

Vegetation Characteristics of Mitchell's Satyr (*Neonympha mitchellii mitchellii*) Habitat



Prepared by:
Michael A. Kost, Ecologist

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

For:
U.S. Fish and Wildlife Service
Region 3 Endangered Species Office
Federal Building, Fort Snelling
Twin Cities, MN 55111

March 31, 2000

Report Number 2000-08



TABLE OF CONTENTS

TABLE OF FIGURES.....i

TABLE OF TABLES.....i

TABLE OF APPENDICIESii

ACKNOWLEDGEMENTS.....1

INTRODUCTION2

METHODS.....2

RESULTS.....5

DISCUSSION.....9

LITERATURE CITED.....10

TABLE OF FIGURES

Figure 1. The southern Michigan interlobate region is illustrated by the pink, purple, and tan area in the southwest and central, southeast portions of the state. Prairie fens occur throughout this area but are seldom found beyond the interlobate region. The red dots indicate present and past Mitchell’s satyr occurrences. Acronyms indicate vegetation sampling sites: Branch County, B; Barry County South, BS; Barry County Southwest, BW; Cass County Southwest, CW; St. Joseph County East, SE; St. Joseph County West, SW; Van Buren County Northeast, VE. (Ferrand and Bell 1982)3

Figure 2. DCA of species cover within plots (n=15). Ordination was performed using PC-ORD version 4 (McCune and Mefford 1999). Species are represented by diamonds and plots by triangles. Plot abbreviations are as follows: B1 and B2, Branch County plots 1 and 2; BS, Barry County South; BW1 and BW2, Barry County Southwest plots 1 and 2; CW1, CW2 and CW3, Cass County Southwest plots 1,2 and 3; SE1 and SE2, St. Joseph County East plots 1 and 2; SW1, SW2 and SW3, St. Joseph County West plots 1, 2 and 3; VE1 and VE2, Van Buren County Northeast plots 1 and 2.7

TABLE OF TABLES

Table 1. Woody strata and ground layer characteristics. Percent cover was estimated by cover class for each attribute below.4

Table 2. Sorensen coefficients comparing plot percent similarity based on species presence (Barbour et al. 1980).8

Table 3. Sorensen Community Coefficients comparing site percent similarity (Barbour et al. 1980). Data for analysis consisted of species presence within all plots and sites.8

TABLE OF APPENDICIES

Appendix 1. Species list for sites and plots. Numbers represent cover class values: 1 = trace, 2 = 0-1% cover, 3 = 1-2% cover, 4 = 2-5% cover, 5 = 5-10% cover, 6 = 10-25% cover, 7 = 25-50% cover, 8 = 50-75% cover, 9 = 75-95% cover, 10 = >95% cover. Note: 1% cover = 1 m x 1 m; trace = .01% cover or less (10 cm x 10 cm or less). Scientific names in capital letters indicate non-native and adventive species. <T> indicates state threatened species and <SC> indicates species of special concern. Species lists were derived using the Floristic Quality Assessment program and plot FQI values are given at bottom of appendix (Herman et al. 1996).	13
Appendix 2. Species list sorted by site (n=7) and plot (n=15) percent frequencies. Importance values were derived by summing the relative plot percent frequency and relative percent cover for each species. .21	
Appendix 3. Strata percent cover by plot. See Table 2 for strata descriptions. Values represent cover class mid-points (see text for cover classes).....	25

ACKNOWLEDGEMENTS

Field assistance was provided by Michigan Natural Features Inventory biologists Mike Penskar, Phyllis Higman, Yu Man Lee, Dave Cuthrell, Jeff Cooper and Daria Hyde. Valuable advice on sampling design and research methods was provided by Dennis Albert, Sue Galatowitsch, Don Faber-Langendean and Jennifer Szymanski. Mary Rabe and Mike Penskar provided many helpful suggestions that improved this report. Kraig Korroch wrote an MS Excel macro to calculate community coefficients. Lorri Peltz-Lewis assisted with Figure 1. Janet Hayward produced the report cover.

Funding for this project is a contribution of Federal Aid in Endangered Species, Michigan Project E-1-29.

INTRODUCTION

The Mitchell's satyr butterfly (*Neonympha mitchellii mitchellii*) is listed with the U.S. Fish and Wildlife Service as a federally endangered species. Records indicate that historically the butterfly occurred in southern Michigan, northern Indiana, northern Ohio, northern New Jersey and possibly Maryland (Shuey 1997). The range of the Mitchell's Satyr has been drastically reduced with present records showing small populations in southern Michigan and only one county in northern Indiana (U.S. Fish and Wildlife Service 1998). While the number of known populations has declined significantly, there does appear to be suitable habitat in at least parts the species' range, particularly in southern Michigan.

In Michigan, Mitchell's satyr is found within prairie fen and along the margins of associated, adjacent communities such as sedge meadow, shrub-carr, and tamarack swamp. Considered rare (G3,S3) both globally and locally, prairie fens in Michigan are restricted to the interlobate region of the southern Lower Peninsula where massive, glacial ice sheets deposited large moraines of sand and gravel (Figure 1) (Albert 1995). The lower slopes of these porous moraines leak calcium and magnesium rich groundwater, creating a unique environment suitable to only a select group of species. The Mitchell's satyr appears to be restricted to this specialized ecosystem. However, its range in Michigan occupies only a portion of the area in which prairie fens occur (Figure 1).

Little formal research has been conducted on Mitchell's satyr's life history. Recent studies indicate that it appears to be a rather sedentary butterfly, with individuals moving only short distances (e.g. 10 - 150 m) within a wetland complex (Szymanski 1998 and 1999). It has been observed using both sedges and forb seedlings as oviposition sites (McAlpine et al. 1960, Legge and Rabe 1996). Mitchell's satyr larvae have been documented feeding *in situ* on *Carex stricta* (Legge and Rabe 1996). In addition, studies conducted of larvae in captivity have demonstrated feeding on *C. alopecoidea*, *C. cephalophora* (collected from a dry oak woods), *Scirpus atrovirens* and grasses (McAlpine et al.

1960) and on *C. stricta* and *C. prairea* (Szymanski 1998). Pupae have been observed attached to *S. atrovirens* (McAlpine et al. 1960).

This study was undertaken to increase our understanding of Mitchell's satyr habitat. The objective of this study was to describe the vegetation characteristics of seven known Mitchell's satyr sites. It is hoped that this information will contribute to both our knowledge of the species and our ability to implement effective management, recovery, and long-term protection strategies.

METHODS

Seven sites occupied by Mitchell's satyr were selected for vegetation sampling these include Branch County (B), Barry County South (BS), Barry County Southwest (BW), Cass County Southwest (CW), St. Joseph County East (SE), St. Joseph County West (SW), Van Buren County Northeast (VE). Vegetation sampling occurred from August 5-13, 1999. Vascular plant species were identified to genus and species when possible. Nomenclature follows Gleason and Cronquist (1991). Mosses were grouped into either Sphagnum spp. or non-sphagnum mosses. The non-sphagnum mosses included the mat-forming pleurocarps as well as the tuft-forming acrocarpous mosses (Crum 1983). Vegetation sampling relied on cover classes to estimate species and vegetation strata cover within 10 m x 10 m plots or relevés. Cover classes were as follows: 1 = trace, 2 = 0-1%, 3 = 1-2%, 4 = 2-5%, 5 = 5-10%, 6 = 10-25%, 7 = 25-50%, 8 = 50-75%, 9 = 75-95%, 10 = >95% (Peet et al. 1998). Cover class values of 1 were considered to have cover of $\leq .01\%$ (e.g., 10 cm x 10cm) and were typically used for small species having a single occurrence within a plot.

