fen	08/07/2009	DC	Swamp metalmark	*Prosapia ignipectus, Lepyronia angulifera*
		07/08/2009	DC, MP	Prairie fen species and associated rare taxa of oak barrens in adjacent uplands	
Jackson	Neely Property	08/14/2009	DC, MP	Prairie fen species and associated rare taxa of oak barrens in adjacent uplands	
		08/14/2009	DC, MP	Prairie fen species and associated rare taxa of oak barrens in adjacent uplands	*Sporobolus heterolepis*
		08/14/2009	DC, MP	rare leafhoppers, spittlebugs	***Prosapia ignipectus***
Jackson	Willis Road Fen	09/27/2009	DC	Papaipema moths	
Kalamazoo	Fort Custer SRA/Whitford and Lawler Lk.	09/12/2009	YL	Eastern Massasauga, Eastern Box Turtle	*Blanchard's Cricket Frog*
Kalamazoo	Ft. Custer SRA/Eagle Lake	09/12/2009	YL, PB	Eastern Massasauga, Eastern Box Turtle	
		05/22/2009	YL, PB	Prairie fen species and associated rare taxa of oak barrens in adjacent uplands	*Cypripedium candidum*
		05/22/2009	YL, PB	Eastern Massasauga, Eastern Box Turtle, Blanding's Turtle, Spotted Turtle, Blanchard's Cricket Frog, Land Snails, Aquatic Snails, Crayfish	*Blanchard's Cricket Frog*
Kalamazoo	Paw Paw Lake Fen (Private tract and MNA Wilke Preserve)	07/06/2009	YL, HP	Mitchell's satyr, Eastern Massasauga, Eastern Box Turtle	

Table 6: 2009 Plant and Animal Survey Effort and Results

County	Survey Site Name	Survey Date	Surveyors	Plant and Animal Targets	Rare Plant or Animal Species Documented (updates in normal font new EOs in bold)
Kalamazoo	Paw Paw Lake Fen (Private and MNA)	10/01/2009	DC	Papaipema moths	
Kalamazoo	Paw Paw Lake Fen/Palmer Memorial Preserve (MNA)	05/22/2009	YL, PB	Eastern Massasauga, Eastern Box Turtle, Blanding's Turtle, Spotted Turtle, Blanchard's Cricket Frog, Land Snails, Aquatic Snails, Crayfish	*Blanchard's Cricket Frog*
		07/06/2009	YL, HP	Mitchell's satyr, Eastern Massasauga, Eastern Box Turtle	
Kalamazoo	Springbrook Fen	07/06/2009	YL, HP	Mitchell's satyr, Eastern Massasauga, Eastern Box Turtle	
Kalamazoo	Vanderbilt Fen/Gourdneck SGA	05/04/2009	BF	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Blanding's Turtle, Spotted Turtle	*Kirtland's Snake, Spotted Turtle*
		May 2009	BF	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Blanding's Turtle, Spotted Turtle	*Eastern Massasauga*
Lenawee	Goose Creek Grasslands - MNA	07/05/2009	DC	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
		08/04/2009	DC, DK	Swamp metalmark	
		08/04/2009	DC, DK	Swamp metalmark	
Lenawee	Ives Road Fen - TNC	07/14/2009	DC	Poweshiek skipper, swamp metalmark	
Livingston	Bullard Lake Fen - MNA	06/16/2009	MP	Prairie fen species and associated rare taxa of oak barrens in adjacent uplands	
Livingston	Gregory State Game Area, Sheets Lake	06/16/2009	MP	Prairie fen species and associated rare taxa of oak barrens in adjacent uplands	
Livingston	Unadilla State Game Area, McIntyre Lake	06/14/2009	MP	Prairie fen species and associated rare taxa of oak barrens in adjacent uplands	
Oakland	Brandt Road Fen	06/29/2009	DC	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
		07/06/2009	DC	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
		09/30/2009	DC	Papaipema moths	
Oakland	Big Valley - MNA	07/07/2009	DC, HP	Poweshiek skipper	*Eastern massasauga*
Oakland	Big Valley - MNA	07/07/2009	DC, HP	Poweshiek skipper	*Oarisma poweshiek*
Oakland	Long Lake Fen	07/09/2009	DC	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
		07/13/2009	DC	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
Oakland	Whalen Lake	07/14/2009	DC	Poweshiek skipper, swamp metalmark	
Oakland	Ratalee Road Fen - MNA	07/13/2009	DC	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
St. Joseph	Cade Lake Fen	07/02/2009	YL, JB	Mitchell's satyr, Eastern Massasauga, Eastern Box Turtle	
St. Joseph	Thompson Lake	07/02/2009	YL, JB	Mitchell's satyr, Eastern Massasauga, Eastern Box Turtle	

Table 6: 2009 Plant and Animal Survey Effort and Results

County	Survey Site Name	Survey Date	Surveyors	Plant and Animal Targets	Rare Plant or Animal Species Documented (updates in normal font new EOs in bold)
		05/20/2009	YL, PB, NF	Eastern Massasauga, Eastern Box Turtle, Blanding's Turtle, Spotted Turtle, Land Snails, Aquatic Snails, Rare Mussels, Crayfish	***Ellipse*** *(mussel)*
St. Joseph	Three Rivers SGA	08/21/2009	DC	Papaipema moths	***Papaipema maritima, Papaipema cerina***
Van Buren	67th Avenue/Paw Paw Fen	08/06/2009	DC, BS, DK	Swamp metalmark	*Lepyronia angulifera, Prosapia ignipectus*
Washtenaw	Green Lake West (pipeline meadow #1)	06/04/2009	MP	Prairie fen species and associated rare taxa of oak barrens in adjacent uplands	
Washtenaw	Green Lake West (pipeline meadow #2)	07/02/2009	MP, RC	Prairie fen species and associated rare taxa of oak barrens in adjacent uplands	
Washtenaw	Green Lake West (pipeline prairie)	06/04/2009	MP	Prairie fen species and associated rare taxa of oak barrens in adjacent uplands	*Angelica venenosa*
		07/02/2009	MP, RC	Prairie fen species and associated rare taxa of oak barrens in adjacent uplands	
Washtenaw	Hadley Road Fen	07/16/2009	MP	Prairie fen species and associated rare taxa of oak barrens in adjacent uplands	
		06/04/2009	MP	Prairie fen species and associated rare taxa of oak barrens in adjacent uplands	
		07/16/2009	MP	Prairie fen species and associated rare taxa of oak barrens in adjacent uplands	
Washtenaw	Hankerd Lake Fen	08/14/2009	DC, MP	Rare leafhoppers, spittlebugs, prairie fen plants and associated rare taxa of oak barrens in adjacent uplands	***Prosapia ignipectus, Dorydiella kansana***
		06/04/2009	MP	Prairie fen species and associated rare taxa of oak barrens in adjacent uplands	***Cypripedium candidum***
		07/02/2009	MP, RC	Prairie fen species and associated rare taxa of oak barrens in adjacent uplands	
Washtenaw	M-52 wet mesic prairie	08/14/2009	DC, MP	Prairie fen species and associated rare taxa of oak barrens in adjacent uplands	*Prosapia ignipectus*
Washtenaw	McLaughlin Lake fen	07/02/2009	MP,RC	Prairie fen species and associated rare taxa of oak barrens in adjacent uplands	
		06/12/2009	YL, PB, DI	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle, Rare Mussels, Land Snails, Aquatic Snails, Crayfish	***Slippershell (mussel)***
Washtenaw	Mill Creek East	07/09/2009	YL, JB	Mitchell's satyr, Eastern Massasauga, Eastern Box Turtle	
Washtenaw	Park Lyndon North	07/14/2009	DC	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
12 Counties	**44 Sites Visited**	**72 Site Visits**	**11 New Eos** (2 plants, 5 insects,1 herp, 3 mussels)		**34 updated** (12 plants, 13 insects, 9 herps)

Table 6: 2009 Plant and Animal Survey Effort and Results

Surveyors:
BB - Barbara Barton, MNFI
BF - Bill Flanagan, Volunteer
DC - David Cuthrell, MNFI
DI - Dick Irwin, Landowner/Volunteer
DK- Dan Kennedy
DM - Doug McQuarter, Volunteer
HP - Henry Pointon, Volunteer
JB - John Bagley, Volunteer
KN - Keenan Noyes, Volunteer
MC - Michael McCustion, Land Manager
MH - Mark Harrison, Landowner
MP - Mike Penskar, MNFI
NF- Nate Fuller
PB - Peter Badra, MNFI
RC- Robert Clancy, MDNR
TD - Tameka Dandredge, USWFS
YL - Yu Man Lee, MNFI

Rare Plant Surveys 2007-2009

Rare Plant Survey Methods

Prior to the first year of field surveys, a list of potential rare plants known to be associated with prairie fens and allied natural communities was prepared. Allied communities consisted of such wetland types as southern wet meadow and rich tamarack swamp, which commonly occur in prairie fen complexes, with all upland areas considered to be savanna related systems within their original pre-European settlement context and thus best categorized as oak barrens. Particular attention was placed on assembling a plant list of the many rare plant species known to be associated with oak barrens, despite the scarcity of such remnants, based on the large number of high priority associated taxa. Emphasis was also placed on oak barrens taxa due to the fact that while prairie fen complexes have been extensively explored, adjacent upland areas have received much less attention.

Following the compilation of a list of target species, potential survey sites were identified each year in consultation with project PI and other colleagues to highlight priority sites. Priority sites consisted of Mitchell's satyr occurrences requiring more detailed plant inventory and characterization, and new prairie fen areas delineated through the methodical aerial photo interpretation of wetland complexes, particularly in the glacial interlobate areas of south-central and southeastern Lower Michigan. Potential survey sites were also selected following review of the Michigan statewide Biotics database in Arcview to determine the presence of historical records and other occurrences known within or near possible inventory sites.

Surveys were timed according to the known phenologies of particular target species or suites of related target species. White ladyslipper (*Cypripedium candidum*), for example, was identified as a target species for spring surveys in late May – early June, whereas warm season grasses such as mat muhly (*Muhlenbergia richardsonis*) and prairie dropseed (*Sporobolus heterolepis*) were scheduled for late season surveys from August through September. Surveys were also opportunistic, in that as ground truthing was performed, aerial photo interpretation could continue to be refined in the field, revealing additional potential sites

Rare Plant Survey Results

Over the three-year period from 2007 to 2009 a total of 34 different sites representing 10 counties in southern Lower Michigan were visited in search of associated rare plant species. Owing to the potential presence of target species with different phenologies, selected sites were revisited multiple times in order to conduct more comprehensive inventories, resulting in a total of 46 site visits over the three-year study period. During 2007 surveys a total of 13 sites were surveyed over a course of 13 dates, resulting in the documentation of five new element occurrences (EOs) and the updating of four EOs (Table 4. and Appendix H). In 2008 a total of nine sites were surveyed over a course of 11 dates, resulting in a total of three new EOs and one updated EO (Table 5. and Appendix H). During 2009 a total of 17 sites were surveyed over 23 dates, resulting in the documentation of two new EOs and the updating of 12 EOs (Table 6 and Appendix H.). In summary, a grand total of 27 EOs were documented during site surveys for plants, consisting of 10 new EOs and 17 updated EOs for the statewide database (Table 7).

Table 7. Summary of New and Updated Rare Plant EOs as part of the Mitchell's Satyr Project: Associated Species Surveys, Southern Lower Michigan, 2007-2009.

Species	Scientific Name	Status	New EOs	Updated EOs	Total EOs known
Cut-leaved water-parsnip	*Berula erecta*	T	-	1	50
Dwarf hackberry	*Celtis tenuifolia*	SC	1	-	36
Edible valerian	*Valeriana edulis* var. *ciliata*	ST	-	2	28
Hairy angelica	*Angelica venenosa*	SC	1	1	41
Kitten-tails	*Besseya bullii*	E	-	1	9
Mat muhly	*Muhlenbergia richardsonis*	T	4	2	21
Pale avens	*Geum virginianum*	SC	1	-	10
Prairie dropseed	*Sporobolus heterolepis*	SC	2	3	34
Prairie fringed orchid	*Platanthera leucophaea*	E	1	-	31
Prairie Indian plantain	*Cacalia plantaginea*	SC	-	3	54
White ladyslipper	*Cypripedium candidum*	T	1	5	107
Totals			**10**	**17**	**421**

Rare Plant Survey Discussion

Of the several element occurrences identified during the 46 sites visits for associated rare plant surveys, the most significant discovery was the documentation of prairie white fringed orchid (*Platanthera leucophaea*) in southwest Michigan, as it constituted the only federally listed species, plant or animal and other than Mitchell's satyr, documented during the three years of field studies (Figure 4.). In addition to being classified as state endangered, this species was discovered in Cass County where it was previously unknown, which is notable in several respects. This rare orchid is known primarily from two principal strongholds in Michigan, occurring in largely disturbed lakeplain prairie remnants near the eastern shore of Lake Erie, and in relatively high quality lakeplain areas concentrated along the eastern shore of Saginaw Bay. Although this species was historically known much more widely in southern Lower Michigan, only two inland sites have been verified in recent decades despite repeated searches, comprised of a site in western Washtenaw County and one site in St. Joseph County. The discovery in Cass County is especially notable, and particularly because this well known and distinctive orchid, which is not uncommonly poached, is often sought by botanists and others. It is plausible that this orchid has remained undiscovered owing to its presence in an area of predominately private land. Given that this federally listed species has declined so severely over the last few decades, the discovery of a small colony is highly significant, and may aid in the recovery of the species.

Of the remaining rare plant occurrences identified, the documentation of four new and two updated occurrences of the state threatened mat muhly (*Muhlenbergia richardsonis*) is particularly significant, in that there are only 21 known occurrences of this species identified in Michigan, and thus during the study we documented more than 25% of the state's population of this taxon. Prairie dropseed (*Sporobolus heterolepis*), a species often associated with mat muhly, and only slightly more common with 34 known state localities, was documented in a similar number of sites, with two new occurrences found in addition to three updates. Lastly, owing to the paucity of oak barrens habitat remnants, it was not anticipated that many species would be identified, thus it is notable that three occurrences of such species were documented, including the discovery of the special concern pale avens (*Geum virginianum*), the special concern hairy angelica (*Angelica venenosa*), and the special concern dwarf hackberry (*Celtis tenuifolia*), the latter two occurring in close proximity adjacent to prairie fen habitats in western Washtenaw County.

Figure 4. The state endangered and federal threatened Eastern prairie fringed orchid (Platanthera leucophaea), discovered in Cass County during site surveys (photo by Yu Man Lee).

Figure 5. The state threatened white ladyslipper orchid (*Cypripedium candidum*), from a newly documented Michigan occurrence discovered during inventories in Washtenaw County (photo by Michael A. Penskar).

Rare Insects Surveys 2007-2009

Rare Insect Survey Methods

Rare insect target species were identified based on historical distribution in the region, current occurrences in prairie fens, or those species with a high likelihood of occurrence based on available habitat within the fen complexes. Natural community and habitat information was based on air photo interpretation, occurrences in the MNFI Biotics database, and by on-the-ground observations by ecologists, botanists, and zoologists. Rare insect inventories were performed in appropriate habitat during periods when the targeted insects were most active (or when adults would be expected to occur). Surveys emphasized both the identification of new occurrences and the review of historical occurrences of rare species.

Butterflies and Moths

Targeted butterflies included a variety of prairie fen specialists including Mitchell's satyr (*Neonympha mitchellii*, state & federally endangered), swamp metalmark (*Calephelis mutica*, special concern), Poweshiek skipper (*Oarisma poweshiek*, state threatened), and Dukes' skipper (*Euphyes dukesi*, state threatened). Surveys for targeted butterflies were conducted by walking through suitable habitat during appropriate weather conditions and visually observing adults in flight, perched on vegetation, or nectaring on flowers. Species that looked similar to the target species were captured with an aerial net, identified in the hand, and then released.

Moth targets focused on the rare moths in the genus *Papaipema* including the silphium borer moth (*Papaipema silphii*, state threatened), the maritime sunflower borer moth (*Papaipema maritima*, special concern), the blazing star borer moth (Papaipema beeriana, special concern), the regal fern borer moth (*Papaipema speciosissima*, special concern), the culver's root borer (*Papaipema sciata*, special concern), and the golden borer moth (*Papaipema cerina*, special concern). Blacklighting consisted of standard mercury-vapor and UV lights powered by a portable generator. A 2 m x 2 m metal conduit frame supporting a large white sheet was used as a collecting surface (Figure 5). This frame was placed in the field in a central location with larval host plants on all sides to maximize the likelihood of collecting adults. These locations were recorded using a hand-held GPS unit and *Papaipema* moth survey forms were completed for each site (Appendix I). When listed species were documented the information was entered into the MNFI Biotics Database.

Leafhoppers and Spittlebugs

Sweep net samples were taken in prairie, wet meadow, and fen remnants which contained appropriate hostplants for several rare leafhoppers including *Flexamia huroni*, state threatened, *Flexamia reflexus*, special concern, *Flexamia delongi* special concern, *Dorydiella kansana*, special concern. Rare spittlebugs were also surveyed for, including the angular spittlebug (*Lepyronia angulifera*, special concern), the Great Plains spittlebug (*Lepyronia gibbosa*, special concern), and the red-legged spittlebug (*Prosapia ignipectus*, special concern). At each location, appropriate host plants were sampled while meandering through potential habitat. A standard sample consisted of approximately sixty swings of a sweepnet, with one swing taken with each step. The contents of the net were emptied into a large killing jar charged with ethyl acetate. When the specimens had stopped moving they were transferred to a zip-lock plastic bag, labeled, and placed into a cooler. Bagged samples were then frozen until they could be processed later in the lab. Processing consisted of sorting all insects from the vegetation, pinning larger specimens and pointing smaller ones. Those specimens that were similar to the targets were labeled and keyed, or directly compared to specimens contained in the Michigan Natural Features Inventory Reference Collection. When listed species were documented, MNFI Rare Animal Survey Forms were completed and the information was entered into the MNFI Biotics Database.

Tree Crickets

Two species of rare tree crickets occur in Michigan, the tamarack tree cricket (*Oecanthus laricis*, special concern) and the pine tree cricket (*Oecanthus pini*, special concern) and both were surveyed for during 2007-08. Surveys were conducted in habitats with either tamarack or white pine. Observers swept the branches of trees with a standard sweep net (Figure 6). A typical sweep net was used, but the handle was extended by 3 meters by fastening a piece of 2 cm conduit onto the handle. Tree crickets were collected, processed, and keyed to species using Bland 2003. When rarities were recorded, MNFI Special Animal Field Forms were completed and the information was entered into the MNFI Biotics Database.

Rare Insect Survey Results

Over the three year period between 2007 and 2009 a total of 50 prairie fens representing 15 counties in southern Michigan were visited in search of associated rare insect species. During 2007 surveys a total of 29 fens were visited over the course of 26 dates and we documented 13 new element occurrences (EOs) and updated 20 records (Table 4 and Appendix J.). In 2008 a total of 22 fens were visited over the course of 19 dates and we documented 19 new EOs and updated 15 (Table 5. and Appendix J). During 2009 a total of 22 fens were visited over 21 dates and we documented 5 new EOs and updated 13 more (Table 6 and Appendix J). A total of 39 new insect element occurrences were documented in addition to the 26 updated element occurrences (EORs). For rare insect species we have provided a summary of the new EOs and updated EOs that were recorded as part of this project (Table 8).

Rare Insect Survey Discussion

One of the focus species for our work involved the Poweshiek skipper (*Oarisma poweshiek*). This species is dramatically declining across much of its range and we wanted to assess the Michigan distribution and relative population densities in our prairie fens. During the 2007-09 surveys, we visited all of known Michigan Poweshiek skipper sites where landowner permission was secured or where suitable habitat remains (14 out of 16 known sites). At many of the extant sites we now have 2-3 years of survey data with GPS point location information. We also subsequently evaluated and re-ranked all of the extant occurrences in the MNFI Biotics Database. Currently Michigan has 3 sites which are ranked as A (Excellent estimated viability), 1 B-ranked site (Good estimated viability), 3 BC-ranked sites (Good or Fair estimated viability), 2 C-ranked sites (Fair estimated viability), 1 site where viability was not assessed, 2 sites where we have failed to find the element in recent years, and 4 sites which are truly historical (either old general roadside records, or specific records where habitat no longer persists). At many of these occupied sites, prescribed fire management or other management is on going and it will be important to continue to monitor the response of the butterfly to management activities. From our early observations, it appears that prescribed fire reduces adult numbers immediately following the prescription (i.e., burns in the spring impact adult counts during July) but each succeeding year after the fire the numbers increase. Unfortunately, at most of the sites we don't have good pre-burn data and this will limit the conclusions we may be able to produce.

Another species which we focused on was the swamp metalmark (*Calephelis mutica*) a species we felt was declining across Michigan and adjoining states. Sadly, during the 3 year span of this study this species was only recorded from 2 sites, while absent from a 23 sites visited. Further studies are needed to determine if we were just not detecting the species at sites or if they truly are declining. Further studies are needed to determine if we were just not detecting the species at sites or if they truly are declining. We need to spend additional time at sites and possibly do larval surveys in addition to any future adult surveys at known sites.

For three species we more than doubled the number of known element occurrences. The Huron River Leafhopper (*Flexamia huroni*) was found at 3 additional locations and reconfirmed as occurring at its

only known location. All four known sites for this species in the world are within a small area of Oakland County, Michigan and all sites contain a nice population of the only confirmed host plant for the leafhopper, muhly grass (*Muhlenbergia richardsonis*) it also is a state-listed rare plant. Prior to this project, the angular spittlebug (*Lepyronia angulifera*) was known from 3 locations in the state. We found it at 8 new fen locations while sweeping in areas of spike rush (*Eleocharis*) flats. The Kansan leafhopper prior to this project was known from 5 locations in Michigan from prairie fens and lakeplain prairies. We located an additional 6 locations, all in prairie fens containing nut-rush (*Scleria* sp.).

The blacklighting surveys added greatly to our knowledge of prairie fen inhabiting *Papaipema* moths and in the process led directly to 4 new locations for the blazing star borer (*Papaipema beeriana*) and 1 new location for both the maritime sunflower borer (*Papaipema maritime*) and golden borer (*Papaipema cerina*).

Figure 6. Blacklighting set-up used during *Papaipema* surveys 2007-2009 (photo by David L. Cuthrell).

Figure 7. Sweeping for the Tamarack Tree Cricket, Oakland County, Michigan, 2008 (photo by Susan Greenlee).

Table 8. Summary of New and Updated Insect EOs as part of the Mitchell's Satyr Project: Associated Species Surveys, Southern Lower Michigan, 2007-2009.

Species	Scientific Name	Status	New EOs	Updated EOs	Total EOs known
Red-legged spittlebug	*Prosapia ignipectus*	SC	7	3	35
Angular spittlebug	*Lepyronia angulifera*	SC	8	3	14
Kansan leafhopper	*Dorydiella kansana*	SC	6	0	11
Huron leafhopper	*Flexamia huroni*	ST	3	1	4
Tamarack tree cricket	*Oecanthus laricis*	SC	7	0	48
Pine tree cricket	*Oecanthus pini*	SC	1	0	8
Blazing star borer moth	*Papaipema beeriana*	SC	4	1	23
Poweshiek skipper	*Oarisma poweshiek*	ST	0	14	16
Swamp metalmark	*Calephelis mutica*	SC	0	2	27
Mitchell's satyr	*Neonympha mitchellii*	SE	0	2	24
Great Plains spittlebug	*Lepyronia gibbosa*	SC	1	0	35
Maritime sunflower borer	*Papaipema maritima*	SC	1	0	9
Golden borer	*Papaipema cerina*	SC	1	0	8
Totals			**39**	**26**	**262**

Rare Herp Surveys 2007-2009

Rare Herp Survey Methods

Rare amphibian and reptile or herp target species were identified based on historical distribution in the region or current occurrences in prairie fens, or had a high likelihood of occurrence based on available habitat within the fen complexes. Natural community and habitat information was based on air photo interpretation, occurrences in the MNFI Biotics database, and by on-the-ground observations by ecologists, botanists, and zoologists. Rare herp inventories were performed using multiple survey methods in appropriate habitat during periods when the targeted species were most active (or when adults would be expected to occur). Surveys emphasized both the identification of new occurrences and the review of previously documented or historical occurrences of rare species. Surveys also focused on identifying additional rare herp species and their distributions at known Mitchell's satyr sites to help better inform and guide management of these sites.

Surveys targeted several rare amphibian and reptile species that are associated with or occur in prairie fens. These include the Eastern Massasauga (*Sistrurus catenatus catenatus*, federal candidate and state special concern), Kirtland's Snake (*Clonophis kirtlandii*, state endangered), Eastern Box Turtle (*Terrapene carolina carolina*, state special concern), Blanding's Turtle (*Emydoidea/Emys blandingii*, state special concern), Spotted Turtle (*Clemmys guttata*, state threatened), and Blanchard's Cricket Frog, (*Acris crepitans blanchardi*, state threatened). Several techniques were used to survey for these species. These included visual encounter surveys, breeding frog call surveys, and coverboard surveys.

Visual encounter surveys were conducted to survey for targeted rare herps during the spring, summer, and/or fall of 2007, 2008, and 2009. Visual encounter surveys are a standard method for surveying terrestrial amphibians and reptiles (Campbell and Christman 1982, Corn and Bury 1990, Crump and Scott 1994, Heyer et al. 1994, Manley et al. 2005). These surveys had potential for detecting all targeted herp species, but particularly focused on the Eastern Massasauga, Eastern Box Turtle, Spotted Turtle, and Blanding's Turtle. Each survey site was visited one to six times for targeted herp surveys during the field season (i.e., April – September/October). Surveys were conducted at multiple locations, areas, or parcels at some sites. Visual encounter surveys were conducted during daylight hours and under appropriate weather and survey conditions when targeted species were expected to be active and/or visible. These surveys consisted of walking slowly through suitable or potential habitats, overturning cover (i.e., logs, boulders, etc.), inspecting retreats, and looking for basking, resting, or active individuals. Rare reptiles and amphibians also were documented during Mitchell's satyr and other rare animal, plant, and natural community surveys. All rare as well as common amphibian and reptile species observed during visual encounter surveys were recorded.

Breeding frog call surveys were conducted in 2007 to survey for the Blanchard's Cricket Frog. Surveys were conducted by listening for calling frogs after dark (from 9 pm to 1 am) for ten minutes from the road or adjacent upland habitat. Species, call index values indicating relative abundance, location, time and weather conditions were recorded. Call indices were defined in the following manner: 1 = individuals can be counted, space between calls (i.e., 1-5 individuals); 2 = individual calls can be distinguished but some overlapping calls (6-12 individuals); and 3 = full chorus, calls are constant, continuous and overlapping, unable to count individuals (Michigan DNR Frog and Toad Survey Protocol 2000). Blanchard's Cricket Frogs and other frog species heard during call surveys were documented.

Coverboard surveys were conducted to survey primarily for the Kirtland's Snake. The Kirtland's Snake is generally difficult to detect with visual surveys because it appears to be nocturnal and semi-fossorial (Harding 1997). Coverboard surveys have been able to detect this species at several sites in Michigan and other states (Anton pers. comm., McCustion pers. comm., Meretsky pers. comm.), and appears to be an effective method for surveying and detecting this species. Coverboard surveys were conducted at a subset

of extant Mitchell's satyr sites and at a known Kirtland's Snake site to test or verify the effectiveness of the survey methodology for detecting the species. At extant Mitchell's satyr sites, coverboards were placed in areas in which the species had not been documented (i.e., unoccupied satyr habitat) to avoid potential take of the species due to placement of the coverboards. Coverboards consisted of 30 cm long x 69 cm wide (12 in long x 27 in wide) or 61 cm long x 69 cm wide (24 in long x 27 in wide) pieces of plastic carpet protector hallway runner stapled to similar sized pieces of 1-cm (3/8 in) thick carpet foam on the underside. This coverboard design was developed and has been utilized by Vicky Meretsky, an academic researcher at Indiana University who has had success finding Kirtland's Snakes at sites in southern Indiana with this type of coverboard. Approximately 20 coverboards were placed at each site (with 19 or 21 at a few sites), resulting in a total of 141 coverboards. Coverboards were placed in and along the edge of the fen and/or sedge meadow and adjacent forested wetland habitats at each site. Coverboards also were placed near or directly over open crayfish burrows or holes whenever possible. Coverboards were numbered and marked at each site. The location of each coverboard was recorded with a GPS unit and marked with a flagging stake and flagging in an adjacent tree or shrub. Coverboards were set in 2007, and were checked two to five times during the field season in 2007. Coverboards also were checked several times during the field season in 2008 and 2009, and were removed in 2009. All amphibian and reptile species found under coverboards were recorded.

Survey data forms (Appendices K, L, M.) were completed for all surveys, and some survey locations were recorded with a GPS or IPAQ (PDA) unit to document survey effort and results. All reptiles and amphibians and other animals encountered during surveys were recorded. The species, number of individuals, age class, location, activity, substrate, and time of observation were noted. Weather conditions and start and end times of surveys also were recorded. When rare herp and other species were encountered, MNFI Special Animal Field Forms were completed, and locations were recorded with a GPS or IPAQ unit. Photos of rare species also were taken for supporting documentation. Rare species occurrences and associated information were entered into the Michigan Natural Heritage Biotics Database maintained by MNFI. All herp observations were submitted to the Michigan Herp Atlas.

Rare Herp Survey Results

Over the three year period, a total of 66 sites, including 28 prairie fens, in 9 counties in southern Michigan were visited in search of associated rare herp species (Tables 4, 5,and 6.). These include 38 breeding frog call survey sites and 7 coverboard survey sites (Tables 4, 5, and 6.). During 2007 surveys, over 50 prairie fens and other sites were visited over the course of 31 dates, and we were able to update nine previously documented element occurrences (EOs) of the Eastern Massasauga, Eastern Box Turtle, and Blanchard's Cricket Frog (Appendix N. and Figures 8, 9, and 10.). In 2008, a total of 9 fens were visited over the course of 14 dates, and we updated one EO of Blanchard's Cricket Frog (Appendix N. and Figure 10.). During 2009, a total of 22 fens and other sites were visited over 21 dates, and we documented 1 new Eastern Massasauga EO and updated 9 EO's of rare herps including the Kirtland's Snake and Spotted Turtle (Appendix N.). In summary, a total of 16 rare herp element occurrences were documented, consisting of 1 new EO and 15 updated EO's (Table 9.). These include updating EO's based on observations of species across multiple survey visits and years and combining or merging several EO's in some cases based on the specifications regarding separation distances for EO's for a particular species.

In addition to the listed or special concern herp species that were documented during surveys over the three-year project period, several amphibians and reptiles that have been identified as Species of Greatest Conservation Need (SGCN) by Michigan's Wildlife Action Plan (WAP) (Eagle et al. 2005) also were documented. These include the Northern Leopard Frog (*Rana pipiens*), Blue Racer (*Coluber constrictor*), and Eastern Hog-nosed Snake (*Heterodon platirhinos*) (Appendix N. and Figure 11.). The Northern Leopard Frog also was proposed to be added as a state special concern species by the Michigan Amphibian and Reptile Technical Advisory Committee during the State's endangered and threatened

species list review process in 2005, but this designation is still under review and needs to be finalized. A total of 18 other herp species also were documented during the surveys over the three-year period. These include the Green Frog (*Rana clamitans melanota*), Bullfrog (*Rana catesbeiana*), Eastern American Toad (*Bufo americanus americanus*), Northern Spring Peeper (*Pseudacris crucifer crucifer*), Wood Frog (*Rana sylatica*), Gray Treefrog (*Hyla versicolor/Hyla chrysoscelis*), Blue-spotted Salamander (*Ambystoma laterale*), Red-backed Salamander (*Plethodon cinereus*), Brown Snake (*Storeria dekayi*), Eastern Garter Snake (*Thamnophis sirtalis sirtalis*), Northern Water Snake (*Nerodia sipedon sipedon*), Northern Ribbon Snake (*Thamnophis sauritus septentrionalis*), Red-bellied Snake (*Storeria occipitomaculata occipitomaculata)*, Northern Map Turtle (*Graptemys geographica*), Painted Turtle (*Chrysemys picta*), Eastern Musk Turtle (*Sternotherus odoratus*), Snapping Turtle (*Chelydra serpentina*), and Eastern Spiny Softshell Turtle (*Apalone spinifera spinifera*) (Appendix N).

Table 9. Summary of New and Updated Rare Herp EOs as part of the Mitchell's Satyr Associated Species Surveys, Southern Lower Michigan, 2007-2009.

Species	Scientific Name	State Rank	New EOs	Updated EOs	Total EOs known
Eastern Massasauga	*Sistrurus catenatus catenatus*	SC	1	5*	258
Kirtland's Snake	*Clonophis kirtlandii*	ST	0	1	18
Eastern Box Turtle	*Terrapene carolina carolina*	SC	0	5*	265
Blanding's Turtle	*Emydoidea blandingii*	SC	0	0	237
Spotted Turtle	*Clemmys guttata*	SC	0	1	161
Blanchard's Cricket Frog	*Acris crepitans blanchardi*	ST	0	3*	134
Totals			1	15	1073

*Updated EO totals include EO's in which multiple EO's were updated and combined or merged into one EO.

Rare Herp Survey Discussion

During rare herp surveys over the three-year project period were able to newly document or reconfirm several rare amphibian and reptile species at six known Mitchell's satyr sites, of which five contain currently extant populations and one may be recently extirpated. We were able to update occurrences of the Eastern Massasauga, Eastern Box Turtle, and/or Blanchard's Cricket Frog at these six sites. Additionally, one new Eastern Massasauga occurrence was documented at an occupied Mitchell's satyr site which is currently being actively managed to restore fen habitat. Most of these observations updated occurrences of rare species at these sites and provided additional information on the locations and distribution of these species. Most of these occurrences had been recently confirmed since 2000 prior to these surveys, with at least one occurrence that had been last observed in the late 1990's. Several occurrences had multiple EO's that were within the EO separation distances for that particular species, and were combined or merged with additional information from these surveys. Additional observations and information compiled from these surveys also allowed us to evaluate and re-rank these occurrences. Many of these occurrences were previously ranked as E or simply extant because of lack of information to estimate viability. With information from these surveys and with new generic EO rank specifications developed and provided by NatureServe (2008), most of the updated occurrences are now ranked as viable with either a B-rank (good estimated viability), C-rank (fair estimated viability), or BC-rank (good to fair estimated viability) based on estimated size, condition, or status of the population, habitat quality, and/or landscape context. Additional information about these occurrences of rare herp species will add to our understanding of the current status and distribution of these species statewide and at these sites.

One of the most significant and exciting results of our rare herp surveys was the reconfirmation of five of the six targeted rare herp species at Vanderbilt Fen in the Gourdneck State Game Area in Kalamazoo County including the discovery of a Kirtland's Snake under one of our coverboards. Kirtland's Snakes had been last documented from this site in 1997 (under a coverboard as well). This observation indicates that this population still exists, and that the coverboard design we used can detect the species. Reconfirming this population is particularly noteworthy since this species is known from only 19 sites total in the state, and the species has been reported from fewer than 5 sites within the last 10 years and from only two or three sites within the last five years (MNFI 2009). Observations of Spotted Turtle and Blanchard's Cricket Frogs at this site also are significant since the Spotted Turtle was last observed at this site in 1977 (which made this a historical EO prior to this observation) and Blanchard's Cricket Frogs were last documented at this site in 1996 (MNFI 2009). Additional surveys for Kirtland's Snakes and other rare herp species should be conducted at this site to obtain more information about the status and viability of populations of these species at this site.

Increased knowledge about the occurrence and distribution of rare herps at known or extant Mitchell's satyr sites and other prairie fen sites can help inform and guide management efforts at these sites. Efforts to manage and restore fen habitat for the Mitchell's satyr and other fen-associated species also represent potential opportunities to manage habitat for rare herp species and contribute to their conservation as well. However, some habitat management activities can have potential adverse impacts on rare herp species such as the Eastern Massasauga and Eastern Box Turtle both in the short term and long term. Habitat management activities such as prescribed burning, shrub removal, and mowing have potential for adversely impacting or harming rare herps such as massasaugas and box turtles. These activities should be conducted when these species are not active or less likely to be on the surface whenever possible (e.g., during the inactive season before emergence or after entering hibernacula, etc.). If activities are conducted during the active season, they should be conducted in a manner that minimizes the potential for adverse impacts, if possible. Habitat management guidelines have been developed for amphibians and reptiles in the Midwest and for particular species (e.g., Eastern Massasauga). These should be consulted prior to design or implementation of management efforts to try to ensure activities are effectively contributing to conservation and minimizing adverse impacts to these rare herps. Surveys and monitoring also should be conducted at sites that are actively being managed to assess and monitor the effectiveness of management efforts and impacts on the herp populations at the sites. Surveys conducted for this project and other past and future projects may provide data that can help evaluate management efforts at these sites to some degree, but targeted monitoring at actively managed sites would be the most effective for evaluating these efforts.

In addition to monitoring potential impacts and effectiveness of ongoing habitat management efforts at Mitchell's satyr sites, additional surveys, monitoring, and research on rare fen-associated herp species are warranted. These surveys primarily focused on obtaining more information about rare herps at known Mitchell's satyr sites. Although some surveys for rare herps were conducted at other fen sites, additional surveys for these species at Mitchell's satyr and known and potential fen sites are needed. Additional targeted surveys for Kirtland's Snake are particularly warranted since there is so little available information on its current status and distribution in Michigan. While we were able to conduct some coverboard surveys and document a Kirtland's Snake under a coverboard at one site during this project, we were not able to check the coverboards at all the sites as frequently as we would have liked. More intensive coverboard surveys at specific sites would likely increase the chance of detecting this species. We also found that the larger-sized coverboards seemed to work better than the smaller coverboards. The larger coverboards seemed to last longer and remain in better condition and also provided more cover or surface area for detecting snakes than the smaller coverboards.

We also were not able to document any Blanding's Turtles and only one Spotted Turtle during our surveys. This may have been due to the timing of the surveys since Spotted Turtles can be observed throughout the spring and early summer but are generally easier to find earlier in the spring (e.g., late March or April). We may not have encountered Blanding's Turtles because the sites we surveyed may not have had as much suitable habitat for this species compared to the other target species. Additional surveys for Spotted Turtles and Blanding's Turtles at some Mitchell's satyr sites and other fen sites in the species' range would be beneficial. Research and monitoring efforts are needed to assess and determine the status and viability of and threats to rare herp populations at known Mitchell's satyr sites. For example, only adult Eastern Box Turtles were found during the herp surveys. Many turtle populations in the state are threatened by lack or population recruitment due to increased nest predation by meso-predators such as raccoons, skunks and opossums. Research and monitoring are needed to determine if the box turtle populations at Mitchell's satyr sites are successfully reproducing and if nest predation is a threat to these populations. Research and monitoring also are needed to determine and assess the impacts of habitat management activities, such as prescribed burning, on rare herp populations and identify strategies for minimizing adverse impacts of these activities. This is critical for ensuring that habitat management efforts are contributing to long-term conservation of these species.

