This is to certify that the

thesis entitled

The Vegetation of Indian Bowl Wet Prairie

and Its Adjacent Plant Communities

presented by

Kathleen Anne Kron

has been accepted towards fulfillment
of the requirements for

M.S. degree in Botany

John H. Beaman
Major professor

Date July 27, 1982

THE VEGETATION OF INDIAN BOWL WET PRAIRIE AND ITS ADJACENT PLANT COMMUNITIES

By

Kathleen Anne Kron

A THESIS

Submitted to

Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Botany and Plant Pathology

1982

ABSTRACT

THE VEGETATION OF INDIAN BOWL WET PRAIRIE
AND ITS ADJACENT PLANT COMMUNITIES

By

Kathleen Anne Kron

Indian Bowl wet prairie and its adjacent plant communities, Berrien County, Michigan, were the subject of a botanical inventory from spring, 1980 to spring, 1982. Results of plot samples of the wet prairie indicate Carex and Solidago co-dominant in July, and no single dominant in August. Point-quarter sampling of the tamarack (Larix) swamp indicates Larix laricina as the dominant. Similar sampling of the floor and slopes of the bowl indicate Carpinus caroliniana as the most important species of the floor, Acer saccharum dominant on the north- and west-facing slopes and Quercus spp. dominant on the south-facing slope. The data from the wet prairie and the literature review indicate that the most appropriate designation of this vegetation is wet prairie rather than fen. Each of the 315 species of vascular plants collected is listed. Ten state threatened species are reported from the Indian Bowl tract.

Dedicated to Paul M. Kron

ACKNOWLEDGMENTS

I would like to express my appreciation to the Hanes Fund Trustees for their generous support in the form of a grant to defray expenses of the project, and to the Michigan State University Department of Botany and Plant Pathology for their support in the form of a scholarship for the summer of 1981.

Many people have been of great help in contributing toward the completion of this project. Special thanks go to my husband, Paul, and to the rest of my family for their unending support, and to Mrs. Christian Lyngby for her willingness to let me study her prairie. Thanks also to Linda Doolittle for her help in the spring flora sample of the bowl.

Finally, I would like to thank my major professor, Dr. John H. Beaman, and the other members of my committee, Dr. Stephen Stephenson, and Dr. Ralph Taggart for their critical comments and questions on this project.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Indian Bowl Prairie and its adjacent plant communities lie between the St. Joseph River and the Valparaiso moraine in central Berrien County, Michigan. This area was called to the author's attention in the spring of 1980 by Ms. Margaret Kohring of the Michigan Field Office of the Nature Conservancy as a site of high priority for acquisition by the Conservancy and in need of study. Although many species had been reported at one time or another from this tract, few collections had been made of the vascular plants and there were no quantitative ecological studies of the area.

Two aspects of this tract make it unique in Michigan. The first is the large bowl-shaped depression in the west side of the moraine, which gives the area its name, and the second is the presence of a large wet prairie. No landforms similar to the bowl formation have been located in the state and wet prairies are infrequent and of small size in Michigan. Besides these major aspects, others add to the floristic and ecological importance of the tract. Several state threatened and special concern plants (see Appendix) have been reported from the area which shows little evidence of disturbance, e.g., there are very few

introduced or naturalized species present. The St. Joseph River, Love Creek and the Valparaiso moraine are natural boundaries which have insulated this tract from outside disturbance. These natural barriers as well as the sodden nature of the soil have resulted in the presence of a unique natural area less than 100 miles from Chicago and in the midst of a heavily agricultural portion of Michigan.

Active preservation efforts are presently being made by the Michigan Field Office of the Nature Conservancy to keep this area free of development or disturbance, either by acquisition by the Conservancy or by cooperation with the property owners.

It is the purpose of this study to contribute to a better understanding of the nature of the Indian Bowl tract through a description of the floristic composition and vegetational structure of the wet prairie, tamarack swamp and bowl formation. Consequently, this will provide a basis for the proper assessment of the importance of preserving the Indian Bowl area.

PHYSICAL DESCRIPTION OF THE AREA

The study area was chosen to include the least disturbed and the floristically richest portion within the possible 325 acres suggested for inclusion in a preserve by Barnes and Kohring (1978). This included an area of approximately 260 acres located at T6S, R17W, section 8 W½ and

the NE¼ of the NE¼ of section 17, Berrien Township, Berrien County, Michigan (Figures 1 and 2). The town of Berrien Springs is one mile southwest of the Indian Bowl tract. The natural boundaries are the St. Joseph River to the west, Love Creek to the south and the Valparaiso moraine to the east and north. Hochberger Road lies at the very easternmost edge of the study area at the top of the moraine. The elevation of the area varies from 600 to 750 feet above sea level. The lowest area is the strip of floodplain forest along the St. Joseph River and the highest is around the top of the moraine. The major portion of the tract lies between 600 and 610 feet above sea level. A network of streams runs throughout the tract. These streams are fed by surface runoff from the slopes of the moraine and a series of seepage springs located in various places along the base of the moraine.

Two major landforms dominate the study area: the bowl-formation in the Valparaiso moraine and the floodplain of the St. Joseph River. The bowl-formation has steeply sloping sides of 25 to 75 percent slope and a relatively level base of 0 to 15 percent slope (hereafter referred to as the slopes and the floor of the bowl, respectively). Between the bowl-formation and the St. Joseph River lies the floodplain which is level to gently sloping at an elevation of 600 feet above sea level.

Four major community types may be observed by general inspection in the Indian Bowl tract (Figure 3). The

Figure 1. Aerial photograph of the Indian Bowl study tract.


North

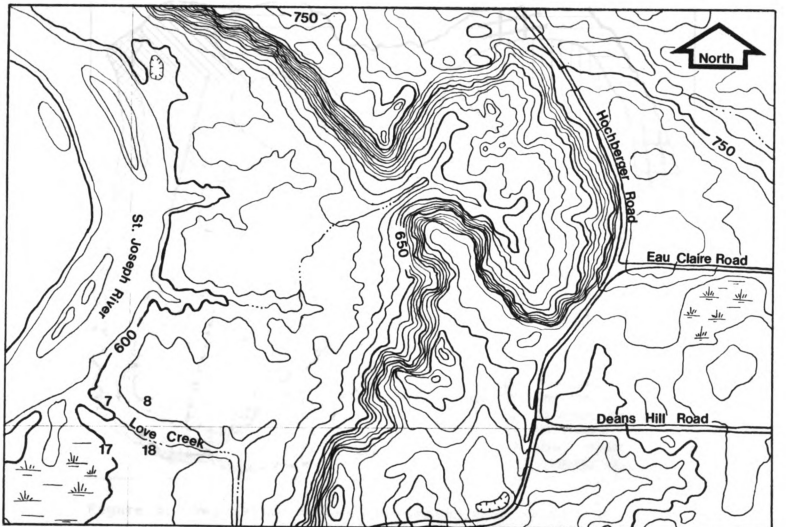

Figure 2. Topographic map of the Indian Bowl study area, Berrien County, Michigan.