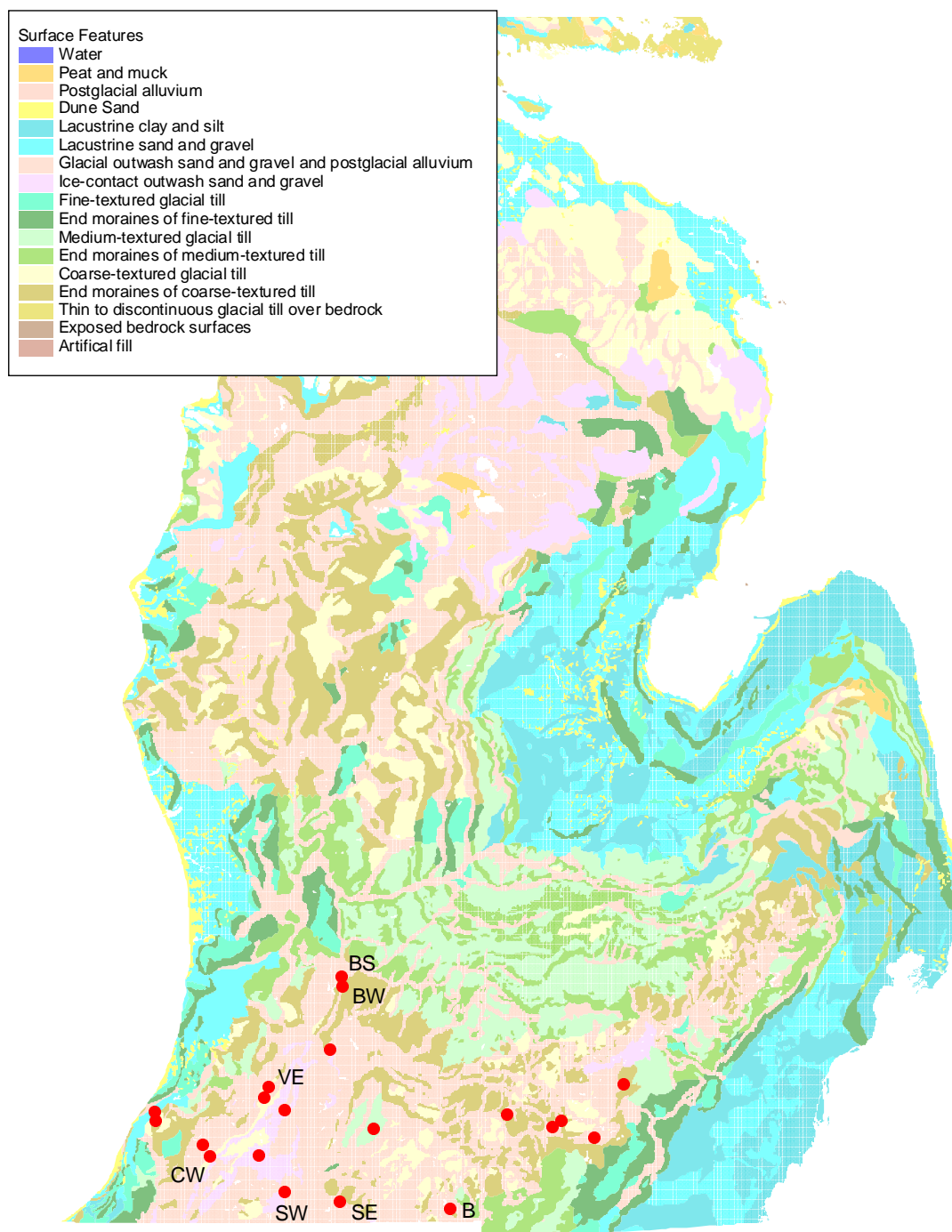


Figure 1. The southern Michigan interlobate region is illustrated by the pink, purple, and tan area in the southwest and central, southeast portions of the state. Prairie fens occur throughout this area but are seldom found beyond the interlobate region. The red dots indicate present and past Mitchell's satyr occurrences. Acronyms indicate vegetation sampling sites: Branch County, B; Barry County South, BS; Barry County Southwest, BW; Cass County Southwest, CW; St. Joseph County East, SE; St. Joseph County West, SW; Van Buren County Northeast, VE. (Ferrand and Bell 1982)

At each of the seven sites, one or more 10 m x 10 m plots (relevés), for a total of 15 plots, were positioned within areas where Mitchell's satyr butterflies were known to occur. Plot locations were chosen to represent the range of known Mitchell's satyr habitat within each site. For example if the butterfly was known to utilize both a shrub-dominated area and an open patch at a given site, a plot was placed in each habitat type. Within each plot, an estimate of aerial cover by cover class, was recorded for each plant rooted within the plot. In addition, an estimate of the total cover of each vegetation layer or stratum was recorded as well as the cover of each species within each stratum. Vegetation strata are described in Table 1. In addition to recording the vegetation characteristics, the upper layer of soil (1.5 m) was also examined using a soil probe at each plot.

Species lists were derived using the Floristic Quality Assessment Program, and Floristic Quality Indices (FQI) were calculated for all plots (Appendix 1) (Herman et al. 1996). Percent frequencies were calculated for each species based on its presence within all plots (n=15) and

sites (n=7) (Appendix 2). Using the mid-point values for each cover class, species covers were summed across plots for all species and a mean cover was derived (Appendix 2). Importance values were calculated by summing the relative plot cover and relative plot frequency for each species (Appendix 2).

A Detrended Correspondence Analysis (DCA) was performed using PC-ORD (McCune and Mefford 1999). Data for the analyses consisted of a species by plot matrix using the mid-point of the cover class values for all species occurring in at least two plots (n=15).

Two matrices of community coefficients based on species presence within plots and sites were calculated using the Sorensen coefficient (Tables 2 and 3) (Barbour et al. 1980). The Sorensen coefficient is a measure of similarity and was used to compare all plots and sites. The Sorensen coefficient is as follows: $2C / (A + B)$ where C is the number of species held in common between 2 plots and A and B represent the total number of species that occur within those plots (Barbour et al. 1980).

Table 1. Woody strata and ground layer characteristics. Percent cover was estimated by cover class for each attribute below.

Strata	Strata Descriptions
Canopy	all woody species >10m in height
Understory	all woody species >5m & <10m in height
Tall Shrub	all woody species >2m & <5m in height
Medium Shrub	all woody species 1m-2m in height
Short shrub	all woody species .5m-1m in height except dwarf shrub species
Dwarf Shrub	shrubs such as <i>Hypericum kalmianum</i> , <i>Potentilla fruticosa</i> , and <i>Rhamnus alnifolia</i>
Ground Layer	all graminoid, forb, and woody species (except dwarf shrubs) less than .5m in height
Graminoid	all Poaceae, Cyperaceae, Typhaceae, Juncaceae, and Juncaginaceae species.
Carex	all <i>Carex</i> species
Forb	all forb and fern species

RESULTS

A total of 211 species occurred within the 15 plots (Appendix 1). While only 5 species occurred in every plot, 62 (29%) were found in only one plot (Appendix 2). Species occurring in all plots include *Aster firmus*, *C. stricta*, *Eupatorium perfoliatum*, *Solidago patula* and *Thelypteris palustris* (Appendix 2). When data from plots collected within the same sites are combined, 14 species are found to occur at all sites. In addition to the species above, this list also includes, *Campanula aparinoides*, *C. leptalea*, *Cirsium muticum*, *Glyceria striata*, *Muhlenbergia glomerata*, *Oxypolis rigidior*, *Toxicodendron vernix*, *Viola* sp. and moss (non-sphagnum). Though not present at every site, 68 species did occur at more than half of the sites (Appendix 2). Plants found to be important to the Mitchell's satyr by McAlpine et al. (1960) such as *C. alopecoidea*, did not occur in any plots, and *Scirpus atrovirens* occurred at two sites, Branch County and St. Joseph County East (Appendix 1).

Species with high mean percent cover values (e.g. >10%) include *C. stricta* (55.87), *C. sterilis* (13.33), *Larix laricina* (12.93), moss (non-sphagnum) (12.43), *Potentilla fruticosa* (11.87), *C. lasiocarpa* (11.70), and *Toxicodendron vernix* (10.67) (Appendix 2). *C. stricta* in particular had an especially high mean cover value, equaling more than four times that of any other species. It was also the only species with a high mean cover value to occur in every plot. Only two species with high mean cover values had site frequencies of 100%, *C. stricta* and *Toxicodendron vernix*.

Importance values can be viewed as an overall measure of species dominance. As expected from both its high frequency and cover values, *C. stricta* had the greatest importance value (26.90). In fact, its importance value was more than 3 times that of any of other species (Appendix 2). Other species with high importance values include *C. sterilis* (7.12), moss (non-sphagnum) (7.05), *Larix laricina* (6.7), *Potentilla fruticosa* (6.46), *Toxicodendron vernix* (6.36), and *C. lasiocarpa* (6.28). All of the species with high cover and importance values are species associated with prairie fen and

several are considered characteristic or indicator species (e.g., *C. sterilis*, *Larix laricina*, *Potentilla fruticosa*) (Eggers and Reed 1987, Michigan Natural Features Inventory 1997).

Overall ground layer cover was consistently high in all plots (e.g., 95-100%) (Appendix 3). Total sedge cover (*Carex* spp.) was also consistently high (e.g. 50-100%) in all plots and was estimated to be greater than forb cover in all but one plot, BW2.

Relative woody strata cover showed woody plants to contribute more than 15% of total plot cover in all but 2 plots, BS and CW3 (Appendix 3). However, woody strata cover varied considerably among plots. For example, in 8 of the plots the upper strata (e.g. canopy, understory, tall and medium shrubs) contributed to the high woody plant covers. While in 4 other plots, the woody plant cover was comprised of species from the short shrub and dwarf shrub strata. Only one plot, SW1, showed a relatively equal distribution of woody strata cover. Of the 17 tree species contributing to the woody strata, all had less than 2% mean cover except for *Larix laricina* (12.93) (Appendix 2). However, *Acer rubrum*, which had a very low mean percent cover (1.83), occurred with greater frequency than *Larix laricina* (86% vs. 71%, respectively). Of the 27 shrub species encountered, only 6 (< 25%) had mean percent cover values of greater than 2% (e.g., *Potentilla fruticosa* (11.87), *Toxicodendron vernix* (10.67), *Lindera benzoin* (5.30), *Betula pumila* (3.13), *Rhamnus alnifolia* (2.90), and *Cornus racemosa* (2.50) (Appendix 2). However, site frequencies were greater than 70% for all of these species, as well as for *Salix discolor* and *Cornus amomum*.

The Floristic Quality Indices (FQI) were highest for plots that contained few adventive species but several rare and/or ecologically restricted species (Appendix 1). Therefore, plots such as B1 and B2, that were taken from a cattle-grazed tamarack savanna and contained several exotic species (e.g., *Lythrum salicaria*, *Agrostis gigantea*, and *Prunella vulgaris*) as well as plants with broad ecological tolerances (e.g., *Acer rubrum*, *Cornus racemosa*, *Solidago*

canadensis, *Ulmus americana*), had lower FQI scores.

Soil samples determined that all plots occurred on organic soil with marl deposits found within 1.5 m of the surface at 5 (33%) of the sites. The remainder of the sites contained black muck over dark brown, fibric peat.

The DCA of species cover estimates shows several distinct clusters of plots (Figure 2). Most significant in this pattern is that plots from the same sites often occur within different clusters. This indicates that plot species composition is often more similar among sites than within sites. It also demonstrates that individual sites contain several distinct habitats. The horizontal axis of the graph (Axis 1) corresponds to an environmental gradient of shade, with the more open plots occurring on the left side of the figure, and those with high tree and shrub cover on the right.