References

Campbell, H.W. and S.P. Christman. 1982. Field techniques for herpetofaunal community analyses. Pages 193-200 *in* N.J. Scott, Jr., ed. Herpetological Communities, USDI Fish and Wildlife Service, Wildlife Research Report 13, Washington, D.C. 239 pp.

Corn, P.S. and R.B. Bury. 1990. Sampling methods for terrestrial amphibians and reptiles. USDA Forest Service, Gen. Tech. Rep. PNW-GTR-256. 34 pp.

Crump, M.L. and N.J. Scott. 1994. Visual encounter surveys. Pages 84-92 *in* W.R. Heyer, M.A. Donnelly, R.W. McDiarmid, L.C. Hayek, and M.S. Foster, eds. Measuring and Monitoring Biological Diversity. Standard Methods for Amphibians. Smithsonian Institution Press, Washington, DC.

Eagle, A.C., E.M. Hay-Chmielewski, K.T. Cleveland, A.L. Derosier, M.E. Herbert, and R.A. Rustem, eds. 2005. Michigan's Wildlife Action Plan. Michigan Department of Natural Resources. Lansing, MI. 1592 pp. http://www.michigan.gov/dnrwildlifeactionplan

Harding, J.H. 1997. Amphibians and Reptiles of the Great Lakes Region. The University of Michigan Press, Ann Arbor, MI. 378 pp.

Heyer, W.R., M.A. Donnelly, R.W. McDiarmid, L.C. Hayek, and M.S. Foster, eds. 1994. Measuring and Monitoring Biological Diversity. Standard Methods for Amphibians. Smithsonian Institution Press, Washington, DC. 364 pp.

Manley, P.N., B. Van Horne, J.K. Roth, W.J. Zielinski, M.M. McKenzie, T.J. Weller, F.W. Weckerly, and C. Vojta. 2005. Multiple species inventory and monitoring technical guide. USDA Forest Service, Washington Office. 193 pp.

Michigan Department of Natural Resources (DNR). 2000. Michigan Frog and Toad Survey Protocol. Wildlife Division, Natural Heritage Unit, Lansing, MI.

Michigan Natural Features Inventory (MNFI). 2009. Natural Heritage Database. Lansing, Michigan.

Figure 8. Eastern Massasauga at Mitchell's satyr site in Berrien County in 2009. (Photos by John Bagley)

Figure 9. Eastern Box Turtles at Mitchell's satyr site in Berrien County in 2009. (Photos by Yu Man Lee)

Figure 10. Blanchard's Cricket Frogs at Mitchell's satyr site in Kalamazoo Co. in 2007 (left photo) and 2008 (right photo). (Photos by Kile Kucher (left) and Barbara Barton (right))

Figure 11. Other herp species found during surveys from 2007-2009 including the Northern Leopard Frog (top left), Blue-Spotted Salamander (top right), Map Turtle (center left), musk turtle (center right), Eastern Hog-nosed Snake (bottom left), and Brown Snake under coverboard (bottom right). (Photos by Kile Kucher and Yu Man Lee)

Inventory and Modeling

Degree Day Model

2007 Modeling Effort (Full report found in Appendix D.)

Introduction

Annual Mitchell's satyr surveys begin as soon as the satyrs emerge. Emergence is determined through surveys by various staff members and volunteers checking occupied sites daily, shortly before the date of earliest emergence. This is time consuming and not always accurate, as coverage of the sites is sometimes spotty. The development of a degree day model would provide surveyors with a tool for determining emergence and also peak flight period based on degree day information from weather stations. This would reduce the number of staff hours and travel costs associated with the annual surveys.

Methods

In 2007, seven extant Mitchell's satyr sites were selected for the placement of dataloggers to collect data for a degree day model based on geographic location and accessibility. Two Hobo® Dataloggers were placed at each site, and positioned at chest height, approximately 4.5 ft above the ground, and oriented in a north direction to minimize exposure to direct sunlight. One was placed in open fen meadow known to contain the butterflies and the second in a semi-shaded upland area nearby. The Michigan dataloggers were set to record temperature and relative humidity every hour beginning at 1800 hrs Daylight Savings Time on 5 April 2007 while the Indiana dataloggers began recording on 3 May 2007.

Field staff began checking for Mitchell's satyr emergence at each site the week of June 15, 2007, approximately five days before the earliest recorded emergence. Data from the dataloggers was downloaded during September and November 2007 and was analyzed to calculate accumulated degree days from April 5th to the first observed emergence date for each site. Degree day data was obtained from the nearest weather station for each site from weather data posted on the Michigan Automated Weather Network (MAWN). A preliminary analysis was done to determine whether a correlation existed between the MAWN weather stations and the sampled fens. MAWN data is commonly used to monitor degree days for the purposes of estimating satyr emergence, but this data most likely varies from actual weather conditions in the fen due to the environmental and ambient conditions surrounding the weather stations (i.e. fens are more humid, have higher temperatures).

Results

First emergence observations for Mitchell's satyrs occurred from June 19th - June 28th. Temperature differences were minimal between the fens, uplands, and MAWN stations. Relative humidity values were slightly higher in the fens. There were no statistically significant differences in cumulative degree days between fens and MAWN stations at either base 50 or base 40. The predicted range for satyr emergence (base 50) was 923.40-1282.00 and 1637.90-2133.10 (base 40).

Discussion

Emergence times varied by site but the majority occurred between June 19th and June 22nd. There did not appear to be an effect of geographic location on cumulative degree day values at emergence although more extensive sampling across the satyr's range may verify this finding. It was determined that the model should be tested during the 2008 satyr flight period to determine its effectiveness in predicting emergence and to refine the model as needed.

2008 Modeling Effort (Full report found in Appendix E.)

Introduction

The methodology was revised in 2008 to assist in refining and improving the model. It was decided to collect data at three additional sites to obtain a more complete set of hourly readings and hopefully narrow the range of degree days for predicted emergence. In addition, since there was little difference in temperature between the fens and the uplands, it was decided to remove the data loggers from the uplands and to instead place them at ground level in the fens.

Methods

Two Hobo® Dataloggers were placed at three additional sites for a total of ten sites in open fen meadows known to contain the butterflies. Half of the data loggers at each site were mounted on 8 x 10 in unpainted pine boards which were attached to a 5 ft metal fence post. The dataloggers were positioned at chest height, approximately 4.5 ft above the ground, and oriented in a north direction to minimize exposure to direct sunlight. The remaining dataloggers were mounted on wooden staked and positioned at ground level approximately one meter southeast of the posts to minimize exposure to shade from the posts. All dataloggers were programmed to record temperatures and relative humidity every hour.

Field staff began checking for Mitchell's satyr emergence at each site the week of June 15, 2008, approximately five days before the earliest recorded emergence. The data loggers were downloaded after the flight period ended. Data was analyzed to calculate accumulated degree days from the date of placement (generally before March 6th) to the first observed emergence date for each site. Degree day data was obtained from the nearest weather station for each site from weather data posted on the Michigan Automated Weather Network (MAWN). Data were collected from the fens in order to determine difference between weather station data and actual conditions within satyr habitats. A 95% confidence interval was calculated from the MAWN weather data, which were the values used to estimate emergence times.

Results

Emergence observations for Mitchell's satyrs occurred from June 18th – July 1st. There did not appear to be an effect of geographic location on cumulative degree day values at emergence although more extensive sampling across the satyr's range may verify this finding. Degree day accumulations were higher in the fens than at the MAWN stations. The 95% confidence interval for predicting Mitchell's satyr emergence using MAWN data is 865.03 - 972.40 degree days (Base 50$_0$ F).

Discussion

The cumulative degree day confidence interval is the best model we have to date for predicting Mitchell's satyr emergence. It may still be difficult to time the surveys with emergence using this model due to the wide range, however; in most years it appears that during the first few days of emergence there are low numbers of individuals so missing those in the surveys would not be critical. If capturing first emergence is critical to survey effort, it is recommended that the lowest cumulative degree value be used as the trigger to begin surveys 824.4 degree days (Base 50$_0$ F).

Field Inventory: Fen Surveys

Results and Discussion of Fen Surveys

A total of 42 potential fen sites were surveyed in 2007 – 2009, resulting in the documentation of 10 new occurrences of prairie fen (Table 10 and Appendix O.).

Table 10. New prairie fen element occurrences documented during 2007 – 2009

Site name	EO Number	County	Size (acres)	EO Rank
Palmatier Lake Fen	158	Barry	8.8	BC
Willis Road	147	Jackson	1.2	C
Swains Lake Southwest	148	Jackson	8.2	C
Waterloo Recreation Area -- Little Portage Lake	155	Jackson	38.2	B
Bullard Lake	149	Livingston	13.9	BC
Cade Lake Fen	159	St. Joseph	4.2	D
Jephtha Lake Fen	146	Van Buren	16.2	BC
Lime Lake/Cedar Creek	153	Van Buren	11.8	B
Buss Road	154	Washtenaw	27.3	B
Pinckney Recreation Area -- Sullivan Lakes, Hadley Road	156	Washtenaw	16.8	BC

Among the newly documented prairie fen element occurrences, three sites are of particularly high quality:

Waterloo Recreation Area – Little Portage Lake
T01S R02E S29, Jackson County

This nearly 40-acre (16 ha) site is a portion of an extensive marl lakebed supporting vegetation similar to that found in open Great Lakes shorelines, including Great Lakes marsh, coastal fen, and lakeplain prairie. Frequency, duration, and depth of inundation shapes vegetative composition and structure within this complex, with species richness and forb density greatest in the least frequently inundated outer bands, and decreasing richness (of forbs and grasses in particular) closer to the lake. Characteristic species include twig-rush (*Cladium mariscoides*), cordgrass (*Spartina pectinata*), switch grass (*Panicum virgatum*), big bluestem (*Andropogon gerardii*), beak-rush (*Rhynchospora capillacea*), nut-rush (*Scleria verticillata*), whorled loosestrife (*Lysimachia quadriflora*), bog lobelia (*Lobelia kalmii*), and sneezeweed (*Helenium autumnale*). Closer to the lake, the wetland supports species of wet meadow and emergent marsh. Soils range from deep marl (>42") adjacent to open water to shallower marl over sand farther from lake. Marl is mixed with shells and sand, and has pH= 8.0. Areas closest to the lake had 3-4" standing water in May but were dry in August. A narrow wet-mesic prairie zone at the upland margin occurs on medium- to coarse-textured iron-mottled, red sands over finer-textured medium brown sands, pH= 8.0 at all depths. This site is unusual among prairie fen element occurrences in its frequent periods of inundation and the concomitant scarcity of sedges (*Carex* spp.) and flood-intolerant forbs.

Van Buren County Northwest
(Site name and location are not provided due to the confidentiality of Mitchell's satyr locations)

This site is a complex of open fen and associated wetlands associated with two lakes and a small stream. The fen is notable for supporting populations of the state and federally endangered Mitchell's satyr butterfly (*Neonympha mitchellii mitchellii*) and several state-listed plant species. This fen is the only newly transcribed site where the presence of Mitchell's satyr butterfly was confirmed. Within this complex, pockets of open marl fen occur along the shores of two lakes and along the drainage connecting these lakes. Seeps, marl flats, and slumping are common within the complex. The largest fen openings, along the two lakes are "benched," with upper fen meadow zones grading to a lower marl flat zone, which is comprised of inundated marl flats along the lakeshores and higher, merely saturated marl flats of greater diversity. Soils range from marl and sandy marl with gravel at the surface, pH= 7.5-8.0, to peats of varying depth over the marl layer. The complex is species-rich and relatively undisturbed, but threatened by invasive species. Characteristic plant species include spike-rushes (*Eleocharis smallii* and *E. rostellata*), hardstem bulrush (*Schoenoplectus acutus*), and several calciphiles and carnivorous plants, including grass-of-Parnassus (*Parnassia glauca*), common bog arrow-grass (*Triglochin maritimum*), false asphodel (*Tofieldia glutinosa*), pitcher-plant (*Sarracenia purpurea*), shrubby cinquefoil (*Potentilla fruticosa*), twig-rush (*Cladium mariscoides*), three-square (*Schoenoplectus pungens*), and Ohio goldenrod (*Solidago ohioensis*). Bladderworts (*Utricularia* spp.) occupy inundated flats. Drier areas of the fen are dominated by sedges (including *Carex stricta* and *C. sterilis*), associated with prairie grasses, shrubby cinquefoil, and numerous forbs. Much of the fen has a scattered tall shrub and tree layer with tamarack (*Larix laricina*), red-cedar (*Juniperus virginiana*), red maple (*Acer rubrum*), spicebush (*Lindera benzoin*), poison sumac (*Toxicodendron vernix*), dogwoods (*Cornus* spp.), and hoary willow (*Salix candida*).

Buss Road
T04S R03E S6, Washtenaw County

This 27-acre (11-ha) site was the highest quality previously undocumented prairie fen surveyed during the three-year period. Buss Road is a large wetland complex on glacial outwash in ice-contact terrain, characterized by several peat domes associated with groundwater discharge zones and upwellings near upland margins, in a matrix of low, wet tussock sedge- (*Carex stricta*) dominated southern wet meadow. The peat domes are vegetated by tussock-forming fen sedges and prairie grasses, with numerous forbs, including several calciphiles that thrive on the alkaline peats and marls. Characteristic species include sedge (*Carex sterilis*), big bluestem (*Andropogon gerardii*), Indian grass (*Sorghastrum nutans*), bog valerian (*Valeriana uliginosa*), whorled loosestrife (*Lysimachia quadriflora*), Ohio goldenrod (*Solidago ohioensis*), common mountain mint (*Pycnanthemum virginianum*), fringed brome (*Bromus ciliatus*), hardstem bulrush (*Schoenoplectus acutus*), spike-rush (*Eleocharis rostellata*), shrubby cinquefoil (*Potentilla fruticosa*), tamarack (*Larix laricina*), common juniper (*Juniperus virginiana*), dogwoods (*Cornus* spp.), and poison sumac (*Toxicodendron vernix*). Sphagnum mosses are local, covering hummocks in some seepy upwelling zones. The wetland complex contains upland ice-contact features (a kame and an esker) supporting closed-in, degraded oak barrens with remnant savanna forbs and grasses. The fen is notable for supporting only the second documented native population of the state-threatened northern bayberry (*Myrica pensylvanica*) in Michigan.

In addition to the ten new prairie fen occurrences documented as part of this project, thirteen previously documented fens were revisited to update data, including element occurrence rank, species lists, other field data, and site boundaries (Table 11 and Appendix O.).

Table 11. Prairie fen element occurrences updated during 2007 – 2009.

Site name	EO Number	County	EO Rank
Hill Creek Fen	122	Barry	B
Rudy Road Fen	35	Cass	C
Lost Nation Fen	109	Hillsdale	BC
Liberty Fen	52	Jackson	A
Mt. Hope Road Fen	77	Jackson	B
Bayley's Fen	17	Jackson	BC
Paw Paw Lake	108	Kalamazoo	B
Whitman Lake Fen	21	Kalamazoo	B
Vanderbilt Fen	120	Kalamazoo	BC
Algoe Lake Prairie Fen	107	Lapeer	B
Little Goose Lake Fen	137	Lenawee	B
Brandt Road Fen	111	Oakland	B
Park Lyndon Fen	22	Washtenaw	B

Among the updated fen sites, three support populations of Mitchell's satyr butterfly. Rudy Road Fen and Paw Paw Lake were remapped to more accurately represent fen acreage based on field visits and interpretation of aerial photographs. Additional data were collected at Liberty Fen to update the fen occurrence. Field surveys resulted in the extension of Bayley's Fen in Jackson County and Brandt Road Fen in Oakland County.

The results of the de novo fen surveys and updates add appreciably to our understanding of the frequency, acreage, distribution, and conservation status of prairie fens in Michigan. As of November 2009, 150 element occurrences of prairie fen have been documented in the state, totaling approximately 4,800 acres (1,900 ha). A significant percentage (37%) of these occurrences are less than 10 ac (4 ha), and 84% are less than 50 ac (20 ha) (Figure 12.). Only ten occurrences (7%) are greater than 100 ac (40 ha), but these comprise 44% of the total acreage (2,100 ac, or 850 ha).

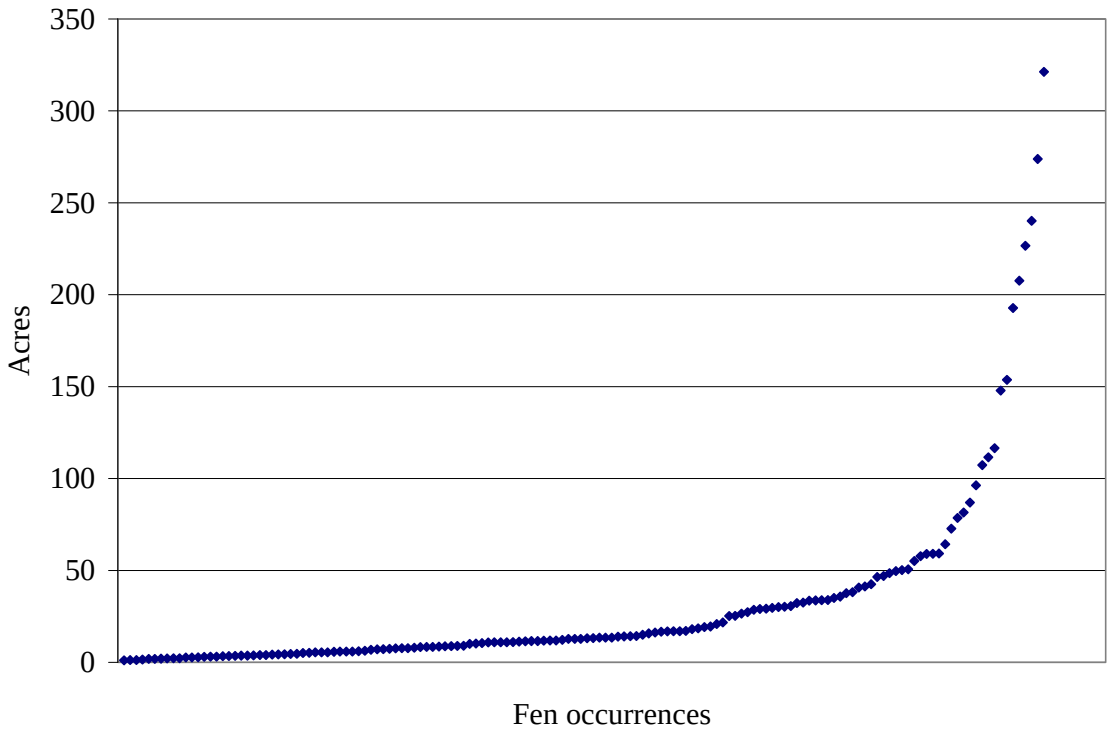


Figure 12. Size distribution of prairie fen element occurrences.

The majority of prairie fens in Michigan occur in two ecoregional sub-subsections: the Jackson Interlobate (VI.1.3) and Battle Creek Outwash Plain (VI.2.1) (Table 12). Eighty percent of prairie fen acreage occurs in these two ecoregions. The Jackson Interlobate and Battle Creek Outwash Plain are characterized by extensive deposits of glacial outwash that contain numerous glacial kettle lakes. The outwash deposits encompass numerous areas of irregular, broken end moraine, ground moraine, and ice-contact features (i.e., kames and eskers) (Albert 1995, Comer et al. 1995). Groundwater seepage at the interface of these features and the outwash deposits supports the development of prairie fen communities. Prairie fen is also present on the margins of many kettle lakes. The community is absent from the glacial lakeplain and rare and local on the rolling ground moraines that characterize much of the south-central Lower Peninsula (Figure 13).

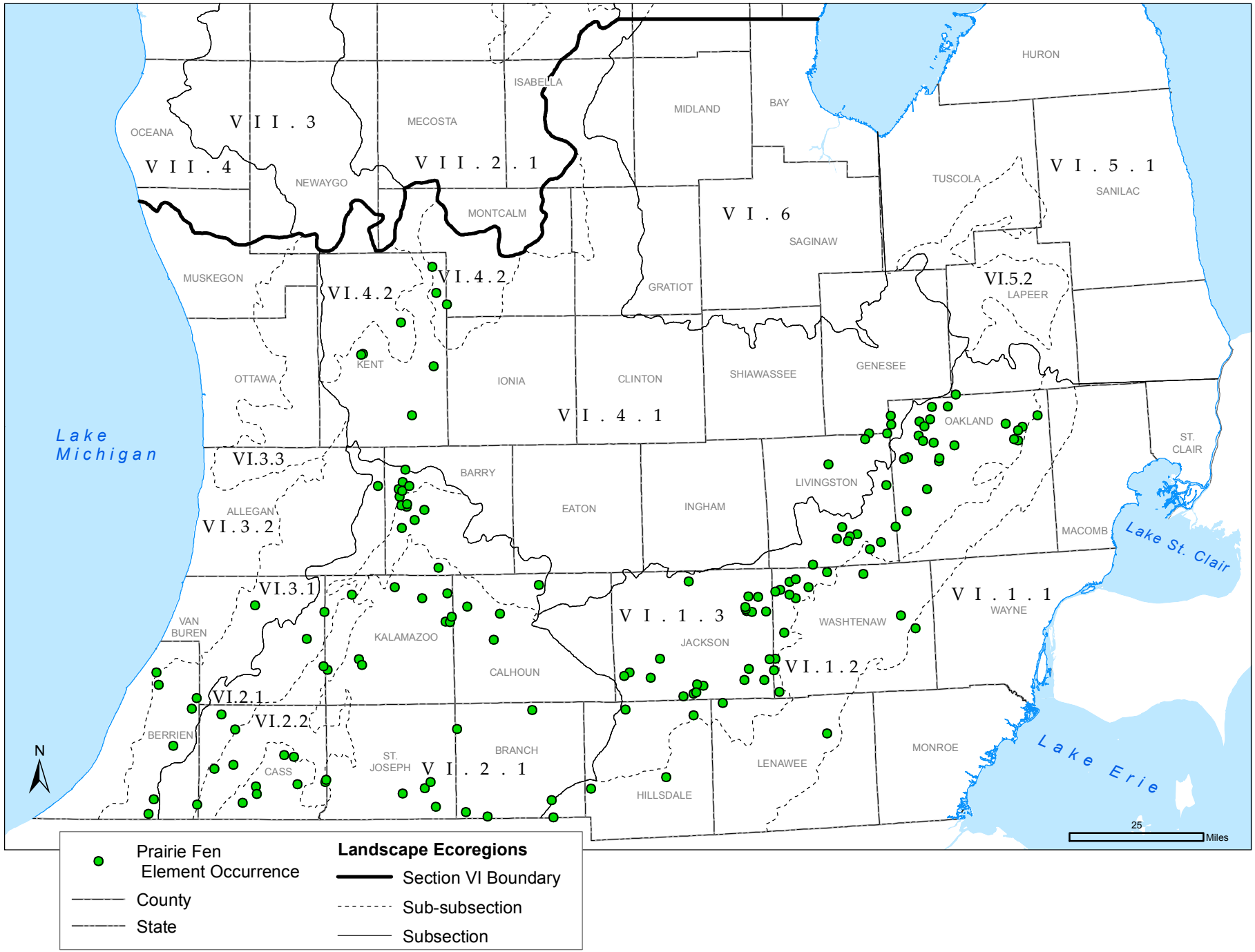


Figure 13. Distribution of Prairie Fens in Michigan

Table 12. Prairie fen occurrences and acreage by ecoregional sub-subsection.

# EOs	Acres	Ecoregional Sub-subsection	Name
67	2,670	6.1.3	Jackson Interlobate
38	1,190	6.2.1	Battle Creek Outwash Plain
15	346	6.2.2	Cassopolis Ice-Contact Ridges
10	184	6.4.1	Lansing
7	141	6.1.2	Ann Arbor Moraines
7	150	6.3.1	Berrien Springs
4	123	6.4.2	Greenville
1	2.7	6.1.1	Maumee Lake Plain
1	6.1	6.3.2	Southern Lake Michigan Lake Plain

At the county level, the majority of prairie fens occur in Oakland, Jackson, and Washtenaw counties, which all encompass a portion of the Jackson Interlobate ecoregion (Table 13.). In total, 1,900 ac (780 ha), or 40% of the total prairie fen acreage documented in Michigan, occur in these three counties. Prairie fens have been documented from 19 counties in southern Lower Michigan.

Table 13. Prairie fen occurrences and acreage by county.

#EOs	Acres	County
23	698	Oakland
21	710	Jackson
15	514	Washtenaw
13	301	Barry
13	436	Livingston
12	532	Cass
10	144	Kalamazoo
8	143	Berrien
7	162	Kent
6	208	Branch
4	53.8	Calhoun
4	368	Hillsdale
4	260	St. Joseph
4	79.3	Van Buren
2	162	Lenawee
1	11.9	Allegan
1	3.7	Genesee
1	10.9	Lapeer
1	11.6	Montcalm

Only 7% of prairie fen occurrences are estimated to have excellent (A-rank) or good to excellent (AB-rank) ecological integrity (Figure 14.). However, because size is considered as part of the ecological integrity or viability score, most of these sites are relatively large, and together comprise nearly 1,300 ac (530 ha), or 27% of the total acreage of prairie fen element occurrences in the state. Half of the occurrences have fair to poor ecological integrity, comprising a total of 840 ac (340 ac), or 18% of the total acreage of prairie fen occurrences.

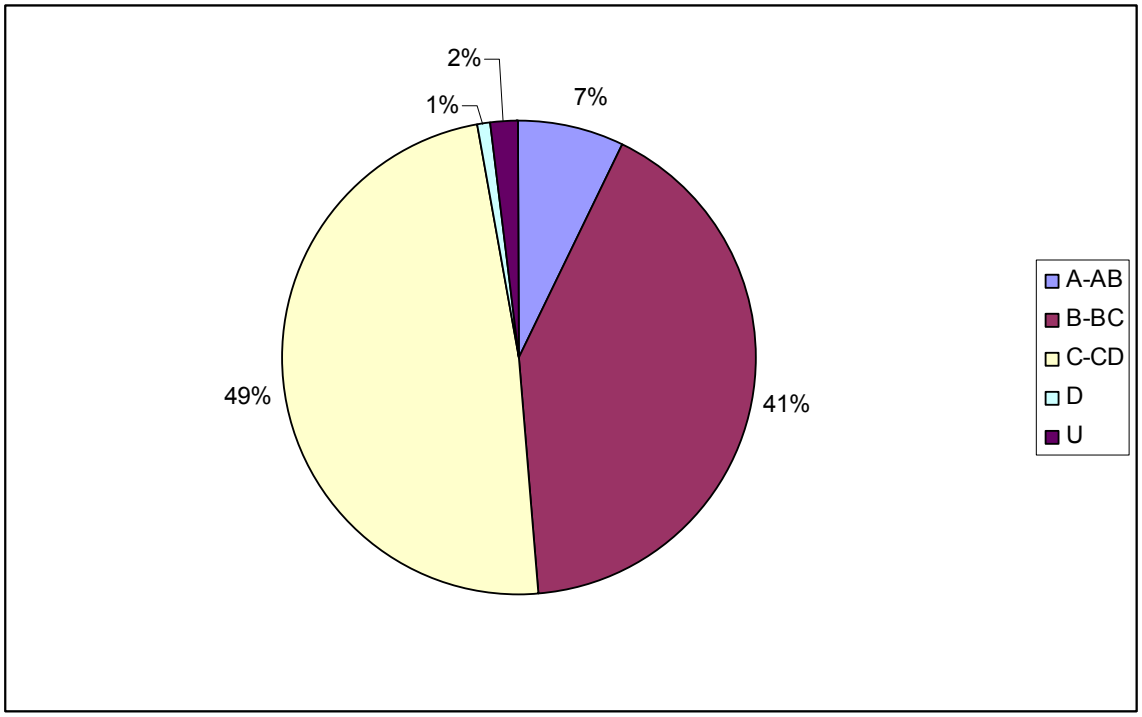


Figure 14. Prairie fen element occurrences by EO rank. EO Rank A-AB: Excellent or excellent to good ecological integrity or viability; B-BC: Good or good to fair ecological integrity or viability; C-CD: Fair or fair to poor ecological integrity or viability; D: Poor ecological integrity or viability; U: Unranked.

Recommendations for Future Work

Among the 150 occurrences of prairie fen in the database, 39 (26%) were last surveyed prior to 1990, and 86 (57%) were last surveyed prior to 2000. Site revisits should be prioritized based on date of last observation, quality of existing data, and consideration of site selection for habitat management and/or monitoring of rare species. Although the distribution and conservation status of prairie fen in Michigan is evidently well-documented, the results of de novo surveys indicate the high likelihood of discovering additional high quality prairie fens with further aerial photograph interpretation and reconnaissance survey work. Priority for new fen surveys should be invested in sites that occur in relatively unfragmented complexes of wetland and upland habitat and that appear to have greatest potential for supporting rare plant and animal species.

In addition to continued surveys, an updated assessment of the three best occurrences of prairie fen at the statewide, section, subsection, and sub-subsection scales (Paskus et al. 2007) should be conducted due to the recent revision of the natural community classification and the identification and update of numerous natural community element occurrences across the state over the past several years.

Literature Cited

Albert, D.A. 1995. Regional landscape ecosystems of MI, MN and WI: A working map and classification. USFS North Central Forest Experiment Station. 1992 Folwell Ave. St. Paul, MN 55108. 250 pp.

Comer, P.J., D.A. Albert, H.A. Wells, B.L. Hart, J.B. Raab, D.L. Price, D.M. Kashian, R.A. Corner, and D.W. Schuen. 1995b. Michigan's native landscape, as interpreted from the General Land Office Surveys 1816-1856. Report to the U.S. E.P.A. Water Division and the Wildlife Division, Michigan Department of Natural Resources. Michigan Natural Features Inventory, Lansing, MI. 76 pp.

Paskus, J.J, A.L. Derosier, E.H. Schools, H.D. Enander, B.S. Slaughter, M.A. Kost, and R.L. Rogers. 2007. Biodiversity Assessment of Michigan Technical Report. Report for Michigan Dept. of Natural Resources, Wildlife Division. Michigan Natural Features Inventory report number 2007-11. 232pp.

Prairie Fen Distribution Modeling Report for 2008

Background and summary of previous work:

Predictive distribution modeling using Geographic Information Systems (GIS), environmental datasets, species or community location data, and computerized statistical methods has become a common means for identifying areas of potential occurrence for a species, and less commonly, natural community types. In addition, the relative influence of the environmental variables that relate to the predicted presence or absence of a species can be described and quantified, contributing to understanding of the species' habitat requirements.

Maxent

Many species distribution models exist, each with unique requirements and implementation (Guisan and Zimmerman 2000, Elith et al. 2006). Maximum entropy species distribution modeling has been shown to perform at the top of presence-only distribution models, and is particularly effective when sample size is small (Hernandez et al. 2006). Maxent, a software implementation of the maximum entropy algorithm, uses known locations (samples) and environmental predictor variables to estimate a target probability distribution (Phillips et al. 2004, 2006). The output of a Maxent run consists of cumulative probability values, continuous from zero (least suitable) to 1 (most suitable).

Decision thresholds

Model evaluation in terms of presence or absence requires the selection of response threshold (the probability of occurrence value that separates present from absent). Liu et al. (2005) lists many methods that have been tested for setting the threshold, most of which depend on balancing sensitivity and specificity. Sensitivity and specificity are measures of classification error derived from the traditional error matrix. Sensitivity is the probability of correctly classifying a presence and specificity is the inverse: the probability that an absence is correctly classified. (Fielding and Bell 1997). As larger thresholds are chosen, specificity errors decrease while sensitivity errors will increase. The fraction of the study area predicted as suitable also increases with an increase in the response threshold.

Wilson et al. (2005) advises setting the threshold based on the model objectives. If the goal is to minimize omission error (when a presence is actually predicted as absence), a simple threshold is selected by choosing the minimum value which allows all the sample points to occur in the predicted suitable area. This guarantees a specificity of 100%, or alternatively an omission rate of 0%. When there isn't any clear reason for protecting against omission or commission error (when an absence is actually predicted as present), the receiver-operating characteristic (ROC) plot method is advised (Manel et al. 2001). A ROC plot is obtained by plotting all sensitivity values on the Y axis against (1 - specificity) values (false positive fraction) for all available thresholds on the X axis (Fielding and Bell 1997). The optimal threshold can be determined from the ROC curve by finding the point where sensitivity and specificity are maximized (Manel et al. 2001, Hernandez et al. 2006). When absence locations are not available for determining the false positive fraction, ROC curves are generated by plotting sensitivity on the X axis and the proportion of all map pixels predicted suitable (fractional predicted area, FPA) on the Y axis (Phillips et al. 2006).

Model evaluation

Overall model performance can be evaluated and compared using the area-under-the-curve (AUC) measure of the ROC plot (Fielding and Bell 1997). The advantage of this measure is that it is independent of the chosen response value threshold. Values of AUC vary between 0.5 for a random model and 1 for a model with perfect discrimination. A ROC curve that maximizes sensitivity for low values of specificity results in a high AUC value and is considered a good model. The AUC derived from a ROC plot of a model that uses only presence data can be interpreted as a measure of the ability of the

algorithm to discriminate between a suitable environmental condition and a random location rather than between suitable and unsuitable conditions, as with AUC developed with measured absences. AUC derived in this manner also penalizes the prediction of proportionally larger spatial areas (Phillips et al. 2006). Maxent is a maximum-likelihood statistical approach. Model "gain" is a measure of the likelihood of the samples; for example, if the gain is 2, it means that the average sample likelihood is e^2 or approximately 7.4 times higher than that of a random background sample. (Phillips et al. 2006). The gain can be interpreted as representing how much better the distribution fits the sample points than the uniform (or most spread out) distribution.

2007 Prairie fen model

Prairie fen distribution was modeled in 2007 using Maxent. The environmental predictor variables that proved most effective in the 2007 model were: National Wetland Inventory (NWI) class, Ecoregional sub-subsection, soil drainage class, local relief (maximum change in elevation within a 250 m radius circle), local wetland percent (proportion of wetland in a 250m radius), current land cover class, circa 1800 vegetation covertype, and proportion of sand in the soil surface layer. The extent of the model included the southern Lower Peninsula, Ecoregional section VI.

A set of 10 presence and 31 absence locations from previous survey efforts (circa 2000) was used as a rigorous test of the model. These test locations were initially considered to be potential prairie fen habitat from aerial photography and were field checked to determine fen presence/absence. All 10 prairie fen presence points were predicted as suitable habitat by the model (0% omission error) but 23 of the 31 absence points were predicted suitable by the model. (75% commission error). This suggested that the model was over-predicting suitable prairie fen locations.

Methods

2008 Prairie fen model

The most recent version of the Maxent software (Version 3.2.19) was released in October of 2008 and was used for the models presented in this report. In 2007, 135 fen locations that were available from the MNFI element occurrence database were used in the model. In 2008, seven new Prairie fens that were documented from 2007 field surveys were added to the existing Prairie fen location layer, resulting in 142 locations (samples) available for modeling. (Figure 13. Note that this figure was updated to include prairie fens documented in 2008 and 2009). The predictor variables from the 2007 model were included with the updated fen layer in a new run of the model.

In an attempt to enhance the modeling results, MNFI Ecologist Mike Kost suggested other environmental variables that are related to prairie fen location and are available as digital GIS layers: valley segment (Vsec) order, Vsec class, ground water flow (Darcy model), and landform. Marl lakes and mines were also suggested but a suitable digital layer was not available. Valley segments were obtained from the Michigan Department of Natural Resources Fisheries Division Institute for Fisheries Research (IFR), where a new valley segment classification was recently completed. The Vsec lines originate from the 1:100,000 National Hydrologic Dataset stream lines, and were classified by temperature (cold, cool, transitional, and warm), type (stream, river) and if of type "river" then also size (small, large), resulting in eleven classes. Stream order, used to define stream size based on a hierarchy of tributaries, was available and ranged from one at the headwaters to seven for rivers discharging into the Great Lakes. Each cell (30 meter pixels) in the study area was assigned the order of the nearest Vsec stream and the classification of that stream segment. These two attributes were included as predictor variables in the distribution model.

The Darcy model was available from Michigan Rivers Inventory and IFR. Darcy is named for Henry Darcy who established Darcy's law (1856) regarding groundwater flow. This layer, a terrain-based model, attempts to quantify shallow subsurface water movement. The dataset values (velocity = length*time-1) represent only the potential groundwater velocities to a surface location, not actual water transport. Both the actual values and values grouped into classes by standard deviation were used in the distribution model.

Two landform classification models (Dikau 1989, 1991; True et al., n.d.) were built using ESRI's model builder (Morgan et al. 2005). Both are implementations of biogeographer Edwin Hammond's system of landform classification (1954, 1964a, 1964b) based on local relief, slope, and profile. Profile identifies whether an area is higher or lower than the surrounding area. Both models modify Hammond's parameters and establish their own groupings of landform types.

The use of soil predictor variables in the distribution model is problematic. Physical and/or chemical properties are not always defined for all soil map units, resulting in gaps of no data in the layer. Maxent usually handles this situation by not using a sample if it is located in a no data gap in even one of the environmental predictor variables. For the 2007 model only 77 fen points were actually used in the model out of the 135 available because of no data gaps in the drainage class and soil sand proportion variables. An experimental component of Maxent allows all samples to be included in the prediction, even if one or more of the predictor layers have no data at the sample's location. The disadvantage to this is the model output also has no data in any area where one of the environmental variables had no data.

Combining the additional predictor variables with the environmental variables that had shown some relationship to Prairie fen location in previous distribution models resulted in 26 predictor variables for input in the 2008 Prairie fen distribution model. This "full" model included soils variables (surface texture, sand, pH, calcium carbonate, saturated hydraulic conductivity, drainage class), land cover variables (NWI class, wetland proportion in 250 m radius, circa 1800 covertype, current land cover), hydrology (vsec order, vsec class, darcy, distance to a stream), climate (maximum spring temperature, minimum spring temperature, annual precipitation, annual snowfall, average day to day radiation, average frost days, average growing degree days), topographic (change in elevation within a 250 m radius) and ecological sub-subsection. All samples were allowed to be used even if one or more environmental layers had no data at that sample location.

Mitchell's Satyr model.

There are 24 locations of Mitchell's Satyr in the MNFI database. Twenty-three were selected as suitable for modeling the distribution of Mitchell's satyr. The unused location has not been observed since 1931, and is located in the extreme eastern portion of Washtenaw County (Figure 2). The suite of environmental variables available to Prairie fen modeling was also considered in the Mitchell's satyr model.