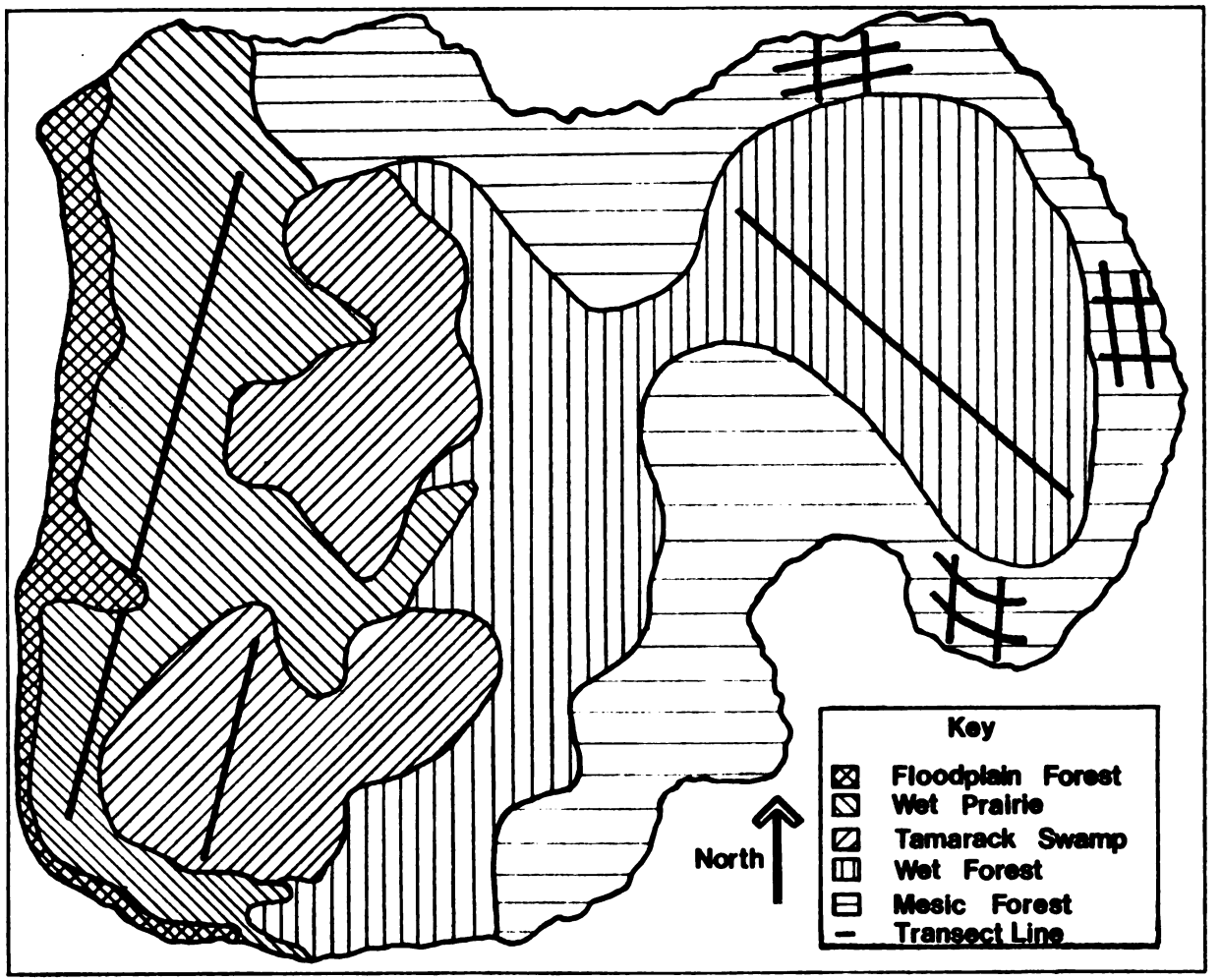

Figure 3. Vegetation map of the Indian Bowl study area, showing the orientation of the transects used in sampling.

western portion of the floodplain is wet prairie, with a very narrow strip of floodplain forest along the St. Joseph River. East of the prairie lies a discontinuous stretch of tamarack swamp running in a north-south direction. East of the tamarack swamp lies the bowl-formation. The slopes of the bowl have mesic deciduous forest and the floor has wet deciduous forest. The wet forest extends through a gap in the west side of the bowl and forms a thicket between the tamarack swamp and the base of the moraine.

Ownership of the area is presently held by four persons: Mr. Dale Dean, Mrs. Christian Lyngby, Mr. Roy Disterheft, and Mr. T. Homer Wilson. The Lyngby property is primarily the wet prairie while the Dean property includes a major portion of the bowl as well as most of the tamarack swamp. The current landholders do not have any of the study area under cultivation or pasturage, nor do they use it for timber. However, a small road has been bulldozed around the base of the bowl, presumably by Dale Dean, who uses it as a snowmobile trail.

HISTORICAL BACKGROUND

Berrien County was first surveyed by Noah Brookfield in 1826. In that survey no mention was made of the Indian Bowl or of the prairie. Perhaps this is because of the position of the section lines which coincide with the St. Joseph River on the west, lie north of the moraine, and

east of the bowl. Kenoyer (1934) interprets the general area from the 1826 survey to be of the beech-maple association, although he notes a swamp, just south of Love Creek in section 18. However, the portion of the moraine which lies north of the prairie is designated as oak-hickory association by Kenoyer (1934).

According to Turner (1857) the St. Joseph River valley at the time of settlement was mainly occupied by the Pottawattomi people with some groups of Miami and Chippewa. The Pottawattomi originally came from the Green Bay area, but travelled south along the western edge of Lake Michigan and around to the St. Joseph River valley. Others settled near Detroit or the Saginaw Bay area (Caton, 1870). Two burial mounds are located to the north of the prairie north of the bend in the St. Joseph River. An interesting garden plot constructed by the Pottawattomi (Hinsdale, 1931) has been located on what is now Pardee Island. The Indian Bowl was reported to be a winter camping ground for the local Pottawattomi (Medley, 1972). It reputedly is warmer than the surrounding areas during the winter.

The Pottawattomi in 1821 ceded, by the treaty of Chicago, all lands in Berrien County north and west of the St. Joseph River. They ceded all land south and east of the river by the 1828 treaty of the Carey Mission (Champion, 1926).

Information on the settlement of the area near the prairie and bowl has been difficult to obtain. No direct

reference has been found in historical chronicles to Indian Bowl, or its prairie. Wolf's Prairie is mentioned (Butler, 1935; Coolidge, 1906; Champion, 1926) as a prairie of nearly 1000 acres in size, now the site of Berrien Springs. This prairie was settled in 1829 by John Pike and extended east to western bluffs of the St. Joseph River. From all available accounts it is not the same as Indian Bowl prairie nor was the prairie ever part of Wolf's Prairie, although apparently directly across the river from it. There are some records regarding the initial settlement of Berrien Township. About 1830-31 Eli Ford settled in section 18 next to the St. Joseph River. In 1832 he built a sawmill on a creek [not named] flowing through section 17 (Ellis, 1880). According to Coolidge (1906) Ford's lumbering activities were extensive. The most important timber crop was Liriodendron tulipifera (tulip poplar) and Juglans nigra (black walnut). Eventually Ford rented the mill to Abram Puterbaugh and began to farm. The creek on which the sawmill was built is now called Love Creek (presumably after J. P. Love, a later owner of portions of section 8 (Lake, 1973)), which forms the southern boundary of Indian Bowl prairie. In 1829 Hugh Marrs is said to have "located 80 acres on the flat on the St. Joseph River opposite the Shaker farm in Oronoko (township)" (Ellis, 1880; Coolidge, 1906). This location is most likely the southwest corner of section 8, where the prairie is now located. He apparently built a house there but was driven to the

bluffs in the flood of 1832. He sold out that spring and moved five miles east of Berrien Springs. In 1856 he purchased the Ford property. In 1873 80 acres in section 8, southwest quarter, were owned by one of Ford's sons (Lake, 1873).