The two isolated plots on the far left (VE1, CW2) of Figure 2 have very high covers of *C. sterilis*, *C. lasiocarpa*, *Eleocharis rostellata*, and *Potentilla fruticosa* and very low covers of other woody plants. Marl deposits were found under both plots and both contained seeps. These two plots represent a calcareous groundwater seepage zone common to many prairie fens (Michigan Natural Features Inventory 1997).

In the upper center of the diagram is a cluster of four plots (SW3, VE2, SW1, SE1) which have high covers of *C. lasiocarpa*, *C. sterilis*, *Larix laricina*, and moderate covers of *Cornus amomum*, *Cornus racemosa*, *Potentilla fruticosa*, and *Toxicodendron vernix*. These plots are in a transitional state and currently represent the shrubby fen and tamarack savanna zones of prairie fen. As the woody component of these plots matures, they are likely to become shrub-carr and tamarack swamp in the future.

The two plots in the upper right (BW1, SW2) of Figure 2 have high covers of *C. leptalea*, *Larix laricina*, *Lindera benzoin*, *Toxicodendron vernix*, and moss (non-sphagnum). The woody plant composition of these plots is very similar to that of plot B1, which stands alone in the lower right of the diagram. All three contain high covers of *Larix laricina*, *Toxicodendron vernix* and moss (non-sphagnum), but B1 also has high

levels of *Leersia oryzoides*, *Sphagnum* sp., *Ulmus americana* and *Bidens coronatus*. These plots, (BW1, SE2, B1) all have very high woody species cover and in the absence of management are likely to convert to tamarack swamp. The high cover values of moss (non-sphagnum) and *C. leptalea* indicate that this process has already begun to occur in the ground layer.

The large cluster of plots in the lower center of Figure 2 is composed of several distinct groups. Three of the plots (BS, BW2, SW2) have high percent covers of several species characteristically abundant in sedge meadows (e.g. *C. stricta*, *Eupatorium maculatum*, *Thelypteris palustris*, and *Aster firmus*) (Kost and De Steven 2000). These plots represent the sedge meadow zone of their respective prairie fen complex. Two other plots in this lower cluster (CW1 and CW3) also contain these species but in addition, have numerous prairie fen species not found in the other 4 plots (e.g., *Cacalia plantaginea*, *Eleocharis elliptica*, *Silphium integrifolium*, *Solidago ohioensis* and *S. uliginosa*). Both plots (CW1 and CW3) were dominated by *C. stricta* and had moderate covers of *C. sterilis*. The two plots are probably best characterized as open prairie fen but CW2 had fewer species and (48 vs. 60, respectively) a higher cover of *C. stricta* (97.5% vs. 87.5%, respectively) making it more similar to the sedge meadow plots than CW1. Plot B2, which is grazed by cattle, represents degraded tamarack savanna.

The Sorensen coefficient is a measure of percent similarity that allows for comparisons of plots and sites based on species presence. Community coefficients of 50 or greater are generally considered the same association (Barbour et al. 1980). Two tables of Sorensen coefficients are given and demonstrate that although there may be significant habitat heterogeneity within sites, a great deal of similarity exists between sites (Tables 2 & 3).

Species and Plot Ordination

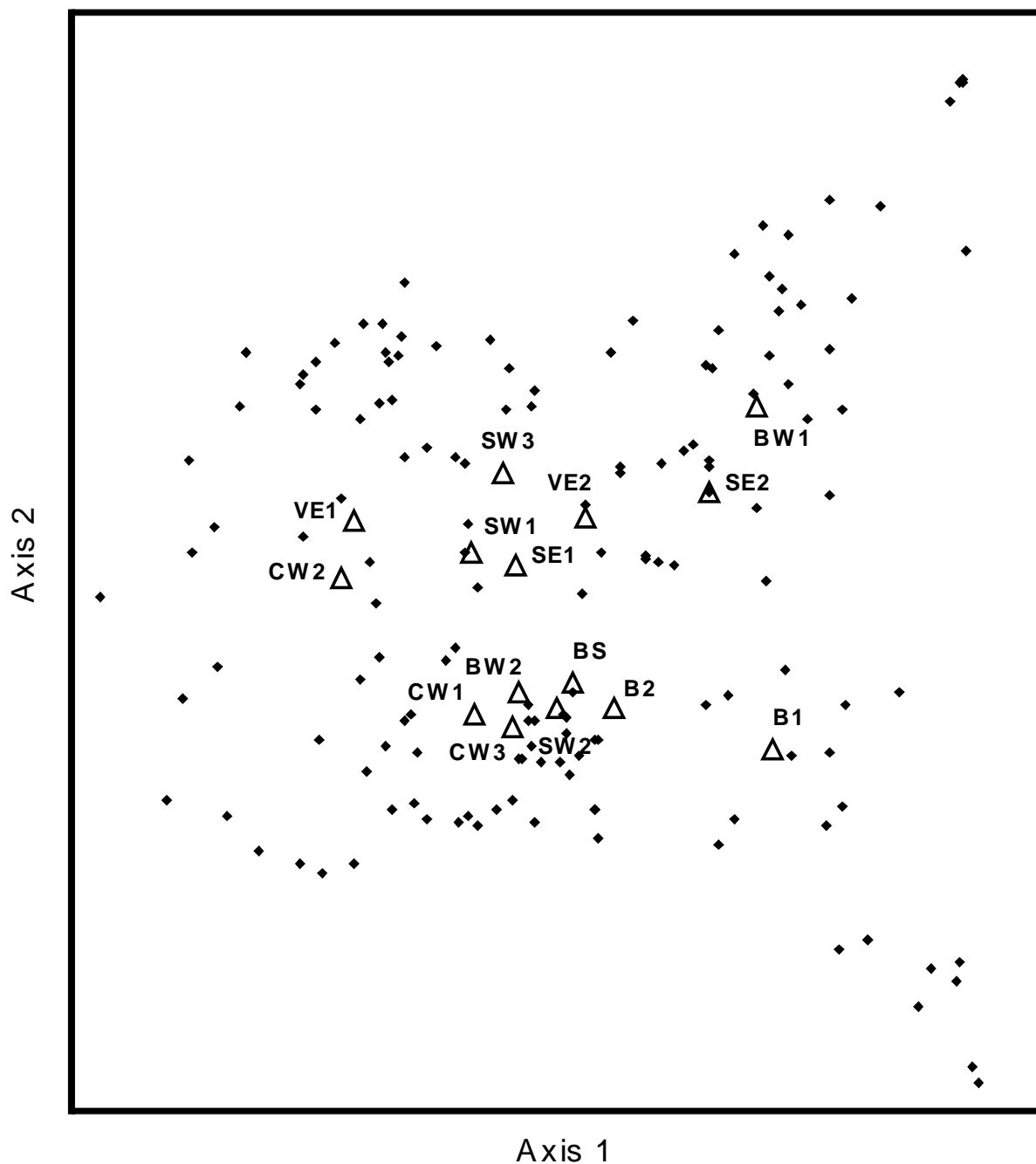


Figure 2. DCA of species cover within plots (n=15). Ordination was performed using PC-ORD version 4 (McCune and Mefford 1999). Species are represented by diamonds and plots by triangles. Plot abbreviations are as follows: B1 and B2, Branch County plots 1 and 2; BS, Barry County South; BW1 and BW2, Barry County Southwest plots 1 and 2; CW1, CW2 and CW3, Cass County Southwest plots 1,2 and 3; SE1 and SE2, St. Joseph County East plots 1 and 2; SW1, SW2 and SW3, St. Joseph County West plots 1, 2 and 3; VE1 and VE2, Van Buren County Northeast plots 1 and 2.

Table 2. Sorensen coefficients comparing plot percent similarity based on species presence (Barbour et al. 1980).

Plots	Branch		Barry South	Barry Southwest		Cass Southwest			St. Joseph East		St. Joseph West			Van Buren Northeast	
	B1	B2	BS	BW1	BW2	CW1	CW2	CW3	SE1	SE2	SW1	SW2	SW3	VE1	VE2
B1		59	42	48	48	36	42	29	54	54	52	58	54	38	49
B2			37	46	44	32	33	26	41	44	39	50	38	34	49
BS				45	54	43	35	42	41	50	41	50	45	40	41
BW1					40	44	35	33	39	50	54	51	47	42	56
BW2						32	32	38	42	47	36	48	38	28	43
CW1								62	54	37	41	58	49	57	49
CW2									48	47	41	56	53	54	49
CW3									41	35	50	45	38	41	38
SE1										55	56	54	60	52	51
SE2											56	53	62	47	62
SW1												72	77	66	58
SW2														66	55
SW3															65
VE1															
VE2															

Table 3. Sorensen Community Coefficients comparing site percent similarity (Barbour et al. 1980). Data for analysis consisted of species presence within all plots and sites.

	BS	BW	B	CW	SE	SW	VE
BS		50	41	48	48	47	43
BW			56	47	57	59	58
B				42	55	53	55
CW					53	60	59
SE						66	65
SW							66
VE							

The plot comparisons in Table 2 indicate that only 39% of the plots belong to the same association; whereas comparisons of site similarity show 50% of the sites to have high similarity values (e.g., >50%) (Table 3). However, most of the lower scores in the site comparison table are a result of comparisons with Barry County South, where only one plot was sampled and therefore included fewer total species (e.g., Barry South, 57 species vs. 84 - 104 at all other sites, see Appendix 1). When Barry County South is excluded from the analysis, 86% of the site comparisons show high similarity values.

DISCUSSION

Prairie fens in Michigan typically contain several distinct vegetation zones (Michigan Natural Features Inventory 1997). It is therefore not surprising that plant species composition varies greatly within individual sites (Table 2 and Figure 2). However, overall plant species composition at Mitchell's satyr sites does appear to be very similar (Table 3).