Results

2008 Prairie fen modeling

Re-running the 2007 fen model with the new fen locations resulted in a slight decrease in model performance. The AUC fell from 0.991 to 0.988, the FPA (simple threshold) increased from 14.8% to 28.3%, and the FPA (ROC threshold) increased from 4.1% to 5.1%. Notable changes in variable contribution (Table 14) were soil sand %, increasing in importance from 1.2% to 9.1%, and circa 1800 covertype, increasing from 3.0% to 8.1%. Ecoregional sub-subsection decreased in importance from 26.4 % to 19.9%. Other predictor variables changed in smaller amounts. Current land cover type remained at a 3.2% contribution but was now the least important variable. Model gain decreased from 3.303 to 3.058.

Table 14. Comparison of Prairie fen models by year (2008 included 7 additional presence points).

	2007	2008
Variable	**Percent contribution**	**Percent contribution**
NWI class	35.3	31.2
Ecoregional sub-subsection	26.4	19.9
Soil drainage class	13.8	11.6
Soil sand %	1.2	9.1
Proportion of wetland in 250 m	6.4	8.5
Local relief	10.7	8.4
Circa 1800 covertype	3.0	8.1
Current land cover class	3.2	3.2
Model AUC	0.991	0.988

The environmental variables used in the full model and a heuristic estimate of their relative contribution are listed in Table 15, with soil surface texture by far the most important (69.5%). One texture class, muck, accounted for most of the positive association. NWI class provided a contribution (11.7%) to the model, with the class “emergent” most associated with Prairie fen suitability, as did soil drainage class (7.1%), with “very poorly drained” identified as most suitable. Phillips (2008) advises that the variable contributions should be interpreted with caution when the predictor variables are correlated, as some of these certainly are. To see the contribution and response of each individual variable, Maxent provides variable response curves to show relationship of predictor to species or community when variable is by itself in the model (Figure X). The evaluation parameters for this model include AUC (0.996), gain (3.592), FPA, minimum threshold (32%) and FPA, ROC method (1.2%).

A model eliminating the environmental variables with less than 0.5% contribution was output to reduce the use of soil variables that aren’t necessary and decrease the amount of no data in the result, and to create a more parsimonious model.

Table 15. Environmental variables used in the model and an estimate of their relative contribution

	Prairie Fen	Mitchell's Satyr
Variable	**Percent contribution**	**Percent contribution**
Soil surface texture	69.9	77.2
NWI class	11	6.1
Soil drainage class	7.1	0.6
Circa 1800 covertype	2.4	0.9
Local relief	1.5	0.7
Soil sand %	1.4	0.1
Local wetland area	1.1	2.9
Current land cover class	1	0.6
Ecoregional sub-subsection	1	0.1
Valley segment class	0.5	0
Minimum spring temperature	0.5	0
Soil calcium carbonate	0.5	8.1
Day-to-day radiation	0.3	0
Soil hydraulic conductivity	0.3	0
Local water area	0.2	0
Annual precipitation	0.2	1.2
Valley segment order	0.2	0
Darcy classes	0.1	1
Growing-degree days	0.1	0
Distance to a stream	0.1	0.1
Elevation	0.1	0
Annual snowfall	0.1	0.1
Maximum spring temperature	0.1	0
Soil Ph	0.1	0
Darcy	0.1	0
Frost Days	0	0

Results – Mitchell's Satyr model.

The predictor variables that best modeled satyr presence/absence included soil surface texture (77.2%), soil calcium carbonate (8.1%), and NWI class (6.1%). Table 2 lists all the predictor variables and their percent contribution. The gain for this model is 5.128, or the average sample has a 196 ($e^{5.128}$) higher likelihood than the average background pixel. The AUC was so close to 1 that the software rounded it to 1.00. The FPA, minimum threshold and ROC threshold, are less than 1%, indicating less than 1% of the southern Lower Peninsula was considered suitable.

As with the Prairie fen process, a model eliminating the variables with < 0.1% contribution was produced to reduce the use of soil variables that weren't contributing and decrease the amount of no data in the result, and to create a more parsimonious model.

Discussion

Updating the 2007 Prairie fen model with new locations resulted in a slight decrease in model performance, indicating the locations were less similar to the existing locations. Using the experimental approach of including all samples appears to work well in revealing relationships with predictor variables and reducing the quantity of the study area predicted as suitable. When all samples are included, the contribution of soil texture becomes highly significant. It seems that soil map units with a surface texture of muck, the most significant class, don't have attributes for percent sand and/or other soil attributes that were also used in the model. When modeling in the standard manner, those locations aren't used and the contribution of soil texture is not nearly as evident.

It is important to note that there are differences between those variables important for Prairie fen, and those important for the Mitchell's satyr. Note that in the variable percent contribution table (Table 2) of the full model, soil drainage class is important for Prairie fen, but soil calcium carbonate is important for Mitchell's satyr, however the variable importance table should be interpreted with caution as mulitcolinearity of predictor variables will affect the percent contribution of individual variables.

Limitations

Model results depend on the accuracy of the underlying spatial data. Each layer contains some inherent error which can be compounded as layers are combined in the modeling process. Realized vs potential niche: While we are using actual locations of elements in the model, the lack of absences may increase the area predicted as suitable beyond what is the actual or realized niche. The model may be predicting somewhere between the realized or utilized niche and the potential suitable habitat.

Literature cited

Albert, D. A. 1995. Regional Landscape Ecosystems of Michigan, Minnesota, and Wisconsin: A Working Map and Classification (Fourth Revision: July 1994). Lansing, MI: Michigan Natural Features Inventory . Report number 1995-01. 250pp. GIS coverage approximate map scale 1:100,000. http://www.mcgi.state.mi.us/mgdl/?rel=thext&action=thmname&cid=2&cat=Ecoregions

Dikau, R. 1989. The application of a digital relief model to landform analysis. In Three Dimensional Applications in Geographical Information Systems, ed. J. F. Raper, 51-77. London: Taylor and Francis.

Dikau, R., E. E. Brabb, and R. M Mark. 1991. Landform classification of New Mexico by Computer. U.S. Geological Survey Open File Report 91-634.

Elith, J., C. H. Graham, R. P. Anderson, M. Dudik, S. Ferrier, A. Guisan, R. J. Hijmans, F. Huettmann, J. R. Leathwick, A. Lehmann, J. Li, L. G. Lohmann, B. A. Loiselle, G. Manion, C. Moritz, M. Nakamura, Y. Nakazawa, J. McC. M. Overton, A. Townsend Peterson, S. J. Phillips, K. Richardson, R. Scachetti-Pereira, R. E. Schapire, J. Soberon, S. Williams, M. S. Wisz, and N. E. Zimmermann. 2006. Novel methods improve prediction of species' distributions from occurrence data. Ecography **29**:129-151.

Fielding, A. H., and J. F. Bell. 1997. A review of methods for the assessment of prediction errors in conservation presence/absence models. Environmental Conservation **24**:38-49.

Guisan, A., and N. E. Zimmermann. 2000. Predictive habitat distribution models in ecology. Ecological Modelling **135**:147.

Hammond, E. H. 1954. Small scale continental landform maps. Annals of theAssociation of American Geographers 44: 32-42.

Hammond, E. H. 1964a. Analysis of properties in landform geography: An application to broadscale landform mapping. Annals of the Association of American Geographers 54(1):11-19.

Hammond, E. H. 1964b. Classes of land surface form in the forty-eight states, U.S.A. Annals of the Association of American Geographers 54(1): map supplement

Hernandez, P. A., C. H. Graham, L. L. Master, and D. L. Albert. 2006. The effect of sample size and species characteristics on performance of different species distribution modeling methods. Ecography 29:773-785.

Liu, C., P. M. Berry, T. P. Dawson, and R. G. Pearson. 2005. Selecting thresholds of occurrence in the prediction of species distributions. Ecography **28**:385-393.

Manel, S., H. C. Williams, and S. J. Ormerod. 2001. Evaluating presence-absence models in ecology: the need to account for prevalence. Journal of Applied Ecology **38**:921-931.

Morgan, J.P., and A.M. Lesh. 2005. Developing landform maps using ESRI'S ModelBuilder. Proceedings of the 2005 ESRI User's Conference, San Diego, CA.

Phillips, S. J., Robert P. Anderson, Robert E. Schapire. 2006. Maximum entropy modeling of species geographic distributions. Ecological Modelling **190**:231-259.

Phillips, S. J., R.E. Schapire, and M. Dudik. 2004. A maximum entropy approach to species distribution modeling. Proceedings of the Twenty-First International Conference on Machine Learning:655-662.

True, C. D., T. Gordon, and D. Diamond. n.d. How the size of a sliding window impacts the generation of landforms. PowerPoint presentation on the Missouri Resource Assessment Partnership's Web site at: http://www.cerc.cr.usgs.gov/morap/projects.asp?project_id=17&project_name=Landform%20Modeling&project_directory=landform_model.

Wilson, K. A., M. I. Westphal, H. P. Possingham, and J. Elith. 2005. Sensitivity of conservation planning to different approaches to using predicted species distribution data. Biological Conservation. **122**:99-112

Public Outreach and Development of New Materials

Landowner Contact

Landowners at Occupied Mitchell's Satyr Sites and Sites with Fen Habitat

Each year from 2007-2009, MNFI contacted landowners of occupied satyr sites as well as at sites with potential for satyr habitat during the month prior to the satyr flight. In addition, we worked closely with staff from The Michigan Department of Natural Resources (MDNR), Landowner Incentive Program (LIP), Southwest Michigan Land Conservancy (SWMLC), The Nature Conservancy and the Michigan Nature Association (MNA) to coordinate landowner contact at sites where their volunteers were conducting surveys or coordinating management activities. Landowners were contacted by telephone or in some cases by home visits. Discussions with each landowner emphasized the importance of wetland communities, fens in particular, and the status of the Mitchell's satyr and other associated rare species. Photographs of the Mitchell's satyr butterfly, other butterflies that are often confused with the satyr and prairie fen habitat were laminated and used when talking with landowners and describing the butterfly and its habitat. Those individuals that had Mitchell's satyr on their land were informed of the status of the species and the significance of having the satyr on their property. They were provided with information on how to manage their land in a way that will preserve or enhance the satyr's habitat and informed about activities that pose a threat to the satyr. Finally, they were encouraged to contact us if they had any questions or concerns.

In addition, landowners identified as having potential prairie fen on their property were called and asked for their permission to allow us to conduct surveys on their land. We coordinated landowner information with the MDNR LIP program as well as land conservancies such as TNC. The majority of landowners contacted were very supportive, and many asked to accompany scientists when they conducted their surveys. Landowners that had a prairie fen on their property were provided with information emphasizing the value of this natural community and outlining activities that threaten fens and fen-associated plants and animals. Results of surveys were provided to landowners through letters or phone calls.

The majority of landowners with the Mitchell's satyr on their property have been very supportive of our efforts to monitor the satyr each year. Some have even entered into agreements with the MDNR LIP program, TNC or a land conservancy to have management conducted on their property to address threats to the satyr and its habitat. To date, 14 of the 18 extant sites have had management activities initiated in the past several years to address invasive species, shrub encroachment or altered hydrology. In 2007, MNFI and MDNR worked closely with a local land conservancy to assist in developing a management plan for a conservation easement and the purchase of development rights acquired on property where the Mitchell's satyr occurs. There have been some cases where some landowners have asked us not to conduct surveys on their land, because they highly value their privacy or in some instances believe that the fen habitat should be left alone and disagree with the opinion that the land needs to be managed. It is important to remember that although we may become very familiar with the habitat at sites we visit each year that we are invited guests on a landowner's property and it is crucial to honor their wishes for notification, privacy and confidentiality. It is important to nurture these relationships and engage landowners in discussions regarding the goals they have for their property and how they may interface with potential conservation actions in the future.

Development of New Materials

Introduction

MNFI produced a brochure and a book to contribute towards an education effort to help increase awareness and support among stakeholders, management partners and the general public about the Mitchell's satyr butterfly and to encourage the support of a conservation strategy for satyrs and their fen habitat.

Mitchell's satyr Brochure

A brochure was created to help people learn more about the Mitchell's satyr butterfly and its habitat as well as potential conservation opportunities. Key themes addressed in the brochure include: identification, habitat needs, look-alike species, threats to the satyr, distribution, life history, private land management and the habitat conservation plan being developed. The brochure was completed in late 2007 and was distributed in earnest in 2008 and 2009 (See Appendix Q). Targeted audiences included: landowners of occupied satyr sites, management partners, landowners with prairie fen habitat, stewardship groups, visitors to nature centers in southern Michigan, attendees at workshops provided by MNFI, MDNR and other partners, and school groups. This publication has been well received and appears to have been successful in addressing many of the objectives of the education/outreach program.

Prairie Fen Book

A book on prairie fens was written and designed as part of a collaborative effort between MNFI, MDNR, and MSU Extension (MSUE). The goal of this extension publication is to provide readers with a better appreciation of prairie fens and their associated plants and animals. In addition this book will help readers develop a more comprehensive understanding of the key ecological processes critical to maintaining this unique community, as well as management strategies to assist in fen conservation. MNFI ecologist, Michael Kost wrote the majority of the text, while scientists from MNFI and TNC contributed vignettes on special topics. MDNR and TNC staff assisted with editorial review while MSUE's Agriculture and Natural Resources (ANR) Communication's Office provided the technical support of design and layout. The final book is 108 pages. It is well written and designed, contains quality photos and graphics and should appeal to scientists, land managers and the general reader alike. It will be available in January of 2010 and will be distributed widely in southern Michigan and Indiana, where most prairie fens occur. MNFI has developed a distribution and marketing plan, to insure that this publication is successful and that it contributes toward the overall education and outreach goal. A sample from this book, along with it's table of contents can be found in Appendix R.

List of Appendices

Appendix A. - Methodology for monitoring known Mitchell's satyr sites.

Appendix B. - Mitchell's Satyr Survey Form.

Appendix C- Population ecology of the Mitchell's satyr (*Neonympha mitchellii mitchellii*) at Coldwater Lake Fen, and the effects of management on the Mitchell's Satyr at Mill Creek Fen.

Appendix D- 2007 Mitchell's Satyr (*Neonympha mitchellii mitchellii*) Research Report.

Appendix E. 2008 Mitchell's Satyr (*Neonympha mitchellii mitchellii*) Research Report.

Appendix F. Final Report: 2008 - Mitchell's Satyr Larval Feeding Experiments, (Development of a Multi-State Mitchell's Satyr Habitat Conservation Plan) 61-7610.

Appendix G. Addendum 2009- Mitchell's Satyr Larval Feeding Experiments (Development of a Multi-State Mitchell's Satyr Habitat Conservation Plan) 61-7610.

Appendix H. Rare Plant Survey Table 2007-2009.

Appendix I. *Papaipema* Survey Form.

Appendix J. Rare Insect Survey Table 2007-2009.

Appendix K. Special Animal Survey Form.

Appendix L. Kirtland's Snake Coverboard Survey Form.

Appendix M. Cricket Frog Call Survey Form.

Appendix N. Associated Herps Survey Table 2007-2009.

Appendix O. Fen Survey Table.

Appendix P. Environmental Variables for Fen Model.

Appendix Q. Satyr Brochure.

Appendix R. Sample of Prairie Fen Book.

Appendix A:

Methodology for monitoring known Mitchell's satyr sites

1) All landowners must be contacted to obtain permission before entering the property. Appropriate individuals responsible for managing State land should also be contacted prior to surveys.
2) Teams of at least two observers should work together to conduct a timed meander survey at the site.
3) One observer should record a GPS track to document the path followed and to record locations of satyrs. Go to Track Set up and set the GPS unit to (STOP WHEN FULL). Set the Record Method to Time and to record a point every 30 seconds. Include the name of the site and the date when naming the track.
4) The other observer should record the starting time (when entering suitable habitat), the weather conditions (temperature, cloud cover, estimated wind speed) and fill out the satyr data form at the end of the survey. Be sure to submit your data form to SWMLC or MNFI when the satyr surveys have been completed.
5) Observers should walk parallel to each other approximately 10 feet apart and use a long thin stick or butterfly net to lightly brush the top of the vegetation as they meander through suitable habitat. (Only those working under a special permit from USFWS as part of a Mark-release-recapture study should attempt to capture satyrs in a net). Observers should make as many loops as needed through the habitat maintaining the 10 foot separation distance (i.e. when the end is reached observers should move over in one direction 20 feet and walk back through the habitat).
6) Observers should look in front, to the sides and behind, paying special attention to areas containing fine-leaved sedges growing in association with low growing shrubs and tamarack, seeps and springs, small openings along streams and between the shrubs.
7) The person using the GPS unit should record points for every satyr seen. (For large sites each observer can record satyrs with a GPS). There is no need to name each point as this is too time consuming. Record the number of the first point and then continue to take points. When the survey is complete, be sure to record the number of the last point taken.(If you are experienced with differentiating males and females, take note of the numbers corresponding to points where females, males and satyrs of unknown sex are seen. Only do this if you are reasonably sure of your identification and if it is practical to do so. At sites with large populations, this may not be feasible).
8) The other observer should keep count of all satyrs seen, and if able, note how many females, males and satyrs of unknown sex are seen. (Can also GPS satyrs at large sites).
9) Observers should work together to insure that satyrs are not double-counted and to make sure that all suitable habitat is covered.
10) If another rare species is encountered that requires stopping to record information, or if you need to walk through an area of unsuitable habitat; stop the track and begin a new track, once you are ready to begin the timed-meander survey for satyrs again. Be sure to record a new starting time each time a new track is recorded and name the track with the site name, date and number 2…3…4…etc.
11) Be aware of how many tracks and points your GPS unit can record and be sure to download the information regularly so that you do not run out of room.
12) If your GPS unit malfunctions, continue the survey and be sure to draw on a topo map the path where you conducted your survey, using topographical features to determine where you traveled.

Documenting the Mitchell's satyr butterfly at new sites

1) Identify presence or absence of potential habitat

-Potential habitat is defined as a mosaic of open prairie fen and sedge meadow mixed with tamarack savanna and shrub-carr. The presence of fine-leaved sedges (e.g. *Carex stricta, Carex sterilis,* and *Carex lasiocarpa*) are key as these are dominant in the ground layer of all known satyr habitats and are considered to be the larval host plant for the satyr. These fine-leaved sedges are often found in association with shrubby cinquefoil (*Potentilla fruiticosa*),tamarack (*Larix laricina*) and poison sumac (*Toxicodendron vernix*).

2) If potential habitat is identified the site should be surveyed for the satyr during the appropriate flight period. This flight period can be determined in the following ways:

-Contact USFWS (E. Lansing Field Office) to determine the beginning of the flight period

-USFWS will use information from permit holders to determine first day of flight.

-USFWS will use degree day calculations as well as earliest and latest flight dates in previous years to determine flight window.

3) Only those persons who can either document skill at butterfly identification or who have attended a field-based training session in satyr identification are considered appropriate to conduct satyr surveys.

-USFWS or MNFI (Michigan Natural Features Inventory) can provide training sessions for consultants, partners, etc.

4) Minimum number of surveys, optimal survey conditions, and length of survey visits for new sites:

-A minimum of 3 survey visits should be conducted during the documented flight period

-These 3 visits should be conducted no more frequently than every 3 days at a site.

-Surveys should be conducted during periods of no rain and winds less than 10 mph.

-Surveys should be conducted between 10am and 6pm, avoiding the period of 12 noon to 2pm if there is no cloud cover and if temperatures exceed 85 degrees. The minimum temperature should be at least 65 degrees.

-Minimum length of survey visit should be 30 minutes per acre of potential habitat. At larger sites (i.e. >20 acres) this may require each visit to span 2 days.

5) Survey methodology

-Observers should walk in a meandering pattern looking forward, to the sides and behind to increase the likelihood that all butterflies in an area are seen. Particular attention should be paid to areas containing fine-leaved sedges growing in association with low growing shrubs and tamarack, seeps and springs, and small openings along streams and between the shrubs.

- Locations of satyrs should be recorded with a GPS unit and GIS shapefiles should be sent to the USFWS.

-Photographs should be submitted to USFWS to identify/document the Mitchell's satyr.

Updated 7-1-08, Daria Hyde, Michigan Natural Features Inventory

Appendix B: MICHIGAN NATURAL FEATURES INVENTORY
Mitchell's Satyr Survey Form

RETURN TO: Michigan Natural Features Inventory, P.O. Box 30444, Lansing, MI, 48909-7944

SITE INFORMATION

Surveyors: _____ **Date**: _____

Surveyor contact information_____

County: _____ **TRS: _____**

Quad name/code: (if available _____

Survey Site Name:_____

Directions to site:

_____

_____

Landowner's name, address /phone number_____

SURVEY/BIOLOGICAL DATA

Weather: Temp_____, Cloud Cover_____, Wind_____, Rain_____

Time Survey Started_____ **Type of GPS Unit used:_____**

Time Survey Completed_____

Mitchell's satyr observed yes__ no__

Describe individuals observed— sex, number, behavior, location, etc.:_____

_____

GPS Track Names _____

GPS Point Names _____

Approximate acreage of potential habitat: _____

Percent of suitable habitat surveyed: _____

Note any threats to the habitat or species_____

Invasive Plants (note abundance): (A = abundant, C = common, O = occasional, R = Rare):

a) Purple loosestrife ___ d) Glossy buckthorn ___

b) Reed canary grass ___ e) Typha ___

c) Giant Reed Grass ___ f) Other _____

List other animal species observed at this site. Note especially listed species and potential predators, competitors, and prey.

Species	ID (+ or ?)	Number obs.	Notes, observations, etc.

Fill out this section for new sites only.

HABITAT DATA

Presence of seeps: yes___ no___
Soil is saturated, dark, and mucky: yes____ no____
Marl present: yes___ no___

Habitat Structural Categories (assess the pertinent wetlands at the scale of at least 5 acres):

a) Forest (canopy cover of trees > 60%)
b) Savanna (scattered trees with 25 to 60% cover)
c) Dense carr (shrubs > 1m tall cover > 60% of the ground)
d) Open carr (shrubs > 1m tall cover 25 to 60% of the ground)
e) Meadow (woody species > 1m tall cover < 25% of the ground)
f) Mosaic of (circle main components): a b c d e

Threats (circle one):

a) Altered hydrology (indicate type of alteration):_____
b) ORV use
c) Grazing
d) Shrub encroachment
e) Development/land use change (indicate type of change):
_____
_____
_____
_____
f) Other: _____
_____
_____
_____

Invasive Plants (note abundance):

(A = abundant, C = common, O = occasional, R = Rare):
a) Purple loosestrife ___ d) Glossy buckthorn ___
b) Reed canary grass ___ e) Typha ___
c) Giant Reed Grass ___ f) Other _____

VEGETATION COVER:
FEN INDICATOR PLANT SPECIES
Please note the following species observed. Note abundance of each species using the following scale:
A = Abundant, C= Common, O = Occasional, R = Rare, NO = Not Observed

Species	Abundance	Species	Abundance
Shrubby cinquefoil		Fringed brome	
Dogwood		Blue-joint grass	
Quaking aspen		Pitcher plant	
Willow		Boneset	
Bog birch		Joe-pye weed	
Tamarack		Riddlles goldenrod	
Alder-leafed buckthorn		Bog valerian	
Poisin sumac		Whorled loosestrife	
Carex sterilis		Round-leafed sundew	
Carex flava		Bog lobelia	
Spike rush		Virginia mountain mint	
Indian grass		Aster spp.	
Little bluestem		Ohio goldenrod	
Big bluestem		Marsh fern	
Marsh wild-timothy		Others….	

Overall height of ground cover (circle one):

a) 0 – 0.5
b) > 0.5 – 1m
c) > 1m

Overall height of shrub layer (circle one):

a) 1 –2m
b) > 2m

Overall height of tree layer (circle one):

a) 2 – 5m
b) 5m – 10m
c) 10m – 20m
d) > 20m

Population ecology of the Mitchell's satyr (*Neonympha mitchellii mitchellii*) at Coldwater Lake Fen, and the effects of management on the Mitchell's Satyr at Mill Creek Fen

Submitted by:
Barbara J. Barton
Michigan Natural Features Inventory
P.O. Box 30444
Lansing, MI 48909-7944

For:
US Fish and Wildlife Service
1 Federal Drive
Fort Snelling, MN 55111-4056

March 12, 2007

Report Number 2007-02

U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR

Michigan Natural Features Inventory

MICHIGAN STATE UNIVERSITY EXTENSION

DNR

Cover Photos:
Upper left: Marked Mitchell's satyr, Dick Schwartz, Eastern Michigan University.
Upper right: Clearing brush, Barbara J. Barton, MNFI.
Lower left: Prescribed fire, Barbara J. Barton, MFNI.
Lower right: Marked Mitchell's satyr, Dick Schwartz, Eastern Michigan University.

Recommended Citation: Barton, B.J. 2007. Population ecology of the Mitchell's satyr (*Neonympha mitchellii mitchellii*) at Coldwater Lake Fen, and the effects of management on the Mitchell's Satyr at Mill Creek Fen. Report Number 2007-02. Report to the US Fish and Wildlife Service, Region 3, Fort Snelling, MN.

Table of Contents

List of Tables

List of Figures

.

Introduction

Mitchell's satyr (*Neonympha mitchellii mitchellii*) is an endangered species confirmed at only 19 sites in North America (17 – Michigan, 2 – Indiana). These populations are extremely isolated from each other, with the two closest populations in Michigan separated by a linear distance of approximately 4 km. Isolation is a serious threat that can cause inbreeding depression, a breakdown of the metapopulation structure, and ultimately extirpation. Because the majority of populations already have extremely low numbers of satyrs, it is imperative that conservation efforts focus on enhancing and increasing suitable habitat, increasing population sizes, and providing connectivity between existing populations and unoccupied but suitable habitats. The urgency of these tasks cannot be understated.

Mitchell's satyr research has included transect counts and mark-release-recapture (MRR) studies to estimate population sizes, and studies of behavior, home range, movement capabilities, distribution and habitat preference (Szymanski 1999, Hyde et al. 1999, Darlow 2000, Hyde et al. 2001, Barton 2003, 2004, Szymanski et al. 2004, Barton and Bach 2005, Barton 2005, Hyde and Barton 2005). This basic information is essential to developing conservation strategies that expand existing habitat and ultimately connect populations. However, due to the short flight period of this species, low numbers of individuals at many sites, and the difficulty in traversing some areas of occupied habitat (due to deep muck, dense shrubs, and downed trees), many questions about the Mitchell's satyr remain unanswered. Essential information on larval food plant preferences, the location of overwintering larvae, specific habitat requirements, and the affects of woody vegetation cover on movements is still unknown.

Since 2003, the author has been conducting population ecology studies to determine movement parameters and population estimates of the Mitchell's satyr (Barton 2003, 2005, Barton and Bach 2005). Prior work by Szymanski (1999) and Darlow (2000) have also contributed knowledge in this area. To summarize, the majority of Mitchell's satyrs do not fly long distances, males have longer mean traveled distances, home ranges sizes are small, and both sexes appear to prefer edge habitat. Individuals have been reported outside of the boundaries of their preferred habitat; several satyrs were found nectaring in an adjacent oak savannah that has been undergoing restoration for several years (Barton 2005). Based on home range sizes and travel distances, it is probable the majority of satyrs stay within fen habitat, with some individuals emigrating into surrounding uplands. These upland areas, many which are degraded oak savannahs, may have historically served as travel corridors for dispersing individuals and now act as barriers to dispersal because of dense shrub cover.

Historically, populations in Michigan were most likely connected to some degree, and the lack of current metapopulation structures may result in the ultimate extirpation of all but the largest sites. In addition, only a small percentage of individuals are dispersing and since there is no suitable habitat to disperse into, these individuals may not reproduce. If the propensity to disperse is genetically related, the populations may gradually be composed exclusively of residents restricted to their current patches. Extinction rates could increase dramatically in these populations due to inbreeding depression or non-viability. To save the species from this fate, habitats must be enlarged, and sub-populations re-connected.

The two primary methods of enlarging and enhancing fen habitats in North America are prescribed fire and mechanical/manual shrub removal, and in Europe grazing and mowing (fire is generally considered destructive) (Middleton et al. 2006). The use of prescribed fire in degraded fen habitat can result in a decrease in invasive woody species, a short-term increase in forbs (Kost and Steven 2000), and an increase in graminoids (Bowles et al. 1996), but may also have negative effects on Mitchell's satyr larval survival as fires are typically set in April when they are in the fourth instar stage and attached to plant stems several millimeters above ground (McAlpine et al. 1960, Tolson et al. 2006). Mechanical and manual shrub removal

Study Sites

Mill Creek Fen (MCF) is located in Washtenaw County and is under private ownership. The site contains a mosaic of degraded fen and beach-maple and oak-hickory forests with springs and seeps though-out. Mill Creek Fen is in the Huron River watershed along a headwater tributary of Mill Creek. The fen complex is a mosaic of prairie fen, sedge meadow, shrubby meadow, tamarack savanna and conifer swamp surrounded by pasture, hayfields, and upland forests of oak/hickory and beech/maple. The site is succumbing to successional changes such as encroachment by woody vegetation. There are four main areas of Mitchell's satyr occupation at this site, all occurring on slight peat mounds.

Coldwater Lake Fen (CLF) is located in Branch County and is also under private ownership. It contains both open meadow and shrubbed in fen habitat, and is bisected by a small creek. The complex is best described as a mosaic of prairie fen, sedge meadow, shrubby meadow, tamarack savanna and swamp hardwood forest surrounded by pasture, hayfields, cropland, upland hardwoods and residential property. Habitat occupied by the satyr has numerous dogwoods (*Cornus* spp.) clumps interspersed with sedges (including *Carex stricta*) and some open areas of sedge meadow. Numerous fen indicator species are evident such as tamarack (*Larix laricina*), shrubby cinquefoil (*Potentilla fruticosa)*, poison sumac (*Toxicodendron vernix*) Joe-pye weed (*Eupatorium maculatum*) and boneset (*E. perfoliatum*), although plant species diversity is not particularly high (Hyde et al. 2003).

Methods

Mill Creek Fen. The effects of clearing on Mitchell's satyr movement and distribution were studied at this site. Three plots with two paired treatment blocks in each were designated at areas with high Mitchell's satyr densities. Each block was 50 m x 20 m and randomly assigned control or treatment status. Treatment was defined as complete clearing of shrubs and trees ≤6" dbh (diameter at breast height) using hand-held brush cutters (Figures 1- 3). Larger trees were girdled with the exception of tamarack trees which were not treated. This species is an important component of the fen habitat and there was little evidence of regeneration, so the decision was made to leave the few large trees in the treatment blocks. In addition, the primary reason to remove the woody vegetation from the treatment plots was to reduce vertical structure, and the tamaracks' contribution was considered minimal. A solution of 50% glyphosate (Aqua Neat®, Riverdale) was applied to cut stumps, and all brush was removed from the blocks and placed outside of the study area. Treatments took place in February and March of 2006.

Figure 1. Clearing of a plot using hand-held brush cutter. Photo by B. J. Barton.

Figure 2. Photograph of a cleared treatment block. Photo by B. J. Barton.

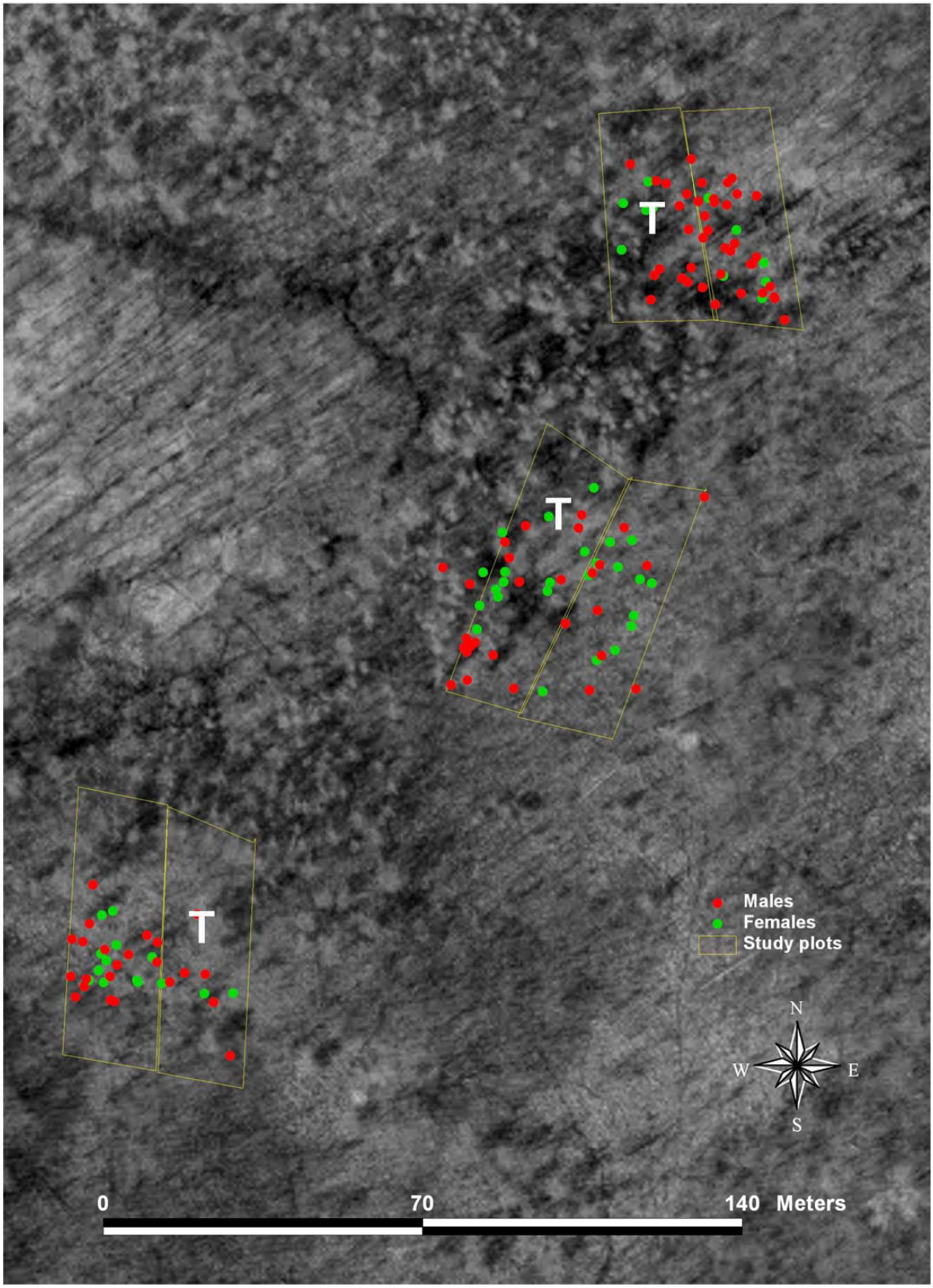


Figure 3. Study plots at Mill Creek Fen, Washtenaw County, Michigan. T= treatment blocks which were cleared of small trees and shrubs. The remaining blocks (controls) were left untreated.

A mark-release-recapture (MRR) study was conducted from 22 June – 10 July 2006 for a total of 13 sampling days. Each plot was surveyed twice per sampling day by walking established linear transects approximately 3 meters apart. This was to minimize trampling within the habitat. Mitchell's satyrs were captured using hand-held nets and unique identifying numbers were placed on the ventral surface of the right hindwing using Sharpee Fine Point™ and Sharpee Ultrafine Point™ permanent markers. Individuals were released immediately after capture. Date, time, sex, and identification number were recorded. Identification number, sex, and date were written on plastic flags and placed at the point of first observation for each Mitchell's satyr captured. Locational information for capture points was collected using Trimble GeoExplorer I and II hand-held global positioning system (GPS) units. A minimum of 120 position readings were collected for each satyr location. Maps and movement statistics were analyzed with ArcView 3.2 Geographic Information Systems (ESRI, Redlands, CA).

The effect of treatment, characterized as the propensity of individuals to move into or out of a plot was analyzed using a logistic regression approach to see if there were any differences in the proportion of individuals (PROC GLIMMIX, SAS®, SAS Institute, Cary, NC). Population estimates were calculated using Program Jolly (Pollack et al. 1990). As with the distance analyses, duplicate records of individuals captured two or more times on the same day were discarded from the analysis in order to standardize the data.

Coldwater Lake Fen. An MRR study (using previously described methodology) was conducted from 24 June – 5 July for a total of 11 sampling days. The initial intent of this study was to cover the entire site; however; the study area boundaries were adjusted due the size of the site and the dense shrub cover. Open meadow and shrub areas were surveyed on alternate days. All areas within the study site boundaries were thoroughly searched for satyrs. Locational information for capture points was collected using Trimble GeoExplorer I and II hand-held global positioning system (GPS) units. A minimum of 120 position readings were collected for each satyr location. Maps were created with ArcView 3.2 Geographic Information Systems (ESRI, Redlands, CA). Population estimates were calculated using the Program Jolly (Pollack et al. 1990). Duplicate records of individuals captured two or more times on the same day were discarded from the analysis in order to standardize the data.

Polygons designating open meadow and shrub areas were constructed using aerial photographs and on the ground verification (Figure 4). Home range estimates were calculated using the minimum convex polygon (MCP) method in the Animal Movement Extension for ArcView 3x (Hooge and Eichenlaub 1997). Minimum convex polygons require at least three capture points per individual and all Mitchell's satyrs captured three times or more (including same day captures) were included in this analysis. The effects of habitat type (meadow, shrub-carr) and sex on home range sizes were determined using a two-way analysis of variance (ANOVA) (PROC GLM, SAS®, SAS Institute, Cary, NC). The data were log transformed to fit the assumptions of the analysis. Chi-squared tests were used to determine the effect of habitat type on density of individual satyrs by sex. The effects of sex, habitat type, and site on total distances traveled per recapture event and distance per day traveled by Mitchell's satyrs were analyzed using repeated measures ANOVA (PROC MIXED, SAS®, SAS Institute, Cary, NC). The data were log transformed in order to satisfy the assumptions of the analysis. If an individual was captured two or more times on the same day, those points were discarded from the analysis in order to standardize the data.

Combined Site Data. To analyze all known home ranges sizes and distances traveled per recapture event, data from this study were combined with the 2003 and 2005 Grand River Fen (GRF) studies (Barton 2004, 2005). The effects of sex and habitat type on home range sizes were analyzed using an ANOVA (PROC GLM, SAS®, SAS Institute, Cary, NC). The effects of sex and habitat type on distances traveled per recapture event were analyzed using repeated measures ANOVA (PROC MIXED, SAS®, SAS Institute, Cary, NC). The data were log transformed in order to satisfy the assumptions of the analysis. If an individual was captured two or more times on the same day, those points were discarded from the analysis in order to standardize the data.