In Turner's Gazeteer (1857) Berrien Springs is said to be the site of an old French fort. Descriptions of the surrounding area suggested the presence of mineral springs,

> ". . . a sulphur spring on the opposite side of the river, surrounded by fine farms, overlooking the bluffs of the St. Joseph River . . . in sight of majestic woods . . . just above town are the beautiful embowered Indian fields . . . even now much frequented [by Indians]. Below and opposite the main mineral springs and its basin are the celebrated Shaker farms and establishment . . ."

It is possible that the references to the Indian Fields and the springs and its basin are to the Indian Bowl prairie and the bowl formation, respectively.

PREVIOUS REPORTS ON THE AREA

Although there has been only one published reference to the Indian Bowl prairie (Thompson, 1975) there have been a few unpublished reports. The earliest is by Medley (1972) written when he was a student at Andrews University in Berrien Springs. Medley compiled an extensive species list for the prairie, tamarack swamp and bowl, but documented this with few herbarium specimens. He suggested that this may be the largest wet prairie remaining in

Michigan. This report lists ten species of plants which were later designated as threatened or rare in the state (Wagner et al., 1977). Thompson (1975) published a list of approximately 200 species of angiosperms for the Indian Bowl prairie in his comparison of wet, mesic and dry prairie stands in southern Michigan. The Michigan Natural Areas Council issued a brief report (Thompson, et al., 1976) listing a few of the species found in each major community type, and indicating that almost 500 species of plants had been identified in the Indian Bowl area. The report recommended that the land be acquired by the Michigan Department of Natural Resources or a similar organization. It was suggested that the prairie be designated a Managed Tract and the remaining area a Natural Area Preserve. Barnes and Kohring (1978) prepared a site plan and environmental impact assessment for the Indian Bowl area. This report was made for the Berrien County Parks and Recreation Commission and proposed the acquisition of the area by the county. Some development has been proposed, including a boardwalk through the prairie and swamp forest, trails through the bowl and cross-country ski trails through the entire area. Within the report is a section by Medley and Kohring (1978) which briefly describes the area. The most recent report, prior to the present study was by Schaddalee (1980). This was prepared for the Michigan Field Office of the Nature Conservancy. It includes a list of 16 reported state threatened and rare species of vascular

plants and three species of state threatened and rare animals. Brief descriptions of the major community types are included, as well as approximate locations of most of the reported threatened and rare species. A detailed list of ownership is included. The end of the report consists of a compiled list of species reported for the area, mostly from Medley's list.

METHODS

The quadrat or plot method (Brower and Zar, 1977) was used to sample the prairie and the herbaceous spring flora of the bowl. Positions of 0.25 m^2 plots along transects were determined using a random numbers table (Brower and Zar, 1977). The percent cover was estimated for each species in each plot. Values of relative dominance and relative frequency were calculated from the plot data. Importance values were calculated by taking the mean ($\bar{x}$) of the relative values. A species-area curve was used to determine the proper number of sampling points necessary to accurately represent the composition of the communities being sampled (Cox, 1976) (Figures 4 through 7).

The prairie vegetation was analyzed by samples taken at two different times. The first sampling was in mid-July, 1980, the second at the end of August, 1981. In the July sample 102 plots were sampled along 1000 meters of transect. The transect is oriented in a northeast-southwest

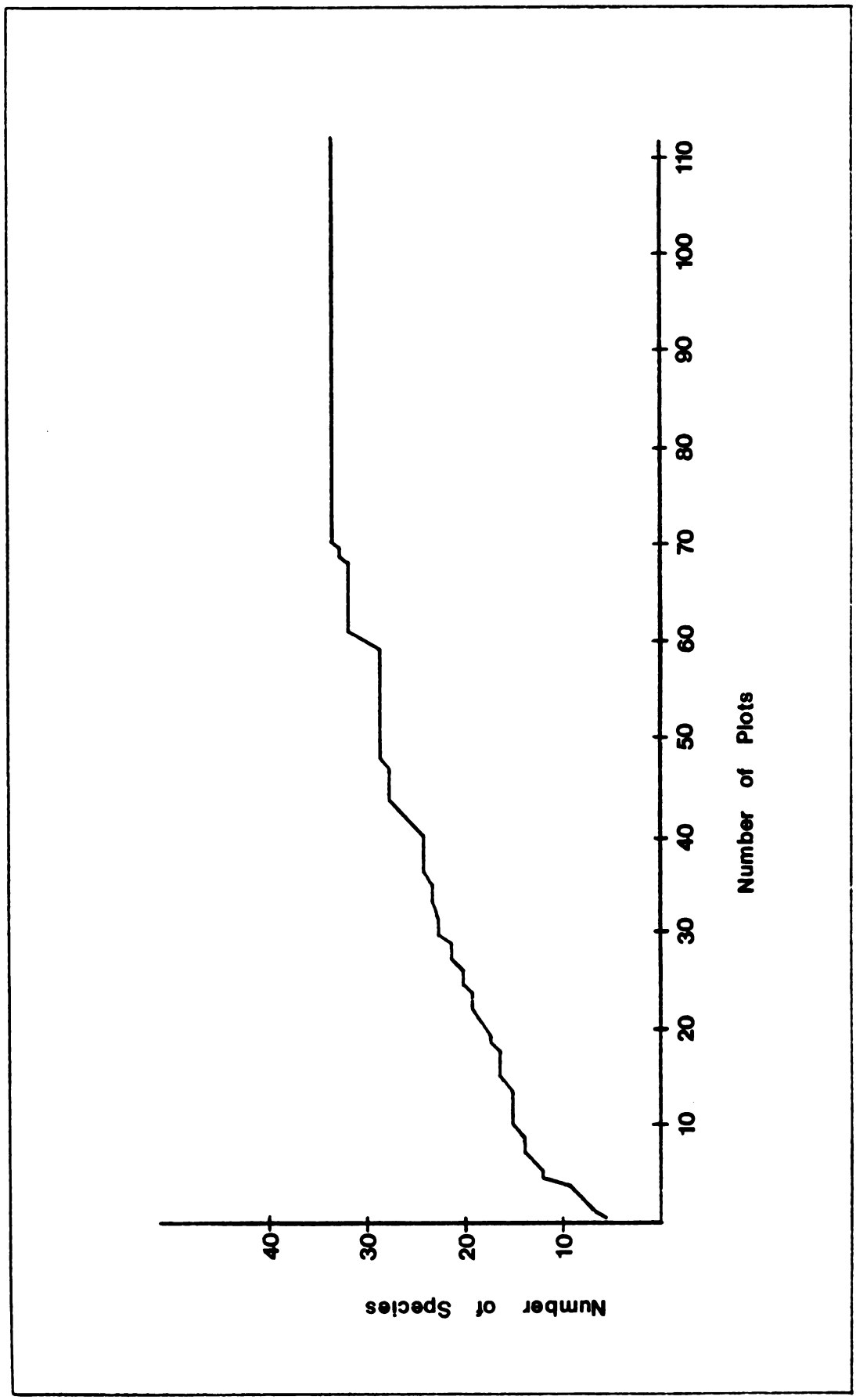

Figure 4. Species-area curve of the July sample of the wet prairie.