This study supports the findings of others who describes the habitat of Mitchell's satyr as a mosaic of open prairie fen and sedge meadow mixed with tamarack savanna and shrub-carr (McAlpine et al. 1960, Shuey et. al 1994, Szymanski 1999). Thin-leaved sedges (e.g. *C. stricta*, *C. sterilis*, *C. lasiocarpa*, *C. diandra*, *C. prairea*, *C. sartwellii*, and *C. leptalea*), especially *C. stricta*, *C. sterilis*, and *C. lasiocarpa*, dominate the ground layer of each of these habitats. Ground layer species found at all sites includes *Aster firmus*, *Campanula aparinoides*, *Cirsium muticum*, *Eupatorium perfoliatum*, *Glyceria striata*, *Muhlenbergia glomerata*, *Oxypolis rigidior*, *Solidago patula*, *Thelypteris palustris*, and *Viola* sp. A small, compact shrub, *Potentilla fruticosa*, that also occurs as part of the ground layer, was a significant component of cover at more than half of the sites. Lastly, *Larix laricina* and *Toxicodendron vernix* form the upper strata at most sites, creating a community structure often referred to as tamarack savanna.

The heterogeneous structure and patterns of community juxtaposition occurring at these Mitchell's satyr sites may be critical to the species' survival. Habitat utilization research has confirmed that Mitchell's satyr butterflies use several different vegetation zones (Szymanski 1999), suggesting an adaptation of behavioral thermoregulation (McAlpine et al. 1960, Shuey et. al 1994, Szymanski 1999). A variety of microhabitats may be necessary to ensure survival during other life stages as well.

However, maintaining this complex community structure and habitat heterogeneity will be difficult without direct intervention by land managers.

The transition of open graminoid-dominated communities to shrub-carr and swamp forest is well documented (Curtis 1959, White 1965). Both present and historical Mitchell's satyr sites have experienced a reduction in open wet meadow acreage and increases in shrub- and tree-dominated areas (MacKinnon and Albert 1996). The food plants of the Mitchell's satyr larvae, particularly the thin-leaved sedges *C. diandra*, *C. lasiocarpa*, *C. prairea*, *C. sartwellii*, *C. sterilis*, and *C. stricta*, are all light-demanding species, seldom occurring in closed canopy environments. As trees and shrubs begin to dominate once open wetlands, light demanding sedges are gradually out-competed by species more tolerant of shade. Without new openings being created, this process of canopy closure results in a direct decline in available habitat for Mitchell's satyr larvae.

Evidence from wetland peat cores and General Land Office surveyor notes indicates that in the past, graminoid dominated wetlands such as prairie fen, sedge meadow and wet prairie were maintained in an open condition by frequent wildfires (Curtis 1959, Davis 1979, Comer et. al. 1995). Because shrub-carr and swamp forest are not easily burned, this conversion may be considered permanent without manual manipulation (e.g., cutting and herbicide) or long term flooding (e.g., beaver dams or impoundments). In the past, beaver also likely played a key role in maintaining a network of open, graminoid-dominated communities. In the absence of wildfire and beaver-induced flooding, land managers will need to take steps to maintain networks of open, sedge-dominated communities if we are to be successful in protecting habitat for the Mitchell's satyr.

LITERATURE CITED

- Albert, D.A. 1995. Regional landscape ecosystems of Michigan, Minnesota, and Wisconsin: a working map and classification. North Central Forest Experiment Station, Forest Service – U.S. Department of Agriculture. St. Paul, MN.
- Barbour, M. G., J. H. Burk and W. D. Pitts. 1980. Terrestrial plant ecology. Benjamin/Cummings Publishing Co., Menlo Park, CA.
- Comer, P.J., D.A. Albert, H.A. Wells, B.L. Hart, J.B. Raab, D.L. Price, D.M. Kashian, R.A. Corner and D.W. Schuen. 1995. Michigan's presettlement vegetation, as interpreted from the General Land Office Surveys 1816-1856. Report to the USEPA Water Division and the Wildlife Division, MI DNR. Michigan Natural Features Inventory, Lansing, MI. digital map.
- Crum, H. 1983. Mosses of the Great Lakes forest. University Herbarium, University of Michigan, Ann Arbor, MI.
- Curtis, J. T. 1959. Vegetation of Wisconsin. The University of Wisconsin Press, Madison, WI.
- Davis, A. M. 1979. Wetland succession, fire and the pollen record: a Midwestern example. The American Midland Naturalist 102:86-94.
- Eggers, S. D. and D. M. Reed. 1987. Wetland plants and plant communities of Minnesota and Wisconsin. US Army Corps of Engineers, St. Paul, MN.
- Ferrand, W.R., and D.L. Bell 1982. Quarternary geology of southern Michigan. Dept. of Geological Sciences, The University of Michigan, Ann Arbor, MI. Map.
- Gleason, H. A. and A. Cronquist. 1991. Manual of vascular plants of Northeastern United States and adjacent Canada. 2d. ed. The New York Botanical Garden, Bronx, NY.
- Herman, K.D., L.A. Masters, M.R. Penskar, A.A. Reznicek, G.S. Wilhelm, and W.W. Brodowicz. 1996. Floristic quality assessment with wetland categories and computer application programs for the state of Michigan. Michigan Dept. of Natural Resources, Wildlife Division, Natural Heritage Program. Lansing, MI.
- Kost, M.A. and D. De Steven. 2000. Plant community responses to prescribed burning in Wisconsin sedge meadows. Natural Areas Journal 20:36-45.
- Legge, J.T. and M.L. Rabe 1996. Observations of oviposition and larval ecology in caged Mitchell's satyr butterflies (*Neonympha mitchellii mitchellii*) (Lepidoptera: Nymphalidae). Report to the U.S. Fish and Wildlife Service, Region 3 Office, Fort Snelling, MN. 17pp.
- MacKinnon, W.A. and D.A. Albert. 1996. Mitchell's satyr historical habitat analysis. Report to the U.S. Fish and Wildlife Service, East Lansing Field Office, Ecological Services, Michigan. 21pp.
- McAlpine, W.S., S.P. Hubbell, and T.E. Pliske. 1960. The distribution, habits, and life history of *Euptychia mitchellii* (Satyridae). Journal of the Lepidopterist Society 14:209-226.

- McCune and Mefford. 1999. PC-ORD. Multivariate Analysis of Ecological Data, Version 4. MJM Software Design, Gleneden Beach, OR.
- Peet R.K., T.R. Wentworth, and P.S. White. 1998. A flexible multipurpose method for recording vegetation composition and structure. *Castanea* 63:262-274.
- Michigan Natural Features Inventory. 1997. Natural community abstract for prairie fen. Lansing, MI 4pp.
- Shuey, J.A., A.A. Reznicek, and E.I. Rogers. 1994. Mitchell's satyr life history and habitat studies at(site name deleted). MDOT, Lansing, MI. 31pp.
- Shuey, J.A. 1997. Conservation status and natural history of Mitchell's satyr, *Neonympha mitchellii mitchellii* French (Insecta: Lepidoptera: Nymphalidae). *Natural Areas Journal* 17:153-163.
- Szymanski, J.A. 1998. Autecological studies of *Neonympha m. mitchellii* at (site name deleted) interim report (1998). Report the U.S. Fish and Wildlife Service. 12pp.
- _____, 1999. Population and spatial ecology of the Mitchell's satyr butterfly, *Neonympha m. mitchellii* French, in southwestern Michigan. A thesis submitted to the faculty of the Graduate School of the University of Minnesota.
- U.S. Fish and Wildlife Service. 1997. Recovery Plan for Mitchell's Satyr Butterfly (*Neonympha mitchellii mitchellii* French). Ft. Snelling, MN viii+71pp.
- White, K. L. 1965. Shrub-carrs of southeastern Wisconsin. *Ecology* 46: 286-304.