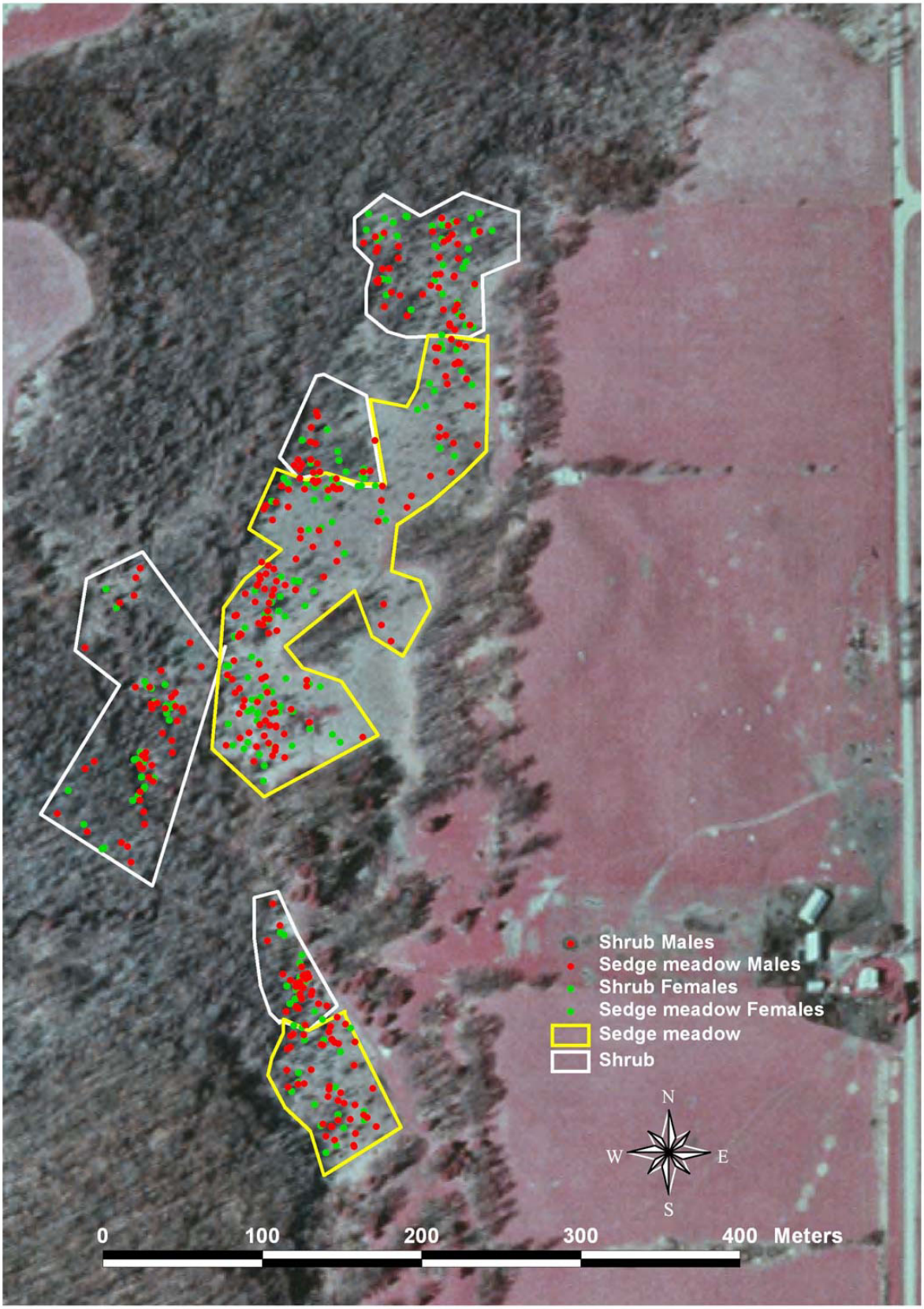


Figure 4. Study area at Coldwater Lake Fen, Branch County, Michigan. Green boundaries outline open meadow habitat, white boundaries outline shrub areas.

Results

Mill Creek Fen. A total of 81 individuals (53 males and 28 females) were marked with 53% percent of males and 64% of females captured more than once (Table 1). The estimated mean daily population size for males was 21.99 (range = 3.00-80.00) and for females 10.03 (range = 2.00-32.00) (Table 2). Assuming an equal sex ratio, the maximum daily population estimate was 160.00 (twice the maximum daily estimate for males). These estimates apply to plot areas only and not the entire fen (Figure 1).

Table 1. 2006 Mark-release-recapture summary for Mill Creek Fen, Washtenaw County, Michigan.

Number of Times Captured	Males	Females	Total
1	25	10	35
2	12	11	23
3	7	3	10
4	5	3	8
5	3	1	4
6	1	0	1
Total	53	28	81

Table 2. 2006 daily population estimates for the study plots at Mill Creek Fen, Washtenaw County, Michigan.

Sample Period	Males Pop. Est.	Females Pop. Est.	Total Pop. Est. (Males x 2)
2	3.00	0.00	6.00
3	8.00	2.00	16.00
4	20.00	5.00	40.00
5	15.33	12.75	31.66
6	21.90	19.20	23.80
7	26.67	14.00	53.34
8	12.26	7.33	24.52
9	80.00	9.00	160.00
10	29.75	32.00	59.50
11	20.00	4.00	40.00
12	5.00	5.00	10.00
Mean	21.99	10.03	42.26

The majority of both males (61%) and females (64%) were recaptured within the same plots of their first captures (Figure 5). Of the remaining satyr movements, there was no effect of treatment on whether they moved out of or into plots (males; n=54, F=0.05, df=52, p=0.816, females; n=28, F=0.13, df=26, p=0.721). Seven males and two females were recaptured in plots different from their original capture (i.e. first capture plot one control block, second capture plot three treatment block).

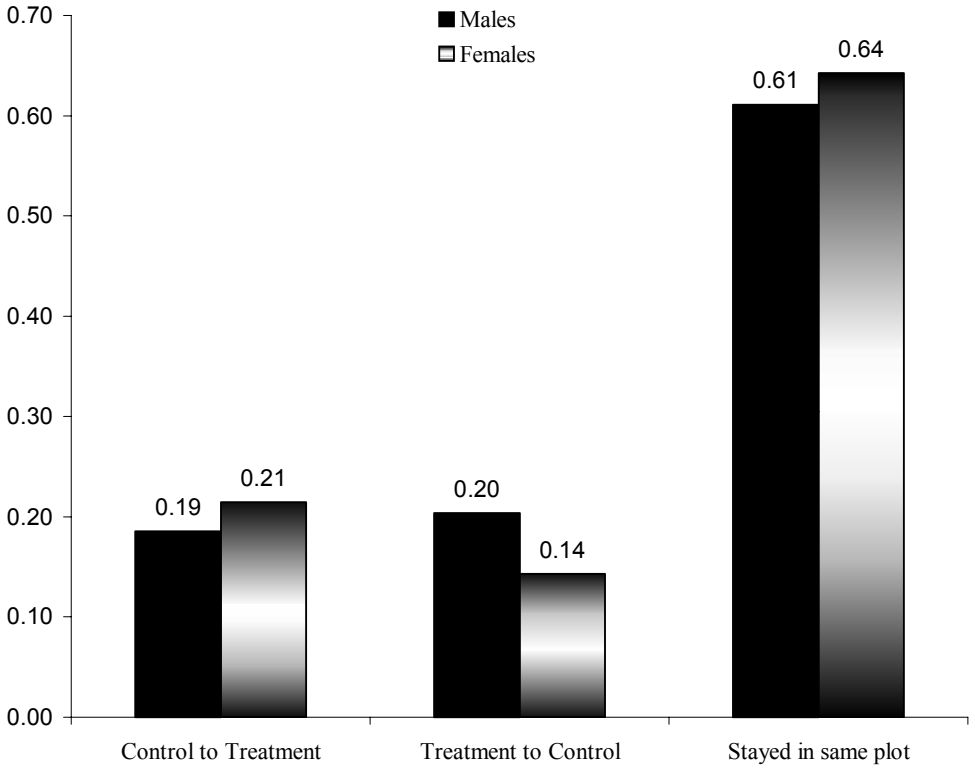


Figure 5. Frequency of movements at Mill Creek Fen, Washtenaw County, Michigan.

Coldwater Lake Fen. A total of 382 individuals (229 males and 153 females) were marked with 31% percent of males and 18% of females captured more than once (Table 3). The estimated mean daily population size for males was 173.20 (range = 45.00-349.97) and for females 111.86 (range = 14.00-243.57) (Table 4). Assuming an equal sex ratio, the maximum daily population estimate was 699.94. It should be emphasized that population estimates are only for Mitchell's satyrs within the designated boundaries of the study area and not the entire fen (Figure 4).

Table 3. 2006 mark-release-recapture summary for Coldwater Lake Fen, Branch County, Michigan.

Number of Times Captured	Males	Females	Total
1	179	126	305
2	38	23	61
3	12	3	15
4	0	1	1
Total	229	153	382

Table 4. 2006 daily population estimates for the Coldwater Lake Fen study area, Branch County, Michigan.

Sample Period	Males Pop. Est.	Females Pop. Est.	Total Pop. Est. (Males x 2)
2	349.97	14.00	699.94
3	*	20.00	*
4	140.32	*	280.64
5	316.05	38.25	632.10
6	137.69	*	275.38
7	*	171.27	*
8	155.20	243.57	310.40
9	45.00	100.00	90.00
10	68.20	195.91	136.40
Mean	173.20	111.86	346.41

*Population estimate not available due to low recaptures data

Habitat type had a significant effect on both sexes, with a greater proportion of males found in open meadow areas (x^2=4.05, df=1, P=0.04) and females in shrub areas (x^2=37.16, df=1, P<0.001). The density of males in shrub areas was 37.95/ha (n=96) and females 21.74/ha (n=55). In the open meadow areas, male density was 48.46/ha (n=126) and female density 2.69/ha (n=7).

The median distance per day traveled by males in the meadow was 15.04 m/day and in the shrub areas was 24.97 m/day; distance/day for females was 6.38 and 7.17 respectively (Table 5). There was a significant effect of sex on distance/day traveled (F=10.27, df=91, P=0.002) with males traveling greater distances than females (Table 5). There was no effect of habitat type (F=1.39, df=91, P=0.241) or interaction between sex and habitat on distance/day traveled (F=.88, df=91, P=0.352).

Table 5. Distance per day traveled at Coldwater Lake Fen, Branch County, Michigan.

	Meadow		Shrubs	
	Males	Females	Males	Females
n	35	10	27	23
Mean (m)	19.73	7.92	34.02	19.31
Standard Error	3.13	1.23	6.99	6.73
Median (m)	15.04	6.38	24.97	7.17

The median distance traveled per recapture event was 38.34 m for males and 17.37 m for females (Table 6). There was an effect of sex (F=9.81, df=91, P=0.002), but not habitat (F=0.01, df=91, P=0.95) nor interaction (F=1.58, df=91, P=0.21). Males had larger travel distances overall (Table 6). The longest distances recorded between consecutive captures for males were 333.14 m for males and 162.74 m for females. Home ranges for both sexes were under 0.10 ha (Table 7). There were no significant effects of sex (F=0.13, df=1, P=0.72), habitat type (F=0.13, df=1, P=0.73), or interaction (F=3.08, P=0.10) on home range sizes at Coldwater Lake Fen.

Table 6. Distance traveled per recapture event at Coldwater Lake Fen, Branch County, Michigan.

	Meadow		Shrubs	
	Males	Females	Males	Females
n	35	10	27	23
Mean (m)	62.76	32.91	80.84	34.49
Standard Error	12.75	11.54	16.88	8.92
Median (m)	36.07	21.05	45.97	16.70
Maximum	333.14	132.51	352.75	162.74
95% CI	36.85-88.67	6.81-59.00	46.14-115.55	15.98-53.00

Combined Site Data. Total home ranges size estimates showed significant differences by sex (F=7.04, df=1, P=0.009), with median values for males at 0.065 ha and for females 0.032 ha (Table 7). There were no effects of habitat type (F=0.25, df=1, P=0.62) or interaction (F=0.24, df=1, P=0.67). The results of the distance traveled per recapture showed a significant difference by sex (F=13.29, df = 645, P<0.001) with males flying farther (Table 8). There was no effect of habitat type (F=3.10, df=645, P=0.079) or interaction (F=3.39, df=645, P=0.066). The longest recorded distances traveled between consecutive captures for males was 710.30m and for females 478.24 m; both recorded from Grand River Fen.

Table 7. Home range estimates using the minimum convex polygon method for male and female Mitchell's satyrs at Coldwater Lake Fen, Branch County, Michigan.

	Meadow		Shrubs	
	Males	Females	Males	Females
n	10	5	2	6
Mean (ha)	.029	.061	.093	.051
Standard Error	.013	.024	.050	.023
Median (ha)	.016	.049	.093	.030

Table 8. Distance traveled per each recapture event from mark-release-recapture studies at Coldwater Lake Fen, Branch County, Michigan (2006), and Grand River Fen, Jackson County, Michigan (Barton 2004 and 2005).

	Distance Traveled	
	Males	Females
n	423	226
Mean (m)	101.91	67.19
Standard Error	5.75	5.67
Median (m)	56.06	31.81
Maximum	710.30	478.24
95% CI	90.62-113.21	56.01-78.38

Table 9. Home range estimates for Mitchell's satyrs at Coldwater Lake Fen, Branch County, Michigan and Grand River Fen, Jackson County, Michigan (data from Barton 2004, 2005).

	Home Range Estimates (ha)	
	Males	Females
n	94	62
Mean	.328	.096
Standard Error	.063	.020
95% CI of the Mean	.203-.452	.056-.136
Median	.065	.032
Range	.001-2.76	.001-.798

Discussion

Population Estimates. During the 2006 study, 82 individuals were marked at MCF compared to only 32 in 2004, even though surveyors covered the entire site during the previous MRR. There are several possible explanations for this difference. First, covering the entire site requires staff to traverse a considerable amount of unsuitable habitat that is extremely difficult to move through; therefore, less effort is spent in suitable areas. Second, the plots in this study were intentionally placed in the areas of highest satyr concentrations, which would naturally produce higher numbers. For surveys at other Mitchell's satyr sites (that have small areas of suitable habitat within a larger wetland/upland complex) it may be most efficient to focus search efforts in known high concentration areas. This method would be well suited for surveys that don't require distributional information. Third, the difference may have been due to natural population fluctuations, although it is unlikely that there would be a nearly a three-fold increase.

The results from Coldwater Lake Fen indicate the site is the second largest known population, behind Grand River Fen in Jackson County, Michigan. It is estimated that approximately two-thirds of the occupied habitat were included in the MRR, resulting in a conservative population estimate.

The difference in densities of male and female Mitchell's satyrs in shrub and open meadow areas is difficult to explain. Females have been observed to oviposit in close proximity to trees and shrubs (Darlow 2000) and therefore may be seeking oviposition sites in the shrub areas. Yet we would expect males to simultaneously be seeking mates, and thus be found in the vicinity of females. Coldwater Lake Fen is the only site where MRR studies have been conducted with both habitat types, so additional research at other Mitchell's satyr sites having both habitat components may provide more insight into this behavior.

Effects of Clearing on Satyr Movements. Clearing had no effect on Mitchell's satyr distribution and dispersal, but this may have been influenced by 1) the size of the blocks, 2) small home range sizes, or 3) temporal effects. The combined median home range sizes for male and female Mitchell's satyrs were 0.065 and 0.032 ha respectively, with 62% of individual home ranges less than 0.10 ha, the same size as the treatment blocks. It is interesting that 63% of Mitchell's satyrs were recaptured within the same 0.10 ha block. The fact that there were no statistical differences between movements into or out of the treatment blocks indicates clearing has not yet produced more favorable conditions for the satyrs. It should be emphasized that this study was conducted during the first growing season and movement patterns may change as vegetation in the cleared blocks recovers over time.

The effectiveness of clearing to enhance habitat and increase Mitchell's satyr populations can only be determined with long-term studies that monitor vegetation changes as well as satyr movements and distribution. It is known from previous studies that Mitchell's satyr is an edge species that also occupies shrub-carr areas within the fen habitat, thus a better understanding of the structural components and cover types favored by the butterfly may assist in determining the best characteristics for artificially created openings (edge shape, amount of woody vegetation, size). The majority of Mitchell's satyrs fly short distances (Szymanski 1999, Barton 2004, Barton 2005); therefore, new habitat would be colonized by only a few individuals each season. Consequently, the benefits of clearing for the Mitchell's satyr may not be realized for several years.

Temporal barriers (Boughton 2000), where individuals arrive in newly created patches too late to reproduce, are important to consider when managing for the Mitchell's satyr. This situation could occur when females have oviposited all of their eggs before reaching the new patch, or when emigrating individuals arrive in a new patch at the end of their lifespan. Species that are short-lived and have limited dispersal capabilities (such as the Mitchell's satyr) would be affected by temporal barriers; new habitat patches must be located close enough to the resident colony that sufficient numbers of gravid females could reach the new habitat and deposit their eggs. This assumes that the quality of the newly created habitat meets the requirements of the species. Given our knowledge that the median distances moved by females is 31 m, new habitat patches should be created no further than 30 m from occupied habitat in order to support immigration into the new area.

Future studies are needed to define habitat requirements and complete the life history description of the Mitchell's satyr. Concurrent research should focus on the effects of management (prescribed fire, clearing) on the Mitchell's satyr, and long term monitoring should be implemented to document the temporal effects with the goal of providing land managers information that can be used to prescribe the best management practices for conservation of the Mitchell's satyr.

Acknowledgements

I would like to thank Doug Landis, Department of Entomology, Michigan State University (MSU), for his assistance with research design, implementation, staffing, and for helping clear poison sumac. The following individuals provided valuable field assistance; Dick Irwin, Dorothy Catey, Todd and Michele Stuckey, Dale and Peggy Woodward, Michael Sanders, Chris Sebolt (MSU), Smruti Damanian, Rachel Osborn, Sean Zera, Ben Ford, Katie Fairchild, Robb Johnston (MSU), Molly Murphy (MSU), Dawn Richards (MSU), Mike Jewett (MSU), John Davenport (MSU), K'Anna Burton, Susan McMahon (EMU), Armand, Becky Shiloh, and Kim Borland. Daniel Kennedy (Landowner Incentive Program, Michigan Department of Natural Resources (MDNR) provided technical assistance. Administrative support was provided by Lyn Scrimger, Sue Ridge, and Connie Brinson. Helen Enander provided GIS technical advice. Daria Hyde assisted with research design and landowner contact. David Cuthrell reviewed the manuscript and provided valuable comments and suggestions. Statistical advice was provided by Ashok Ragavendran (Statistical Consulting Services-MSU) and Anna Fiedler (Department of Entomology-MSU). Trimble GPS units were furnished by Marshall Strong (Wildlife Division- MDNR) and the US Fish and Wildlife Service. Funding was provided by Section 6 and Habitat Conservation Plan (HCP) grants from the US Fish and Wildlife Service and the MDNR, and a Rhodes (Gene) Memorial Fellowship from the Department of Entomology, MSU.

Literature Cited

Barton, B.J. 2004. Population Ecology of Mitchell's Satyr Butterflies (*Neonympha mitchellii mitchellii*). Master's Thesis, Eastern Michigan University, Ypsilanti.

_____. 2005. Dispersal and home range estimates for the Mitchell's satyr at Jackson County Central Fen, Michigan. Report number MNFI 2005-22. Report to U.S. Fish and Wildlife Service, Region 3 Office, Fort Snelling, MN.

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

Boughton D.A. 2000. The dispersal system of a butterfly: a test of source-sink theory suggests the intermediate-scale hypothesis. The American Naturalist **156:**131-144

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

Darlow, N. 2000. Behavior, habitat usage and oviposition of the Mitchell's satyr butterfly, *Neonympha mitchellii mitchellii*. Master's Thesis, University of York, United Kingdom.

Jolly G.M. 1965. Explicit estimates from capture-recapture data with both death and immigration-stochastic model. Biometrika. **52:**225–247

Hooge, P. and B. Eichenlaub. 1997. Animal movement extension to ArcView Version 1.1. Alaska Science Center - Biological Science Office, U.S. Geological Survey, Anchorage, AK, USA.

Hyde, D.A., M.L. Rabe, D.L. Cuthrell and J.L. Cooper. 1999. Surveys for the recovery of Mitchell's Satyr Butterfly (*Neonympha mitchellii mitchellii*) in Michigan: Year One Progress Report 1998. Report to the USFWS, Region 3 Endangered Species Office. Michigan Natural Features Inventory report number 1999-09. 22pp. + appendices.

Hyde, D.A., M.L. Rabe, D.L. Cuthrell, and M. A. Kost. 2001. Surveys for the recovery of Mitchell's satyr butterfly (*Neonympha m. mitchellii*) in Michigan: 2000 final report. Report to the US Fish and Wildlife Service, Fort Snelling, MN. Michigan Natural Features Inventory Report Number 2000-09.

Hyde, D.J. Paskus, N.Fuller, and J. Simoes. 2003. Site Conservation Plan for Mitchell's Satyr Butterfly: Coldwater Lake Fen Complex, Branch County, Michigan. Report for the Michigan Department of Natural Resources. Michigan Natural Features Report Number 2003-21.

Hyde, D. and B. Barton. 2005 Survey results for the Mitchell's Satyr. 2005. Report to the US Fish and Wildlife Service, Twin Cities, MN. Michigan Natural Features Inventory Report Number 2005-21.

Kost, M.A. and D. Steven. 2000. Plant community responses to prescribed burning in Wisconsin sedge meadows. Natural Areas Journal **20:**36-45.

McAlpine, W.S., S.P. Hubbell, and T.E. Pliske. 1960. The distribution, habits, and life history of *Euptchia mitchellii* (Satyridae). Journal of the Lepidopterists' Society **14:**209-226.

Middleton, B.A., B. Holsten, and R. van Diggelen. 2006. Biodiversity management of fens and fen meadows by grazing, cutting and burning. Applied Vegetation Science **9:**307-316.

Pollock, K.H., J.D. Nichols, C. Brownie, and J.E. Hines. 1990. Statistical Inference for Capture-Recapture Experiments. Wildlife Monographs 107.

Szymanski, J. 1999. Population and spatial ecology of the Mitchell's satyr butterfly *Neonympha m. mitchellii* French, in Southwestern Michigan. Master's Thesis, University of Minnesota, Minneapolis.

Tolson, P.J., C.L. Ellsworth., and M.L. Magdich. 2006. Captive rearing and breeding of the Mitchell's satyr butterfly, *Neonympha mitchellii mitchellii*. Interim Report. Toledo Zoo, Ohio.

2007 Mitchell's Satyr (*Neonympha mitchellii mitchellii*) Research Report

Submitted by:
Barbara J. Barton
Michigan Natural Features Inventory
P.O. Box 30444
Lansing, MI 48909-7944

For:
US Fish and Wildlife Service
1 Federal Drive
Fort Snelling, MN 55111-4056
January 31, 2008
Report Number 2008-02

Cover Photo by David Kenyon, MDNR- (from left to right) Barb Barton, Daria Hyde, and Melissa Nicholsen - MNFI.

Recommended Citation: Barton, B.J. 2008. 2007 Mitchell's Satyr (*Neonympha mitchellii mitchellii*) Research Report. Report Number 2008-02. Report to the US Fish and Wildlife Service, Region 3, Fort Snelling, MN.

Table of Contents

Table of Tables

Table of Figures

2007 Mitchell's Satyr (*Neonympha mitchellii mitchellii*) Research Report

Four research projects were undertaken in 2007; 1) a mark-release-recapture study (MRR) to monitor the population at Jackson County Central in Jackson County, Michigan, 2) a study to determine a correlation between transect data and population estimates, 3) an attempt to direct oviposition in 32 enclosures as part of a study on the effects of fire on satyr emergence, and 4) the development of a degree day model for emergence. Each study is presented in individual sections for ease of reading.

SECTION 1 – Population Monitoring at Jackson County Central

Introduction

Population estimates and vagility data for the Mitchell's satyr population at Jackson County Central (JCC) were first obtained in 2003 and again in 2005. The site is undergoing active management by The Nature Conservancy (TNC) and long-term monitoring of the population (every two years) was proposed in 2006 to determine the effects of management on the population. Current management practices include brush removal, herbicide application, and prescribed fire. Using mark-release-recapture (MRR) techniques, we will be able to examine changes in distribution and population levels over time. The information will be useful in developing management plans for this and other sites.

Methods

An MRR was conducted from 22 June – 9 July 2007 using standard MRR techniques in both JCC and a smaller fen to the east (Figure 1). The JCC site was subdivided into two halves bisected by the creek and we surveyed one half per day. The eastern fen was surveyed as staffing availability permitted (three surveys). Population estimates were calculated using Program Jolly (Pollack et al. 1990). Vagility data were analyzed using Animal Movement Extension (Hooge 1997). Vagility from all reported Mitchell's satyr studies are summarized for comparison. Descriptive statistics were only calculated using data from Barton (2004, 2005, 2007) and Barton and Bach (2005) as Szymanski's (1999) raw data are no longer available.

Results

There were fourteen sample days from 22 June to 9 July 2007. The majority of individuals were captured only once (Table 1). We marked 897 satyrs with an average recapture rate of 20% (Table 2). The maximum daily population estimate for both sexes combined was 3020 (Table 3). Assuming a 50/50 sex ratio, the maximum daily population estimate calculated from multiplying the maximum daily male estimate by two was 3668 individuals. These estimates are larger than those from prior studies at this site (Barton 2004, 2005, 2007). In the eastern fen, we marked 35 males (four recaptures) and 35 females (one recapture) with none found moving between fens.

Vagility. All vagility data are right-skewed, thus median values are presented. Median travel distances were greater for males than females ($p<0.0001$, Wilcoxon Sign-rank test) (Table 4). Males traveled slightly greater distances per day and had slightly larger home ranges than females

($p<0.0001$, Wilcoxon Sign-rank test) (Table 4). The maximum distance traveled between captures was 602.65 m for males and 193.36 m for females. Females in previous studies had much greater maximum distances, and this may be attributed to lower recaptures due to the sampling scheme (Barton 2004, 2007, Barton and Bach 2005).

A summary of all vagility data from previous studies of Mitchell's satyrs is presented in Tables 5-7 (data compiled from Szymanski 1999, Barton 2004, 2005, 2007, Barton and Bach 2005). Descriptive statistics (Table 8) were only calculated from my research as raw data were not available from J. Szymanski. The maximum distance traveled between consecutive captures was 710.30 m for males and 478.24 m for females (both at Jackson County Central, 2005). The median home range sizes for both sexes were small; 0.06 ha for males and 0.03 ha for females. The median values for distances traveled per day by each individual were 22.39 m/day for males and 13.36 m/day for females. The data support the theory that Mitchell's satyrs stay close to their natal areas.

Discussion

The 2007 season resulted in higher numbers of Mitchell's satyrs at Jackson County Central than previously recorded, and high numbers were also recorded at other satyr sites (Hyde, personal communication). The large numbers made it difficult to cover the entire study area in one day, which is why the decision was made to cover half the site each day in order to capture more butterflies per side. This resulted in fewer recapture data per individual for vagility estimates (the average residency rate (analogous to lifespan) for both males and females is approximately 4 days). However, this did not seem to be a factor in the quality of the data; there was little difference when comparing vagility data between years. The one exception is in the category of longest distance traveled, where 2007 values were lower. This can be directly attributed to the lower probability of recapture for each individual.

While MRR studies are extremely labor intensive, they provide the best methods for determining butterfly movements, population estimates, and home range estimates. We are still documenting basic life history information for this species, and the more data we can gather the more knowledge land managers will have in order to conserve the species. The opportunity to conduct MRR studies on the eastern fen allows researchers to document whether movement is occurring between two closely situated fens and whether there is a functioning metapopulation at this complex. This can only be accomplished by increasing field crew numbers in order to facilitate

daily MRR activities which would cover both sites in their entirety. Documenting a metapopulation and satyr movement between sub-populations will help determine whether Mitchell's satyrs travel through unsuitable habitat between these two fens. This information is important to conservation efforts, which includes the acquisition of nearby occupied habitats.

SECTION 2 – Timed Meander/Population Estimate Correlation at Jackson County Central

Introduction

All accessible Mitchell's satyr sites are monitored annually using timed meander (TM) survey methodology developed by Daria Hyde and David Cuthrell (Michigan Natural Features Inventory (MNFI) and others. These surveys are conducted by a variety of individuals, including MNFI, Southwest Michigan Land Conservancy, Michigan Department of Natural Resources (MDNR), The Nature Conservancy (TNC), and volunteers. The data that are obtained show the number of satyrs observed/time/number of observers, but do not provide an estimate of the population. In this study, we attempted to produce a mathematical model to estimate population size based on TM survey data by conducting a TM survey during an MRR at JCC.

Methods

The study was conducted in the northern 2/3 of the JCC fen on the east side of the creek (Figure 1), with seven TM surveys occurring. Two observers walked in a meandering pattern looking forward, to the sides, and behind to increase the likelihood that all butterflies were seen. Particular attention was paid to areas containing fine-leaved sedges growing in association with low growing shrubs and tamarack (*Larix laricina*), seeps and springs, and small openings along streams and between the shrubs. MRR activities were conducted over the entire JCC site throughout the flight period of the satyr. MRR data from within the TM survey area was extracted using ArcView 3.2 (ESRIS Corp.), and Program Jolly (Pollack et al.1990) was used to estimate population size. Pearson's test was conducted to determine whether population estimates or number of satyr handled during the MRR could be correlated with TM counts. Our objective was to develop a model that would allow the estimation of population size based on TM counts alone.

Results

Pearson's correlation test showed no correlation between the TM survey data and the population estimates ($n=7$, $r = -0.022$, $p = 0.64$) (Figure 2), however the results are suspect because of low sample sizes (Table 10). Additionally, population estimate data were not normally distributed and contained an outlier (sample period 2), further invalidating the test. Larger sample sizes would increase the validity of the data.

Discussion

It is a is a worthwhile goal to develop a model to predict population size based on TM data, but may be difficult to do given the duration of the flight season (which results in too few data) and the cost of such an effort. Data from this study suggests that there may be a correlation (if the outlier is removed), and this can only be verified by conducting a more intensive study. I would recommend further work on this issue because it would be more cost effective in the long-term to be able to obtain population estimates from TMs rather than MRR studies.

SECTION 3 – The Effects of Fire on Adult Emergence

Introduction

Mitchell's satyr (*Neonympha mitchellii mitchellii*) is a federally endangered butterfly which, in Michigan, is restricted to just 17 prairie fen sites. Effective conservation of Mitchell's satyr requires an understanding of how to stabilize and improve habitat conditions for this species. Because major threats to the satyr's fen habitat are invasion of exotic shrubs and conversion to native shrub-carr, there is strong interest in the use of prescribed fire to maintain habitat quality. However, the effect of fire on Mitchell's satyr survival and population dynamics are largely unknown.

Historically, populations in Michigan were most likely connected to some degree and the lack of current metapopulation structures may result in the ultimate extirpation all but the largest sites. In addition, only a small percentage of individuals are dispersing and, since there is no suitable habitat to disperse into, these individuals may not reproduce. If the propensity to disperse is genetically related, the populations may gradually be composed exclusively of residents restricted to their current patches. Extinction rates could increase dramatically in these populations due to inbreeding depression or non-viability. To save the species from this fate, habitats must be enlarged and sub-populations re-connected.

Research in Virginia has shown that the satyr exhibits classic metapopulation structure when patches are within flying distance, and individuals will cross unsuitable habitat to reach other occupied patches (S. Roble, personal communication). Patch sizes in this metapopulation are similar to many of the Michigan sites, however; with the possible exception of JCC fen in Jackson County, isolation of the Michigan sites has resulted in single populations scattered throughout the southern part of the State. While recent studies have revealed that the species is not as sedentary as once believed (Barton 2004, Barton and Bach 2005, Barton 2005, Barton 2007), it is highly unlikely that any mixing occurs because Michigan populations are separated by at least 4 km of unsuitable habitat, a distance farther than the satyrs are capable of flying.

The two primary methods of enlarging and enhancing satyr habitat are mechanical/manual shrub removal and prescribed fire. The use of prescribed fire in degraded fen habitat can result in a decrease in invasive woody species, a short-term increase in forbs (Kost and Steven 2000), and an increase in graminoid cover (Bowles et al. 1996), but may also have negative effects on larval survival. Fires are typically set in April, when larvae are in the fourth instar stage. McAlpine et al. (1960) observed diapausing satyrs hanging from silken pads two inches above the soil surface, and overwintering larvae in captivity were found an average of 3.68 mm (95% CI = 2.33 – 5.04, n=19) above the substrate (Tolson et al. 2006). If larvae are above ground and not in the duff, fire could have serious consequences, depending on the intensity and coverage. There is a critical need to understand the effects of prescribed fire on Mitchell's satyr survival and population dynamics. The study attempted to document the effects of prescribed fire on larval survival and adult emergence.

Methods

On June 29th; 8 females were place in net enclosures attached over sedge tussocks (see Appendix A, Figure 1) to concentrate oviposition as part of the study of prescribed fire on satyr emergence. The females were checked several hours later and found perched at the top of the enclosures. They were removed 48 hours later on 2 July per study protocol.

Results

We could not locate two of the females and do not know whether they were eaten by predators or escaped (unlikely). One female was released unharmed. One female was dead; four others were injured and could not fly. Before removing the above females, we captured an additional eight and placed them in enclosures. After discovering the injuries in the first set of eight, I terminated this study due to unacceptable risk to the satyrs. We then attempted to release the newly captured eight individuals approximately 1 hour after capture. Two of the females were injured while held in the enclosures. The remaining six were unharmed and released. The fatality report is presented in Appendix A.

Discussion

Research on the effects of fire on satyr survival is considered a top priority by the Mitchell's satyr Working Group. The enclosures should be redesigned, providing structures that are stable with no folds, corners, or other "hiding places" that could trap the satyrs and result in fatal injuries.

This study should be repeated during the 2008 field season with new enclosures, and an experimental prescribed burn done in the spring of 2009.

SECTION 4 – Degree Day Modeling

Introduction

Annual Mitchell's satyr surveys begin as soon as the satyrs emerge. Emergence is determined through surveys by various staff members and volunteers checking occupied sites daily, shortly before the date of earliest emergence. This is time consuming and not always accurate, as coverage of the sites is sometimes spotty. The development of a degree day model would provide surveyors with a tool for determining emergence and also peak flight period based on degree day information from weather stations.

Methods

Seven extant Mitchell's satyr sites were selected based on geographic location and accessibility (Figure 3). Two Hobo® Dataloggers were placed at each site, one in open fen meadow known to contain the butterflies and the second in a semi-shaded upland area nearby. They were mounted on 8 x 10 in unpainted pine boards which was attached to a 5 ft metal fence post (Figure 3). The dataloggers were positioned at chest height, approximately 4.5 ft above the ground, and oriented in a north direction to minimize exposure to direct sunlight. The Michigan dataloggers were set to record temperature and relative humidity every hour beginning at 1800 hrs Daylight Savings Time on 5 April 2007. The Indiana dataloggers began recording on 3 May 2007. We had planned to place the dataloggers by April 1 but did not receive them from the supplier in time. We also had difficulty obtaining permission to access the Indiana site and thus did not use that data in this analysis. The dataloggers will be left on site through the end of the flight season in 2008 and a complete data set will be obtained.

Field staff began checking for Mitchell's satyr emergence at each site the week of 15 June 2007, approximately five days before the earliest recorded emergence. The dataloggers were downloaded during September and November 2007. Daily minimum and maximum temperatures were derived from the hourly data. The single sine method (Baskerville and Emin 1969) was used to calculate accumulated degree days from 5 April to the first observed emergence date for each site using an online calculator from the University of California Integrated Pest Management (IPM) online (http://www.ipm.ucdavis.edu/WEATHER/ddretrieve.html, accessed 10 October 2007) using minimum cutoffs of 50° Fahrenheit and 40° Fahrenheit. I obtained degree day data from the nearest weather station for each site from weather data posted on the Michigan Automated Weather Network (MAWN)

(http://www.agweather.geo.msu.edu/mawn/station.asp?id=clr, assessed 10 October 2007). Degree days generally begin to accumulate in March, so in order to compare both data sets I subtracted accumulated degree days from the MAWN data set for the time period of 1 March – 4 April. This was done so that a preliminary analysis could determine whether a correlation existed between the MAWN weather stations and the sampled fens. MAWN data is commonly used to monitor degree days for the purposes of estimating satyr emergence, but this data most likely varies from actual weather conditions in the fen due to the environmental and ambient conditions surrounding the weather stations (i.e. fens are more humid, have higher temperatures). Cumulative degree days on the dates of Mitchell's satyr emergence from the fens and MAWN sites were compared using Wilcoxon Sign-Rank tests and a predictive cumulative degree day range was developed. Washtenaw County West was omitted from the degree day analysis because it was not surveyed for first emergence.

Results

First emergence observations for Mitchell's satyrs occurred from 19 June – 28 June (Table 11).

Temperature differences were minimal between the fens, uplands, and MAWN stations (Table 12). Relative humidity values were slightly higher in the fens (Table 13). There were no statistically significant differences in cumulative degree days between fens and MAWN stations at either base 50 ($p=0.81$ Wilcoxon Sign-rank test) or base 40 ($p=0.44$, Wilcoxon Sign-rank test). The predicted range for satyr emergence (base 50) was 923.40-1282.00 and 1637.90-2133.10 (base 40).

Discussion

Emergence times varied by site but the majority occurred 19 June-22 June. There did not appear to be an effect of geographic location on cumulative degree day values at emergence (Figure 4), although more extensive sampling across the satyr's range may verify this finding.

The effectiveness of this model will be tested during the upcoming satyr flight period to determine its effectiveness in predicting emergence. The degree day range prediction derived from data during this study will be refined during the 2008 field season since a more complete set of hourly readings will be available from all sample sites plus three additional fens (for a total of 10 study areas).Once data has been collected in the next flight season, the model will be refined and hopefully the range of degree days narrowed.