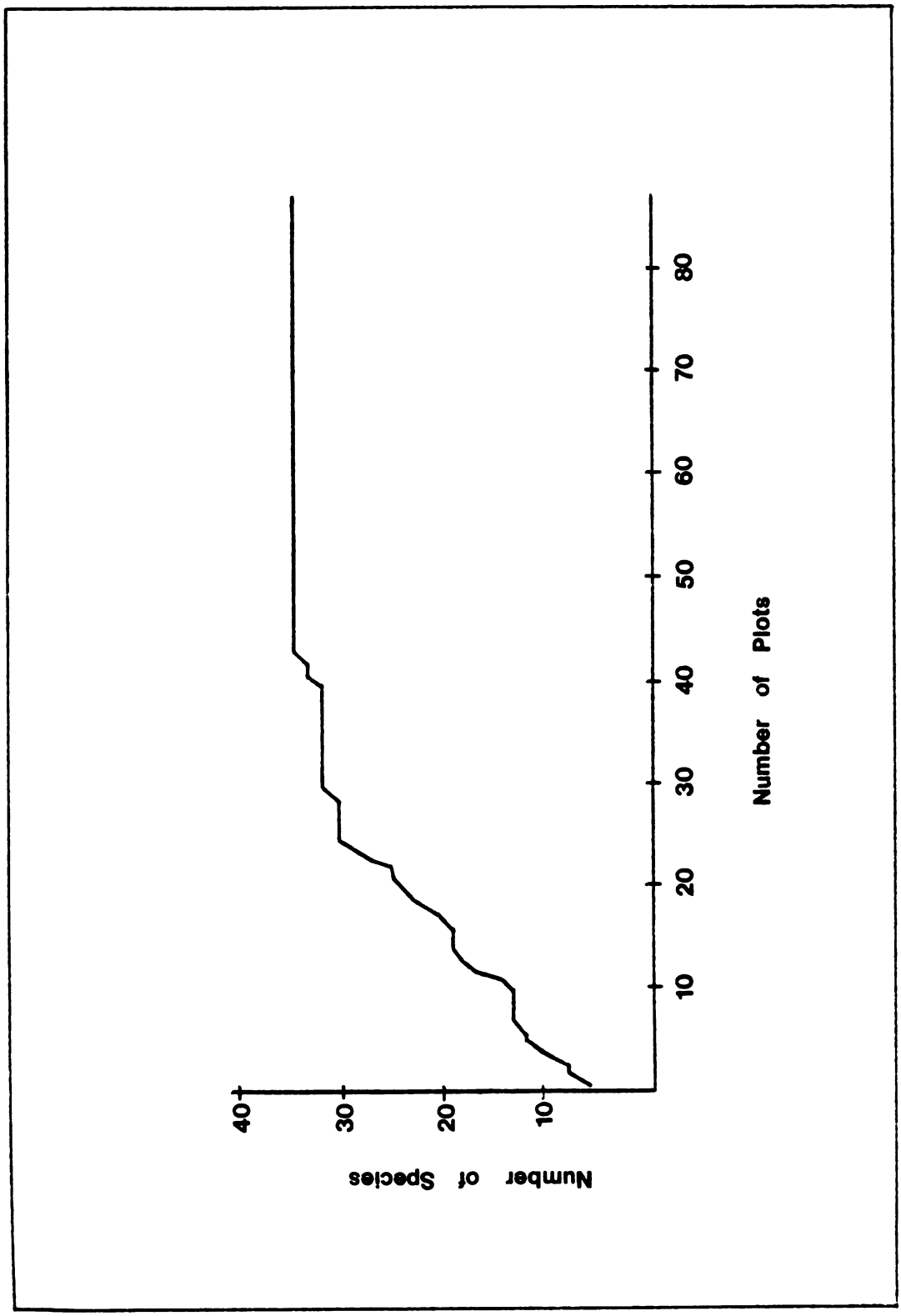

Figure 5. Species-area curve of the August sample of the wet prairie.

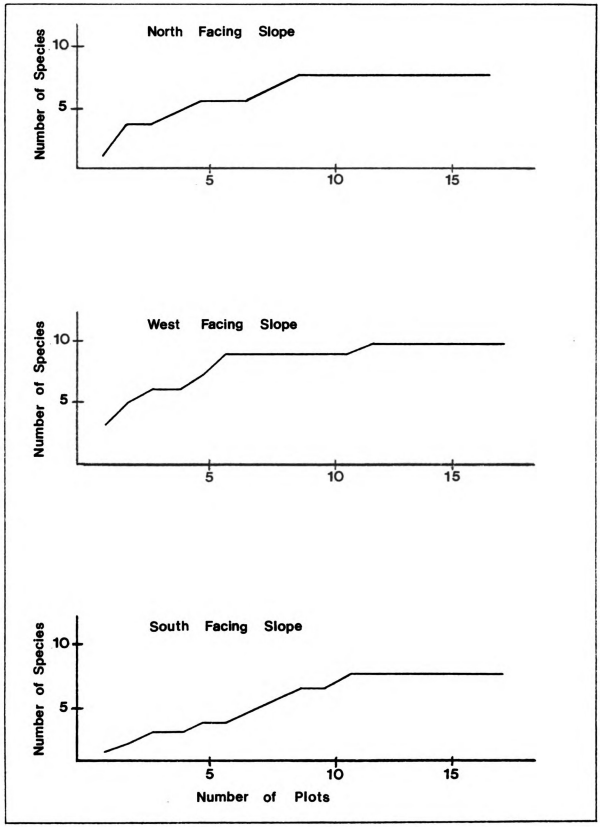

Figure 6. Species-area curves of the herbaceous spring flora sample of the slopes of the bowl.