SCIENTIFIC NAME	Site		Branch		Barry South		Barry Southwest		Cass Southwest			St. Joseph East		St. Joseph West			Van Buren Northeast	
	Plot	B1	B2	BS	BW1	BW2	CW1	CW2	CW3	SE1	SE2	SW1	SW2	SW3	VE1	VE2		
	COMMON NAME																	
<i>Cacalia plantaginea</i> <T>	TUBEROUS INDIAN PLANTAIN	0	0	0	0	0	3	2	0	0	0	0	0	0	4	2	2	
<i>Calamagrostis canadensis</i>	BLUE-JOINT GRASS	0	0	0	2	0	2	3	2	0	4	2	0	2	2	0	2	
<i>Caltha palustris</i>	MARSH-MARIGOLD	0	0	2	0	2	0	0	0	3	0	0	2	0	0	0	0	
<i>Campanula aparinooides</i>	MARSH BELLFLOWER	2	0	2	0	2	0	2	1	2	2	2	2	2	2	2	2	
<i>Carex alata</i>	WINGED SEDGE	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Carex buxbaumii</i>	SEdge	0	0	0	0	0	0	0	0	3	0	0	0	0	2	0	0	
<i>Carex diandra</i>	SEdge	0	0	5	6	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Carex flava</i>	SEdge	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	
<i>Carex gracillima</i>	SEdge	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Carex hystericina</i>	SEdge	0	4	2	2	2	0	0	2	6	5	0	0	0	0	0	2	
<i>Carex lacustris</i>	SEdge	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	
<i>Carex lasiocarpa</i>	SEdge	4	0	0	0	7	0	6	0	7	0	6	4	7	6	4	4	
<i>Carex leptalea</i>	SEdge	2	5	2	4	0	3	0	2	6	6	3	3	3	2	3	3	
<i>Carex normalis</i>	SEdge	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Carex prairea</i>	SEdge	0	0	3	3	0	2	0	0	0	0	6	0	4	2	0	0	
<i>Carex sartwellii</i>	SEdge	2	0	0	0	0	0	0	0	0	0	0	2	3	0	0	0	
<i>Carex sp.</i>	SEdge	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Carex sterilis</i>	SEdge	0	0	0	6	0	4	6	4	3	0	7	3	7	8	6	6	
<i>Carex stricta</i>	SEdge	8	9	9	7	7	9	7	10	7	2	8	10	7	7	7	7	
<i>Carex tetanica</i>	SEdge	0	0	0	0	0	0	0	2	2	0	2	0	0	0	0	0	
<i>Cephalanthus occidentalis</i>	BUTTONBUSH	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Chara sp.</i>	CHARA	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	
<i>Chelone glabra</i>	TURTLEHEAD	0	0	2	2	0	0	0	0	0	0	2	2	2	2	0	0	
<i>Cicuta bulbifera</i>	WATER HEMLOCK	0	0	2	0	0	0	0	1	1	0	0	0	0	0	0	0	
<i>Cicuta maculata</i>	WATER HEMLOCK	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	
<i>Circaea lutetiana</i>	ENCHANTER'S-NIGHTSHADE	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Cirsium muticum</i>	SWAMP-THISTLE	2	2	2	1	4	2	2	0	3	3	2	4	2	2	2	2	
<i>Cladium mariscoides</i>	TWIG-RUSH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	
<i>Clematis virginiana</i>	VIRGIN'S BOWER	0	0	0	2	0	2	3	2	0	0	0	0	0	2	2	2	
<i>Coreopsis tripteris</i>	TALL COREOPSIS	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	
<i>Cornus amomum</i>	SILKY or PALE DOGWOOD	0	0	0	5	0	0	0	0	2	0	4	0	4	0	4	4	
<i>Cornus racemosa</i>	GRAY DOGWOOD	2	2	0	0	5	0	0	2	2	1	3	6	3	0	5	5	
<i>Cuscuta sp.</i>	DODDER	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	
<i>Cyperus strigosus</i>	UMBRELLA SEDGE	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Cypripedium calceolus parviflorum</i>	SMALL YELLOW LADY'S-SLIPPER	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	

SCIENTIFIC NAME	Site		Branch		Barry South		Barry Southwest		Cass Southwest			St. Joseph East			St. Joseph West			Van Buren Northeast	
	Plot	B1	B2	BS	BW1	BW2	CW1	CW2	CW3	SE1	SE2	SW1	SW2	SW3	VE1	VE2			
<i>Cypripedium reginae</i>		0	0	0	2	0	0	0	0	0	0	2	2	0	0	0			
<i>Deschampsia cespitosa</i>		0	0	0	0	0	0	0	0	2	0	1	0	2	0	0			
<i>Desmodium canadense</i>		0	0	0	2	0	0	0	1	0	0	0	0	0	0	0			
<i>Dioscorea villosa</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	0	2			
<i>Drosera rotundifolia</i>		0	0	0	0	0	0	0	0	2	2	2	0	3	2	0			
<i>Dryopteris cristata</i>		0	0	0	2	2	0	0	0	0	1	0	0	0	0	1			
ELAEAGNUS UMBELLATA		0	0	0	0	2	0	0	0	0	0	0	0	0	0	2			
<i>Eleocharis elliptica</i>		0	0	0	0	0	2	0	2	3	0	2	0	4	0	0			
<i>Eleocharis erythropoda</i>		0	3	0	0	0	0	0	2	3	0	0	0	0	5	0			
<i>Eleocharis rostellata</i>		0	0	0	0	0	0	6	0	0	0	0	0	0	6	3			
<i>Eleocharis sp.</i>		0	0	0	0	0	2	0	0	0	0	0	0	0	0	0			
<i>Epilobium leptophyllum</i>		0	0	0	0	2	0	0	0	0	0	0	0	0	0	0			
<i>Epilobium sp.</i>		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0			
<i>Equisetum arvense</i>		0	2	0	0	0	0	0	0	0	0	0	0	0	0	0			
<i>Equisetum fluviatile</i>		2	0	0	2	0	0	0	0	0	2	2	0	0	2	0			
<i>Eriophorum viridi-carinatum</i>		0	0	0	0	0	0	0	0	0	0	0	0	0	2	0			
<i>Eupatorium maculatum</i>		4	4	4	2	6	4	3	4	2	2	3	4	3	0	0			
<i>Eupatorium perfoliatum</i>		4	4	3	2	5	3	2	3	6	4	3	5	2	2	2			
<i>Eupatorium rugosum</i>		0	2	0	0	0	0	0	0	0	0	0	0	0	0	0			
<i>Euthamia graminifolia</i>		2	2	0	0	0	0	0	0	0	0	0	0	0	0	0			
<i>Fragaria virginiana</i>		0	2	0	0	0	0	0	0	0	0	0	0	0	0	0			
<i>Fraxinus nigra</i>		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0			
<i>Galium asprellum</i>		0	0	0	2	2	2	0	3	0	0	0	2	0	0	0			
<i>Galium boreale</i>		0	0	2	2	0	2	0	2	0	0	0	0	0	0	0			
<i>Galium tinctorium</i>		0	0	0	0	0	0	0	0	0	0	1	0	2	0	0			
<i>Galium triflorum</i>		0	2	2	2	0	0	0	0	0	1	0	0	0	0	2			
<i>Gaylussacia baccata</i>		2	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
GLECHOMA HEDERACEA		0	0	2	4	5	0	0	0	0	0	0	0	0	0	0			
<i>Glyceria striata</i>		2	2	2	2	2	0	0	2	3	2	2	2	2	2	2			
<i>Helianthus giganteus</i>		2	2	2	0	0	2	0	0	0	2	2	2	2	2	0			
<i>Helianthus sp.</i>		0	0	0	0	0	0	0	2	0	0	0	0	0	0	0			
<i>Hypericum kalmianum</i>		0	0	0	2	0	2	2	2	0	0	2	0	0	5	2			
<i>Ilex verticillata</i>		2	2	2	2	0	0	0	0	0	0	0	0	0	0	0			
<i>Impatiens capensis</i>		0	0	2	0	2	0	0	2	0	1	0	0	0	0	0			
<i>Iris virginica</i>		0	0	2	0	4	0	2	2	2	0	0	2	0	0	0			

SCIENTIFIC NAME	Site		Branch		Barry South		Barry Southwest		Cass Southwest			St. Joseph East		St. Joseph West			Van Buren Northeast	
	Plot	B1	B2	BS	BW1	BW2	CW1	CW2	CW3	SE1	SE2	SW1	SW2	SW3	VE1	VE2		
	COMMON NAME																	
<i>Juncus brachycephalus</i>	RUSH	2	0	0	0	0	0	0	2	2	0	0	0	2	2	0	0	
<i>Juncus canadensis</i>	CANADIAN RUSH	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Juncus dudleyi</i>	DUDLEY'S RUSH	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Juncus effusus</i>	SOFT-STEMMED RUSH	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	
<i>Juniperus virginiana</i>	RED-CEDAR	0	4	0	0	0	0	0	0	0	4	0	0	0	0	0	2	
<i>Larix laricina</i>	TAMARACK; LARCH	7	0	0	7	0	0	0	0	6	7	5	3	7	0	6		
<i>Lathyrus palustris</i>	MARSH PEA	2	2	0	2	2	2	0	0	0	1	2	2	0	0	2		
<i>Leersia oryzoides</i>	CUT GRASS	8	4	0	0	0	2	0	0	0	4	0	0	0	0	0	0	
<i>Lemna minor</i>	SMALL DUCKWEED	0	0	2	0	0	0	0	0	2	2	0	0	1	0	0	0	
<i>Liatris spicata</i>	MARSH BLAZING STAR	0	0	0	0	0	0	3	2	0	0	0	0	0	0	2	0	
<i>Lindera benzoin</i>	SPICEBUSH	2	4	3	6	2	0	0	0	0	7	0	2	2	0	6		
<i>Liparis loeselii</i>	LOESEL'S TWAYBLADE	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	
<i>Liriodendron tulipifera</i>	TULIP TREE	0	0	0	0	0	0	0	0	0	0	0	2	3	0	0	0	
<i>Lobelia kalmii</i>	BOG LOBELIA	0	0	0	0	0	0	0	2	0	2	0	2	0	2	2	2	
<i>Lycopus americanus</i>	COMMON WATER HOREHOUND	2	2	2	0	2	0	2	0	1	0	0	2	0	0	0	0	
<i>Lycopus uniflorus</i>	NORTHERN BUGLE WEED	2	0	0	2	0	0	0	0	1	2	2	2	2	2	2	2	
<i>Lysimachia ciliata</i>	FRINGED LOOSESTRIFE	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	
<i>Lysimachia quadriflora</i>	WHORLED LOOSESTRIFE	2	2	0	2	0	0	1	0	1	0	2	2	2	2	2	2	
LYTHRUM SALICARIA	PURPLE LOOSESTRIFE	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Maianthemum canadense</i>	CANADA MAYFLOWER	2	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Menispermum canadense</i>	MOONSEED	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
<i>Mentha arvensis</i>	WILD MINT	0	0	3	2	2	2	2	0	2	0	2	3	0	0	0	0	
<i>Monarda fistulosa</i>	WILD BERGAMOT	0	0	2	0	0	0	0	0	0	0	0	2	0	0	0	0	
MOSS (NON-SPHAGNUM)	MOSS (NON-SPHAGNUM)	5	4	4	6	5	0	6	0	3	8	4	4	4	7	6		
<i>Muhlenbergia glomerata</i>	MARSH WILD-TIMOTHY	2	0	2	0	2	2	2	2	1	0	2	2	2	2	2	2	
<i>Muhlenbergia mexicana</i>	LEAFY SATIN GRASS	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	
NASTURTIUM OFFICINALE	WATERCRESS	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	
<i>Onoclea sensibilis</i>	SENSITIVE FERN	0	2	0	2	4	0	0	2	0	0	0	2	0	0	2	2	
<i>Osmunda regalis</i>	ROYAL FERN	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	4	
<i>Oxypolis rigidior</i>	COWBANE	2	0	2	2	3	2	2	2	2	2	2	2	2	2	2	2	
<i>Panicum clandestinum</i>	PANIC GRASS	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2	
<i>Panicum implicatum</i>	PANIC GRASS	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	2	
<i>Parnassia glauca</i>	GRASS-OF-PARNASSUS	0	0	0	2	0	0	0	0	0	0	2	2	2	2	2	0	
<i>Parthenocissus quinquefolia</i>	VIRGINIA CREEPER	0	2	2	2	2	2	0	0	0	2	0	0	1	0	4		
<i>Pedicularis lanceolata</i>	SWAMP-BETONY; LOUSEWORT	0	0	2	2	0	2	2	0	0	2	2	2	2	2	2	0	