Acknowledgements

I would like to thank Doug Landis, Department of Entomology, Michigan State University (MSU), for his assistance with research design, implementation, staffing, equipment, and field assistance. The following individuals provided valuable field assistance; Michael Sanders (MNFI), Melissa Nicholsen (MNFI), Rachel Osborn (MNFI), Sean Zera (MNFI), Sophia DiPietro (MNFI), Joelle Gehring (MNFI), Molly Murphy (MSU), Chris Hamm (MSU), Amanda Nickerson (MSU), Matt Hull (MSU), Alissa Berro (MSU), Dr. P. Ann Ryan, Roger Kuhlman, David Mifsud, and Matt Cook. Administrative support was provided by Lyn Scrimger, Sue Ridge, and Connie Brinson. Helen Enander (MNFI) provided GIS technical advice. Daria Hyde (MNFI) conducted transect surveys and designed the transect survey protocol, and provided landowner contact and field assistance. Trimble GPS units were furnished by Marshall Strong (MDNR) and the US Fish and Wildlife Service. I would like to thank Larry Lyons, Christine Harburgh (MDNR), Jim Bess (Otis Consulting), Southwest Michigan Land Conservancy, The Nature Conservancy, Berrien County North Nature Center, Barry State Game Area, Todd Zimont, Scott Weaver, and Dick Irwin for their participation in this study. David Cuthrell (MNFI) provided field assistance, equipment construction, and landowner contact. Kraig Korrach (MNFI), Mike Monfils (MNFI), Joelle Gehring (MNFI), and Sarah Mayhew (MDNR) assisted with data analysis. I would like to thank Mike DeCapita and Carrie Tansy of the U.S. Fish and Wildlife Service for their support. Funding was provided by the Michigan Department of Natural Resources through a Habitat Conservation Plan (HCP) grant from the US Fish and Wildlife Service and the.

Literature Cited

Barton, B. J. 2004. Population Ecology of Mitchell's Satyr Butterflies (*Neonympha mitchellii mitchellii*). Master's Thesis, Eastern Michigan University, Ypsilanti.

_____. 2005. Dispersal and home range estimates for the Mitchell's satyr at Jackson County Central Fen, Michigan. Report number MNFI 2005-22. Report to U.S. Fish and Wildlife Service, Region 3 Office, Fort Snelling, MN.

_____. 2007. Population ecology of the Mitchell's satyr (*Neonympha mitchellii mitchellii*) at Branch County Lake Fen, and the effects of management on the Mitchell's Satyr at Mill Creek Fen. Report Number 2007-02. Report to the US Fish and Wildlife Service, Region 3, Fort Snelling, MN.

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

Baskerville, G. L. and P. Emin. 1969. Rapid estimation of heat accumulation from maximum and minimum temperatures. Ecology 50(3):514-517.

Bowles, M. J. McBride, N. Stoynoff, K. Johnson. 1996. Temporal changes in vegetation composition and structure in a fire-managed prairie fen. Natural Areas Journal 16(4): 275-288.

Kost, M. A., and D. Steven. 2000. Plant community responses to prescribed burning in Wisconsin sedge meadows. Natural Areas Journal 20(1): 36-45.

McAlpine, W. S., S. P. Hubbell, and T. E. Pliske. 1960. The distribution, habits, and life history of *Euptchia mitchellii* (Satyridae). Journal of the Lepidopterists' Society 14:209-226.

Hooge, P. N. and B. Eichenlaub. 1997. Animal movement extension to ArcView Version 1.1. Alaska Science Center - Biological Science Office, U.S. Geological Survey, Anchorage, AK, USA.

Pollock, K.H., J.D. Nichols, C. Brownie, and J.E. Hines. 1990. Statistical Inference for Capture-Recapture Experiments. Wildlife Monographs 107.

Szymanski, J. 1999. Population and spatial ecology of the Mitchell's satyr butterfly *Neonympha m. mitchellii* French, in Southwestern Michigan. Master's Thesis, University of Minnesota, Minneapolis.

Tolson, P. J., C. L. Ellsworth., and M. L. Magdich. 2006. Captive rearing and breeding of the Mitchell's satyr butterfly, *Neonympha mitchellii mitchellii*. Interim Report. Toledo Zoo, Ohio.

Table 1. Capture history of Mitchell's satyrs at Jackson County Central, Jackson County, Michigan in 2007.

# Captures	Male	Female	Total
1x	419	299	718
2x	92	55	147
3x	19	9	28
4x	3	1	4
Total	533	364	897

Table 2. Number of marks and handles during the 2007 Mitchell's satyr MRR at Jackson County Central in Jackson County, Michigan.

Sex	# Handles	# Marked	# Recaptured	Recapture Rate (Recap/Marked)
Male	672	533	114	0.21
Female	440	364	65	0.18
Total	1112	897	179	0.20

Table 3. Daily population estimates for Mitchell's satyrs at Jackson County Central in Jackson County, Michigan in 2007.

Sample Period	Male Pop. Est.	Female Pop. Est.	Total Pop. Est.	95% CI (Total Pop. Est.)
1	1834.05	794.00	3020.27	1913.32 - 4127.22
2	1504.88	731.67	2625.84	1596.08 - 3655.60
3	921.86	694.25	1698.76	1054.45 - 2343.08
4	1140.95	890.00	2155.88	1438.09 - 2873.67
5	789.00	1003.50	1758.69	947.65 - 2569.73
6	1121.00	1133.00	2329.90	1595.45 - 3064.35
7	791.67	718.88	1568.88	1119.73 - 2018.03
8	962.13	767.44	1923.00	1046.37 - 2799.63
9	355.40	751.00	1119.00	657.04 - 1580.96
10	859.00	968.60	2099.00	349.18 - 3848.82
11	407.00	329.67	614.33	234.72 - 993.95
12	79.00	486.50	767.00	-
13	17.00	374.00	597.00	-

Table 4. Vagility data for Mitchell's satyrs at Jackson County Central, Jackson County Michigan in 2007.

	All Distances		Dist per day		Dist per day per individual		Home Range	
	Male	Female	Male	Female	Male	Female	Male	Female
n	127	57	115	45	101	46	62	24
mean (m)	76.55	55.6	30.65	19.59	29.23	17.87	0.16	0.11
SE	8.6	7.19	3.83	4.23	4.16	2.91	0.03	0.04
median (m)	40.76	37.57	17.16	11.25	17.42	11.14	0.06	0.03
maximum	602.65	193.36	250.37	170.02	301.33	90.97	0.87	0.63

Table 5. Summary of home ranges from MRR studies in Michigan 2003-2007 (Barton 2004, 2005, 2007, Barton and Bach 2005).

Site	n	Median	Mean	SE
Females				
Jackson County Central 2003	7	0.003	0.038	0.018
Jackson County Central 2005	44	0.032	0.005	0.027
Branch County 2006	11	0.032	0.115	0.027
Jackson County Central 2007	24	0.030	0.110	0.040
Berrien County South 1998	2	*	0.0008	*
Berrien County North 1998	9	*	0.036	*
Males				
Jackson County Central 2003	8	0.062	0.182	0.000
Jackson County Central 2005	74	0.100	0.390	0.096
Branch County 2006	12	0.020	0.040	0.014
Jackson County Central 2007	63	0.060	0.160	0.030
Berrien County South 1998	9	*	0.033	*
Berrien County North 1998	13	*	0.026	*

Table 6. Summary of all distances moved between captures from MRR studies in Michigan 2003-2007 (Szymanski 1999, Barton 2004, 2005, 2007, Barton and Bach 2005).

Site	n	Median	Mean	SE	Maximum
Females					
Jackson County Central 2003	45	35.78	78.44	13.96	445.27
Jackson County Central 2005	148	33.94	71.17	7.28	478.24
Branch County 2006	33	17.38	34.01	7.04	162.74
Jackson County Central 2007	57	37.57	55.60	7.19	193.36
Berrien County South 1997	4	15.15			48.70
Berrien County South 1998	19	10.38			54.11
Berrien County North 1997	2	21.38			36.69
Berrien County North 1998	39	21.90			88.27
Males					
Jackson County Central 2003	53	56.86	103.89	15.90	509.52
Jackson County Central 2005	308	62.25	107.87	7.07	710.30
Branch County 2006	62	38.33	70.63	10.27	352.75
Jackson County Central 2007	127	40.76	76.55	8.60	602.65
Berrien County South 1997	48	15.17			290.04
Berrien County South 1998	54	22.12			148.35
Berrien County North 1997	52	20.32			420.64
Berrien County North 1998	39	21.90			89.21

Table 7. Summary of distances traveled per day (m/day) between captures from MRR studies in Michigan 2003-2007 (Barton 2004, 2005, 2007, Barton and Bach 2005).

Site	n	Median	Mean	SE	Maximum
Females					
Jackson County Central 2003	45	14.11	39.35	11.37	445.27
Jackson County Central 2005	148	17.15	35.26	4.81	437.40
Branch County 2006	33	6.72	15.86	4.76	150.31
Jackson County Central 2007	45	11.13	19.59	4.23	170.02
Males					
Jackson County Central 2003	53	16.04	36.71	7.15	342.89
Jackson County Central 2005	308	26.31	52.60	4.24	628.09
Branch County 2006	62	17.63	25.95	3.60	167.41
Jackson County Central 2007	115	17.16	30.65	3.83	250.37

Table 8. Descriptive statistics for Mitchell's satyr vagility data, derived from Jackson County Central, Jackson County, MI (2003, 2005, 2007) and Branch County Lake Fen, Branch County, MI (2006) (Barton 2004, 2005, 2007).

	n	Median	Mean	SE
Males				
Home range (ha)	157	0.06	0.26	0.04
Distance between captures (m)	487	55.93	99.24	5.32
Distance per day (all captures) (m)	475	22.39	45.49	3.04
Distance per day per individual (m)	365	22.39	42.71	3.04
Females				
Home range (ha)	86	0.03	0.10	0.02
Distance between captures (m)	284	32.24	64.64	4.75
Distance per day (all captures) (m)	271	14.10	30.98	3.38
Distance per day per individual (m)	202	13.36	28.44	3.56

Table 9. Timed meander (TM) survey data and population estimates for Mitchell's satyrs at Jackson County Central fen in 2007.

Date	Population Estimate from Timed Meander Survey Area	# of Satyrs Observed During Timed Meander Surveys
6/23/2007	39	50
6/26/2007	159	64
6/28/2007	190	150
7/1/2007	68	84
7/2/2007	431	10
7/5/2007	50	93
7/7/2007	9	26

Table 10. Population estimates and timed-meander survey data for Jackson County Central, 2007.

Date	Sample Period	Population Estimate	# of Satyrs Observed During Timed Meander Surveys
06/23/2007	2	39.11	50
06/26/2007	3	159.25	64
06/28/2007	4	190	150
07/01/2007	5	68.33	84
07/02/2007	6	430.77	10
07/05/2007	7	50	93
07/07/2007	8	9	26

Table 11. Mitchell's satyr sites and first observation dates.

Site	County	Date Satyrs were First Observed
Barry County South	Barry	6/22/2007
Berrien County North	Berrien	6/21/2007
Cass County Southwest	Cass	6/20/2007
LaGrange County	LaGrange (IN)	6/19/2007
Jackson County Central	Jackson	6/20/2007
St. Joseph County West	St. Joseph	6/28/2007
Washtenaw County West	Washtenaw	Not surveyed

Table 12. Temperature summary (F°) from study areas and nearest Michigan Automated Weather Network (MAWN) weather stations.

Site	Sub-site	n	Mean	SE	Minimum	Maximum	Median
	Fen	3812	63.83	0.27	17.60	99.22	64.46
	Upland	3812	63.28	0.245	16.77	96.82	64.76
Barry County South	Clarksville	3811	63.42	0.23	21.50	98.70	65.20
	Fen	5347	61.13	0.23	16.10	95.47	61.46
	Upland	n/a	n/a	n/a	n/a	n/a	n/a
Berrien County North	Benton Harbor	5347	62.67	0.19	21.30	93.60	64.60
	Fen	5349	61.43	0.23	12.57	97.45	61.89
	Upland	5349	61.25	0.23	12.32	96.82	61.63
Cass County Southwest	Lawton	5348	62.58	0.2	18.47	94.3	64.30
	Fen	5204	60.83	0.23	16.70	98.97	61.21
	Upland	5204	62.61	0.22	17.30	100.81	62.98
Jackson County Central	Hudson	5204	61.53	0.22	16.40	100.50	63.10
	Fen	5350	60.99	0.22	17.78	96.77	61.08
	Upland	5350	62.20	0.20	18.13	94.99	63.52
St. Joseph County West	Constantine	5350	63.13	0.20	19.40	92.40	64.80
	Fen	5206	61.12	0.21	15.40	97.40	61.85
	Upland	5206	60.51	0.22	15.32	98.58	61.36
Washtenaw County West	Hudson	5183	61.16	0.21	16.40	93.60	62.30

Table 13. Relative humidity summaries (%) from study areas and nearest Michigan Automated Weather Network (MAWN) weather stations.

Site	Sub-site	n	Mean	SE	Minimum	Maximum	Median
Barry County South	Fen	3812	74.26	0.38	16.79	100.00	81.25
	Upland	3812	72.79	0.38	16.18	99.99	78.73
	Clarksville	3811	63.42	0.23	17.80	94.00	65.20
Berrien County North	Fen	5347	77.16	0.29	17.00	99.99	84.50
	Upland	n/a	n/a	n/a	n/a	n/a	n/a
	Benton Harbor	5347	68.46	0.27	15.90	100.00	69.70
Cass County Southwest	Fen	5349	79.73	0.30	17.22	100.00	89.68
	Upland	5349	61.25	0.23	12.32	96.82	61.63
	Lawton	5348	n/a	n/a	n/a	n/a	n/a
Jackson County Central	Fen	5204	74.71	0.32	17.03	99.12	82.87
	Upland	5204	72.61	0.32	16.32	100.00	78.80
	Hudson	5183	73.34	0.31	71.00	100.00	77.50
St. Joseph County West	Fen	5350	78.78	0.30	17.37	99.74	89.98
	Upland	5350	75.51	0.29	15.98	100.00	95.30
	Constantine	5350	72.43	0.28	17.50	100.00	95.30
Washtenaw County West	Fen	5206	77.79	0.28	19.61	99.85	85.64
	Upland	5206	77.38	0.29	19.04	100.00	85.03
	Hudson	5183	73.34	0.31	71.00	100.00	77.50

Table 14. Mitchell's satyr first observed dates and corresponding cumulative degree days (Base 50) from the study sites and nearest MAWN weather stations. Cumulative degree days were calculated starting from the date and time of datalogger placement.

Site	First Observed Date	Date of Datalogger Placement	Date of Datalogger Download	Cumulative Degree Days Since 5 Apr 08 - Fen	Cumulative Degree Days Since 5 Apr 08 - MAWN Station	Actual Cumulative Degree Days - MAWN Station
Barry County South	22-Jun-07	5-Apr-07	11-Sep-07	964.21	846.3	931.7
Berrien County North	21-Jun-07	5-Apr-07	14-Nov-07	864.47	942.20	1058.50
Cass County Southwest	20-Jun-07	5-Apr-07	14-Sep-07	942.49	945.60	1089.10
Jackson County Central	20-Jun-07	5-Apr-07	8-Nov-07	957.20	823.70	923.40
St. Joseph County West	28-Jun-07	5-Apr-07	14-Nov-07	1102.19	1151.00	1282.00

Table 15. Mitchell's satyr first observed dates and corresponding cumulative degree days (Base 40) from the study sites and nearest MAWN weather stations. Cumulative degree days were calculated starting from the date and time of datalogger placement.

Site	First Observed Date	Date of Datalogger Placement	Date of Datalogger Download	Cumulative Degree Days Since 5 Apr 08 - Fen	Cumulative Degree Days Since 5 Apr 08 - MAWN Station	Actual Cumulative Degree Days - MAWN Station
Barry County South	22-Jun-07	5-Apr-07	11-Sep-07	1558.31	1450.30	1658.50
Berrien County North	21-Jun-07	5-Apr-07	14-Nov-07	1439.81	1561.50	1832.80
Cass County Southwest	20-Jun-07	5-Apr-07	14-Sep-07	1847.61	1551.80	1854.70
Jackson County Central	20-Jun-07	5-Apr-07	8-Nov-07	1557.35	1405.90	1637.90
St. Joseph County West	28-Jun-07	5-Apr-07	14-Nov-07	1777.73	1847.10	2133.10

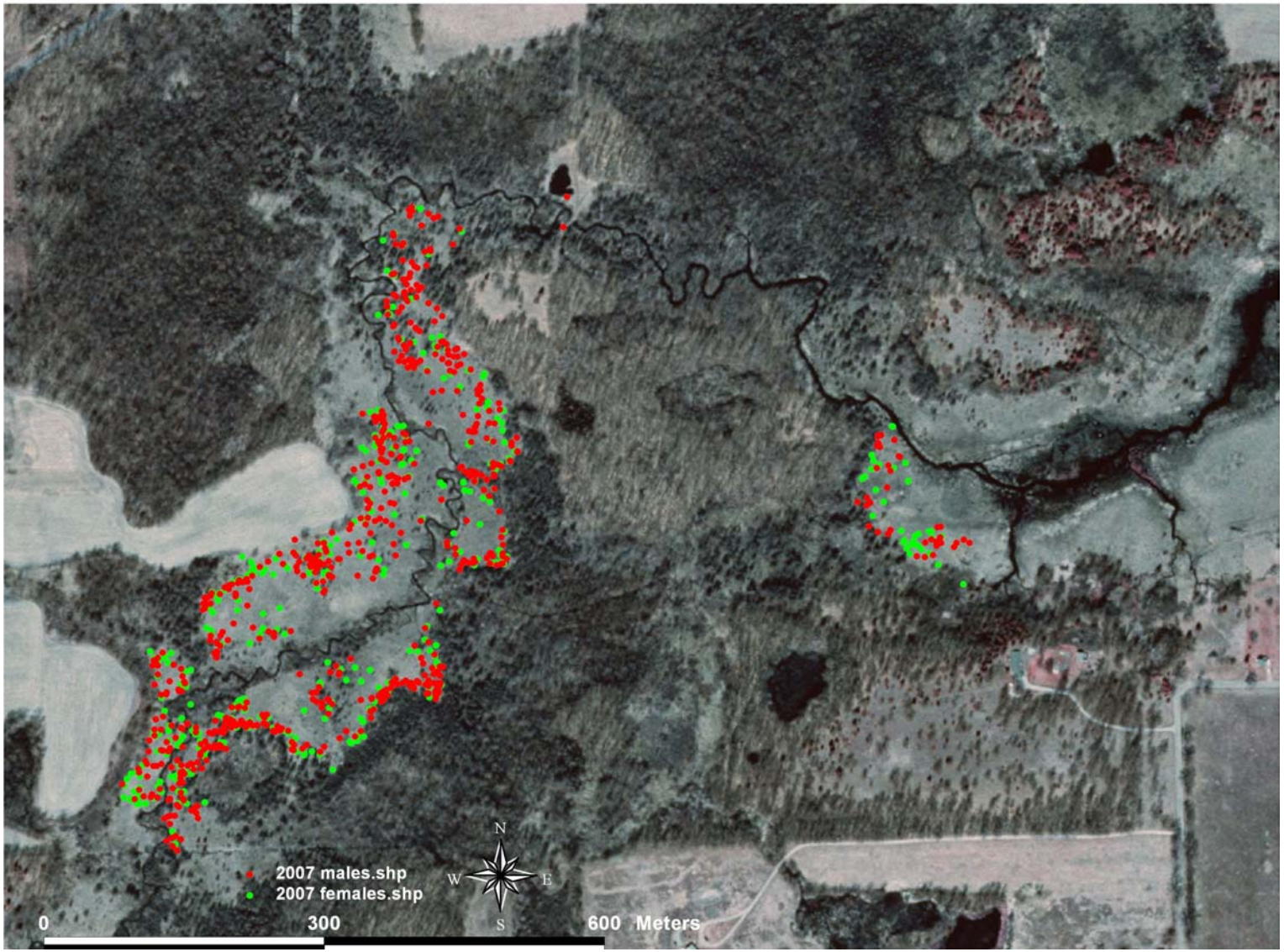


Figure 1. 2007 Mitchell's satyr capture points at Jackson County Central, Jackson County, Michigan. Transect survey area is outlined in red. The eastern fen is on the right.

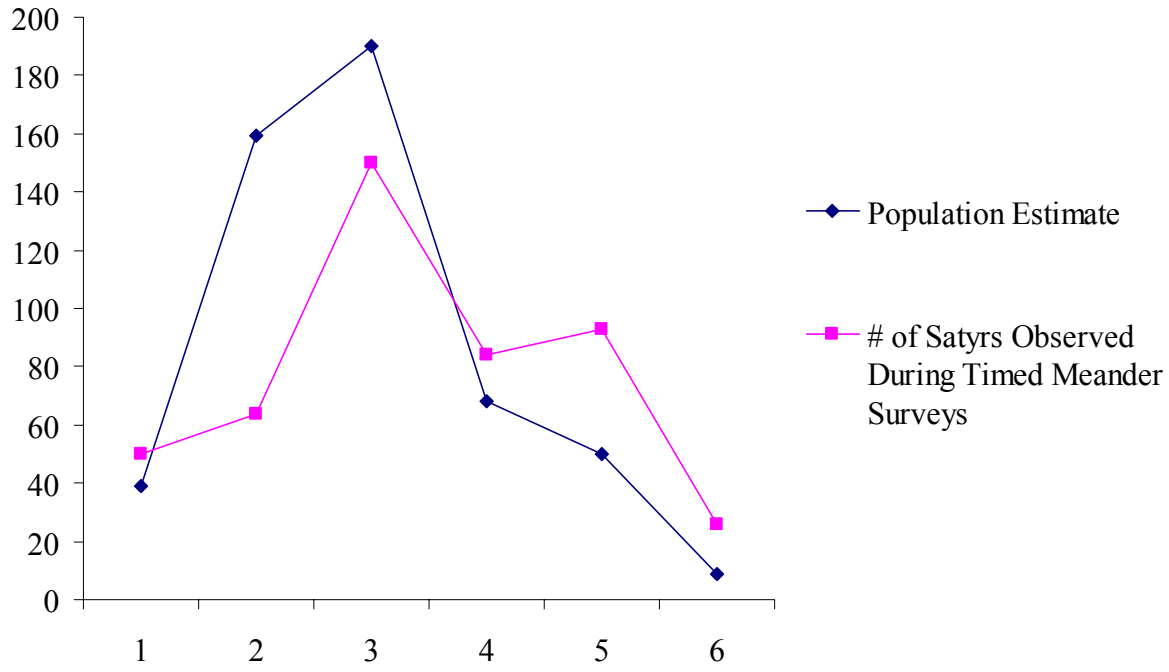


Figure 2. Timed-meander survey data and population estimates from Jackson County Central, 2007.

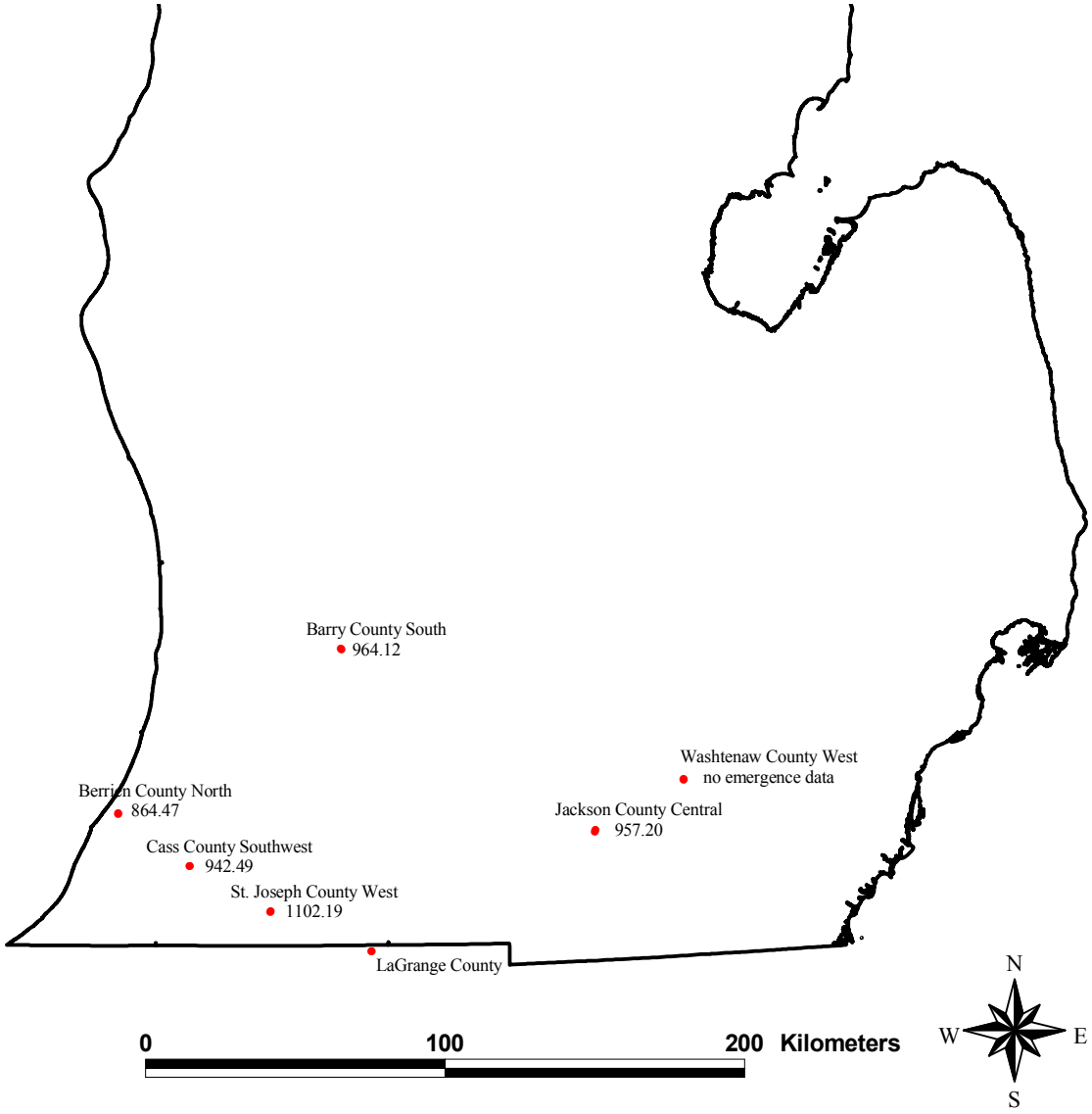


Figure 3. Location of dataloggers and cumulative degree days (base 50) at the time of satyr emergence.

Figure 4. Hobo datalogger on metal fence post in fen. Data collected included hourly temperature and relative humidity readings.

Appendix A.

Mitchell's Satyr 2007 Fatality Report

Mitchell's Satyr Fatality Report

Permit # TE104664-0

Submitted to the US Fish and Wildlife Service on July 2, 2007

by Barbara J. Barton

Michigan Natural Features Inventory

P.O. Box 3044

Lansing, MI 48909

Incidental Take – Total of 10 individuals

1. 23 June 2007 – 1 male and 1 female

Two satyrs were injured during capture. One female had a broken forewing and was unable to fly. She was placed in a glassine envelope and placed in my freezer. She will be deposited at Michigan State University. The male was removed from the net in perfect condition, but his forewing simply fell off when he was released. Cause unknown. I was unable to locate the male.

2. 25 June 2007 – 1 male

One male was injured during capture. He apparently sustained a torn wing while in the net, and when released dropped into the vegetation. He was not located.

3. 2 July 2007 – 7 females

On 29 June, 8 females were place in net enclosures attached over sedge tussocks to concentrate oviposition as part of the study of prescribed fire on satyr emergence. They were checked on several hours later, and were perched at the top of the enclosures. Per study protocol, they were removed on 2 July, 48 hours later. We could not locate two of the females and do not know whether they were eaten by predators or escaped

(unlikely). One female was released unharmed. One female was dead; four others were injured and could not fly. All were placed in glassine envelopes as described above.

Before removing the above females, we captured an additional eight and placed them in enclosures. After discovering the injuries in the first set of eight, I terminated the experimented and attempted to release the newly captured eight individuals approximately one hour after capture. Two of the females were injured while held in the enclosures. The remaining six were unharmed and released.

I believe the causes of the injuries were satyrs becoming trapped in folds in the netting and trying to extricate themselves. They exhibited severe wing wear (tattering and scale loss). When last observed the day of their placement, they were resting on the sides of the netting, but apparently they moved up at some point in time.

Figure 1. Net enclosure.

Actions to Prevent Further Take

No further injuries occurred during mark-recapture efforts. I believe that the torn wings were due to overall wing condition in young adult satyrs this year. We are seeing an unusually high number of "crinkled wings", a condition brought on by drought conditions and low humidity during development (Chris Rickards, personal communication). The wings also appeared to be softer than usual during the early part of the flight season. To reduce the possibility of wing injury, all satyrs that have crinkled, previously torn or deformed wings were not marked but immediately released. To prevent further take in prescribed burn study, no more females were collected and the study was terminated. All enclosures were removed.

2008 Mitchell's Satyr (*Neonympha mitchellii mitchellii*) Research Report

Submitted by:

Barbara J. Barton

Michigan Natural Features Inventory

P.O. Box 30444

Lansing, MI 48909-7944

For:

US Fish and Wildlife Service

1 Federal Drive

Fort Snelling, MN 55111-4056

October 13, 2008

Report Number 2008-05

Michigan Natural Features Inventory

MICHIGAN STATE UNIVERSITY EXTENSION

Cover Photo by Barbara J. Barton (MNFI)- Michael Sanders (MNFI) conducting mark-release-recapture study.

Recommended Citation: Barton, B.J. 2008. 2008 Mitchell's Satyr (*Neonympha mitchellii mitchellii*) Research Report. Report Number 2008-05. Report to the US Fish and Wildlife Service, Region 3, Fort Snelling, MN.

Table of Contents

Table of Tables

Table of Figures

SECTION 1 – Population Monitoring at Washtenaw County West

Introduction

In 2006, we began a study of the effects of clearing on Mitchell's satyr (*Neonympha mitchellii mitchellii*) distribution and movement at an occupied satyr site in Washtenaw County, Michigan (Barton 2007). Clearing of woody vegetation is a common management technique used by land managers to "set back" succession, yet the effectiveness of clearing in improving habitat conditions for the satyr is unknown. In order to assess how the clearing of shrubs and trees in occupied habitat affects satyr movements, we proposed mark-release-recapture (MRR) studies every two years to obtain information on the satyrs' use of the cleared plots. The first MRR affiliated with this project was conducted in the summer of 2006 (Barton 2007). The results of the 2008 MRR are presented in this report.

Methods

Study site--Washtenaw County West (WCW) is located in Washtenaw County and is under private ownership. The site contains a mosaic of degraded fen and beach-maple and oak-hickory forests with springs and seeps though-out. Washtenaw County West is in the Huron River watershed along a headwater tributary of Mill Creek. The fen complex is a mosaic of prairie fen, sedge meadow, shrubby meadow, tamarack savanna and conifer swamp surrounded by pasture, hayfields, and upland forests of oak/hickory and beech/maple. The site is succumbing to successional changes such as encroachment by woody vegetation. There are four main areas of Mitchell's satyr occupation at this site, all occurring on slight peat mounds.

In 2006, three plots with two paired treatment blocks in each were designated at areas with high Mitchell's satyr densities. Each block was 50 m x 20 m and randomly assigned control or treatment status. Treatment was defined as complete clearing of shrubs and trees <6" dbh (diameter at breast height) using hand-held brush cutters. Larger trees were girdled with the exception of tamarack trees which were not treated. This species is an important component of the fen habitat and there was little evidence of regeneration, so the decision was made to leave the few large trees in the treatment blocks. In addition, the primary reason to remove the woody vegetation from the treatment plots was to reduce vertical structure, and the tamaracks' contribution was considered minimal. A solution of 50% glyphosate (Aqua Neat®, Riverdale) was applied to cut stumps, and all brush was removed from the blocks and placed outside of the study area. Treatments took place in February and March of 2006.

An MRR study was conducted from 01 July – 14 July 2008 for a total of eight sampling days. Each plot was surveyed by two individuals walking linear transects approximately 3 meters apart. This was to minimize trampling within the habitat. Mitchell's satyrs were captured using hand-held nets and unique identifying numbers were placed on the ventral surface of the right hindwing using Sharpee Fine Point™ and Sharpee Ultrafine Point™ permanent markers. Individuals were released immediately after capture. Date, time, sex, and identification number were recorded. Identification number, sex, and date were written on plastic flags and placed at the point of first observation for each Mitchell's satyr captured. Locational information for capture points was collected using Trimble GeoExplorer I and II hand-held global positioning system (GPS) units. Maps and movement statistics were analyzed with ArcView 3.2 Geographic Information Systems (ESRI, Redlands, CA). Due to the low number of recaptures we were unable to obtain a population estimate or conduct a statistical analysis of the propensity of individuals to move into or out of treated plots.

Results

First emergence was detected on 30 June 2008. The MRR was conducted from 1 July – 14 July for a total of 9 sampling days. A total of 58 individuals were marked (37 males and 21 females) with only 4 recaptures (all males) (Figure 1). The low recapture rate prohibited estimation of the population size. Wing conditions of the satyrs at the end of the study were still fresh to slightly worn, which is highly unusual as previous MRRs showed wing wear at the end of the flight periods to be mostly worn to well-worn (Barton, unpublished data). This suggests that the flight period was interrupted, perhaps due to severe weather or some other unknown circumstance. Several severe thunderstorms occurred during the flight period, which may have resulted in premature satyr mortality before their wings would have worn out naturally. Severe storms are common at the Jackson County Central site during the latter part of the flight period and are thought to hasten the end of the flight (Barton, personal observation).

No conclusions could be drawn from the data regarding preference for treatment versus control plots due to the low number of recaptures.

Discussion

While we did not obtain sufficient data to analyze movement between control and treatment plots, it is recommended that MRR studies be continued every two years to capture trends in population size and to characterize the temporal changes in habitat. Butterfly populations are known to fluctuate annually and thus a long-term monitoring study is warranted to assess both the health of the population and the effects of the treatment (clearing) on satyr movements.

It was noted during this study that a number of invasive plant species are taking hold in the study plots (Figure 2). These include Russian olive (*Elaeagnus angustifolia*), cattails (*Typha spp.*), phragmites (*Phragmites australis*), and reed canary grass (*Phalaris arundinacea*). It is recommended that management action be undertaken to remove invasives before the habitat becomes unsuitable for the satyrs. The study plots were created in the center of known "hot spots" for Mitchell's satyrs, and the degradation of these areas may result in their extirpation.

SECTION 2 – Degree Day Modeling

Introduction

Annual Mitchell's satyr surveys begin as soon as the satyrs emerge. Emergence is determined through surveys by various staff members and volunteers checking occupied sites daily, shortly before the date of earliest emergence. This is time consuming and not always accurate, as coverage of the sites is sometimes spotty due to lack of personnel. The development of a degree day model would provide surveyors with a tool for more accurately estimating emergence, thus reducing the number of staff hours and travel costs associated with the annual surveys.

Methods

Ten extant Mitchell's satyr sites were selected based on geographic location and accessibility (Figure 3). Two Hobo® Dataloggers were placed at each site in open fen meadows known to contain the butterflies. Half were mounted on 8 x 10 in unpainted pine boards which was attached to a 5 ft metal fence post. The dataloggers were positioned at chest height, approximately 4.5 ft above the ground, and oriented in a north direction to minimize exposure to direct sunlight. The remaining dataloggers were mounted on wooden staked and positioned at ground level approximately one meter southeast of the posts to minimize exposure to shade from the posts. All dataloggers were programmed to record temperatures and relative humidity every hour.

Field staff began checking for Mitchell's satyr emergence at each site the week of 15 June 2008, approximately five days before the earliest recorded emergence. The dataloggers were downloaded after the flight period ended. Daily minimum and maximum temperatures were derived from the hourly data for each site. The single sine method (Baskerville and Emin 1969) was used to calculate accumulated degree days from the date of placement (generally before 6 March) to the first observed emergence date for each site using an online calculator from the University of California Integrated Pest Management (http://www.ipm.ucdavis.edu/WEATHER/ddretrieve.html, accessed 16 August 2008) using minimum cutoffs of 50°F. Degree day data was obtained from the nearest weather station for each site from weather data posted on the Michigan Automated Weather Network (MAWN) (http://www.agweather.geo.msu.edu/mawn/station.asp?id=clr, assessed 16 August 2008). Data were collected from the fens in order to determine difference between weather station data and

actual conditions within satyr habitats. A 95% confidence interval was calculated from the MAWN weather data, which will be the values used to estimate emergence times.

Results

Emergence observations for Mitchell's satyrs occurred from 18 June – 01 July (Table 1). There did not appear to be an effect of geographic location on cumulative degree day values at emergence although more extensive sampling across the satyr's range may verify this finding (Figure 3). Degree day accumulations were higher in the fens than at the MAWN stations (Table 1). The 95% confidence interval for predicting Mitchell's satyr emergence using MAWN data from Table 1 is 865.03 – 972.40 degree days (Base 50° F) (n = 7, $\bar{X}$ = 918.7, SE = 21.94).

Discussion

The cumulative degree day confidence interval is the best model we have to date for predicting Mitchell's satyr emergence. It may still be difficult to time the surveys with emergence using this model due to the wide range, however; in most years it appears that during the first few days of emergence there are low numbers of individuals so missing those in the surveys would not be critical. If capturing first emergence is critical to survey effort, it is recommended that the lowest cumulative degree value be used as the trigger to begin surveys (824.4 Base 50°).

SECTION 3 – The Effects of Fire on Adult Emergence

Introduction

The two primary methods of enlarging and enhancing satyr habitat are mechanical/manual shrub removal and prescribed fire. The use of prescribed fire in degraded fen habitat can result in a decrease in invasive woody species, a short-term increase in forbs (Kost and Steven 2000), and an increase in graminoid cover (Bowles et al. 1996), but may also have negative effects on larval survival. Fires are typically set in April, when larvae are in the fourth instar stage. McAlpine et al. (1960) observed diapausing satyrs hanging from silken pads two inches above the soil surface, and overwintering larvae in captivity were found an average of 3.68 mm (95% CI = 2.33 – 5.04, n=19) above the substrate (Tolson et al. 2006). If larvae are above ground and not in the duff, fire could have serious consequences, depending on the intensity and coverage. There is a critical need to understand the effects of prescribed fire on Mitchell's satyr survival and population dynamics.

In 2007, eight females were placed in enclosure to direct oviposition. Due to a faulty enclosure design there was high mortality and the study was aborted. The enclosures were redesigned and we again attempted to direct oviposition during this flight period in order to continue the study.

Methods

In June of 2008, four blocks with two paired plots (treatment and control were designated in the fen and flags placed on appropriate sedge tussocks to indicate enclosure locations. On 8 June 2008, 10 females were captured and eight were placed in the enclosures and two in rearing cages provided by the Toledo Zoo. The rearing cages were to be used as backup enclosures should the newly designed enclosures not function properly. On 10 June 2008, 16 females were captured and placed in enclosures.