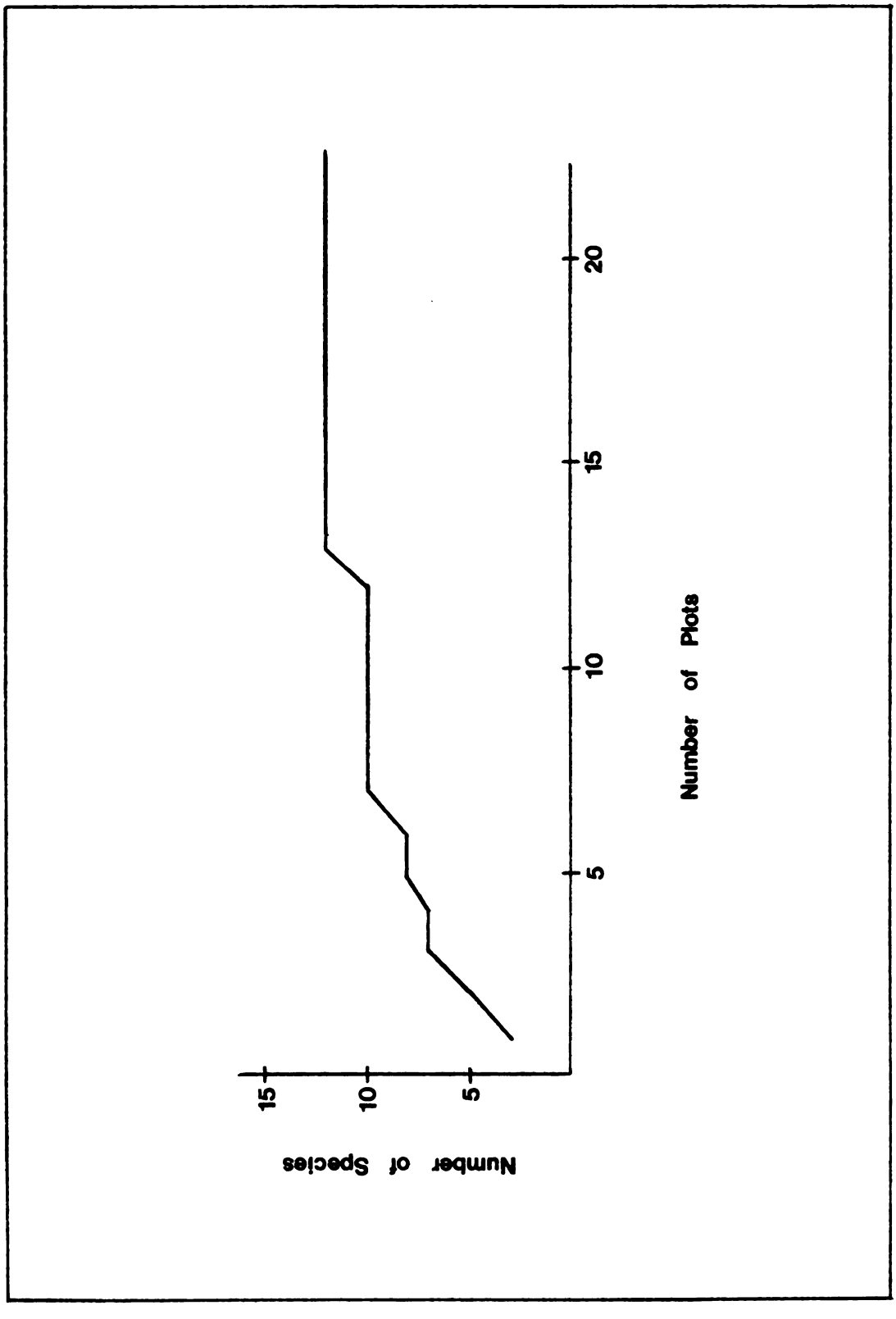

Figure 7. Species-area curve of the herbaceous spring flora sample of the floor of the bowl.

line beginning at the southern end of the prairie (Figure 3). The August sample consisted of 83 plots along 800 meters of transect with the same orientation as the July sample.

The herbaceous spring flora of the bowl was sampled at the beginning of May, 1981. Transects were oriented on each of the northern, western and southern aspects of the slopes of the bowl, perpendicular to the contour of the slope (Figure 3). One transect was placed in a northwest-southeast line through the central portion of the floor of the bowl (Figure 3). Sixteen plots were sampled along the north-facing slope; 15 along the west-facing, 17 along the south-facing slope, and 21 plots from the floor of the bowl.

Fourteen randomly placed 1 m^2 permanent plots were also used to sample the prairie at five different times during the growing season of 1981. Cover estimates were recorded for each species in each of the 14 plots in May, at the beginning and end of June, in mid-July and in mid-September. Relative dominance and relative frequency values were calculated using the same techniques as previously described in the sampling methods of the spring flora and the wet prairie.

The point-quarter method (Cottam and Curtis, 1956) was used to sample the arborescent vegetation of the tamarack swamp and the bowl. The positions of the points along each of the transects were determined using a random numbers

table (Brower and Zar, 1977). A species-area curve was used to determine the optimum number of sampling points necessary to accurately represent the composition of the community being sampled (Cox, 1976) (Figures 8 through 10). Trees one inch dbh (diameter at breast height) or greater were recorded. Values of relative dominance, relative density and relative frequency were calculated from the data. Importance values were calculated as the summation of the means of the relative values.

The tamarack swamp was sampled in January, 1981. Fifty-two points were sampled along 300 meters of transect placed in a northeast-southwest line beginning at the southern end of the swamp (Figures 3 and 8).

Within the bowl two transects were placed on each of the northern, western and southern aspects of the slopes perpendicular to the contour of the slope (Figures 3 and 9). One transect was placed in a northwest-southeast line through the central portion of the floor of the bowl (Figures 3 and 10). Sixty-eight points were sampled along 600 meters of transect on the slopes and 43 points were sampled along 500 meters of transect on the floor of the bowl.

The woody vegetation of the slopes of the bowl was also sampled using the line-intercept method (Brower and Zar, 1977). Two transects, each 100 meters apart and 100 meters long, were placed on each of the three slope aspects (Figure 3). Line-intercept cover data were recorded

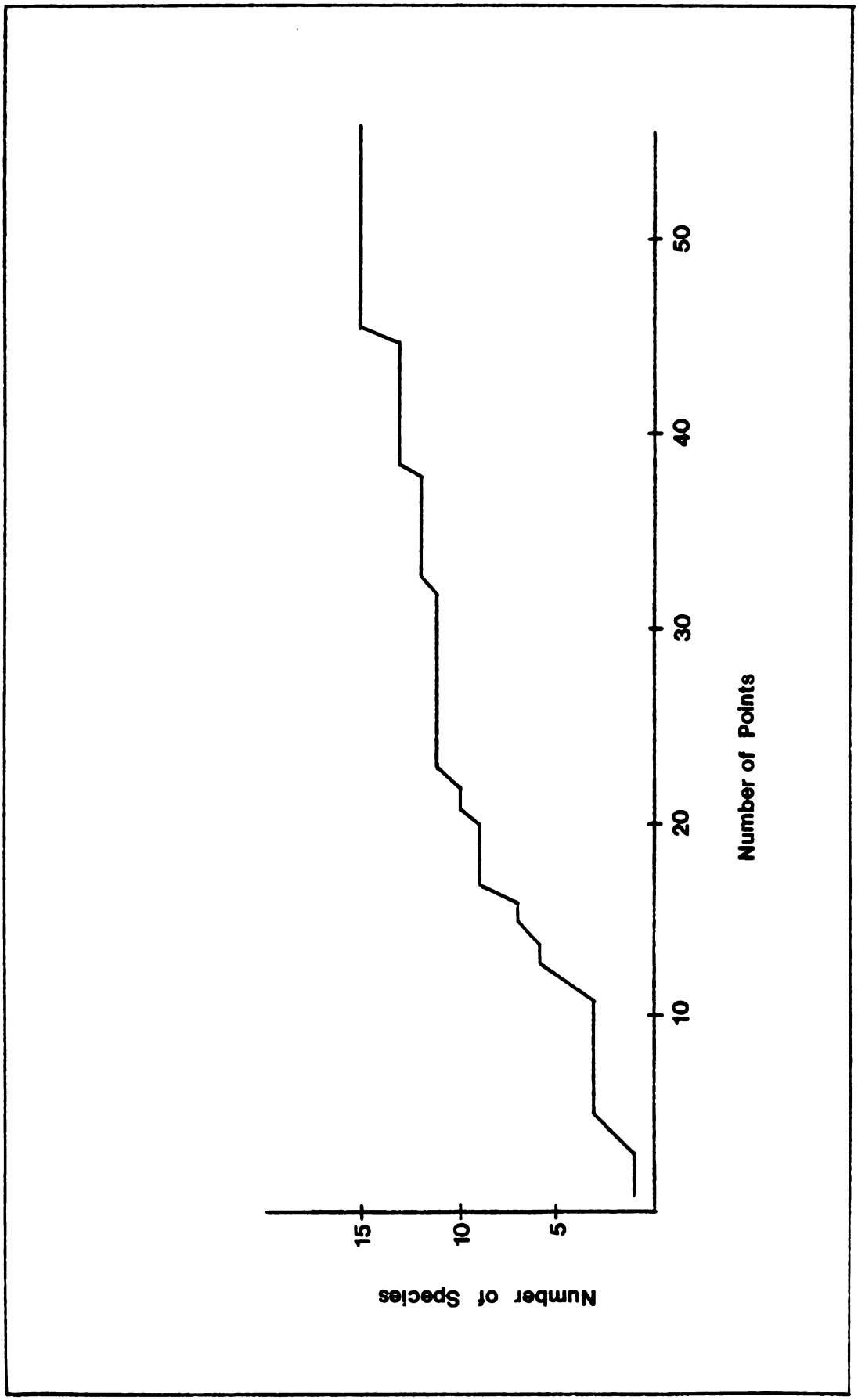

Figure 8. Species-area curve of the point-quarter sample of the tamarack swamp.