SCIENTIFIC NAME	Site		Branch		Barry South		Barry Southwest		Cass Southwest			St. Joseph East			St. Joseph West			Van Buren Northeast	
	Plot	B1	B2	BS	BW1	BW2	CW1	CW2	CW3	SE1	SE2	SW1	SW2	SW3	VE1	VE2			
<i>Utricularia intermedia</i>		0	0	0	0	0	0	0	0	1	0	0	0	2	2	0			
<i>Vaccinium corymbosum</i>		0	2	0	6	0	0	0	0	0	0	0	2	0	0	0			
<i>Vernonia missurica</i>		0	0	0	0	0	0	0	2	0	0	0	0	0	0	0			
<i>Viola sp.</i>		3	2	2	4	0	2	2	0	2	2	2	2	2	2	2			
<i>Vitis riparia</i>		0	4	0	0	4	0	0	0	0	0	0	0	0	0	0			
<i>Zanthoxylum americanum</i>		0	2	0	0	0	0	0	0	0	0	0	0	0	0	0			
<i>Zigadenus glaucus</i>		0	0	0	0	0	2	0	0	0	0	0	0	0	0	0			
<i>Zizia aurea</i>		0	0	2	0	0	6	0	0	0	0	0	0	0	2	0			
Total Number of Species per Plot		62	67	57	84	46	60	47	48	60	56	61	58	64	63	80			
Total Number of Species per Site		91		57	104		90			84			88			98			
Floristic Quality Index		34	27	35	39	28	41	38	33	34	34	40	36	43	46	41			

Appendix 2. Species list sorted by site (n=7) and plot (n=15) percent frequencies. Importance values were derived by summing the relative plot percent frequency and relative percent cover for each species.

SCIENTIFIC NAME	COMMON NAME	Site % Frequency	Plot % Frequency	Sum of Plot Covers	Mean Plot Cover	Importance Value
<i>Carex stricta</i>	SEDGE	100.00	100.00	838.00	55.87	26.90
<i>Eupatorium perfoliatum</i>	COMMON BONESET	100.00	100.00	51.50	3.43	3.20
<i>Thelypteris palustris</i>	MARSH FERN	100.00	100.00	51.50	3.43	3.20
<i>Aster firmus</i>	SMOOTH SWAMP ASTER	100.00	100.00	49.50	3.30	3.13
<i>Solidago patula</i>	SWAMP GOLDENROD	100.00	100.00	33.50	2.23	2.65
<i>Toxicodendron vernix</i>	POISON SUMAC	100.00	93.33	160.00	10.67	6.36
<i>Cirsium muticum</i>	SWAMP-THISTLE	100.00	93.33	14.51	0.97	1.97
MOSS (NON-SPHAGNUM)	MOSS (NON-SPHAGNUM)	100.00	86.67	186.50	12.43	7.05
<i>Carex leptalea</i>	SEDGE	100.00	86.67	55.50	3.70	3.10
<i>Viola</i> sp.	VIOLET	100.00	86.67	10.50	0.70	1.74
<i>Glyceria striata</i>	FOWL MANNA GRASS	100.00	86.67	7.50	0.50	1.65
<i>Oxypolis rigidior</i>	COWBANE	100.00	86.67	7.50	0.50	1.65
<i>Muhlenbergia glomerata</i>	MARSH WILD-TIMOTHY	100.00	80.00	5.51	0.37	1.48
<i>Campanula aparinoides</i>	MARSH BELLFLOWER	100.00	73.33	5.01	0.33	1.36
<i>Eupatorium maculatum</i>	JOE-PYE WEED	85.71	86.67	44.50	2.97	2.77
<i>Aster lanceolatus</i>	EASTERN LINED ASTER	85.71	80.00	9.00	0.60	1.59
<i>Solidago rugosa</i>	ROUGH GOLDENROD	85.71	80.00	8.51	0.57	1.57
<i>Salix discolor</i>	PUSSY WILLOW	85.71	73.33	16.01	1.07	1.69
<i>Bromus ciliatus</i>	FRINGED BROME	85.71	73.33	5.50	0.37	1.37
<i>Cornus racemosa</i>	GRAY DOGWOOD	85.71	66.67	37.51	2.50	2.23
<i>Senecio aureus</i>	GOLDEN RAGWORT	85.71	66.67	6.51	0.43	1.29
<i>Lysimachia quadriflora</i>	WHORLED LOOSESTRIFE	85.71	66.67	4.01	0.27	1.22
<i>Carex lasiocarpa</i>	SEDGE	85.71	60.00	175.50	11.70	6.28
<i>Lindera benzoin</i>	SPICEBUSH	85.71	60.00	79.50	5.30	3.38
<i>Rhamnus alnifolia</i>	ALDER-LEAVED BUCKTHORN	85.71	60.00	43.50	2.90	2.30
<i>Acer rubrum</i>	RED MAPLE	85.71	60.00	27.51	1.83	1.81
<i>Pedicularis lanceolata</i>	SWAMP-BETONY; LOUSEWORT	85.71	60.00	4.50	0.30	1.12
<i>Lathyrus palustris</i>	MARSH PEA	85.71	60.00	4.01	0.27	1.11
<i>Carex hystericina</i>	SEDGE	85.71	53.33	31.00	2.07	1.81
<i>Boehmeria cylindrica</i>	FALSE NETTLE	85.71	53.33	4.51	0.30	1.01
<i>Rubus pubescens</i>	DWARF RASPBERRY	85.71	46.67	23.50	1.57	1.48
<i>Parthenocissus quinquefolia</i>	VIRGINIA CREEPER	85.71	46.67	6.01	0.40	0.95
<i>Lycopus americanus</i>	COMMON WATER HOREHOUND	85.71	46.67	3.01	0.20	0.86
<i>Carex sterilis</i>	SEDGE	71.43	66.67	200.00	13.33	7.12
<i>Potentilla fruticosa</i>	SHRUBBY CINQUEFOIL	71.43	66.67	178.00	11.87	6.46
<i>Pycnanthemum virginianum</i>	COMMON MOUNTAIN MINT	71.43	66.67	12.00	0.80	1.46
TYPHA ANGUSTIFOLIA	NARROW-LEAVED CAT-TAIL	71.43	66.67	7.00	0.47	1.31
<i>Solidago canadensis</i>	CANADA GOLDENROD	71.43	66.67	5.00	0.33	1.25
<i>Calamagrostis canadensis</i>	BLUE-JOINT GRASS	71.43	60.00	8.50	0.57	1.24
<i>Rudbeckia hirta</i>	BLACK-EYED SUSAN	71.43	60.00	4.50	0.30	1.12
<i>Lycopus uniflorus</i>	NORTHERN BUGLE WEED	71.43	60.00	4.01	0.27	1.11
<i>Larix laricina</i>	TAMARACK; LARCH	71.43	53.33	194.00	12.93	6.72
<i>Selaginella</i> sp.	SPIKEMOSS	71.43	53.33	4.51	0.30	1.01
<i>Helianthus giganteus</i>	TALL SUNFLOWER	71.43	53.33	4.00	0.27	1.00
<i>Sphagnum</i> spp.	SPHAGNUM MOSS	71.43	40.00	82.00	5.47	3.13
<i>Carex prairea</i>	SEDGE	71.43	40.00	25.00	1.67	1.41
<i>Iris virginica</i>	SOUTHERN BLUE FLAG	71.43	40.00	6.00	0.40	0.84
<i>Onoclea sensibilis</i>	SENSITIVE FERN	71.43	40.00	6.00	0.40	0.84
<i>Juncus brachycephalus</i>	RUSH	71.43	40.00	3.00	0.20	0.75
<i>Equisetum fluviatile</i>	WATER HORSETAIL	71.43	33.33	2.50	0.17	0.62
<i>Thalictrum dasycarpum</i>	PURPLE MEADOW-RUE	71.43	33.33	2.50	0.17	0.62