Results

During the removal of females from eight enclosures and two cages on 8 June, two satyrs were found dead with evidence of predation and two satyrs were missing from the cages and presumed predated upon. During removal of females from 16 enclosures on 12 June, seven were missing and presumed predated upon, one was found in spider's web (wing only), and one was alive but had broken forewing and was unable to fly. She was left on site with the hopes that she would

continue to lay eggs. Due to the high level of mortality the study was terminated. The incidental take report submitted to the USFWS is presented in Appendix A.

Discussion

Research on the effects of fire on satyr survival is considered a top priority by the Mitchell's satyr Working Group, yet non-lethal methods of testing this are not yet realized. Given the reported locations of larvae during hibernation, there can be little doubt that some mortality occurs during fire. The question of how many larvae perish has yet to be answered. The Mitchell's Satyr Working Group should continue to generate ideas on methodology that would test the effects of fire without causing unnecessary mortality to the individual satyrs used in these experiments.

Acknowledgements

I would like to thank Doug Landis and Chris, Department of Entomology, Michigan State University (MSU), for his assistance with research design, implementation, staffing, equipment, and field assistance. The following individuals provided valuable field assistance; Michael Sanders (MNFI), Daria Hyde (MNFI), Roger Kuhlman, and Rudolfo Villegas and crew (The Nature Conservancy). Administrative support was provided by Nancy Toben, Sue Ridge, and Connie Brinson. Helen Enander (MNFI) provided GIS technical advice. Trimble GPS units were graciously furnished by Marshall Strong (MDNR). I would like to thank Larry Lyons, Christine Harburgh (MDNR), Jim Bess (Otis Consulting), Southwest Michigan Land Conservancy, The Nature Conservancy, Sarrett Nature Center, Barry State Game Area, and various private landowners for their participation in this study. I would like to thank Carrie Tansy of the U.S. Fish and Wildlife Service for her support. Funding was provided by the Michigan Department of Natural Resources through a Habitat Conservation Plan (HCP) grant from the US Fish and Wildlife Service.

Literature Cited

Barton, B. J. 2004. Population Ecology of Mitchell's Satyr Butterflies (*Neonympha mitchellii mitchellii*). Master's Thesis, Eastern Michigan University, Ypsilanti.

_____. 2005. Dispersal and home range estimates for the Mitchell's satyr at Jackson County Central Fen, Michigan. Report number MNFI 2005-22. Report to U.S. Fish and Wildlife Service, Region 3 Office, Fort Snelling, MN.

_____. 2007. Population ecology of the Mitchell's satyr (*Neonympha mitchellii mitchellii*) at Coldwater Lake Fen, and the effects of management on the Mitchell's Satyr at Mill Creek Fen. Report Number 2007-02. Report to the US Fish and Wildlife Service, Region 3, Fort Snelling, MN. 17 p.

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

Baskerville, G. L. and P. Emin. 1969. Rapid estimation of heat accumulation from maximum and minimum temperatures. Ecology 50(3):514-517.

Bowles, M. J. McBride, N. Stoynoff, K. Johnson. 1996. Temporal changes in vegetation composition and structure in a fire-managed prairie fen. Natural Areas Journal 16(4): 275-288.

Kost, M. A., and D. Steven. 2000. Plant community responses to prescribed burning in Wisconsin sedge meadows. Natural Areas Journal 20(1): 36-45.

McAlpine, W. S., S. P. Hubbell, and T. E. Pliske. 1960. The distribution, habits, and life history of *Euptchia mitchellii* (Satyridae). Journal of the Lepidopterists' Society 14:209-226.

Hooge, P. N. and B. Eichenlaub. 1997. Animal movement extension to ArcView Version 1.1. Alaska Science Center - Biological Science Office, U.S. Geological Survey, Anchorage, AK, USA.

Pollock, K.H., J.D. Nichols, C. Brownie, and J.E. Hines. 1990. Statistical Inference for Capture-Recapture Experiments. Wildlife Monographs 107.

Szymanski, J. 1999. Population and spatial ecology of the Mitchell's satyr butterfly *Neonympha m. mitchellii* French, in Southwestern Michigan. Master's Thesis, University of Minnesota, Minneapolis.

Tolson, P. J., C. L. Ellsworth., and M. L. Magdich. 2006. Captive rearing and breeding of the Mitchell's satyr butterfly, *Neonympha mitchellii mitchellii*. Interim Report. Toledo Zoo, Ohio.

Table 1. Degree day information for eight Mitchell's satyr sites in Michigan and Indiana in 2008.

Site	Emergence Date	DD Post	MAWN DD	MAWN Station	MAWN DATES
Cedar Lake IN	24-Jun	997.4	942.6	Constantine	5 Mar - 24 June
Cass County Southwest	21-Jun	869.35	824.4	Lawton	1 Mar - 21 June
Branch Co.	18-Jun	843.74	n/a	Coldwater	5 Mar - 18 June
Jackson Co. Central	27-Jun	997.62	920.2	Albion	6 Mar - 27 June
Washtenaw Co. West	30-Jun	1023.9	974.2	Albion	1 Mar - 30 June
Paw Paw Lake	30-Jun	1036.67	986.6	Lawton	5 Mar - 30 June
Berrien County North	01-Jul	992.91	919.6	Benton Harbor	5 Mar - 1 July
Barry County South	30-Jun	1090.65	863.4	Clarksville	5 Mar - 30 June

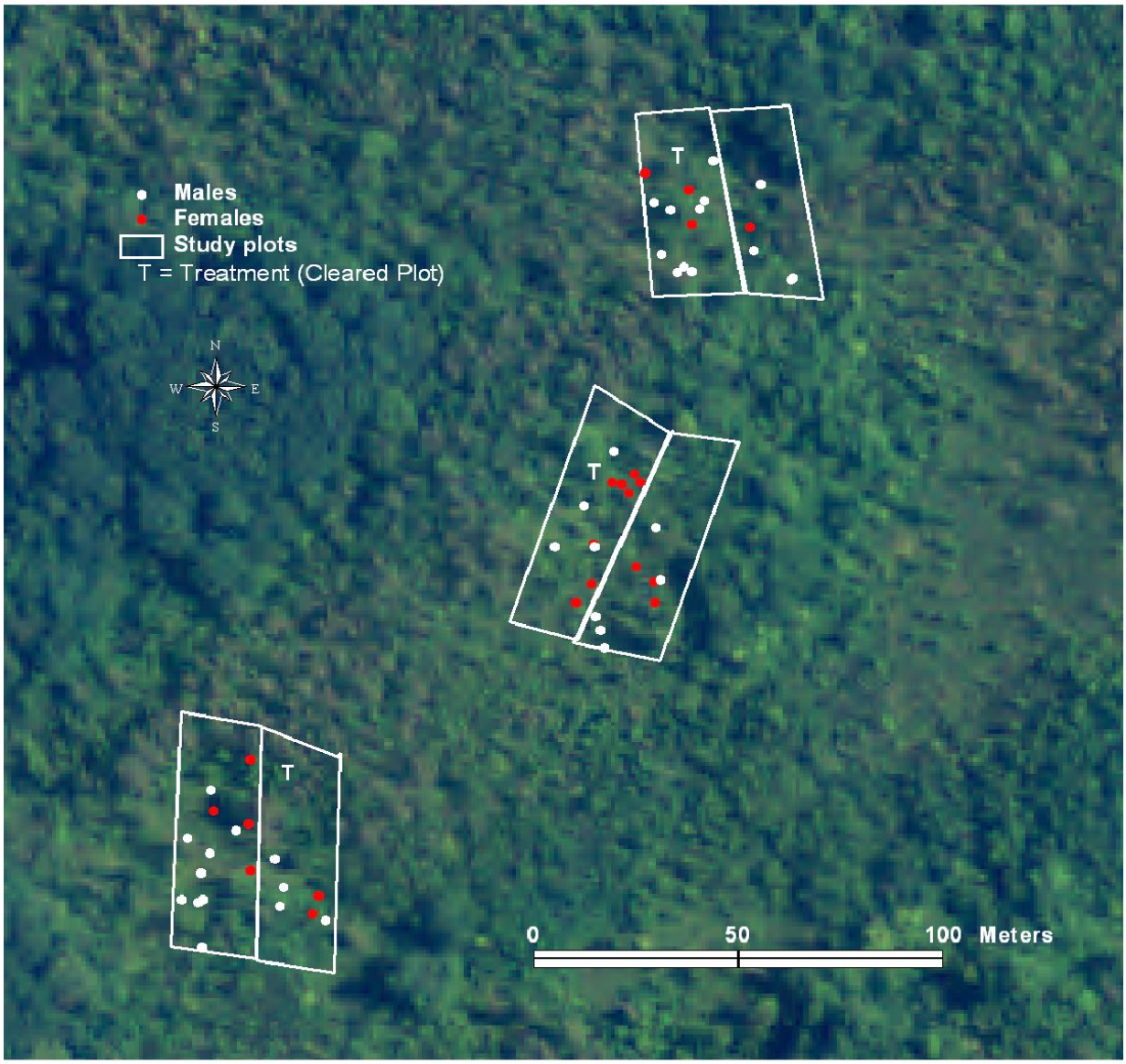


Figure 1. Capture points of Mitchell's satyrs at Washtenaw County West during the 2008 mark-release-recapture.

Figure 2. Treatment plot three showing the encroachment of cattails (*Typha spp.*).

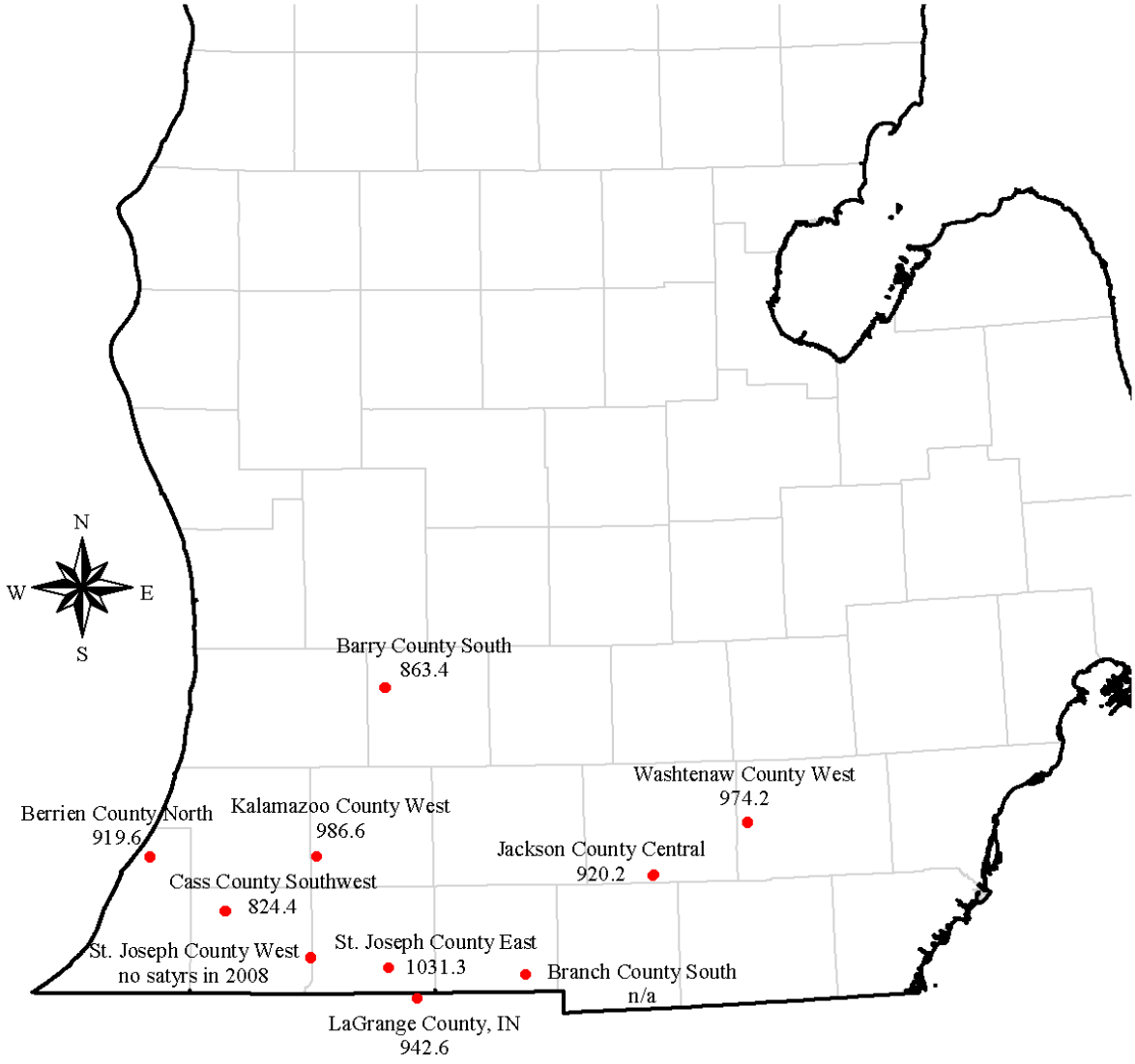


Figure 3. Location of dataloggers and cumulative degree days (Base 50°) at the time of satyr emergence from Michigan Automated Weather Network (MAWN).

Figure 4. Enclosures to direct oviposition of Mitchell's satyr females in study plots. A) the rejected enclosure design from the 2007 study, B) the improved enclosure design used in 2008. Photos by B.J. Barton.

Figure 5. Photograph of the bottom of enclosure which was secured by creating a "trough" with a shovel then pressing the net into it.

Appendix A.

Mitchell's Satyr 2007 Fatality Report

Mitchell's Satyr INCIDENTAL TAKE Report

Permit # TE174564-1

Submitted to the U.S. Fish and Wildlife Service on July 14, 2008

by Barbara J. Barton

Michigan Natural Features Inventory

P.O. Box 3044

Lansing, MI 48909

Incidental Take – 13 Females

1. 10 July 2008 – 4 females

During the removal of females from 8 enclosures and 2 cages, 2 satyrs were found dead with evidence of predation and 2 satyrs were missing from the cages and presumed predated upon.

2. 12 July 2008 – 9 females

During removal of females from 16 enclosures, 7 were missing and presumed predated upon, 1 was found in spider's web (wing only), and one was alive but had broken forewing and was unable to fly. She was left on site with the hopes that she would continue to lay eggs.

.

Final Report:2008 - Mitchell's Satyr Larval Feeding Experiments

MI DNR Mitchell's satyr 07 HCP (Development of a Multi-State Mitchell's Satyr Habitat Conservation Plan) 61-7610

Prepared by:

Peter J. Tolson, Ph.D and Candee L. Ellsworth
Department of Conservation and Research
The Toledo Zoo
P.O. Box 140130
Toledo, OH 43614-0801

For:
Michigan Natural Features Inventory
P.O. Box 30444
Lansing, MI 48909-7944

September 2008

Introduction

The Mitchell's satyr, *Neonympha m. mitchelli*, is a critically endangered butterfly still extant in several sedge-dominated fen communities in Indiana and Michigan, but has been extirpated from Ohio, New Jersey, and possibly Maryland (see Shuey 1997). The prospects for saving this species seem the best in Michigan, where there are 17 sites where the butterfly is known to be present (all confirmed in 2006), two sites where there is still potential for them to be present, and five sites where the satyr has been recently extirpated. These sites are described in Hyde et al. (2001; 2004). In addition, Michigan has several additional localities that seem to possess the necessary environmental conditions and community structure to support populations of the Mitchell's satyr, yet the butterflies are absent, and it is unknown whether the lack of Mitchell's satyr populations at these sites is due to stochastic processes or their inherent unsuitability as *Neonympha* habitat (see Rabe et al., 2002).

One of the most important tasks of a habitat conservation plan is determining which habitat attributes contribute to the successful retention or colonization of Mitchell's satyr in any given fen. As the USFWS Recovery Plan states, "Very little is understood about the ecological requirements…of the Mitchell's satyr" (USFWS 1998). Critical tasks include determination of which species of wetland grasses and sedges are utilized by early-instar larvae as host plants. Although Mitchell's satyr often occurs in sedge meadows and fens dominated by the tussock sedge, *Carex stricta*, and some larvae unequivocally feed on *C. stricta*, anecdotal reports, older publications, and some of the grey literature all report that Mitchell's satyr early-instar larvae feed on a variety of grasses and sedges.

Figure 1. Larval *Neonympha* on *Carex stricta*

McAlpine et al. (1960) documented that larvae hatching from eggs oviposited by a wild-caught female refused *C. stricta*, but fed on potted fox-tailed sedge, *C. alopecoidea*, bulrush, *Scirpus atrovirens,* and, surprisingly, the upland yellow nut sedge, *C. cepalophora.* These observations led the authors to conclude that "*E. mitchellii* feeds on a variety of sedges". Legge and Rabe (1996) reported that the most common "substrate" used by Mitchell's satyr larvae were "fine sedge leaves" that were not identified. Feeding damage was observed on two species of sedges that were "not *C. stricta*". Possibly this sedge species was *C. lasiocarpa* as noted in Table 5 (Pg. 10). In a letter to Legge (Pers. comm. 1997) Bill Bergman of Highland Park, IL describes raising larvae on sedges "from various wet locations" The species were not identified but

Bergman stated that "They all seemed to work." Szymanski and Shuey (2002) reported larval feeding on *C. lacustris*, *C. prairea*, and *C. stricta*.

Further efforts to define the range of larval host plants used by *N. mitchelli* began in 2006 as a cooperative effort between the Michigan Natural Features Inventory and The Toledo Zoo. This document is a progress report on those activities.

Materials and Methods

Host plant collections- Potential host plants were selected and collected by Daria Hyde and Michael Penskar of the Michigan Natural Features Inventory with assistance from Peter J. Tolson, Candee L. Ellsworth of The Toledo Zoo, Michael DeCapita of the USFWS, and Todd Hogrefe of the Michigan Department of Natural Resources within the Barry County State Game Area in Barry County, MI. The first collections were made on 22 JUN 06 and included *C. leptalea*, *C. sterilis*, *Eleocharis elliptica*, *Panicum amplicatum*, and *Poa palustris*. *Carex stricta* has been under cultivation at the Zoo since 2003. Additional collections were made on 6 JUN 07 at the Lost Nations Game Area in Hillsdale County, MI and included *Carex buxbaumii, C. flava, C. lasiocarpa, C. prairea, C. tetanica*, and *Rhynchospora capillacea*.

Egg collection

2007- Captive bred Mitchell's satyr larvae were obtained by a second-generation breeding of adults produced from conservation breedings in 2005 and 2006.

2008- Thirty eggs were collected on 11 JUL 08 from four females at Paw Paw Lake by Peter Tolson, Mitchell Magdich, and Candee Ellsworth of the Toledo Zoo and Nate Fuller of the Southwest Michigan Land Conservancy.

Figure 2. Collection tubs at Lime Lake

Females were netted and placed overnight in a polyester-netted tub planted with *Carex* and forbs and were released unharmed. Figure 1 (above) shows the tubs *in situ* at Lime Lake. In an attempt to collect additional eggs for the larval feeding experiments, we once again visited the Lime Lake site on 21-22 JUL 08 and were able to collect an additional four females. One of the females was copulating, so we gently released the pair, along with the other three, into a similar tub. When we checked the tub the next morning we found the male and one of the females dead. This take equaled the maximum allowed by our permit and the collection activities were terminated. The satyrs were not predated and exhibited no injuries.

Experimental setup

2006-2007- Plants to be tested for larval feeding were planted in 50 cm x 65 cm poly tubs (MacCourt Products, Inc., Denver, CO) in a four-plant species grid surrounding a central area ca. 100 cm^2 containing newly-oviposited *N. m. mitchelli* eggs on small plants that were used by captive-bred females for oviposition. These plants were primarily *Pilea pumila* and *Viola nephrophylla*. Newly hatched larvae needed to travel ca. 5 cm on bare soil to reach any of the potential host plants. Figure 1 (right) is a photograph of two of the experimental setups used to test *Neonympha* larvae.

Figure 3. Netted polyethylene enclosures used for the larval feeding experiments.

2008- We simplified the system by using 12" diameter Belvin bulb pans sparsely planted with the test grasses and sedges- to reduce spider predation. A plastic sleeve was installed around the plants and cap of chiffon fabric was placed over the top of the cylinder to increase ventilation. *Carex stricta* was always offered as one of the four plant species available to the larvae. Figure 2 (below) shows the Belvin bulb pan experimental set up.

Monitoring- Satyr eggs were monitored twice per day for hatching and movement of the larvae to specific host plants. Individual larvae that had selected host plants were monitored at least daily until well into the 3rd instar, when they became sedentary and entered diapause. There was no attempt to avoid mortality when larvae chose a potential host plant. If a larva moved to a plant but did not feed, or fed sparingly, it was not transferred from the plant it originally selected to a more palatable species. Plant selections and perch heights were noted each day. Perch heights were measured to the nearest mm.

Figure 4. Plastic Belvin bulb pan with clear plastic sleeve**.**

Results

Hatching

Figure 5. First instar larvae hatching on *Lycopodium* sp.

2007- The first Mitchell's satyr eggs were detected on 28 JUN 07. Oviposition continued through 5 JUL 07. The breeding group was estimated to consist of 12 males and six females. Butterflies were not dissected to determine sex and all were kept in the breeding cage until death. Because adults were kept in a group no egg totals were tabulated for individual females. A total of 309 eggs was discovered, but only 88 larvae were detected and subsequently used for host plant selection experiments. Others may have hatched and died without being detected. Several larvae in each group descended to the substrate from the oviposition plant after hatching, but remained on the substrate, apparently without attempting to feed. All of these larvae (n=14) subsequently died. Hatching larvae are shown in Figure 5.

2008- The only Mitchell's satyr eggs collected were detected on 11 JUL 08. Thirty eggs were discovered- 23 on the lower framing of the enclosure and seven on *Pilea pumila*. In 2008 the eggs on the tub framing hatched overnight on 19 JUL 08 and the larvae were recovered the next morning. Twenty-one larvae were detected and used for the subsequent host plant experiments. Three larvae descended to the substrate and died before selecting a host plant.

Host plant selection

2007- An additional replicate of the host plant experiment from 2006 using two grasses was replicated in 2007. Species tested were *C. stricta*, *Panicum* sp. and *Poa palustris*. Initial host plant selections of this replicate are presented in Table I.

Tub #	*C. stricta*	*Panicum amplicatum*	*Poa palustris*	Substrate	Total
5	9	3	7	2	21

Table I. Mitchell's satyr initial host plant selections for Tub 5.

Tub #	*C. stricta*	*C. tetanica*	*Panicum*	*Rhyncospora*	Substrate	Total
6	7	2	5	4	3	21
7	2	4	4	4	3	17
8	7	2	8	6	6	29

Table II. Mitchell's satyr initial host plant selections for Tubs 6, 7, and 8.

First instar larvae overwhelmingly tended to remain on the host plant selected until death or the 3rd instar. All larvae that initially selected *Carex tetanica* and *Rhyncospora capillacea* and remained on those species died. Feeding damage was evident on both species. As in 2006, the most movement occurred between *Carex stricta*, *Panicum* sp., and *Poa palustris.* For example, on 11 JUL 07, nine larvae selected *C. stricta* and three larvae selected *Panicum* after hatching. By 13 JUL 07 two larvae from *Panicum* and 1 larva from *C. stricta* had migrated to *Poa palustris*. By mid August most larvae had migrated to *C. stricta* to begin diapause.

2008

This year was very unusual in that larvae were very vagile and moved from plant to plant very frequently, feeding on every plant provided. In 2008 the species tested were *Carex buxbaumii*, *Carex lasiocarpa*, *Carex prairea*, and *Carex stricta*. Table III show the initial selections on 19 JUL after the larvae were recovered from the oviposition tub. Table IV shows the cumulative totals for observations of larvae on each species of plant in 2008.

Tub #	*C. stricta*	*C. prairea*	*P. palustris*	*C. buxbaumii*	Substrate	Total
1	3	2	6	2	3	16

Table III. Mitchell's satyr initial host plant selections for Tub 1 (not all larvae had hatched).

Tub #	*C. stricta*	*C. prairea*	*P. palustris*	*C. buxbaumii*	C. lasiocarpa	Total
1	296	142	26	96	169	729

Table IV. Cumulative observations on sedge and grass species for Tub 1.

Feeding heights

2007- Larvae feeding on *C. stricta* in Tub 5 ranged from 1-222 mm, in height above the substrate, with a mean feeding height of 73.47 mm (n observations =32). Larvae at lower heights on *C. stricta* were either on the base of the plant or on a bent leaf close to the substrate. Only one larva was seen consuming a new shoot. All the other larvae observed were on mature leaves. In Tub 6 larvae feeding on *C. stricta* ranged from 4-162 mm in height above the substrate, with a mean feeding height of 56.87 mm (n observations =15). In Tub 7 larvae feeding on *C. stricta* ranged from 0-81 mm in height above the substrate, with a mean feeding height of 36.86 mm (n observations =43). In Tub 8 larvae feeding on *C. stricta* ranged from 2-174 mm in height above the substrate, with a mean feeding height of 69.08 mm (n observations =72).

Larvae feeding on *C. tetanica* in Tub 6 ranged from 2-178 mm in height above the substrate, with a mean feeding height of 49.74 mm (n observations =19). Only two larvae were seen consuming new shoots. All the other larvae observed were on mature leaves. In Tub 7 larvae feeding on *C. tetanica* ranged from 17-142 mm in height above the substrate, with a mean feeding height of 51.17 mm (n observations =6). In Tub 8 larvae feeding on *C. stricta* ranged from 3-60 mm in height above the substrate, with a mean feeding height of 34.14 mm (n observations =7).

Larval feeding on *Panicum* in Tub 5 ranged from 12-64 mm in height above the substrate, with a mean feeding height of 34.20 mm (n observations =5). In Tub 6 larvae feeding on *Panicum* ranged from 0-247 mm in height above the substrate, with a mean feeding height of 38.29 mm (n observations =35). In Tub 7 larvae feeding on *Panicum* ranged from 2-83 mm in height above the substrate, with a mean feeding height of 37.00 mm (n observations =65). In Tub 8 larvae feeding on *Panicum* ranged from 2-115 mm in height above the substrate, with a mean feeding height of 34.87 mm (n observations =116). Most larvae fed at the basal leaves of the plants- often touching or nearly touching the substrate. We observed that the defensive hairs on the *Panicum* stems provided a substantial barrier to larvae trying to climb the stem.

Poa palustris was only offered in Tub 5. Larval feeding on *Poa* in Tub 5 ranged from 4-76 mm in height above the substrate, with a mean feeding height of 31.30 mm (n observations =37).

Rhyncospora capillacea was offered in Tubs 6, 7, and 8. Larval feeding on *Rhyncospora* in Tub 6 ranged from 0-112 mm in height above the substrate, with a mean feeding height of 28.38 mm (n observations =32). In Tub 7 larvae feeding on *Rhyncospora* ranged from 15-121 mm in height above the substrate, with a mean feeding height of 40.76 mm (n observations =21). In Tub 8 larvae feeding on *Rhyncospora* ranged from 0-142 mm in height above the substrate, with a mean feeding height of 17.70 mm (n observations =30). Larvae were difficult to observe in *Rhyncospora*- often hiding in the dense tufts of leaves. By 4 AUG all these larvae had either moved to *Panicum* or *C. stricta* or had perished.

2008- Larvae feeding on *C. stricta* in Tub 1 ranged from 2-414 mm, in height above the substrate, with a mean feeding height of 160.72 mm (n observations =296). Larvae at lower heights on *C. stricta* were either on the base of the plant or on a bent leaf close to the substrate. Several larvae were seen consuming a new shoots. All the other larvae observed were on mature leaves.

Larvae feeding on *C. lasiocarpa* in Tub 1 ranged from 2-355 mm, in height above the substrate, with a mean feeding height of 142.20 mm (n observations =169).
Larvae feeding on *C. prairea* in Tub 1 ranged from 10-326 mm, in height above the substrate, with a mean feeding height of 161.24 mm (n observations =142).

Larvae feeding on *C. buxbaumii* in Tub 1 ranged from 2-307 mm, in height above the substrate, with a mean feeding height of 138.03 mm (n observations =142).

Larvae feeding on *P. palustris* in Tub 1 ranged from 2-108 mm, in height above the substrate, with a mean feeding height of 37.23 mm (n observations =26).

One striking difference between 2007 and 2008 was larval activity. In 2007 most larvae had ceased feeding and entered diapause by mid-August. In 2008 larvae were still active and feeding as late as 12 September.

Discussion

Thru the course of these experiments, the numbers of experimental subjects and replicates were limited by the numbers of larvae available to us. Although our USFWS permit would have allowed us to collect up to 60 eggs from wild females, the site chosen for collection near Dowagiac for 2007 had fewer numbers of satyrs than anticipated, and we elected to experiment with our captive-hatched larvae rather than deplete the population further at the proposed collection site. In 2008 limited egg numbers restricted our activities even further. We will propose increasing our take for *Neonympha* eggs to 100 for the 2009 field season.

Plants chosen for the trials were selected by Daria Hyde of the Michigan Natural Features Inventory. Species to use in the trials in both 2007 and 2008 were those that had transplanted most successfully after the collection and were numerous enough to make replicate tubs.

Our research reconfirmed that 1st instar Mitchell's satyr larvae will select and feed upon several different grasses and sedges, not all of which can support successful development. We have identified six species of *Carex- buxbaumii, lasiocarpa, leptalea, prairea, sterilis,* and *stricta*- and two grasses- *Panicum amplicatum* and *Poa palustris*-, which support normal development until the 3rd instar diapause in August. Feeding height data are not to be interpreted in terms of plant palatability or preferred perch

heights, as they simply reflect many observations over approximately one-two months. These data reflect many observations of the same larvae over the course of the study, and simply give some indication of where the larvae are eating in the layer of grasses and sedges. While feeding heights on *Poa* in 2008 were significantly lower than the species of *Carex*, the *Poa* plants themselves were very small and were only used to transport the newly hatched larvae from the oviposition tub.

We made no attempts to "rescue" larvae that had apparently made poor choices, as we wanted to see if a particular potential host plant would support larval growth through the 3rd instar. In 2007 it became obvious that after only two days larvae feeding on *C. tetanica* were not doing well- becoming yellowish, lethargic and finally dying. Deaths of larvae on *C. tentanica* and *Rhyncospora capillacea* extended over several days as new waves of recently- hatched larvae chose these species. Similarly, many larvae died on the substrate (soil, moss, or wood fragments) as they wandered about but did not climb on any of the available plants. We made no attempts to place these larvae on host plants, although we did replace larvae that were inadvertently brushed off the host plant as we were looking for them.

Literature Cited

Hyde, D.A., M.L. Rabe, D.L. Cuthrell, and M.A. Kost. 2001. Surveys for the recovery of Mitchell's satyr, *Neonympha m. mitchellii*, in Michigan: Final Report to USFWS Region 3. 98p.

Legge, J.T. and M.L. Rabe. 1996. Observations of oviposition and larval ecology in caged Mitchell's satyr butterflies (*Neonympha mitchelli mitchelli*) (Lepidoptera: Nymphalidae). Report to the U.S. Fish and Wildlife Service, Region 3 Office, Ft. Snelling, MN. 17 pp.

----------. 2004. Summary of 2003 Mitchell satyr activities, Report to The Mitchell's Satyr Working Group, 1p.

McAlpine, W.S., S.P. Hubbell, and T. E. Pliske. 1960. Distribution, habits, and life history of *Euptychia mitchellii* (Satyridae). J. Lepid. Soc. 14(3):209-226.

Rabe, M.L., M.A. Kost, H.D. Enander, and E.H. Stolls. 2002. Use of a habitat model to identify potential release sites for Mitchell's satyr (*Neonympha m. mitchelli*) in Michigan. Final Report to USFWS Region 3. 34p.

Roble, S.M., C.T. Kessler, B. Grimes, C.S. Hobsen, and A.C. Chazal. 2001. Biology and conservation status of *Neonympha mitchellii*, a globally rare butterfly new to the Virginia fauna. Banesteria 18:1-23.

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

Szymanski, J.A. 1999. Population and spatial ecology of the Mitchell's satyr butterfly, *Neonympha m. mitchellii* French, in Southwestern Michigan. Master's Thesis, University of Minnesota, Minneapolis, MN. 78p.

U.S. Fish and Wildlife Service 1998. Mitchell's satyr butterfly *Neonympha mitchelli mitchelli* Recovery Plan. Ft. Snelling, MN. viii+ 71pp.

Addendum 2009- Mitchell's Satyr Larval Feeding Experiments

MI DNR Mitchell's satyr 07 HCP (Development of a Multi-State Mitchell's Satyr Habitat Conservation Plan) 61-7610

Prepared by:

Peter J. Tolson, Ph.D
Department of Conservation and Research
The Toledo Zoo
P.O. Box 140130
Toledo, OH 43614-0801

For:
Michigan Natural Features Inventory
P.O. Box 30444
Lansing, MI 48909-7944

November 2009

Introduction

The Mitchell's satyr, *Neonympha m. mitchelli*, is a critically endangered butterfly still extant in several sedge-dominated fen communities in Indiana and Michigan, but has been extirpated from Ohio, New Jersey, and possibly Maryland (see Shuey 1997). The prospects for saving this species seem the best in Michigan, where there are 17 sites where the butterfly is known to be present (all confirmed in 2006), two sites where there is still potential for them to be present, and five sites where the satyr has been recently extirpated. These sites are described in Hyde et al. (2001; 2004). In addition, Michigan has several additional localities that seem to possess the necessary environmental conditions and community structure to support populations of the Mitchell's satyr, yet the butterflies are absent, and it is unknown whether the lack of Mitchell's satyr populations at these sites is due to stochastic processes or their inherent unsuitability as *Neonympha* habitat (see Rabe et al., 2002).

One of the most important tasks of a habitat conservation plan is determining which habitat attributes contribute to the successful retention or colonization of Mitchell's satyr in any given fen. As the USFWS Recovery Plan states, "Very little is understood about the ecological requirements…of the Mitchell's satyr" (USFWS 1998). Critical tasks include determination of which species of wetland grasses and sedges are utilized by early-instar larvae as host plants. Although Mitchell's satyr often occurs in sedge meadows and fens dominated by the tussock sedge, *Carex stricta*, and some larvae unequivocally feed on *C. stricta*, anecdotal reports, older publications, and some of the grey literature all report that Mitchell's satyr early-instar larvae feed on a variety of grasses and sedges.

Figure 1. Larval *Neonympha* on *Carex stricta*

McAlpine et al. (1960) documented that larvae hatching from eggs oviposited by a wild-caught female refused *C. stricta*, but fed on potted fox-tailed sedge, *C. alopecoidea*, bulrush, *Scirpus atrovirens,* and, surprisingly, the upland yellow nut sedge, *C. cepalophora.* These observations led the authors to conclude that "*E. mitchellii* feeds on a variety of sedges". Legge and Rabe (1996) reported that the most common "substrate" used by Mitchell's satyr larvae were "fine sedge leaves" that were not identified. Feeding damage was observed on two species of sedges that were "not *C. stricta*". Possibly this sedge species was *C. lasiocarpa* as noted in Table 5 (Pg. 10). In a letter to Legge (Pers. comm. 1997) Bill Bergman of Highland Park, IL describes raising larvae on sedges "from various wet locations" The species were not identified but

Bergman stated that “They all seemed to work.” Szymanski and Shuey (2002) reported larval feeding on *C. lacustris*, *C. prairea*, and *C. stricta*. Further efforts to define the range of larval host plants used by *N. mitchelli* began in 2006 as a cooperative effort between the Michigan Natural Features Inventory and The Toledo Zoo. This document is an adendum on those activities.

Materials and Methods

Host plant collections- Potential host plants were selected and collected by Daria Hyde and Michael Penskar of the Michigan Natural Features Inventory with assistance from Peter J. Tolson, Candee L. Ellsworth of The Toledo Zoo, Michael DeCapita of the USFWS, and Todd Hogrefe of the Michigan Department of Natural Resources within the Barry County State Game Area in Barry County, MI. The first collections were made on 22 JUN 06 and included *C. leptalea*, *C. sterilis*, *Eleocharis elliptica*, *Panicum amplicatum*, and *Poa palustris*. *Carex stricta* has been under cultivation at the Zoo since 2003. Additional collections were made on 6 JUN 07 at the Lost Nations Game Area in Hillsdale County, MI and included *Carex buxbaumii, C. flava, C. lasiocarpa, C. prairea, C. tetanica*, and *Rhynchospora capillacea*.

Egg collection

2009- Fifteen eggs were collected on 8 JUL 09 from four females at Paw Paw Lake by Peter Tolson, Mitchell Magdich, and Candee Ellsworth of the Toledo Zoo and Nate Fuller of the Southwest Michigan Land Conservancy. Females were netted and placed overnight in a polyester-netted tub planted with *Carex* and forbs and were released unharmed.

Experimental setup

2009- We used the same 12” diameter Belvin bulb pans sparsely planted with the test grasses and sedges as in 2008. A plastic sleeve was installed around the plants and cap of chiffon fabric was placed over the top of the cylinder to increase ventilation. *Carex stricta* was always offered as one of the four plant species available to the larvae.

Monitoring- Satyr eggs were monitored twice per day for hatching and movement of the larvae to specific host plants.

Results

Hatching 2009 Of the fifteen eggs collected, partial hatching was observed on 17-18 JUL. Five eggs were infertile. Four larvae died attempting to hatch. Two larvae made it to the soil but died there almost immediately. The remaining four larvae were transferred to *C. stricta* but never fed and also died.

Discussion

Through the course of these experiments, the numbers of experimental subjects and replicates were limited by the numbers of larvae available to us. Although our USFWS permit would have allowed us to collect up to 60 eggs from wild females, the site chosen for collection near Paw-Paw was of very low productivity for eggs. We suggest that this locality may be reproductively compromised. We will propose increasing our take for *Neonympha* eggs to 100 for the 2010 field season from a more robust population.

Plants chosen for the trials were selected by Daria Hyde of the Michigan Natural Features Inventory. We had planned to use species of plants that larvae preferred: *C. stricta*, *C. prairea*, and *Panicum amplicatum*.

With the opening of a new $500,000 Butterfly Conservation Center at the Toledo Zoo in 2009, we have even greater potential to aid in the efforts to reintroduce N. m. mitchelli at selected fens in Michigan and Indiana. This new facility resulted in a record number of Karner blue butterflies produced in 2009- 1538 butterflies, more than double the old record of the 756 adults produced in 2008.