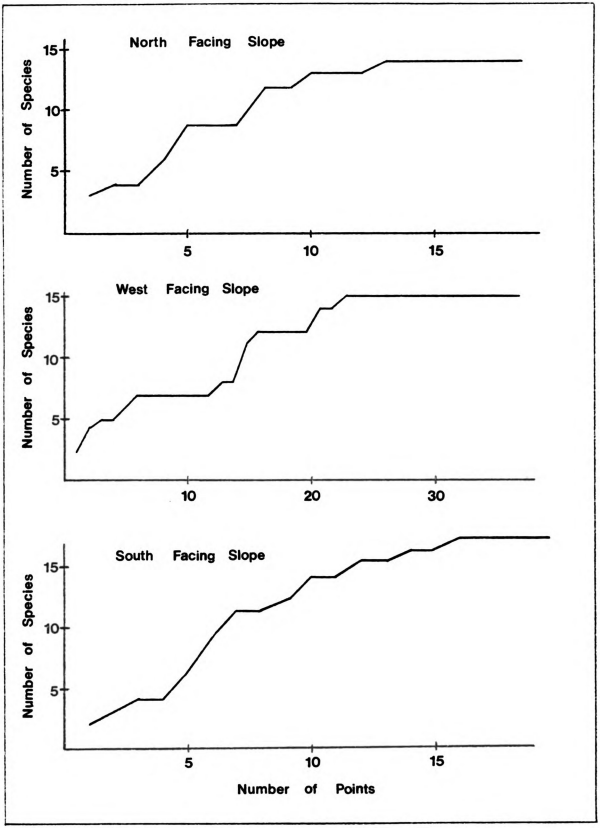

Figure 9. Species-area curves of the point-quarter sample of the slopes of the bowl.

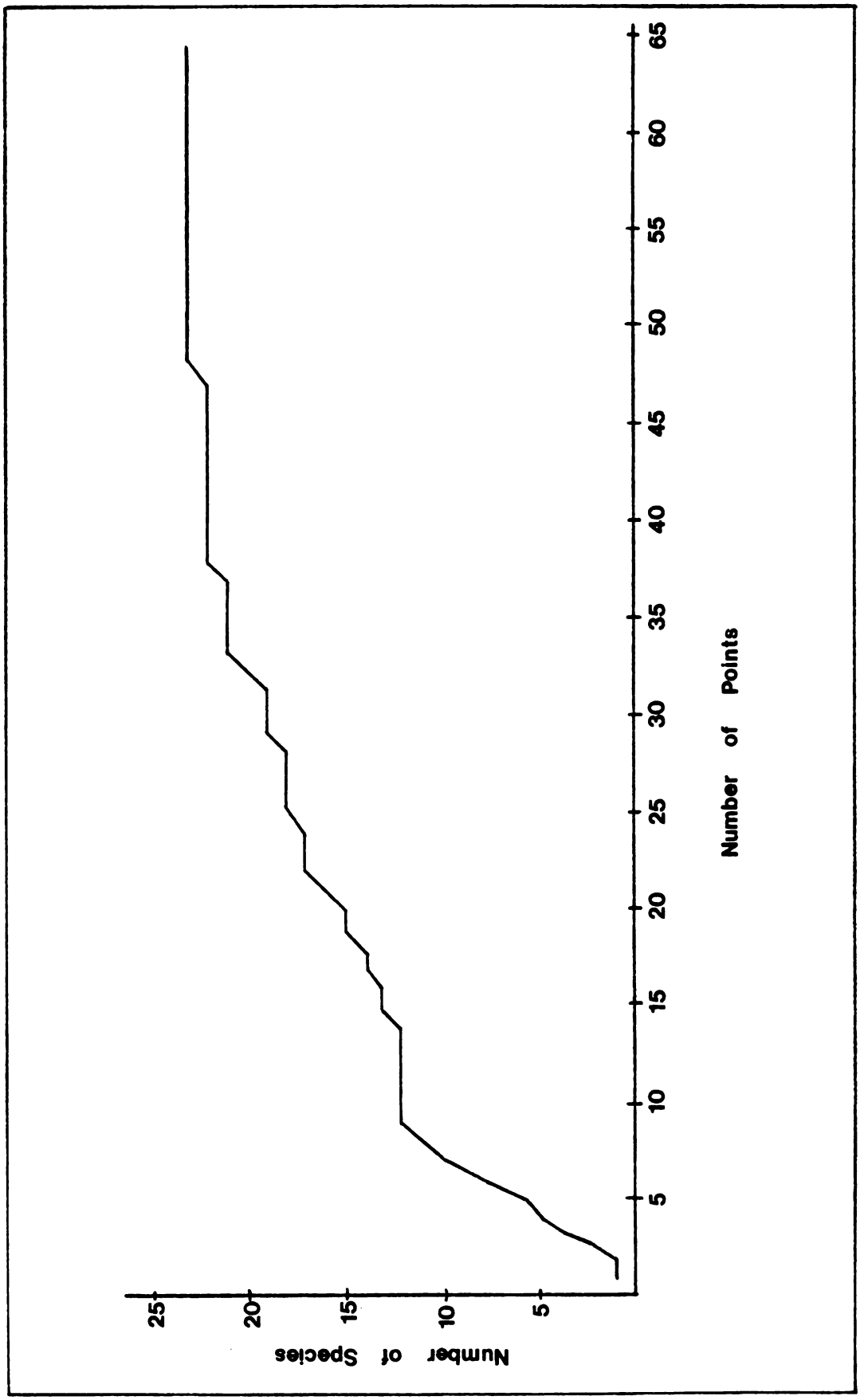

Figure 10. Species-area curve of the point-quarter sample of the floor of the bowl.

for the upper- and understory trees. Relative dominance was calculated from the data.

The soils of the prairie and the tamarack swamp were sampled using a one-inch bore, one meter in length. Fifteen cores were randomly taken in the prairie and fifteen were randomly taken in the tamarack swamp. Samples of the A horizon were taken randomly on the floor of the bowl, and the western, northern and southern aspects of the slopes of the bowl. Ten samples of the floor and ten from each aspect of the slopes of the bowl were taken. Each set of samples from a given area were mixed and a sample of that mixture was sent to the Michigan State University Soil Testing Service for analysis.

Voucher specimens were collected in triplicate throughout the summer and fall of 1980 and 1981. A permit was obtained through the Michigan Department of Natural Resources to collect state threatened plants. One set of specimens is deposited in the University of Michigan Herbarium, another in the Beal-Darlington Herbarium of Michigan State University, and a third in the Andrews University Herbarium. A thorough search was made for each of the reported state threatened and special concern species of vascular plants (Medley, 1972; Thompson, 1975, Schaddalee, 1980) which had not been documented by previous collections. Each of the state threatened and special concern plant species is mapped according to its distribution within the study area.