SCIENTIFIC NAME	COMMON NAME	Site % Frequency	Plot % Frequency	Sum of Plot Covers	Mean Plot Cover	Importance Value
Galium triflorum	FRAGRANT BEDSTRAW	71.43	33.33	2.01	0.13	0.61
Solidago riddellii	RIDDELL'S GOLDENROD	57.14	53.33	4.00	0.27	1.00
Hypericum kalmianum	KALM'S ST. JOHN'S-WORT	57.14	46.67	10.50	0.70	1.08
Mentha arvensis	WILD MINT	57.14	46.67	5.50	0.37	0.93
Betula pumila	BOG BIRCH	57.14	40.00	47.00	3.13	2.07
AGROSTIS GIGANTEA	REDTOP	57.14	40.00	4.00	0.27	0.78
Chelone glabra	TURTLEHEAD	57.14	40.00	3.00	0.20	0.75
Lobelia kalmii	BOG LOBELIA	57.14	40.00	3.00	0.20	0.75
Cornus amomum	SILKY or PALE DOGWOOD	57.14	33.33	18.50	1.23	1.11
Asclepias incarnata	SWAMP MILKWEED	57.14	33.33	2.50	0.17	0.62
Aster umbellatus	TALL FLAT-TOP WHITE ASTER	57.14	33.33	2.50	0.17	0.62
Solidago gigantea	LATE GOLDENROD	57.14	33.33	2.50	0.17	0.62
Agropyron trachycaulum	WHEATGRASS	57.14	33.33	2.01	0.13	0.61
Dryopteris cristata	CRESTED SHIELD FERN	57.14	33.33	1.51	0.10	0.59
Eleocharis erythropoda	SPIKE-RUSH	57.14	26.67	11.00	0.73	0.77
Caltha palustris	MARSH-MARIGOLD	57.14	26.67	3.00	0.20	0.53
Impatiens capensis	SPOTTED TOUCH-ME-NOT	57.14	26.67	1.51	0.10	0.48
Clematis virginiana	VIRGIN'S BOWER	42.86	40.00	4.00	0.27	0.78
Solidago uliginosa	BOG GOLDENROD	42.86	40.00	4.00	0.27	0.78
Solidago altissima	TALL GOLDENROD	42.86	33.33	22.50	1.50	1.23
Ulmus americana	WHITE or AMERICAN ELM	42.86	33.33	15.01	1.00	1.00
Eleocharis elliptica	GOLDEN-SEEDED SPIKE RUSH	42.86	33.33	6.50	0.43	0.74
Drosera rotundifolia	ROUND-LEAVED SUNDEW	42.86	33.33	3.50	0.23	0.65
Galium asprellum	ROUGH BEDSTRAW	42.86	33.33	3.50	0.23	0.65
Parnassia glauca	GRASS-OF-PARNASSUS	42.86	33.33	2.50	0.17	0.62
Ribes hirtellum	SWAMP GOOSEBERRY	42.86	33.33	2.50	0.17	0.62
Polygonum scandens	FALSE BUCKWHEAT	42.86	33.33	2.01	0.13	0.61
PRUNELLA VULGARIS	LAWN PRUNELLA	42.86	33.33	2.01	0.13	0.61
Leersia oryzoides	CUT GRASS	42.86	26.67	70.00	4.67	2.55
Andropogon gerardii	BIG BLUESTEM GRASS	42.86	26.67	6.00	0.40	0.62
Galium boreale	NORTHERN BEDSTRAW	42.86	26.67	2.00	0.13	0.50
Ilex verticillata	WINTERBERRY	42.86	26.67	2.00	0.13	0.50
Salix serissima	AUTUMN WILLOW	42.86	26.67	2.00	0.13	0.50
Sorghastrum nutans	INDIAN GRASS	42.86	26.67	2.00	0.13	0.50
Lemna minor	SMALL DUCKWEED	42.86	26.67	1.51	0.10	0.48
Vaccinium corymbosum	SMOOTH Highbush Blueberry	42.86	20.00	18.50	1.23	0.89
Zizia aurea	GOLDEN ALEXANDERS	42.86	20.00	18.50	1.23	0.89
Juniperus virginiana	RED-CEDAR	42.86	20.00	7.50	0.50	0.55
Amphicarpaea bracteata	HOG-PEANUT	42.86	20.00	4.50	0.30	0.46
Rosa palustris	SWAMP ROSE	42.86	20.00	4.50	0.30	0.46
Symplocarpus foetidus	SKUNK-CABBAGE	42.86	20.00	4.50	0.30	0.46
Pilea pumila	CLEARWEED	42.86	20.00	2.50	0.17	0.40
Apocynum cannabinum	INDIAN HEMP	42.86	20.00	1.50	0.10	0.37
Carex tetanica	SEDGE	42.86	20.00	1.50	0.10	0.37
Salix bebbiana	BEBB'S or BEAKED WILLOW	42.86	20.00	1.50	0.10	0.37
Utricularia intermedia	FLAT-LEAVED BLADDERWORT	42.86	20.00	1.01	0.07	0.36
Cicuta bulbifera	WATER HEMLOCK	42.86	20.00	0.51	0.03	0.34
Cacalia plantaginea <T>	TUBEROUS INDIAN PLANTAIN	28.57	33.33	7.50	0.50	0.77
Phalaris arundinacea	REED CANARY GRASS	28.57	26.67	5.51	0.37	0.60
Apios americana	GROUNDNUT	28.57	26.67	4.00	0.27	0.56
Muhlenbergia mexicana	LEAFY SATIN GRASS	28.57	26.67	1.51	0.10	0.48
Eleocharis rostellata	SPIKE-RUSH	28.57	20.00	36.50	2.43	1.43
GLECHOMA HEDERACEA	GROUND IVY	28.57	20.00	11.50	0.77	0.68
Bidens coronatus	TALL SWAMP-MARIGOLD	28.57	20.00	8.01	0.53	0.57

SCIENTIFIC NAME	COMMON NAME	Site % Frequency	Plot % Frequency	Sum of Plot Covers	Mean Plot Cover	Importance Value
Carex sartwellii	SEDGE	28.57	20.00	2.50	0.17	0.40
Liatris spicata	MARSH BLAZING STAR	28.57	20.00	2.50	0.17	0.40
Rhynchospora alba	BEAK-RUSH	28.57	20.00	2.50	0.17	0.40
Cypripedium reginae	SHOWY LADY-SLIPPER	28.57	20.00	1.50	0.10	0.37
Maianthemum canadense	CANADA MAYFLOWER	28.57	20.00	1.50	0.10	0.37
Panicum implicatum	PANIC GRASS	28.57	20.00	1.50	0.10	0.37
Scirpus acutus	HARDSTEM BULRUSH	28.57	20.00	1.50	0.10	0.37
Deschampsia cespitosa	HAIR GRASS	28.57	20.00	1.01	0.07	0.36
Scirpus atrovirens	BULRUSH	28.57	20.00	1.01	0.07	0.36
Carex diandra	SEDGE	28.57	13.33	25.00	1.67	0.97
Vitis riparia	RIVERBANK GRAPE	28.57	13.33	7.00	0.47	0.43
Osmunda regalis	ROYAL FERN	28.57	13.33	4.00	0.27	0.34
Carex buxbaumii	SEDGE	28.57	13.33	2.00	0.13	0.28
Aster novae-angliae	NEW ENGLAND ASTER	28.57	13.33	1.00	0.07	0.25
Chara sp.	CHARA	28.57	13.33	1.00	0.07	0.25
Cicuta maculata	WATER HEMLOCK	28.57	13.33	1.00	0.07	0.25
Cuscuta sp.	DODDER	28.57	13.33	1.00	0.07	0.25
Cypripedium calceolus parviflorum	SMALL YELLOW LADY'S-SLIPPER	28.57	13.33	1.00	0.07	0.25
ELAEAGNUS UMBELLATA	AUTUMN-OLIVE	28.57	13.33	1.00	0.07	0.25
Monarda fistulosa	WILD BERGAMOT	28.57	13.33	1.00	0.07	0.25
Panicum clandestinum	PANIC GRASS	28.57	13.33	1.00	0.07	0.25
POA COMPRESSA	CANADA BLUEGRASS	28.57	13.33	1.00	0.07	0.25
POA PRATENSIS	KENTUCKY BLUEGRASS	28.57	13.33	1.00	0.07	0.25
ROSA MULTIFLORA	JAPANESE or MULTIFLORA ROSA	28.57	13.33	1.00	0.07	0.25
Rubus occidentalis	BLACK RASPBERRY	28.57	13.33	1.00	0.07	0.25
Rumex orbiculatus	GREAT WATER DOCK	28.57	13.33	1.00	0.07	0.25
Arisaema triphyllum	JACK-IN-THE-PULPIT	28.57	13.33	0.51	0.03	0.23
Desmodium canadense	SHOWY TICK-TREFOIL	28.57	13.33	0.51	0.03	0.23
Populus tremuloides	QUAKING ASPEN	28.57	13.33	0.51	0.03	0.23
Scutellaria galericulata	COMMON SKULLCAP	28.57	13.33	0.51	0.03	0.23
Liparis loeselii	LOESEL'S TWAYBLADE	28.57	13.33	0.01	0.00	0.22
Solidago ohioensis	OHIO GOLDENROD	14.29	20.00	5.50	0.37	0.49
Allium cernuum	NODDING WILD ONION	14.29	20.00	4.50	0.30	0.46
Silphium integrifolium <T>	ROSE WOOD	14.29	13.33	7.00	0.47	0.43
LYTHRUM SALICARIA	PURPLE LOOSESTRIFE	14.29	13.33	5.00	0.33	0.37
RHAMNUS FRANGULA	GLOSSY BUCKTHORN	14.29	13.33	3.51	0.23	0.32
Liriodendron tulipifera	TULIP TREE	14.29	13.33	2.00	0.13	0.28
Rudbeckia fulgida <SC>	BLACK-EYED SUSAN	14.29	13.33	2.00	0.13	0.28
Cladium mariscoides	TWIG-RUSH	14.29	13.33	1.00	0.07	0.25
Euthamia graminifolia	GRASS-LEAVED GOLDENROD	14.29	13.33	1.00	0.07	0.25
Sagittaria latifolia	COMMON ARROWHEAD	14.29	13.33	1.00	0.07	0.25
Salix candida	SAGE or HOARY WILLOW	14.29	13.33	1.00	0.07	0.25
Galium tinctorium	STIFF BEDSTRAW	14.29	13.33	0.51	0.03	0.23
Betula alleghaniensis	YELLOW BIRCH	14.29	13.33	0.01	0.00	0.22
Cephalanthus occidentalis	BUTTONBUSH	14.29	6.67	3.50	0.23	0.22
Juncus canadensis	CANADIAN RUSH	14.29	6.67	3.50	0.23	0.22
NASTURTIUM OFFICINALE	WATERCRESS	14.29	6.67	3.50	0.23	0.22
Spartina pectinata	CORDGRASS	14.29	6.67	3.50	0.23	0.22
Coreopsis tripteris	TALL COREOPSIS	14.29	6.67	1.50	0.10	0.15
Agrostis hyemalis	TICKLEGRASS	14.29	6.67	0.50	0.03	0.12
Amelanchier sp.	JUNE BERRY	14.29	6.67	0.50	0.03	0.12
Aronia prunifolia	BLACK CHOKEBERRY	14.29	6.67	0.50	0.03	0.12
ASPARAGUS OFFICINALIS	ASPARAGUS	14.29	6.67	0.50	0.03	0.12
Athyrium filix-femina	LADY FERN	14.29	6.67	0.50	0.03	0.12