Appendix H: Rare Plant Survey Table: 2007 - 2009

County	Survey Site Name	Survey date	Surveyors	Rare Plant Targets	Rare plant species documented (updates in normal font new EOs in bold)
2007 data					
Cass	Cook Lake - Rudy Road Fen	05/23/2007	YL, KK, NH, LL	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	*Cypripedium candidum*
Hillsdale	Lost Nation State Game Area	06/06/2007	MP, CE	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	*Cypripedium candidum*
Jackson	Grand River Fen - Melling & Conin Tract	07/13/2007	MP, RO, DC, AF	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	***Muhlenbergia richardsonis, Geum virginianum***
Lenawee	Skiff Lake	07/13/2007	DC, MP, RO, AF	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	*Bessya bullii* on adjacent hillside prairie remnant
Washtenaw	Park Lyndon North	07/19/2007	MP, DC, MH	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	none
Washtenaw	McLaughlin Lake Fen, Waterloo Rec Area	07/19/2007	MP, DC, MH	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	none
Oakland	Big Crotched Lake	07/20/2007	DC, KK	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	***Muhlenbergia richardsonis***
Washtenaw	Mt. Hope Road Fen	07/26/2007	DC, MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	none
Washtenaw	Willis Road Fen	07/26/2007	DC, MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	***Sporobolus heterolepis***
Washtenaw	Long Lake Fen	07/27/2007	MP, DC	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	***Sporobolus heterolepis***
Livingston	Unadilla State Game Area	08/07/2007	MP, DC	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	none
Washtenaw	Glenn Road Fen	08/07/2007	MP, DC	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	none
Jackson	Grand River Fen	09/07/2007	DC	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	*Muhlenbergia richardsonis*
2008 Data					
Jackson	Little Portage Lake North	05/22/2008	BS, MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	none
Oakland	Rattalee Lake Road Fen - MNA	07/06/2009	DC	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	***Muhlenbergia richardsonis***
Washtenaw	Green Lake West (pipeline prairie)	07/15/2008	MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	***Angelica venenosa***
Washtenaw	Hankerd Lake Fen	07/16/2008	MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	none

Appendix H: Rare Plant Survey Table: 2007 - 2009

2008 Data continued					
Washtenaw	Green Lake Meadow	08/26/2008	DC, BS, MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	***Celtis tenuifolia***
Washtenaw	Sullivan Lake Fen	08/19/2008	MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	none
Washtenaw	Hadley Road Fen	08/20/2008	MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	none
Washtenaw	Hadley Road Fen	08/26/2008	DC, BS, MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	none
Washtenaw	Sullivan Lake Fen	08/26/2008	DC, BS, MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	none
Branch	Coldwater Lake Fen - Quimby Road	08/27/2009	MP, DH, SW	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	none
Washtenaw	Willis Road Fen	09/25/2008	DC, MP, MM	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	*Sporobolus heterolepis*
2009 Data					
Kalamazoo	Paw Paw Lake Fen	05/22/2009	YL, PB	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	*Cypripedium candidum*
Cass	Cook Lake - Rudy Road Fen (Thomas tract)	06/03/2009	MP, YL, JB	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	*Cacalia plantaginea, Cypripedium candidum*
Cass	Cook Lake - Rudy Road Fen (Jewell tract)	06/03/2009	MP, YL, JB	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	none
Cass	Cook Lake - Rudy Road Fen (Hassel tract)	06/03/2009	MP, YL, JB	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	*Cacalia plantaginea, Cypripedium candidum, Valeriana edulus* var. *ciliata*
Washtenaw	M-52 wet mesic prairie	06/04/2009	MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	***Cypripedium candidum***
Washtenaw	Hankerd Lake Fen	06/04/2009	MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	none
Washtenaw	Green Lake West (pipeline meadow #1)	06/04/2009	MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	none
Washtenaw	Green Lake West (pipeline meadow #2)	06/04/2009	MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	none
Washtenaw	Green Lake West (pipeline prairie)	06/04/2009	MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	*Angelica venenosa*
Berrien	Butternut Creek		YL	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	*Cacalia plantaginea*
Livingston	Unadilla State Game Area, McIntyre Lake	06/14/2009	MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	none
Livingston	Gregory State Game Area, Sheets Lake	06/16/2009	MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	none

Appendix H: Rare Plant Survey Table: 2007 - 2009

2009 Data continued					
Washtenaw	M-52 wet mesic prairie	07/02/2009	MP, RC	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	none
Washtenaw	Hadley Road Fen	07/02/2009	MP, RC	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	none
Washtenaw	McLaughlin Lake fen	07/02/2009	MP, RC	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	none
Jackson	Bayley's Fen	07/08/2009	DC, MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	*Muhlenbergia richardsonis, Sporobolus heterolepis*
Jackson	Dennis Neely Property	07/08/2009	DC, MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	none
Washtenaw	Hankerd Lake Fen	07/16/2009	MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	none
Cass	Lowe Foundation	07/07/2009	MP, MM, YL, JB	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	*Berula erecta*
Cass	Lagrange Valley Conservancy	07/07/2009	MP, MM, YL, JB, MH	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	***Plantanthera leucophaea***
Washtenaw	Hankerd Lake Fen	08/14/2009	DC, MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	none
Washtenaw	M-52 wet mesic prairie	08/14/2009	DC, MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	none
Jackson	Willis Road Fen	08/14/2009	DC, MP	prairie fen species and associated rare taxa of oak barrens in adjacent uplands	*Sporobolus heterolepis*

34 different sites visited, 46 total site visits with rare plant EOs documented

10 new EOs, 17 updates

Appendix I: Michigan Natural Features Inventory Papaipema Moth Survey Form

Survey Site:			Date _ _ _ _ - _ _ - _ _	Managed Area:
Surveyors:			overall start time :	
			overall end time :	
GPS coordinates of blacklight setup			Waypoint or file name:	

	Scientific Name																	Environmental Data							
Start time of the period																	TOTALS	temperature [C] [F]	relative humidity - %	wind speed - max [km/h] [mph]	wind speed - avg [km/h] [mph]	cloud cover - %	precipitation level	moon visibility	barometric pressure [kPa] [inHg]
1st hour :																									
2nd hour :																									
3rd hour :																									
4th hour :																									
5th hour :																									
6th hour :																									
7th hour :																									
TOTALS																									

Dominant Plant Species	

Notes/Comments/Diagrams

Michigan Natural Features Inventory Papaipema Moth Survey Form

Instructions

1) **Survey Site**: the name of the specific location (e.g. Brandt Rd fen)

2) **Managed Area**: the name of the state game area, rec area, or nature preserve (e.g. Holly SRA)

3) Please write times using the **24 hr clock**

4) Please use **decimal degrees** or **degrees/minutes/seconds**

5) Check the box to indicate what **units** were used for the **temperature** and **wind speed** data.

6) **Cloud cover** should be estimated to the nearest 10%.

7) **Precipitation level**: **0** = none **T** = trace **1** = light **2** = moderate **3** = heavy

8) **Moon visibility**: **0** = not visible at all - obscured by clouds, other features, or below the horizon
1 = partially obscured by clouds or other features (e.g. trees, buildings)
2 = completely visible

9) **Barometric pressure**: The barometric pressure may be recorded at the same time as other env. data, if possible, but at a minimum it should be looked up later for either the beginning or end of the overall sampling period and noted whether the pressure was rising, stable, or falling.

10) You may begin the survey at any time but begin the "2nd hour" interval when the next full hour starts (e.g. you begin the 1st hour at 20:30 but the "2nd hour" begins at 21:00 and every hour thereafter is on the hour). Next to each hour designation write in the start time of that period. **Note that the first and last 1 hour periods may be partial hours so be sure to record the start and end times.**

11) You may place a small tick or question mark in the appropriate box when a known or suspect moth is collected or observed (e.g. a possible silphim borer is collected during the "3rd hour" so a "?" is marked under P. silphii next to "3rd hour"). Specimens collected within the same 1 hour period may be kept in the same kill jar and transferred later to reclosable storage bags with a slip indicating date, location, sampling period/time, and collector(s). Specimens will be ID'd later in the lab and the total number of each species will be written in the appropriate sampling hour row/column.

Papaipema spp. in Michgan in order by Hodges Number (special concern, threatened, or endangered are in bold):

(SC) *cerina* (Grt., 1874)
cataphracta (Grt., 1864)
aerata (Lyman, 1901)
arctivorens Hamp., 1910
harrisii (Grt., 1881)
impecuniosa (Grt., 1881)
verona (Sm., 1899)
astuta Bird, 1907
leucostigma (Harr., 1841)
lysimachiae Bird, 1914
pterisii Bird, 1907
(SC) *speciosissima* (G. & R., 1868)
inquaesita (G. & R., 1868)
rutila (Gn., 1852)
baptisiae (Bird, 1902)
nr. *Birdi* (Dyar, 1908)
nepheleptena (Dyar, 1908)
circumlucens (Sm., 1899)
appassionata (Harv., 1876)
furcata (Sm., 1899)
nebris (Gn., 1852)
necopina (Grt., 1876)
(T) *silphii* Bird, 1915
(SC) *maritima* Bird, 1909
eupatorii (Lyman, 1905)
nelita (Stkr., 1898)
rigida (Grt., 1877)
(SC) *aweme* (Lyman, 1908)
cerussata (Grt., 1864)
(SC) *sciata* Bird, 1908
limpida (Gn., 1852)
(SC) *beeriana* Bird, 1923
unimoda (Sm., 1894)

Appendix J: Rare Insect Surveys: 2007-2009

County	Survey Site Name	Survey date	Surveyors	Animal Targets	Rare animal species observed, documented (updates in normal font new EOs in bold)
2007 data					
Lenawee	Goose Creek Grasslands - MNA	07/01/2007	DC	Swamp metalmark	
Oakland	Brandt Road Fen (Holly Fen)	07/09/2007	DC, KK	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
Oakland	Bridge Valley	07/09/2007	DC, RO, KK, DK, AF	Poweshiek skipper, swamp metalmark	
Oakland	Rattalee Lake Road	07/09/2007	DC, KK	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
Livingston	Big Valley - MNA	07/10/2007	RO, AF	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
Oakland	Bullard Lake	07/10/2007	RO, AF	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
Oakland	Halsted Lake Fen	07/10/2007	DC, KK	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
Jackson	Long Lake Fen	07/10/2007	DC, KK	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
Oakland	Grand River Fen - TNC (Liberty Fen)	07/11/2007	BB	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
Oakland	Long Lake Fen	07/11/2007	DC, KK	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
Livingston	Rattalee Lake Road Fen - MNA	07/11/2007	DC, KK	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
Washtenaw	Whalen Lake	07/11/2007	DC, KK	Poweshiek skipper, swamp metalmark	
Washtenaw	Park Lyndon North	07/12/2007	DC, KK, AF	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
Jackson	Snyder Lake Fen West	07/12/2007	DC, KK, AF	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
Jackson	Grand River Fen - Melling/Connin Tracts	07/13/2007	DC, MP, RO, AF	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
Lenawee	Skiff Lake	07/13/2007	DC, MP, RO, AF	Poweshiek skipper, swamp metalmark	*Neonympha mitchellii*
Hillsdale	Goose Creek Grasslands - MNA	07/15/2007	DC	Poweshiek skipper, swamp metalmark	*Oarisma poweshiek*
Washtenaw	Lost Nation SGA	07/17/2007	DC, KK	Poweshiek skipper, swamp metalmark	*Calephelis mutica*
Washtenaw	McLaughlin Lake fen - Waterloo RA	07/19/2007	DC, MP, MH	Poweshiek skipper, swamp metalmark, rare leafhoppers, spittlebugs	
Oakland	Park Lyndon North	07/19/2007	DC, MP, MH	Poweshiek skipper, swamp metalmark, rare leafhoppers, spittlebugs	*Lepyronia angulifera, Prosapia ignipectus*
Oakland	Big Crotched Lake Fen	07/20/2007	DC, KK	Poweshiek skipper, swamp metalmark, rare leafhoppers, spittlebugs	***Prosapia ignipectus***
Oakland	Long Lake Fen	07/20/2007	DC, KK	Poweshiek skipper, swamp metalmark, rare leafhoppers, spittlebugs	***Lepyronia angulifera,*** *Prosapia ignipectus, Flexamia huroni*
Oakland	Big Valley - MNA	07/25/2007	DC, KK	swamp metalmark, rare leafhoppers, spittlebugs	***Flexamia huroni, Prosapia ignipectus***
Livingston	Bridge Valley	07/26/2007	KK	swamp metalmark, rare leafhoppers, spittlebugs	***Flexamia huroni***
Washtenaw	Bullard Lake	07/26/2007	KK	swamp metalmark, rare leafhoppers, spittlebugs	

2007 data continued					
Washtenaw	Long Lake Fen	07/26/2007	DC, MP	Swamp metalmark	
Washtenaw	Mt. Hope Road Fen	07/26/2007	DC, MP	Swamp metalmark	
Washtenaw	Willis Road Fen	07/26/2007	DC, MP	swamp metalmark, rare leafhoppers, spittlebugs	
Washtenaw	Long Lake Fen	07/27/2007	DC, MP	Rare leafhoppers, spittlebugs	***Prosapia ignipectus***
Cass	Mt. Hope Road Fen	07/27/2007	DC, MP	Rare leafhoppers, spittlebugs	
Cass	Skidmore Property	07/27/2007	KK	swamp metalmark, rare leafhoppers, spittlebugs	
Barry	Wakalee Fen (Tamarack Swamp)	07/27/2007	KK	swamp metalmark, rare leafhoppers, spittlebugs	
Barry	Turner Creek South	07/30/2007	DC	swamp metalmark, rare leafhoppers, spittlebugs	*Lepyronia angulifera*
Cass	Bowen Mills Road	07/31/2007	DC	swamp metalmark, rare leafhoppers, spittlebugs	***Dorydiella kansana***
Berrien	Affrezio Tract	08/05/2007	DC	swamp metalmark, rare leafhoppers, spittlebugs	***Prosapia ignipectus***
Cass	Butternut Creek	08/05/2007	DC	swamp metalmark, rare leafhoppers, spittlebugs	
Washtenaw	Hassle Tract	08/05/2007	DC	swamp metalmark, rare leafhoppers, spittlebugs	
Livingston	Glenn Road Fen	08/07/2007	DC, MP	swamp metalmark, rare leafhoppers, spittlebugs	
Oakland	Unadilla SGA	08/07/2007	DC, MP	swamp metalmark, rare leafhoppers, spittlebugs	
Oakland	Golden Preserve	08/27/2007	DC	swamp metalmark, rare leafhoppers, spittlebugs, tree crickets	***Oecanthus laricis***
Barry	Rattalee Lake Road Fen - MNA	08/27/2007	DC	swamp metalmark, rare leafhoppers, spittlebugs	***Lepyronia angulifera***
Allegan	Turner Creek South	09/05/2007	DC	Papaipema moths	*Lepyronia angulifera,* ***Dorydiella kansana***
Jackson	Jackson Lake Fen (Ebersole)	09/06/2007	DC	Papaipema moths	
Oakland	Grand River Fen (Connin Tract)	09/07/2007	DC	Papaipema moths	***Papaipema beeriana***
Oakland	Long Lake Fen	09/17/2007	DC, RO	Papaipema moths	
Washtenaw	Big Valley - MNA	09/18/2007	DC, DK	Papaipema moths	***Papaipema beeriana***
Jackson	Willis Road Fen	09/20/2007	DC, KB	Papaipema moths	
Oakland	Grand River Fen - TNC (Liberty Fen)	09/23/2007	DC	Papaipema moths	*Papaipema beeriana*
Oakland	Brandt Road Fen	09/24/2007	DC	Papaipema moths	
Oakland	Brandt Road Fen	07/01/2008	DC	Poweshiek skipper	*Oarisma poweshiek*
Oakland	Bridge Valley	07/04/2008	DC	Poweshiek skipper	*Flexamia huroni*

2008 Data					
Oakland	Halsted Lake	07/04/2008	DC	Poweshiek skipper	*Oarisma poweshiek*
Oakland	Long Lake Fen (Eaton Road)	07/04/2008	DC	Poweshiek skipper	*Lepyronia angulifera*, *Prosapia ignipectus, Flexamia huroni*
Oakland	Big Valley - MNA	07/06/2008	DC	Poweshiek skipper	*Flexamia huroni, Prosapia ignipectus*
Livingston	Bullard Lake - MNA	07/06/2008	DC	Poweshiek skipper	
Livingston	Fenton Road	07/06/2008	DC	Poweshiek skipper	
Oakland	Rattalee Lake Road Fen - MNA	07/06/2008	DC	Poweshiek skipper	*Poweshiek skipperling*
Jackson	Grand River Fen - Connin Tract	07/08/2008	DC, BS	Poweshiek skipper	*Oarisma poweshiek, Mitchell's satyr*
Jackson	Grand River Fen - TNC	07/08/2008	DC, BS	Poweshiek skipper	*Oarisma poweshiek, Mitchell's satyr*
Hillsdale	Goose Creek Grasslands - MNA	07/10/2008	DC	Poweshiek skipper	*Oarisma poweshiek*
Washtenaw	Park Lyndon North	07/10/2008	DC	Poweshiek skipper, rare leafhoppers, spittlebugs	*Lepyronia angulifera, Prosapia ignipectus,* ***Oecanthus laricis, Dorydiella kansana***
Jackson	Fowlkes Tract - TNC	08/18/2008	DC	Poweshiek skipper	
Washtenaw	Park Lyndon North	08/20/2008	DC	Rare leafhoppers, spittlebugs, tree crickets	***Dorydiella kansana***, *Lepyronia angulifera,* ***Oecanthus laricis***
Washtenaw	Green Lake Meadow	08/26/2008	DC, BS, MP	Rare leafhoppers, spittlebugs, tree crickets	***Oecanthus laricis***
Washtenaw	Hadley Road Fen	08/26/2008	DC, BS, MP	Rare leafhoppers, spittlebugs, tree crickets	***Oecanthus laricis***
Washtenaw	Sullivan Lake Fen	08/26/2008	DC, BS, MP	Rare leafhoppers, spittlebugs, tree crickets	***Lepyronia angulifera, Dorydiella kansana***
Kent	Lamberton Lake Fen	08/27/2008	DC	Poweshiek skipper	***Oecanthus laricis, Lepyronia angulifera***
Van Buren	Jeptha Lake Fen	08/28/2008	DC, NF	Rare leafhoppers, spittlebugs, tree crickets	***Oecanthus pini, Dorydiella kansana***
Van Buren	Lime Lake/Portman Tract	08/28/2008	DC, BS, NF, TB	Rare leafhoppers, spittlebugs, tree crickets	***Lepyronia angulifera, Lepyronia gibbosa, Oecanthus laricis***
Kalamazoo	Paw Paw Prairie Fen	08/29/2008	DC, MS, BS, SC	Rare leafhoppers, spittlebugs, tree crickets	***Lepyronia angulifera***, ***Oecanthus laricis***
Calhoun	Mott Road Fen (Custer)	09/18/2008	DC	Papaipema moths	
Van Buren	Lime Lake/Portman Tract	09/22/2008	DC, NF	Papaipema moths	
Jackson	Fowlkes Tract - TNC	09/23/2008	DC	Papaipema moths	***Papaipema beeriana***
Jackson	McCreedy Fen (MSU)	09/24/2008	DC, AF	Papaipema moths	
Washtenaw	Willis Road Fen	09/25/2008	DC, MP, MM	Papaipema moths	
Oakland	Brandt Road Fen	09/26/2008	DC, MM	Papaipema moths	
Van Buren	Jeptha Lake Fen	10/02/2008	DC	Papaipema moths	
Van Buren	Paw Paw Prairie Fen - TNC	10/07/2008	DC, YL	Papaipema moths	***Papaipema beeriana***

2009 Data					
Jackson	Grand River Fen - TNC (Liberty Fen)	05/07/2009	DC	Poweshiek skipper, swamp metalmark	Oarisma poweshiek, Mitchell's satyr
Oakland	Brandt Road Fen	06/29/2009	DC	Poweshiek skipper, swamp metalmark	Oarisma poweshiek
Jackson	Grand River Fen - TNC (Liberty Fen)	07/03/2009	DC	Poweshiek skipper, swamp metalmark	Oarisma poweshiek
Jackson	Liberty Fen - Connin Tract	07/03/2009	DC	Poweshiek skipper, swamp metalmark	
Jackson	Liberty Fen - Melling Tract	07/03/2009	DC	Poweshiek skipper, swamp metalmark	Oarisma poweshiek
Lenawee	Goose Creek Grasslands - MNA	07/05/2009	DC	Poweshiek skipper, swamp metalmark	Oarisma poweshiek
Oakland	Brandt Road Fen	07/06/2009	DC	Poweshiek skipper, swamp metalmark	Oarisma poweshiek
Oakland	Big Valley - MNA	07/07/2009	DC, HP	Poweshiek skipper, swamp metalmark	Oarisma poweshiek
Jackson	Bayley's Fen	07/08/2009	DC, MP	Poweshiek skipper, swamp metalmark	
Jackson	Dennis Neely Property	07/08/2009	DC, MP	Poweshiek skipper, swamp metalmark	
Oakland	Long Lake - NW unit	07/09/2009	DC	Poweshiek skipper, swamp metalmark	Oarisma poweshiek
Oakland	Long Lake - SE unit	07/09/2009	DC	Poweshiek skipper, swamp metalmark	Oarisma poweshiek
Oakland	Long Lake - SW unit	07/09/2009	DC	Poweshiek skipper, swamp metalmark	Oarisma poweshiek
Jackson	Grand River Fen - Connin Tract	07/11/2009	DC	Poweshiek skipper, swamp metalmark	Oarisma poweshiek
Oakland	Long Lake - Central unit	07/13/2009	DC	Poweshiek skipper, swamp metalmark	Oarisma poweshiek
Oakland	Ratalee Road Fen - MNA	07/13/2009	DC	Poweshiek skipper, swamp metalmark	Oarisma poweshiek
Livingston	Bullard Lake Fen - MNA	07/14/2009	DC	Poweshiek skipper, swamp metalmark	
Washtenaw	Park Lyndon North	07/14/2009	DC	Poweshiek skipper, swamp metalmark	Oarisma poweshiek
Oakland	Whalen Lake	07/14/2009	DC	Poweshiek skipper, swamp metalmark	
Jackson	Grand River Fen - Weaver's	08/03/2009	DC, BS, DK	swamp metalmark	
Hillsdale	Lost Nation SGA	08/03/2009	DC, BS, DK	swamp metalmark	
Lenawee	Goose Creek Grasslands - MNA	08/04/2009	DC, DK	swamp metalmark	
Lenawee	Ives Road Fen - TNC	08/04/2009	DC, DK	swamp metalmark	
Van Buren	67th Avenue/Paw Paw Fen	08/06/2009	DC, BS, DK	swamp metalmark	Lepyronia angulifera, Prosapia ignipectus
Barry	Yankee Springs	08/06/2009	DC, BS, DK	swamp metalmark	
Jackson	Grand River Fen - TNC (Liberty Fen)	08/07/2009	DC	swamp metalmark	Prosapia ignipectus, Lepyronia angulifera
Washtenaw	Hankerd Lake Fen	08/14/2009	DC, MP	rare leafhoppers, spittlebugs	***Prosapia ignipectus, Dorydiella kansana***
Washtenaw	Long Lake Fen (M-52 wet mesic prairie)	08/14/2009	DC, MP	rare leafhoppers, spittlebugs	Prosapia ignipectus
Jackson	Willis Road Fen	08/14/2009	DC, MP	rare leafhoppers, spittlebugs	***Prosapia ignipectus***
St. Joseph	Three Rivers SGA	08/21/2009	DC	Papaipema moths	***Papaipema maritima, Papaipema cerina***
Cass	SWMLC Hassel Tract	09/24/2009	DC	Papaipema moths	
Jackson	Willis Road Fen	09/27/2009	DC	Papaipema moths	
Oakland	Brandt Road Fen	09/30/2009	DC	Papaipema moths	
Kalamazoo	Paw Paw Lake	10/01/2009	DC	Papaipema moths	

Appendix K. MITCHELL'S SATYR HCP SPECIAL ANIMAL SURVEY FORM

I. LOCATION INFORMATION

Landowner_____ Site Name_____ Date_____

Surveyor(s) _____

Quad_____County_____ Town, Range, Sec_____

Directions/access _____

_____

II. SURVEY INFORMATION

Time Start _____ Time End _____ Weather: Start Air Temp _____ End Air Temp _____

% Sun _____ Wind _____ Precip _____ Comments _____

Rare species searched for & survey method_____

Rare species found _____

Species found (common or rare)	Number	Location (GPS, landmarks)	Notes (habitat, behavior, condition, etc.)

Survey comments (area surveyed, potential for other rare species, revisit warranted, photos taken? etc.)

_____

_____

_____

III. GENERAL SITE DESCRIPTION (describe in relation to species surveyed for – presence, quantity, and quality of appropriate habitat, crayfish burrows, hostplants/nectar sources, dominant vegetation, natural communities, habitat structure, etc.)

_____

_____

_____

_____

_____

IV. MANAGEMENT CONSIDERATIONS

Threats (e.g., ORV's, excessive mt. bike use, grazing, structures, past logging, plantations, development, erosion, ag, runoff, hydrologic alteration, etc.) _____

_____

Exotic species (plants or animals)_____

_____

_____

Stewardship Comments _____

_____

_____

V. LISTED ANIMAL OR PLANT SPECIES or COMMUNITY EOS _____

_____

_____

VI. ADDITIONAL ASSOCIATED SPECIES FOUND

Species found (common or rare)	Number	Location (GPS, landmarks)	Notes (habitat, behavior, condition, etc.)

VII. Map/drawing of general area surveyed and approximate locations of suitable habitat and/or rare species found

Mitchell's Satyr HCP Coverboard Survey Form

Survey Date: _____ **County:** _____ **Surveyors:** _____

Survey Start Time: _____ **Site:** _____ **T, R, S:** _____

Survey End Time: _____ **Location:** _____ **Landowner:** _____

Beginning Weather: **Air temp (°F):** _____ **Sky Code:** _____ **Wind Code:** _____

Rel. humidity (%): _____ **Precipitation Code:** _____ **Last Rain Event:** _____

CB #	Large / Small	Crayfish Burrows (& #)	Worms / Ants	Snakes	Comments
1	L S	Y N			
2	L S	Y N			
3	L S	Y N			
4	L S	Y N			
5	L S	Y N			
6	L S	Y N			
7	L S	Y N			
8	L S	Y N			
9	L S	Y N			
10	L S	Y N			
11	L S	Y N			
12	L S	Y N			
13	L S	Y N			
14	L S	Y N			
15	L S	Y N			
16	L S	Y N			
17	L S	Y N			
18	L S	Y N			
19	L S	Y N			
20	L S	Y N			

Ending Weather: **Air temp (°F):** _____ **Sky Code:** _____ **Wind Code:** _____

Rel. humidity (%): _____ **Precipitation Code:** _____ **Crayfish Burrow Density:** High / Medium / Low / Not Observed

Appendix L.

Other Species Present: List additional species observed at this site. Note especially listed species and potential predators. :

Species:	Number observed	Notes, observations, etc.

Directions to survey site and location if first time to site/location and how to access survey site/location:

Attach map, air photo or drawing indicating survey area, survey routes and locations of massasaugas and/or suitable habitat.

Sky Codes:

0 = Sunny/clear to few clouds (0-5% cloud cover)
1 = Mostly sunny (5-25% cloud cover)
2 = Partly cloudy, mixed or variable sky (25-50%)
3 = Mostly cloudy (50-75%)
4 = Overcast (75-100%)
5 = Fog or haze

Wind Codes (Beaufort wind scale):

0 = Calm (< 1 mph) smoke rises vertically
1 = Light air (1-3 mph) smoke drifts, weather vane inactive
2 = Light breeze (4-7 mph) leaves rustle, can feel wind on face
3 = Gentle breeze (8-12 mph) leaves and twigs move, small flag extends
4 = Moderate breeze (13-18 mph) moves small tree branches, twigs & leaves, raises loose paper
5 = Strong breeze (19-24 mph) small trees sway, branches move, dust blows
6 = Windy (> 24 mph) larger tree branches move, whistling

Precipitation Codes:

0 = None
1 = Mist
2 = Light rain or drizzle
3 = Heavy rain
4 = Snow/hail

Macrohabitats:

PFO = Palustrine Forested Wetland: standing water at least part of the year, tree canopy cover exceeds 30%.
PSS = Palustrine Scrub-Shrub Wetland: shrub cover exceeds 30%, but tree cover does not.
SDG = Palustrine Emergent Wetland dominated by sedges.
CAT = Palustrine Emergent Wetland dominated by cattails.
UFO = Upland Forest: >30% tree canopy cover, elevated above any potential flooding by sloping topography.
USS = Upland Scrub-Shrub: berry bushes, willows, crab apples and hawthorns, typically mid-succession.
OLD = Oldfield: fallow fields covered with herbaceous or grassy cover, includes CRP lands.

MNFI Amphibian Calling/Cricket Frog Survey Form

Survey Date: _____ **County:** _____ **Surveyors:** _____

Survey Start Time: _____ **Site:** _____ **T, R, S:** _____

Survey End Time: _____ MS HCP LIP Known BLCR Site? **Landowner(s):** _____

Beginning Weather: **Air temp (°F):** _____ **Sky Code:** _____ **Wind Code:** _____ **Rain last 48 hours?** Yes No

Rel. humidity (%): _____ **Precipitation Code:** _____ **Moonlight?** Yes No

Stop #	Location Description	T, R, S	Start Time	End Time	Habitat*	Species - Call Index (0, 1, 2, 3)	Comments (known site?)

Ending Weather: **Air temp (°F):** _____ **Sky Code:** _____ **Wind Code:** _____

Rel. humidity (%): _____ **Precipitation Code:** _____

*Habitat description and/or macrohabitat categories

Appendix M.

Directions to survey site and locations if first time to site/location or comments on how to access survey site/location:

Attach map, air photo, or drawing indicating survey area, survey routes, and locations of cricket frogs and/or suitable habitat.

Sky Codes:

0 = Sunny/clear to few clouds (0-5% cloud cover)
1 = Mostly sunny (5-25% cloud cover)
2 = Partly cloudy, mixed or variable sky (25-50%)
3 = Mostly cloudy (50-75%)
4 = Overcast (75-100%)
5 = Fog or haze

Wind Codes (Beaufort wind scale):

0 = Calm (< 1 mph) smoke rises vertically
1 = Light air (1-3 mph) smoke drifts, weather vane inactive
2 = Light breeze (4-7 mph) leaves rustle, can feel wind on face
3 = Gentle breeze (8-12 mph) leaves and twigs move, small flag extends
4 = Moderate breeze (13-18 mph) moves small tree branches, twigs & leaves, raises loose paper
5 = Strong breeze (19-24 mph) small trees sway, branches move, dust blows
6 = Windy (> 24 mph) larger tree branches move, whistling

Precipitation Codes:

0 = None
1 = Mist
2 = Light rain or drizzle
3 = Heavy rain
4 = Snow/hail

Macrohabitats:

PFO = Palustrine Forested Wetland: standing water at least part of the year, tree canopy cover > 30%; dominants >=6 m (20 ft).
PSS = Palustrine Scrub-Shrub Wetland: shrub cover exceeds 30%, but tree cover does not; dominants <6 m (20 ft) tall.
POW = Palustrine Open Water; water not flowing, area < 8 ha (~20 ac), water <2m (6.6 ft) deep.
LOW = Lacustrine Open Water; water not flowing, area >= 8 ha (20 ac), water >= 2 m (6.6 ft)
SDG = Palustrine Emergent Wetland dominated by sedges.
CAT = Palustrine Emergent Wetland dominated by cattails.
UFO = Upland Forest: >30% tree canopy cover, elevated above any potential flooding by sloping topography.
USS = Upland Scrub-Shrub: berry bushes, willows, crab apples and hawthorns, typically mid-succession.
OLD = Oldfield: fallow fields covered with herbaceous or grassy cover, includes CRP lands.

Amphibian Call Codes (by species):

0 = no calls of the given species
1 = individuals of the species can be counted; space between calls; separate, distinct calls
2 = some overlapping calls of the species
3 = full chorus of the species; calls constant, continuous, and overlapping

Appendix N. Associated Herps Survey Table 2007-2009.

County	Survey Site Name	Survey Date	Surveyors	Animal Targets	Rare animal species documented (updates in normal font new EOs in bold)	Additional Comments (threats, other species of note found, etc.)
2007 Data						
Barry	Bowens Mill Road Fen/Barry SGA	06/01/2007	KK	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle		Visual surveys. Green Frogs and Map Turtle found. Reed canary grass.
		08/02/2007	KK	Eastern Massasauga, Eastern Box Turtle, Blanding's Turtle		Visual surveys. Green Frogs, Spring Peepers, and Northern Ribbon Snakes found. Reed canary grass and cattails.
Barry	Deep Lake Fen Uplands/Barry SGA	08/13/2007	KK	Eastern Massasauga, Eastern Box Turtle		Visual surveys. Dry, open uplands. Spotted knapweed and autumn olive present.
Barry	Deep Lake Fen/Barry SGA	05/25/2007	KK	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle		Visual surveys. Autumn olive and reed canary grass present.
Barry	Snow Lake/Barry SGA	08/13/2007	KK	Eastern Massasauga, Eastern Box Turtle		Visual surveys. Wet meadow. Reed canary grass invading. Green Frogs found.
Barry	Stream between Shaw Lake and Bassett Lake/Barry SGA	08/14/2007	YL, KK	Eastern Massasauga, Eastern Box Turtle		Visual surveys. Wet meadow. Cattails, purple loosestrife, and Phragmites present. Also shrub encroachment occurring.
Barry	Turner Creek - Bassett Lake Southwest/Barry SGA	06/01/2007	KK	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle		Visual surveys and set 20 coverboards. Many Green Frogs found.
		06/22/2007	KK	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle		Visual surveys and checked coverboards. Bullfrog heard calling.
		07/05/2007	KK, NH	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle		Visual surveys and checked coverboards. American Toad found.
		08/14/2007	YL, KK	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle		Visual surveys and checked coverboards
Barry	Turner Creek /Barry SGA	05/25/2007	KK	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle	*Eastern Massasauga*	Visual surveys. Surveyed multiple areas along Turner Ck.. Massasauga found on adjacent private property. Many Green Frogs found.
		08/13/2007	KK	Eastern Massasauga, Eastern Box Turtle		Visual surveys. Surveyed upland old fields planted with prairie grasses and wildflowers. Little to no cover for snakes. Spotted knapweed and autumn olive present.
Berrien	Blue Creek Fen (TNC)	06/20/2007	KK	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle		Visual surveys. Red-backed Salamander found under log.
Berrien	Butternut Creek	05/24/2007	KK, NH	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle	*Eastern Box Turtle*	Visual surveys

Appendix N. Associated Herps Survey Table 2007-2009.

2007 data continued						
		06/05/2007	KK	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle	*Eastern Box Turtle*	Visual surveys and set 21 coverboards. Surveyed west of County Line Rd. Brown Snake, Spring Peeper, and Green Frog also were observed.
		06/19/2007	YL, KK	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle		Visual surveys and checked coverboards
		06/28/2007	YL, BY, CH	Mitchell's satyr, Eastern Massasauga, Eastern Box Turtle, Spotted Turtle	*Eastern Box Turtle*	Mitchell's satyr surveys. Visual herp surveys.
Berrien	Butternut Creek (cont.)	08/09/2007	KK	Eastern Massasauga, Eastern Box Turtle, Kirtland's Snake		Visual surveys and coverboard check. Surveyed W. and E. side of County Line Rd. Many Green frogs along creek and woody encroachment by dogwood on E. side of road.
Cass	Cook Lake-Rudy Road Fen (SWMLC-Hassel)	05/23/2007	YL, KK, NH, LL	Eastern Massasauga, Eastern Box Turtle		Visual surveys. Found new EO of small white lady-slipper (*Cypripedium candidum)*
Cass	Lime Lake and vicinity (9 locations)	06/19/2007	YL, KK	Blanchard's Cricket Frog		Evening frog call surveys. Green Frogs and Bullfrogs heard calling.
Cass	Priest Lake and vicinity (3 locations)	06/19/2007	YL, KK	Blanchard's Cricket Frog		Evening frog call surveys. Green Frogs and Bullfrogs heard calling.
		05/24/2007	KK, NH	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle	*Eastern Box Turtle*	Visual surveys
		06/06/2007	KK, BC	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle		Visual surveys and set 21 coverboards. Juvenile Eastern Garter Snake found.
		06/19/2007	YL, KK	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle		Visual surveys and checked coverboards.
		07/04/2007	BY, DC	Mitchell's satyr	*Eastern Massasauga*	Mitchell's satyr surveys.
		08/09/2007	KK	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle		Visual surveys and checked coverboards.
Cass	Shavehead Lake/Camp Friedenswald	09/25/2007	YL, DC	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle		Visual surveys and checked coverboards.
Cass	Shavehead Lake/Camp Friedenswald and vicinity (9 locations)	06/19/2007	YL, KK	Blanchard's Cricket Frog		Evening frog call surveys. Green Frogs and Bullfrogs heard calling.
Jackson	Grand River Fen (East)	05/31/2007	YL, KK	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle		Visual surveys and set 20 coverboards. Northern Leopard Frog found. Eastern Massasauga and Spotted Turtle reported on property by landowner.
Jackson	Skiff Lake Fen (West)	06/14/2007	KK	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle, Blanchard's Cricket Frog		Visual surveys. American Toad, Green Frogs, and Northern Leopard Frogs found. Very shrubby fen.

Appendix N. Associated Herps Survey Table 2007-2009.