RESULTS

Wet Prairie

The results of the sampling of the vegetation of the wet prairie show a change in the structure and composition of the vegetation throughout the growing season. Plots taken in July indicated that the prairie is co-dominated by Carex and Solidago (Table 1). Seven of the 33 taxa encountered comprise almost 90 percent of the vegetation. Plots taken at the end of August indicated that the prairie then had no single dominant or co-dominants but that Solidago, Carex and Sorghastrum nutans make up 50 percent of the cover (Table 2). The number of taxa which comprise 90 percent of the vegetation of the prairie had increased to eleven. Comparison of the taxa encountered in July and August showed that 50 percent were common to both samples. The most important change in the prairie from the July to August sample was the natural dying of much of the Carex and the increase in the cover of Solidago and Sorghastrum nutans (Figure 11). Filipendula rubra and Thelypteris palustris maintained their relative importance as sub-dominants in the prairie throughout the season. (The position of F. rubra as a sub-dominant in prairies in Ohio has been noted by Jones (1944).) Taxa which exhibited little change in dominance were Boehmeria cylindrica, Convolvulus sepium, Iris virginica, Rhamnus alnifolius and Silphium integrifolium (Figure 11).

Table 1. Results of the plot sample of the wet prairie, taken July 12, 1980.

Species	Relative Dominance	Relative Frequency	Importance Value
Carex spp.	44.1	21.2	32.6
Solidago spp.	18.2	21.5	19.9
Thelypteris palustris	7.8	11.4	9.6
Filipendula rubra	7.2	8.0	7.6
Bromus ciliatus	5.7	4.4	5.0
Thalictrum dasycarpum	3.6	6.3	5.0
Calamagrostis canadensis	3.6	2.7	3.1
Eupatorium maculatum	1.3	3.4	2.3
Convolvulus sepium	0.7	3.1	1.9
Onoclea sensibilis	2.0	1.2	1.6
Iris virginica	0.6	2.2	1.4
Eupatorium perfoliatum	0.6	1.9	1.3
Lathyrus palustris	0.3	2.2	1.2
Boehmeria cylindrica	0.4	1.5	0.9
Oxypolis rigidior	0.4	1.5	0.9
Zizia aurea	0.5	1.0	0.7
Anemone canadensis	0.2	1.2	0.7
Cornus purpusii	0.3	0.7	0.5
Sagittaria latifolia	0.3	0.5	0.4
Rhamnus alnifolius	0.2	0.5	0.4
Smilacina stellata	0.2	0.5	0.3
Silphium integrifolium	0.4	0.2	0.3
Galium obtusum	0.1	0.5	0.3
Lysimachia ciliata	0.1	0.5	0.3

Table 1. continued.

Species	Relative Dominance	Relative Frequency	Importance Value
Salix sericea	0.3	0.2	0.3
Symplocarpus foetidus	0.3	0.2	0.3
Impatiens capensis	0.2	0.2	0.2
Viburnum lentago	0.2	0.2	0.2
Acer rubrum	0.1	0.2	0.2
Vernonia missurica	0.1	0.2	0.2
Ribes sp.	0.0	0.2	0.1
Rumex orbiculatus	0.0	0.2	0.1
Spartina pectinata	0.0	0.2	0.1

Table 2. Results of the plot sample of the wet prairie, taken August 30, 1981.

Species	Relative Dominance	Relative Frequency	Importance Value
Solidago spp.	21.9	15.8	18.9
Carex spp.	15.7	12.5	14.1
Sorghastrum nutans	11.2	7.3	9.3
Thelypteris palustris	5.5	10.2	7.8
Eupatorium maculatum	8.5	5.9	7.2
Filipendula rubra	6.8	5.9	6.3
Thalictrum dasycarpum	5.3	5.9	5.6
Spartina pectinata	5.6	3.1	4.3
Oxypolis rigidior	2.2	4.5	3.4
Aster spp.	2.9	3.1	3.0
Andropogon gerardii	2.6	2.1	2.4
Lathyrus palustris	1.0	3.6	2.3
Calamagrostis canadensis	1.7	2.4	2.0
Zizia aurea	1.6	2.1	1.9
Galium obtusum	1.5	2.1	1.8
Iris virginica	0.5	2.6	1.5
Convolvulus sepium	0.5	2.4	1.4
Vernonia missurica	0.7	1.4	1.1
Eupatorium perfoliatum	0.3	1.0	0.6
Boehmeria cylindrica	0.2	1.0	0.6
Salix sericea	0.9	0.2	0.6
Allium cernuum	0.2	1.0	0.6
Pedicularis lanceolata	0.2	0.7	0.5
Silphium integrifolium	0.4	0.5	0.4

Table 2. continued

Species	Relative Dominance	Relative Frequency	Importance Value
Rhamnus alnifolius	0.6	0.2	0.4
Onoclea sensibilis	0.4	0.2	0.3
Parnassia glauca	0.1	0.5	0.3
Agrimonia pubescens	0.3	0.2	0.3
Helianthus giganteus	0.3	0.2	0.3
Cirsium muticum	0.1	0.5	0.3
Cicuta maculata	0.3	0.2	0.3
Dichanthelium sp.	0.1	0.2	0.2
Apios americana	0.1	0.2	0.2
Sagittaria latifolia	0.0	0.2	0.1