SCIENTIFIC NAME	COMMON NAME	Site % Frequency	Plot % Frequency	Sum of Plot Covers	Mean Plot Cover	Importance Value
Betula papyrifera	PAPER BIRCH	14.29	6.67	0.50	0.03	0.12
Carex alata	WINGED SEDGE	14.29	6.67	0.50	0.03	0.12
Carex flava	SEDGE	14.29	6.67	0.50	0.03	0.12
Carex lacustris	SEDGE	14.29	6.67	0.50	0.03	0.12
Carex normalis	SEDGE	14.29	6.67	0.50	0.03	0.12
Circaea lutetiana	ENCHANTER'S-NIGHTSHADE	14.29	6.67	0.50	0.03	0.12
Cyperus strigosus	UMBRELLA SEDGE	14.29	6.67	0.50	0.03	0.12
Dioscorea villosa	WILD YAM	14.29	6.67	0.50	0.03	0.12
Eleocharis sp.	SPIKE-RUSH	14.29	6.67	0.50	0.03	0.12
Epilobium leptophyllum	FEN WILLOW-HERB	14.29	6.67	0.50	0.03	0.12
Equisetum arvense	COMMON HORSETAIL	14.29	6.67	0.50	0.03	0.12
Eriophorum viridi-carinatum	GREEN-KEELED COTTON-GRASS	14.29	6.67	0.50	0.03	0.12
Eupatorium rugosum	WHITE SNAKEROOT	14.29	6.67	0.50	0.03	0.12
Fragaria virginiana	WILD STRAWBERRY	14.29	6.67	0.50	0.03	0.12
Gaylussacia baccata	HUCKLEBERRY	14.29	6.67	0.50	0.03	0.12
Helianthus sp.	SUNFLOWER	14.29	6.67	0.50	0.03	0.12
Juncus dudleyi	DUDLEY'S RUSH	14.29	6.67	0.50	0.03	0.12
Juncus effusus	SOFT-STEMMED RUSH	14.29	6.67	0.50	0.03	0.12
Lysimachia ciliata	FRINGED LOOSESTRIFE	14.29	6.67	0.50	0.03	0.12
Menispermum canadense	MOONSEED	14.29	6.67	0.50	0.03	0.12
Prunus nigra	CANADA PLUM	14.29	6.67	0.50	0.03	0.12
Prunus serotina	WILD BLACK CHERRY	14.29	6.67	0.50	0.03	0.12
Rubus sp.	RASPBERRY	14.29	6.67	0.50	0.03	0.12
Salix sp.	WILLOW	14.29	6.67	0.50	0.03	0.12
Sarracenia purpurea	PITCHER-PLANT	14.29	6.67	0.50	0.03	0.12
Sassafras albidum	SASSAFRAS	14.29	6.67	0.50	0.03	0.12
Saxifraga virginiana	EARLY SAXIFRAGE	14.29	6.67	0.50	0.03	0.12
Scirpus americanus	THREE-SQUARE; BULRUSH	14.29	6.67	0.50	0.03	0.12
Scirpus validus	SOFTSTEM BULRUSH	14.29	6.67	0.50	0.03	0.12
Solidago caesia	BLUE-STEMMED GOLDENROD	14.29	6.67	0.50	0.03	0.12
Spiraea alba	MEADOWSWEET	14.29	6.67	0.50	0.03	0.12
Spiraea tomentosa	HARDHACK; STEEPLEBUSH	14.29	6.67	0.50	0.03	0.12
Tilia americana	LINDEN; BASSWOOD	14.29	6.67	0.50	0.03	0.12
Toxicodendron radicans	POISON-IVY	14.29	6.67	0.50	0.03	0.12
Triglochin maritimum	COMMON BOG ARROW-GRASS	14.29	6.67	0.50	0.03	0.12
Typha latifolia	BROAD-LEAVED CAT-TAIL	14.29	6.67	0.50	0.03	0.12
Vernonia missurica	MISSOURI IRONWEED	14.29	6.67	0.50	0.03	0.12
Zanthoxylum americanum	PRICKLY-ASH	14.29	6.67	0.50	0.03	0.12
Zigadenus glaucus	WHITE CAMAS	14.29	6.67	0.50	0.03	0.12
Anemone canadensis	CANADA ANEMONE	14.29	6.67	0.01	0.00	0.11
Anemone quinquefolia	WOOD ANEMONE	14.29	6.67	0.01	0.00	0.11
Asclepias syriaca	COMMON MILKWEED	14.29	6.67	0.01	0.00	0.11
Carex gracillima	SEDGE	14.29	6.67	0.01	0.00	0.11
Carex sp.	SEDGE	14.29	6.67	0.01	0.00	0.11
Epilobium sp.	WILLOW-HERB	14.29	6.67	0.01	0.00	0.11
Fraxinus nigra	BLACK ASH	14.29	6.67	0.01	0.00	0.11
Polemonium reptans <T>	JACOB'S LADDER	14.29	6.67	0.01	0.00	0.11
Polygonatum pubescens	DOWNY SOLOMON SEAL	14.29	6.67	0.01	0.00	0.11
Quercus bicolor	SWAMP WHITE OAK	14.29	6.67	0.01	0.00	0.11
Smilacina stellata	STARRY FALSE SOLOMON-SEA	14.29	6.67	0.01	0.00	0.11
Smilax tamnoides	BRISTLY GREEN-BRIER	14.29	6.67	0.01	0.00	0.11
TARAXACUM OFFICINALE	COMMON DANDELION	14.29	6.67	0.01	0.00	0.11
Totals		8742.86	6086.67	3317.79	221.19	200.00

Appendix 3. Strata percent cover by plot. See Table 2 for strata descriptions. Values represent cover class mid-points (see text for cover classes).

Strata	Branch		Barry South		Barry Southwest		Cass Southwest			St. Joseph East			St. Joseph West			Van Buren Northeast	
	B1	B2	BS	BW1	BW2	CW1	CW2	CW3	SE1	SE2	SW1	SW2	SW3	VE1	VE2		
Canopy	0.0	0.0	0.0	37.5	0.0	0.0	0.0	0.0	0.0	7.5	0.0	0.0	0.0	0.0	0.0	17.5	
Understory	37.5	3.5	0.0	7.5	1.5	0.0	0.0	0.0	17.5	17.5	7.5	0.0	17.5	0.0	0.0	17.5	
Tall Shrub	37.5	17.5	3.5	37.5	7.5	3.5	0.0	0.0	3.5	37.5	3.5	17.5	17.5	0.0	0.0	62.5	
Medium Shrub	37.5	3.5	1.5	17.5	7.5	3.5	3.5	0.5	3.5	7.5	3.5	7.5	37.5	0.5	7.5	7.5	
Short Shrub	7.5	3.5	0.5	3.5	1.5	1.5	0.5	0.5	3.5	3.5	3.5	3.5	17.5	0.5	3.5	3.5	
Dwarf Shrub	0.5	0.0	3.5	3.5	0.5	17.5	37.5	0.5	17.5	3.5	3.5	1.5	3.5	62.5	37.5	37.5	
Ground Layer	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	
Total Strata Cover	218.0	125.5	106.5	204.5	116.0	123.5	139.0	99.0	143.0	174.5	119.0	127.5	191.0	161.0	243.5	243.5	
Sum of Woody Strata Cover	120.5	28.0	9.0	107.0	18.5	26.0	41.5	1.5	45.5	77.0	21.5	30.0	93.5	63.5	146.0	146.0	
Woody Strata % Relative Cover	55.3	22.3	8.5	52.3	15.9	21.1	29.9	1.5	31.8	44.1	18.1	23.5	49.0	39.4	60.0	60.0	
Graminoid	97.5	97.5	85.0	85.0	62.5	97.5	85.0	97.5	97.5	85.0	97.5	97.5	97.5	97.5	85.0	85.0	
Carex	97.5	97.5	85.0	85.0	62.5	85.0	85.0	97.5	97.5	85.0	97.5	97.5	97.5	85.0	85.0	85.0	
Ratio of Carex : Ground Layer (%)	100.0	100.0	87.2	87.2	64.1	87.2	87.2	100.0	100.0	87.2	100.0	100.0	100.0	87.2	87.2	87.2	
Forb	37.5	37.5	62.5	37.5	85.0	85.0	37.5	62.5	37.5	37.5	37.5	85.0	37.5	17.5	37.5	37.5	
Ratio of Forb : Ground Layer (%)	38.5	38.5	64.1	38.5	87.2	87.2	38.5	64.1	38.5	38.5	38.5	87.2	38.5	17.9	38.5	38.5	