2007 data continued						
Jackson	Skiff Lake Fen (East)	06/14/2007	KK	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle, Blanchard's Cricket Frog		Visual surveys. Northern Leopard Frogs, Green Frogs, Bullfrog, Eastern Garter Snake, Northern Water Snake, and Painted Turtles found. Exotics found - garlic mustard, reed canary grass, autumn olive, and buckthorn.
Kalamazoo	Bear Creek - Fulton SGA	08/10/2007	KK	Eastern Massasauga, Eastern Box Turtle		Visual surveys. Surveyed three areas within the game area. Green Frogs found. Autumn olive and purple loosestrife.
Kalamazoo	Bear Creek (Castleman, N. of Fulton SGA)	08/10/2007	KK	Eastern Massasauga, Eastern Box Turtle		Visual surveys
Kalamazoo	Paw Paw Lake Fen - Boat launch	06/18/2007	KK, NH	Blanchard's Cricket Frog	*Blanchard's Cricket Frog*	Evening frog call surveys. Heard cricket frogs calling (call index 2). Bullfrogs also heard.
Kalamazoo	Paw Paw Lake Fen/Palmer Memorial Preserve (MNA)	06/11/2007	KK	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle, Blanchard's Cricket Frog	*Blanchard's Cricket Frog*	Visual surveys and set 19 coverboards. N. Water Snake, Musk Turtle, Painted Turtle, Map Turtle, toad metamorphs, Green Frogs, N. Leopard Frogs, and Bullfrog seen. Buckthorn.
		06/20/2007	KK	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Blanding's Turtle, Spotted Turtle, Blanchard's Cricket Frog		Visual surveys and checked coverboards. Found a small "black" snake under coverboard but escaped before could identify. Green Frogs also observed.
		07/05/2007	KK	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Blanding's Turtle, Blanchard's Cricket Frog		Visual surveys and checked coverboards. Found garter snake skin/shed under a coverboard.
		08/03/2007	KK	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Blanding's Turtle, Blanchard's Cricket Frog	*Eastern Box Turtle, Blanchard's Cricket Frog*	Visual surveys and checked coverboards. Snapping Turtle, Green Frogs, N. Water Snake, E. Garter Snakes (under coverboards), Painted Turtle, and Bullfrog also observed.
		08/15/2007	YL, KK	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Blanding's Turtle, Blanchard's Cricket Frog		Visual surveys and checked coverboards. Two Northern Brown Snakes and three Eastern Garter Snakes were found under coverboards.
		08/16/2007	NH	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Blanding's Turtle, Blanchard's Cricket Frog		Visual surveys and checked coverboards. Two Northern Brown Snakes and three Eastern Garter Snakes were found under same coverboards as on 8/15/07.
Kalamazoo	Springbrook Fen (North)	08/15/2007	KK	Eastern Massasauga, Eastern Box Turtle, Blanding's Turtle		Visual surveys. Only small amount of habitat for massasaugas. Narrowleaf cattail invading from road.
Kalamazoo	Springbrook Fen (South)	08/15/2007	KK	Eastern Massasauga, Eastern Box Turtle, Blanding's Turtle		Visual surveys. Green Frogs in stream. Little potential for supporting massasaugas. Narrow-leaved cattail and buckthorn invading.
Kalamazoo	Springbrook Fen (Mid)	08/15/2007	KK	Eastern Massasauga, Eastern Box Turtle, Blanding's Turtle		Visual surveys. Green Frogs, Spring Peeper, N. Water Snake, and E. Garter Snake found. Buckthorn and spotted knapweed.

Appendix N. Associated Herps Survey Table 2007-2009.

2007 data continued						
		06/13/2007	KK	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle, Blanchard's Cricket Frog	*Eastern Box Turtle, Eastern Massasauga, Blanchard's Cricket Frog*	Visual surveys and set 20 coverboards for Kirtlands Snake. Found 2 box turtles, 1 massasauga, 1 cricket frog, heard 2-3 calling.
Kalamazoo	Vanderbilt Fen - Gourdneck SGA	08/16/2007	NH	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Blanding's Turtle, Blanchard's Cricket Frog		Visual surveys and checked coverboards. Painted Turtles and Green Frogs found.Glossy buckthorn and purple loosestrife.
Kalamazoo	Vanderbilt Fen/Gourdneck SGA and vicinity (2 locations)	06/18/2007	KK, NH	Blanchard's Cricket Frog	*Blanchard's Cricket Frog*	Evening frog call surveys. Heard cricket frog calling at Vanderbilt Ave (call index 1). Green Frogs and Bullfrogs heard too.
Oakland	Long Lake	08/01/2007	KK, NH	Eastern Massasauga, Eastern Box Turtle, Blanding's Turtle		Visual surveys. N. Brown Snakes, E. Garter Snakes, N. Leopard Frogs, Green Frogs, Bullfrogs, and Am. Toad documented. Mat muhly found at new location farther W. than when Dave and Kile surveyed site.
Van Buren	Lime Lake Fen and vicinity (5 locations)	06/18/2007	KK, NH	Blanchard's Cricket Frog		Evening frog call surveys. Green Frogs and Bullfrogs heard calling.
Van Buren	Paw Paw Conservation District and vicinity (4 locations)	06/18/2007	KK, NH	Blanchard's Cricket Frog		Evening frog call surveys. Green Frogs and Bullfrogs heard calling.
Van Buren	Paw Paw Prairie Fen and vicinity (5 locations)	06/18/2007	KK, NH	Blanchard's Cricket Frog		Evening frog call surveys. Green Frogs and Bullfrogs heard calling.
		05/30/2007	YL, KK, DI	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle		Visual surveys and set 20 coverboards. Wood Frog found. May have been too hot for visual surveys for herps.
		06/20/2007	YL, BB, DK	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle		Visual surveys and checked coverboards.
		06/29/2007	YL, DK, TH	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle		Visual surveys and checked coverboards. Found one Red-bellied Snake under a coverboard.
		07/10/2007	YL, KB	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Blanding's Turtle		Visual surveys and checked coverboards.
Washtenaw	Mill Creek East	08/17/2007	YL, DC	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle		Visual surveys and checked coverboards. Two Brown Snakes found under two coverboards.

Surveyors:

BB - Barbara Barton, MNFI
BC - Brad Cogdell, Land Manager
BY - Brad Yocum, MNDI Seasonal
CH - Chris Hoving, MDNR Wildlife Division
DC - David Cuthrell, MNFI
DI - Dick Irwin, Landowner/Volunteer
DK - Dan Kennedy, MDNR Wildlife Division
KB - Kim Borland, MNFI Seasonal
KK - Kile Kucher, MNFI Seasonal
LL - Larry Lyons, Volunteer
NH - Nathan Herbert, MNFI Seasonal
TH - Todd Hogrefe, MDNR Wildlife Division
YL - Yu Man Lee, MNFI

Appendix N. Associated Herps Survey Table 2007-2009.

County	Survey Site Name	Survey date	Surveyors	Animal Targets	Rare animal species observed, documented (updates in normal font new EOs in bold)	Additional Comments (threats, other species of note found, etc.)
2008 Data						
Barry	Turner Creek - Bassett Lake Southwest/Barry SGA	05/20/2008	BB, HE	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle		Visual surveys and checked coverboards
		09/08/2008	MS	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle		Visual surveys and checked coverboards. Northern Leopard Frogs found throughout site, and garter snake shed found under a coverboard.
Berrien	Butternut Creek	04/23/2008	YL, BB	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle		Visual surveys and checked coverboards. Surveyed west and east side of County Line Rd. Am. Toad and Gray Treefrog heard calling on W.side of County Line Rd. Dead Blue Racer found on E side of road.
		09/05/2008	DC, MS	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle		Visual surveys and checked coverboards
Cass	Shavehead Lake/Camp Friedenswald	05/23/2008	BB, BC	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle		Visual surveys and checked coverboards. Found three Eastern Garter Snakes near/next to coverboards and a Green Frog.
		09/19/2008	MS, BC	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle		Visual surveys and checked coverboards. Wood Frog observed.
Jackson	Concord Lake Fen	05/09/2008	BB, DK	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle		Visual surveys. Northern Water Snake found.
Jackson	Grand River Fen (East)	05/15/2008	BB	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle		Visual surveys and checked coverboards. Green Frog and American Toad found.
		09/10/2008	MS	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle		Visual surveys and checked coverboards. Two E. Garter Snakes found under small coverboard. N. Leopard Frogs found throughout site.
Jackson	Skiff Lake (East)	06/06/2008	BB	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle		Visual surveys. Northern Leopard Frogs and Northern Water Snake found.
Kalamazoo	Paw Paw Lake Fen/Palmer Preserve	05/08/2008	YL, BB	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle	*Blanchard's Cricket Frog*	Visual surveys and checked coverboards. Found one cricket frog in fen.
		08/29/2008	DC, MS	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle		Visual surveys and checked coverboards. Garter Snake skin shed found under one of the coverboards. Green Frogs also found throughout site.
Kalamazoo	Vanderbilt Fen - Gourdneck SGA	05/08/2008	YL, BB	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle		Visual surveys and checked coverboards. E. Hognose found stretched out on hummock.

Appendix N. Associated Herps Survey Table 2007-2009.

2008 Data (cont.)						
Kalamazoo	Vanderbilt Fen - Gourdneck SGA	09/05/2008	DC, MS	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle		Visual surveys and checked coverboards. Garter Snake skin shed found under coverboard.
Washtenaw	Mill Creek East	04/24/2008	BB, DI	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Spotted Turtle, Blanding's Turtle		Visual surveys and checked coverboards.
		09/02/2008	BB, MS	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle		Visual surveys and checked coverboards.

Surveyors:

BB - Barbara Barton, MNFI

BC - Brad Cogdell, Land Manager/Volunteer

DC - David Cuthrell, MNFI

DI - Dick Irwin, Landowner/Volunteer

DK - Dan Kennedy, MDNR Wildlife Division

HE = Helen Enander, MNFI

MS = Mike Sanders, MNFI Seasonal

YL - Yu Man Lee, MNFI

County	Survey Site Name	Survey date	Surveyors	Animal Targets	Rare animal species observed, documented (updates in normal font new EOs in bold)	Additional Comments (threats, other species of note found, etc.)
2009 Data						
Barry	Turner Creek - Bassett Lake Southwest/Barry SGA	06/02/2009	YL, PB	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Crayfish, Land Snails, Aquatic Snails		Visual surveys, checked coverboards.Steady rain during survey; not suitable conditions for rare herp survey. Crayfish and snail survey results will be provided later.
		11/08/2009	YL, KN	Kirtland's Snake		Checked and removed coverboards. Juvenile Map Turtle observed on log along lakeshore.
Barry	Turner Creek/Barry SGA	06/02/2009	YL, PB	Eastern Massasauga, Eastern Box Turtle, Crayfish, Land & Aquatic Snails		Visual surveys. Am. Toad and N. Ribbon Snake found. Crayfish & snail survey results provided later.
Berrien	Butternut Creek	06/09/2009	YL, PB	Eastern Massasauga, Eastern Box Turtle, Kirtland's Snake, Spotted Turtle, Crayfish, Land Snails, Aquatic snails	*Eastern Box Turtle*	Visual surveys. Four Eastern Box Turtles found. Common herp species found include E. Hognose, Blue Racer and potentially a Red-Backed Salamander. Crayfish found walking.Crayfish and snail survey results will be provided later. Cacalia plantaginea found.

Appendix N. Associated Herps Survey Table 2007-2009.

2009 Data (cont)						
		07/03/2009	YL, JB	Eastern Massasauga, Eastern Box Turtle, Kirtland's Snake, Mitchell's satyr	*Eastern Massasauga*	Visual surveys and Mitchell's satyr surveys. Massasauga found in preserve on east side of County Line Rd. Also found probably 200+ Cacalia plantaginea on both sides of the road.
Berrien	Butternut Creek (cont.)	10/14/2009	YL	Eastern Massasauga, Kirtland's Snake		Removed coverboards, too cold for snakes.
Cass	Cook Lake-Rudy Road Fen (private)	06/03/2009	YL, PB, MP	Eastern Massasauga, Eastern Box Turtle, Blanding's Turtle, Spotted Turtle, Crayfish, Land Snails, Aquatic Snails, Rare Plants	*Eastern Box Turtle*	Visual surveys. Northern Ribbon Snake found. Glossy buckthorn present. Crayfish and snail survey results will be provided later.
Cass	Cook Lake-Rudy Road Fen (SWMLC and private)	06/03/2009	YL, PB, MP	Eastern Massasauga, Eastern Box Turtle, Blanding's Turtle, Spotted Turtle, Crayfish, Land Snails, Aquatic Snails, Rare Plants		Visual surveys. Eastern Garter Snakes and several rare plants found. Crayfish and snail survey results provided later. Garlic mustard in the uplands. Several rare plants were found.
Cass	Cook Lake-Rudy Road Fen (SWMLC-private)	06/03/2009	YL, PB, MP	Eastern Massasauga, Eastern Box Turtle, Crayfish, Land Snails, Aquatic Snails, Rare Plants		Visual surveys. Shrub/woody encroachment. Crayfish and snail survey results provided later. Cypripedium candidum found.
Cass	LaGrange Lake/Big Rock Valley (Ed Lowe Foundation)	07/07/2009	YL, MP, JB, MC	Eastern Massasauga, Eastern Box Turtle, Mitchell's satyr		Visual surveys and Mitchell's satyr surveys.
Cass	LaGrange Lake/LaGrange Valley Conservancy	07/07/2009	YL, MP, JB, MH	Eastern Massasauga, Eastern Box Turtle, Mitchell's satyr		Visual surveys and Mitchell's satyr surveys. Found prairie-fringed orchid (~5-6 plants).
Cass	Mill Creek West (private)	07/03/2009	YL, JB	Eastern Massasauga, Eastern Box Turtle, Mitchell's satyr		Visual surveys and Mitchell's satyr surveys
		07/02/2009	YL, JB	Eastern Massasauga, Eastern Box Turtle, Mitchell's satyr		Visual surveys and Mitchell's satyr surveys
Cass	Shavehead Lake/Camp Friedenswald	10/20/2009	YL	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle		Visual surveys. Checked and removed coverboards. Weather warm enough to see herps.
Cass	Thompson Lake	07/02/2009	YL, JB	Eastern Massasauga, Eastern Box Turtle, Mitchell's satyr		Visual surveys and Mitchell's satyr surveys
Cass/ St. Joseph	Mill Creek West (Three Rivers SGA & Zimont)	05/04/2009	YL, PB	Eastern Massasauga, Eastern Box Turtle, Blanding's Turtle, Spotted Turtle, Rare Mussels, Crayfish, Land Snails, Aquatic Snails	*Rainbow (mussel)*	Visual surveys N. and S. of Norton Rd. Mussel surveys in Wood Creek NE of Norton Rd. only. Green Frogs found. Shells and/or live specimens of several mussel species found including: rainbow (SC), cylindrical papershell, spike, wabash pigtoe, fatmucket, pocketbook, giant floater, and strange floater. Crayfish and snail results will be provided later. Cattails and Phragmites present - not sure native or exotic.
Jackson	Grand River Fen (TNC)	06/11/2009	YL, PB	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle, Crayfish, Land Snails, Aquatic snails		Visual surveys. N. Leopard Frog found. Drizzle and then intermittent rain - not ideal survey condition for herps. Crayfish and snail survey results will be provided later.

Appendix N. Associated Herps Survey Table 2007-2009.

2009 Data (cont)						
Jackson	Grand River Fen (TNC)	07/08/2009	YL, HP, BB, TD, DM	Eastern Massasauga, Eastern Box Turtle, Micthell's satyr		Visual surveys and Mitchell's satyr surveys. Poweshiek skippers observed.
Kalamazoo	Eagle Lake/Ft. Custer SRA	09/12/2009	YL	Eastern Massasauga, Eastern Box Turtle		Visual surveys. Green Frogs found.
Kalamazoo	Paw Paw Lake Fen/Palmer Memorial Preserve (MNA)	05/22/2009	YL, PB	Eastern Massasauga, Eastern Box Turtle, Blanding's Turtle, Spotted Turtle, Blanchard's Cricket Frog, Crayfish, Land Snails, Aquatic Snails	*Blanchard's Cricket Frog*	Visual surveys. Blanchard's Cricket Frogs heard calling along lakeshore. N. Ribbon Snake, N. Water Snake, Softshell Turtle, Musk Turtle, and Map Turtle observed. Crayfish and snail survey results provided later.
Kalamazoo	Paw Paw Lake Fen(Private & MNA)	05/22/2009	YL, PB	Eastern Massasauga, Eastern Box Turtle, Blanding's Turtle, Spotted Turtle, Blanchard's Cricket Frog, Crayfish, Land Snails, Aquatic Snails	*Blanchard's Cricket Frog*	Visual surveys. Heard cricket frog calling along lakeshore. Also found N. Ribbon Snake. Crayfish and snail survey results will be provided later. Found Cypripedium candidum.
		07/06/2009	YL, HP	Eastern Massasauga, Eastern Box Turtle, Mitchell's satyr		Visual surveys and Mitchell's satyr surveys. Reed canary grass, glossy buckthorn, and cattails observed.
Kalamazoo	Springbrook Fen (North)	07/06/2009	YL, HP	Eastern Massasauga, Eastern Box Turtle, Mitchell's satyr		Visual surveys and Mitchell's satyr surveys
Kalamazoo	Vanderbilt Fen/Gourdneck SGA	05/04/2009	BF	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Blanding's Turtle, Spotted Turtle	*Kirtland's Snake, Spotted Turtle*	Visual surveys and checked coverboards. Also has found Eastern Massasaugas at this site during visual surveys and coverboard surveys during 2008-2009.
		May 2009	BF	Eastern Massasauga, Kirtland's Snake, Eastern Box Turtle, Blanding's Turtle, Spotted Turtle	*Eastern Massasauga*	Visual surveys and checked coverboards. Two Eastern Massasaugas found at this site during visual surveys and coverboard surveys.
Kalamazoo	Whitford and Lawler Lakes/Ft. Custer SRA	09/12/2009	YL	Eastern Massasauga, Eastern Box Turtle	*Blanchard's Cricket Frog*	Visual surveys. Massasauga and Blanchard's Cricket Frog reported from this area previously. Cricket frog found along trail at stream crossing west of the lakes and east of the road.
Oakland	Big Valley	07/07/2009	DC, HP	Poweshiek skipper*	*Eastern Massasauga*	*Incidental massasauga observation during Poweshiek skipper survey
St. Joseph	Cade Lake Fen	07/14/2009	YL, HP	Eastern Massasauga, Eastern Box Turtle, Blanding's Turtle, Mitchell's satyr and prairie fen		Visual surveys and Mitchell's satyr surveys. Found fen habitat, but no satyr or rare herps.
Van Buren	Lime Lake/Cedar Creek Fen (Private/SWMLC)	05/20/2009	YL, PB, NF	Eastern Massasauga, Eastern Box Turtle, Blanding's Turtle, Spotted Turtle, Crayfish, Land Snails, Aquatic Snails		Visual surveys. Eastern Garter Snakes and Eastern Hognose Snake found. Crayfish and snail survey results will be provided later.

Appendix N. Associated Herps Survey Table 2007-2009.

2009 Data (cont)						
		06/12/2009	YL, PB, DI	Eastern Massasauga, Eastern Box Turtle, Spotted Turtle, Rare Mussels, Crayfish, Land Snails, Aquatic Snails	*Slippershell (mussel)*	Visual surveys and checked and removed coverboards. Slippershell mussel (T) found during mussel surveys in the creek. Spike and cylindrical papershell also found. Brown Snake, Red-bellied Snake, Green Frogs, and Wood Frogs found. Crayfish and snail survey results will be provided later.
Wastenaw	Mill Creek East	07/09/2009	YL, JB	Eastern Massasauga, Eastern Box Turtle, Micthell's satyr		Visual surveys and Mitchell's satyr surveys.

Surveyors:

BB - Barbara Barton, MNFI
BF - Bill Flanagan, Volunteer
DC - David Cuthrell, MNFI
DI - Dick Irwin, Landowner/Volunteer
DM - Doug McQuarter, Volunteer
HP - Henry Pointon, Volunteer
JB - John Bagley, Volunteer
KN - Keenan Noyes, Volunteer
MC - Michael McCustion, Land Manager
MH - Mark Harrison, Landowner
MP - Mike Penskar, MNFI
PB - Peter Badra, MNFI
TD - Tameka Dandredge, USWFS
YL - Yu Man Lee, MNFI

Appendix 0: Fen Survey Table: 2007 - 2009

Survey Site	County	Survey date	Surveyors	EO number (new Eos in bold)	Old rank/ new rank	Notes
Algoe Lake Prairie Fen	Lapeer	07/11/2008	Brad Slaughter	107	B/B	Took photos. Brief walk-through.
Bear Creek Wetlands	St. Joseph	06/19/2008	Brad Slaughter	no EO	N/A	Negative survey for fen.
Brandt Road Fen	Oakland	07/11/2008	Brad Slaughter	111	B/B	Updated species list.
		07/06/2009	David Cuthrell	111	?	Updated EO-Expand EO to the north
Bullard Lake	Livingston	05/16/2007	Brad Slaughter, Ryan O'Connor, Dan Kennedy, Nathan Herbert	**149**	**new/BC**	New prairie fen EO.
Buss Road Fen	Washtenaw	06/25/2008	Brad Slaughter, Ryan O'Connor, Dan Kennedy, Tom Tucker	**154**	**new/B**	New prairie fen EO with southern wet meadow inclusion.
		07/09/2008	Brad Slaughter, Dave Cuthrell, Dan Kennedy	**154**	new/B	New prairie fen EO with southern wet meadow inclusion.
		09/09/2008	Brad Slaughter	**154**	new/B	New prairie fen EO with southern wet meadow inclusion.
Cade Lake Fen	St. Joseph	10/22/2009	Michael Kost	**159**	**new/D**	New EO
Collins Property	Hillsdale	09/03/2008	Brad Slaughter, Ed Schools	no EO	N/A	negative survey for fen.
Grand River Fen	Jackson	07/08/2008	Dave Cuthrell, Brad Slaughter	52	A/A	Confirmed rank
		07/08/2008	Dave Cuthrell, Brad Slaughter	52	A/A	Confirmed rank
Green Lake Meadow	Washtenaw	08/26/2008	Dave Cuthrell, Mike Penskar, Brad Slaughter	no EO	N/A	no EO.

Appendix 0: Fen Survey Table: 2007 - 2009

Survey Site	County	Survey date	Surveyors	EO number (new Eos in bold)	Old rank/new rank	Notes
Hadley Road Fen	Washtenaw	08/26/2008	Dave Cuthrell, Mike Penskar, Brad Slaughter	**156**	**new/BC**	Lumped with Sullivan Lake for new prairie fen EO.
Hill Creek Fen	Barry	09/02/2008	Brad Slaughter, Mike Kost, Mark MacKay	122	B/B	Documented new plant EO. Brief walk-through.
Jephtha Lake Fen	Van Buren	08/31/2007	Brad Slaughter	**146**	**new/BC**	New prairie fen EO on marl lakebed. Previously surveyed for rare insects (YL, RC 1999).
Lime Lake/Cedar Creek Fen	Van Buren	07/03/2008	Brad Slaughter, Tyler Bassett, Nate Fuller, Chris Hamm	**153**	**new/B**	New prairie fen EO.
Little Goose Lake Fen	Lenawee	07/25/2008	Brad Slaughter	137	BC/B	Updated rank and Tracker.
Lost Nation Fen	Hillsdale	07/25/2008	Brad Slaughter, Kristin Bissell	109	B/BC	Downgraded based on significant invasion. Updated species list and Tracker.
Mt. Hope Rd. Fen	Jackson	09/29/2008	Brad Slaughter	77	B/B	Tested soils to determine if wet mesic prairie occurred within complex. Did not document any WMP.
Otis Sanctuary	Barry	10/07/2009	Michael Kost	no EO yet		Not fen EO, will revisit in 2010. May write up a small area as fen and the rest as tamarack swamp.
Palmatier Lake/ Werner Lake Fen	Barry	10/08/2009	Michael Kost	**158**	BC	New EO
Park Lyndon Fen	Washtenaw	07/16/2008	Brad Slaughter	22	B/B	Updated species list.
Paw Paw Lake	Kalamazoo	08/29/2008	Dave Cuthrell, Mike Sanders, Brad Slaughter, S. Campbell	108	B/B	Updated species list, remapped. Notes lost.

Look-alikes

There are a number of more common butterflies that occur in similar habitats and are frequently mistaken for the Mitchell's satyr:

Appalachian Eyed brown
Satyrodes appalachia

- Larger
- Lighter brown, tan
- Lacks orange bands
- Extra eyespot on leading edge of hindwing
- The related Eyed Brown is similar

Wood nymph
Cercyonis pegala

- Larger, darker
- Only one or two eye spots on forewing
- Lacks orange bands

Little wood satyr
Megisto cymela

- Similar in size
- Only two eye spots per wing
- Lacks orange bands

✳ Butterflies on this page approximately life size

Private lands & Mitchell's satyr

Because the Mitchell's satyr occurs on private lands, landowner participation in conserving this endangered species is critical to successful species recovery. To learn about incentives for managing your land in ways that benefit this endangered species and protect your interests:

In Michigan:
MDNR Landowner Incentive Program:
(517) 373-1263
http://www.michigan.gov/dnrlip

USFWS Federal Private Lands Program:
http://endangered.fws.gov/landowner/index.html

Learn more:

The Mitchell's Satyr Habitat Conservation Plan

A plan is being developed to help conserve the butterfly and its habitat in Michigan and Indiana. For information on progress in conserving Mitchell's satyr, as well as background on its biology and habitat, visit:

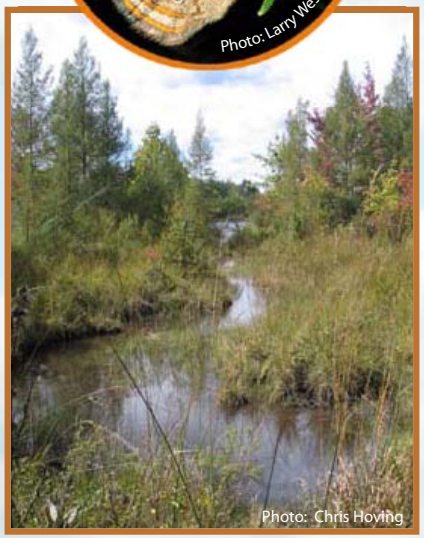
http://www.michigan.gov/dnrnongame

In Michigan:
Endangered Species Coordinator
Phone : (517) 373-1263
Email: hogrefet@michigan.gov

In Indiana:
Lee Casebere - Indiana DNR
Phone : (317) 232-4053
Email: Lcasebere@dnr.in.gov

Michigan Natural Features Inventory

Mitchell's Satyr



Neonympha mitchellii mitchellii (French)

The Mitchell's satyr is protected under federal law because it is in danger of becoming extinct in the near future.

What does a Mitchell's satyr look like?

The Mitchell's satyr is a medium-sized, dark brown butterfly, with a wingspan that ranges from 1.5 inches to 1.75 inches . The undersides of its wings each have a row of four or five eye-spots, ringed by two orange bands. The three central eyespots on its hindwing are largest.

Where does it live?

The Mitchell's satyr is restricted to a unique type of wetland called a fen, that is fed by carbonate-rich ground water from seeps and springs. Typically, sites where it occurs are dominated by narrow-leaved sedges (such as *Carex stricta*), often in areas with scattered tamarack and poison sumac.


Photo: Daria Hyde

Why are Mitchell's satyrs so rare?

Loss of its unique wetland habitat is the greatest threat to the Mitchell's satyr—many sites have been altered or drained completely. Habitats were maintained historically by low-intensity fires and flooding by beavers. In the absence of these disturbances, trees, shrubs and invasives such as glossy buckthorn can shade out the satyr's food plant. Digging ponds, filling wetlands and installing drain tiles in adjacent fields can change water quality and flow through these wetlands.

Distribution

Although found in several states historically, the Mitchell's satyr is currently known from only 19 sites in southern Michigan and northern Indiana.

Life cycle . . .

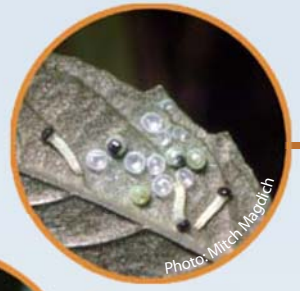


Photo: Mitch Magdich

Eggs

In July, females lay their miniscule eggs close to the ground, on tiny plants. The eggs hatch in seven to eleven days.

* Life cycle photos larger than actual size.


Photo: Mitch Magdich

Caterpillars

The caterpillars are very small and difficult to find. They feed on tussock sedge (*Carex stricta*) and other fine-leaved sedges and grasses. The species overwinters as a caterpillar, close to the ground.


Photo: Larry West

Chrysalis

After overwintering, the caterpillars resume eating until they form a chrysalis in June. Although they do not eat or move, many changes occur internally.

Butterfly

The adult butterflies emerge from their chrysalises in late June and live for only a few weeks. Males emerge a few days before females. During their flight period, they mate, lay eggs, and die.

When can I see Mitchell's satyrs?

Mitchell's satyr adults fly for only three weeks in late June through mid-July. They are often seen flying low over vegetation, with a characteristic slow, bobbing flight.


Photo: Mindy Walker

Where can I see Mitchell's satyrs?

Sarrett Nature Center, in Benton Harbor, Michigan has a boardwalk for easy viewing of the satyr and its habitat.

For more information:
Phone: (269) 927-4832
http://www.sarett.com/

Exploring the Prairie Fen Wetlands of Michigan

Michael A. Kost and Daria A. Hyde

Blank front cover

MICHIGAN STATE
UNIVERSITY
EXTENSION

E-3045 • New • November 2009

Exploring the Prairie Fen Wetlands of Michigan

by

Michael A. Kost and Daria A. Hyde

Bradford S. Slaughter, MNFI

Contributing Authors:

Peter J. Badra, Barbara J. Barton, David L. Cuthrell, Amy L. Derosier,
Yu Man Lee, Jack D. McGowan-Stinski, Ryan P. O'Connor,
Douglas R. Pearsall, Steven S. Woods

Michigan
Natural
Features
Inventory

www.msue.msu.edu/mnfi

ISBN 1-56525-023-0

Kost, Michael A., and D.A.Hyde. 2009. Exploring the Prairie Fen Wetlands of Michigan.
Extension Bulletin E-3045.
East Lansing, Mich.: Michigan Natural Features Inventory,
Michigan State University Extension.

Produced by ANR Communications

Acknowledgements

We offer our sincere thanks and gratitude to the many individuals and organizations whose contributions and support made this publication possible. For lending their invaluable expertise to this book, we offer our appreciation to the following contributing authors: Peter Badra, Barbara Barton, David Cuthrell, Amy Derosier, Yu Man Lee, Ryan O'Connor, Douglas Pearsall, Jack McGowan-Stinski and Steven Woods. We are sincerely grateful for the creative advice and technical support of our colleague Suzan Campbell, who organized numerous photographs and lent her critical eye to the editing, layout and organization of this book. We appreciate the excellent technical skills of Helen Enander, MNFI's mapmaker extraordinaire. Thanks also to Connie Brinson, Kraig Korroch, Suzanne Ridge and Nancy Toben for their critical administrative support of this project.

We are grateful to the photographers and graphic artists who generously provided their photos and drawings for use in this publication. Their images evoke the beauty and wonder of prairie fens and help to describe the complexity and richness of these communities. We have provided a list of photo and graphic sources at the end of this book. We thank Christopher Hoving, Michigan DNR; Douglas Pearsall, TNC; Virginia Hambric; and our colleagues at MNFI, Joshua Cohen, Yu Man Lee, Ryan O'Connor and Bradford Slaughter, for their insightful editorial comments and suggestions. We are thankful for the helpful advice and guidance offered by Nate Fuller and Larry Lyons, Southwest Michigan Land Conservancy, and our MNFI colleagues Dennis Albert, David Cuthrell, Michael Monfils and Mike Penskar.

We gratefully acknowledge the support and expertise of our partners at the Michigan DNR, especially Stephen Beyer, Todd Hogrefe and Christopher Hoving; our colleagues at the U.S. Fish and Wildlife Service (USFWS), Tameka Dandridge and Carrie Tansy; as well as members of the Mitchell's Satyr Working Group. Their commitment to the conservation of prairie fens is truly inspiring. Funding for this publication was provided by the Michigan DNR through a grant from the USFWS as well as MSU Extension's Program Development Fund. Finally, we gratefully acknowledge staff members at ANR Communications at MSU, especially Leslie Johnson for her detailed editorial review, Ken Fettig for his guidance on this project, and Alicia Burnell for bringing our words, ideas and photographs to life through her artistic design of this publication.

Table of contents

Michael A. Kost, MNFI

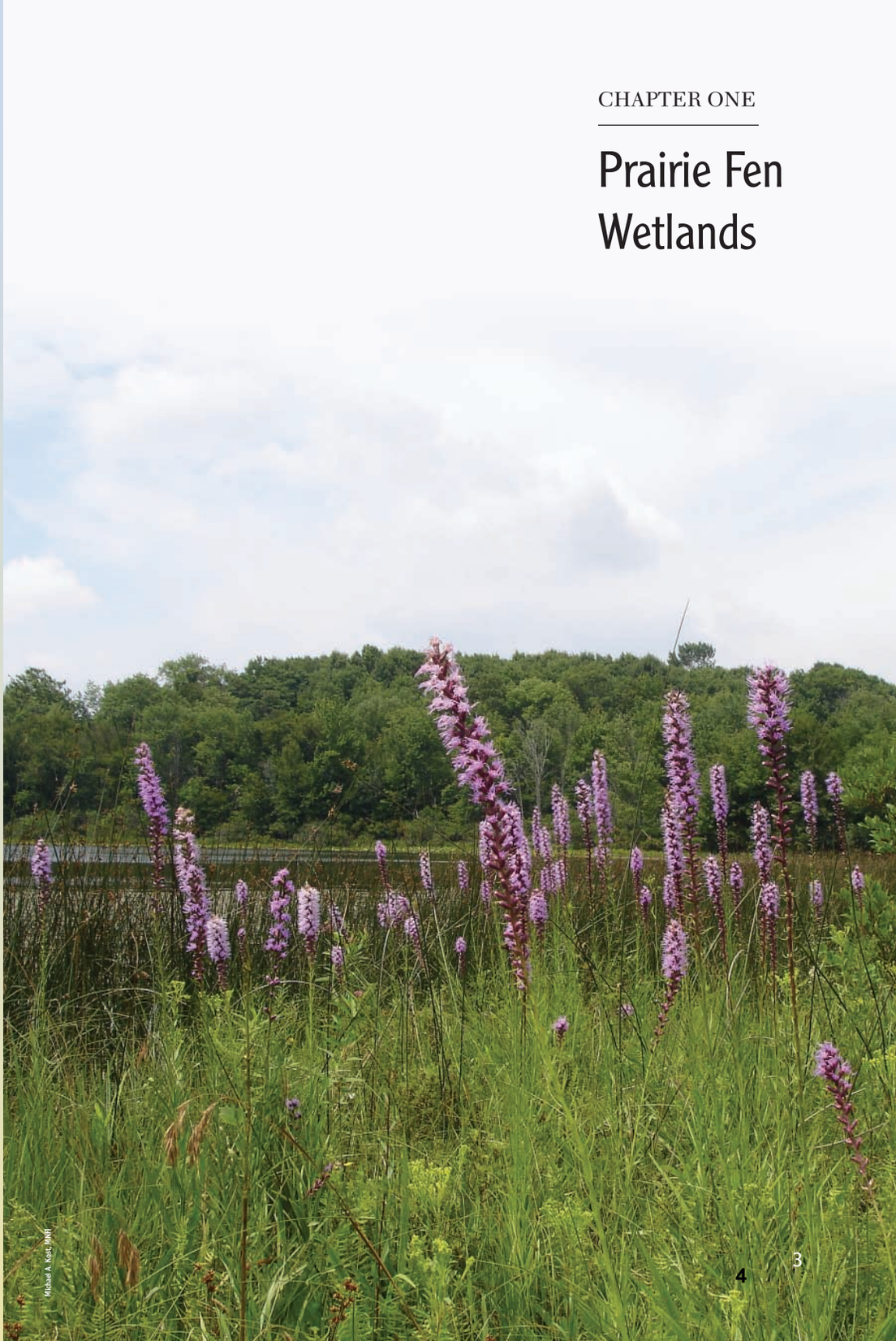
Introduction

Nestled within wet depressions among the rolling hills of southern Lower Michigan, prairie fen wetlands are one of Michigan's biological treasures. These globally rare wetlands are dominated by sedges and grasses and provide habitat to hundreds of native plants and animals. In addition to being incredibly rich in biological diversity, prairie fens form the pristine headwaters of many of the region's rivers and lakes. The streams and lakes that emanate from prairie fens sustain countless species and provide recreational activities cherished by swimmers, boaters and anglers. These wetland communities serve as a rich biological reservoir and form a critical component of the natural landscape of southern Michigan.

Walking through a prairie fen is an amazing experience at any time of the year. The community comes alive in spring with the boisterous calls of mating frogs and toads, melodious songs of nesting birds and colorful blooms of wildflowers. During summer, the sounds of tree crickets and other insects fill the air, and a beautiful array of butterflies, moths and flowering plants forms a dazzling spectacle of color. In fall, migrating songbirds and waterfowl descend on prairie fens to feed on berries and aquatic plants and take refuge among the groves of shrubs and trees and isolated lakes. It is during this time of year that the needles of tamarack, Michigan's only native deciduous conifer tree, turn from bright green to golden yellow, bringing yet another striking display of color to prairie fens. With winter comes a blanket of white and near silence, softly accentuated by the constant gurgling of tiny streams that flow continuously from the many springs that form this unique native ecosystem.

CHAPTER ONE

Prairie Fen Wetlands



Michael A. Kost, MNFI

What is a prairie fen wetland?

A prairie fen is a type of peatland through which flows a continuous supply of cold groundwater rich in calcium and magnesium carbonates. An abundance of groundwater springs and seeps ensures that wet conditions prevail throughout the year. The constantly saturated conditions prevent the breakdown of plant matter, which accumulates year after year, eventually forming loose peat soils. The name "prairie fen" became widely used for describing the fens located within the prairie peninsula region of the Midwest because the community contains many wildflowers and grasses commonly observed in prairies. Prairie fens occur in the glaciated regions of the upper Midwest, predominantly in southern Ontario, Canada, and Michigan, Ohio, Indiana, Illinois, Wisconsin and Minnesota.

Several other types of fens are known to occur in northern Michigan, including northern fen, coastal fen, poor fen and patterned fen. These natural communities are described in detail in "Natural Communities of Michigan: Classification and Description," which is available through the Michigan Natural Features Inventory Web site.

Spicebush swallowtail nectaring on swamp milkweed.

Michael A. Kost, MNFI

Why are prairie fens important?

Like many wetlands, prairie fens deliver critically important ecological services: providing clean water for streams and lakes, storing and slowly releasing storm and floodwaters, and serving as habitat for a broad diversity of plants and animals. Through the process

of photosynthesis, the rich plant community of prairie fens releases oxygen (O_2) and water to the atmosphere, providing clean air for breathing and moisture for rainfall. Plants also release clean water vapor to the atmosphere through both respiration and transpiration. Another critical benefit provided by plants through photosynthesis is the removal of carbon dioxide (CO_2), a greenhouse gas, from the atmosphere. In a process known as carbon sequestration, much of the carbon removed from the atmosphere through photosynthesis becomes incorporated into plant tissue, where it is eventually stored for thousands of years in the organic (peat) soils of prairie fens.

In addition to providing habitat for wildlife and clean air and water, prairie fens serve as places for people to connect with and be nourished by nature. Filled with a dazzling array of plant and animal life, prairie fens make exceptional outdoor classrooms for studying the natural world. Whether people visit for bird watching, botanizing, hunting, fishing or quietly exploring nature, these

Michael A. Kost, MNFI

rich wetlands provide places where people can unplug from the hustle and bustle of modern life and be renewed. Prairie fens offer opportunities to spend time with nature, surrounded by life in all its glory, and connect with something much greater than oneself.

We hope the following discussion of the ecology and conservation of prairie fens will inspire readers to visit a prairie fen and become involved in conservation efforts to protect and manage these special wetlands.