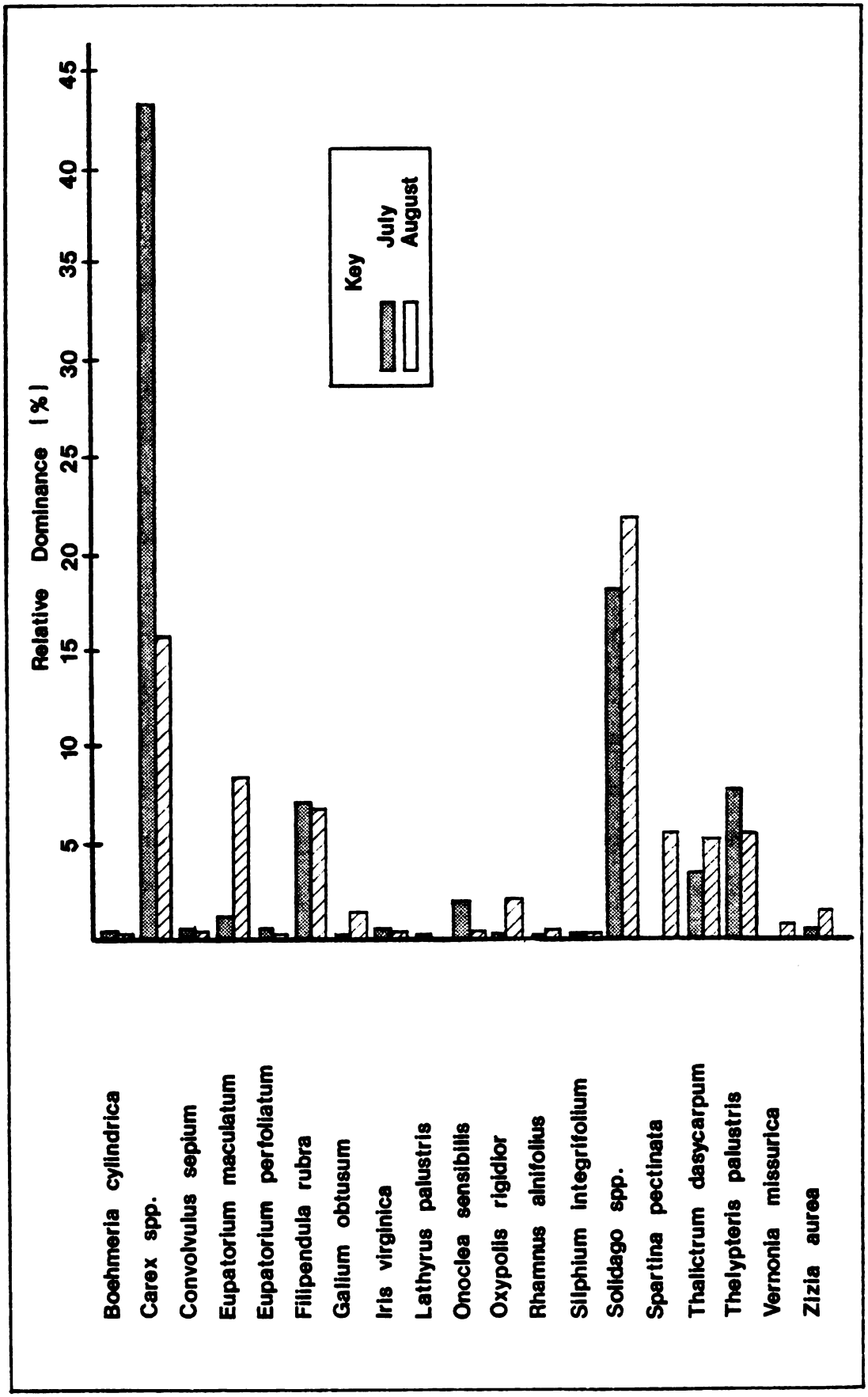

Figure 11. Comparison of relative dominance values of species encountered in the July and August samples of the wet prairie.

The seasonal change in the vegetational structure of the prairie may also be seen in the results of the permanent plot samples. The plots were sampled at five intervals from May to September. While the total number of species encountered increased from eight to 17, six species were encountered throughout the season. The change in percent cover of these species can be seen in Figure 12. Carex shows an increase in cover from May to July and a sharp decrease from July to September. Solidago increases rapidly in cover from the beginning to the end of June. The number of species encountered in each sample increased (Tables 3 through 7) from eight in May to 17 in September. The importance and number of members of the Asteraceae especially increased during this time. In May Carex was dominant and Solidago and Calamagrostis were sub-dominant (Table 3). As the season progressed the importance of Carex and Solidago in the prairie changed and by September (Table 7) Solidago and Eupatorium were co-dominant and Carex and Aster sub-dominant.

Both the transect samples and the permanent plot samples of the prairie indicate that it has a prolonged phenology which results in a dynamic vegetational structure rather than a static one. This can be seen by the increase in the number of species from the beginning to the end of the season and their changing importance in the prairie during that time. The prairie as a whole may be characterized as a community which is dominated throughout the

Figure 12. Change in mean percent cover of six species encountered from May to September in the permanent plot sample of the wet prairie.

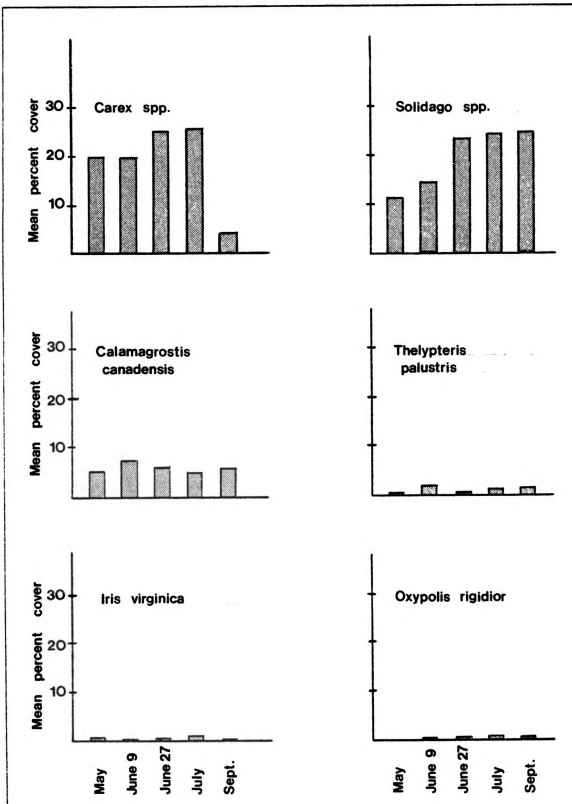
Carex spp.
Solidago spp.
Calamagrostis canadensis
Thelypteris palustris
Iris virginica
Oxypolis rigidior
Mean percent cover
30
20
10
May
June 9
June 27
July
Sept.

Table 3. Results of the permanent plot sample of the wet prairie, taken May 15, 1981.

Species	Relative Dominance	Relative Frequency	Importance Value
Carex spp.	53.9	28.0	41.0
Solidago spp.	30.6	28.0	29.3
Calamagrostis canadensis	13.7	18.0	15.9
Thelypteris palustris	0.6	12.0	6.3
Iris virginica	0.9	8.0	4.5
Lathyrus palustris	0.2	2.0	1.1
Oxypolis rigidior	0.1	2.0	1.1
Parthenocissus quinquefolia	0.1	2.0	1.1

Table 4. Results of the permanent plot sample of the wet prairie, taken June 9, 1981.

Species	Relative Dominance	Relative Frequency	Importance Value
Carex spp.	45.9	25.0	35.5
Solidago spp.	31.5	25.0	28.4
Calamagrostis canadensis	16.6	16.1	16.3
Thelypteris palustris	4.6	14.3	9.5
Iris virginica	0.6	7.1	3.9
Oxypolis rigidior	0.3	3.6	1.9
Asclepias syriaca	0.2	1.8	1.0
Convolvulus sepium	0.2	1.8	1.0
Eupatorium spp.*	0.1	1.8	0.9
Sagittaria latifolia	0.1	1.8	0.9
Agrostis sp.	0.0	1.8	0.9

* includes *Eupatorium maculatum*, *E. fistulosum*, and *E. perfoliatum*

Table 5. Results of the permanent plot sample of the wet prairie, taken June 27, 1981.

Species	Relative Dominance	Relative Frequency	Importance Value
Carex spp.	42.7	23.7	33.2
Solidago spp.	40.2	23.7	32.0
Calamagrostis canadensis	10.1	11.9	11.0
Thelypteris palustris	1.4	10.2	5.8
Iris virginica	0.5	8.5	4.5
Asclepias syriaca	3.9	3.4	3.7
Oxypolis rigidior	0.4	5.1	2.7
Convolvulus sepium	0.4	3.4	1.9
Eupatorium spp.*	0.1	3.4	1.7
Galium obtusum	0.1	1.7	0.9
Lysimachia ciliata	0.1	1.7	0.9
Boehmeria cylindrica	0.1	1.7	0.9
Elymus virginicus	0.1	1.7	0.9

* includes Eupatorium maculatum, E. fistulosum, and E. perfoliatum

Table 6. Results of the permanent plot sample of the wet prairie, taken July 11, 1981.

Species	Relative Dominance	Relative Frequency	Importance Value
Carex spp.	40.5	16.9	28.7
Solidago spp.	34.8	14.5	24.6
Thelypteris palustris	6.6	16.9	11.8
Eupatorium spp.*	6.6	14.5	10.5
Calamagrostis canadensis	7.4	8.4	7.9
Iris virginica	0.7	8.4	4.6
Galium obtusum	0.9	4.8	2.9
Lathyrus palustris	0.6	4.8	2.7
Convolvulus sepium	0.5	3.6	2.1
Oxypolis rigidior	0.6	2.4	1.5
Asclepias syriaca	0.4	1.2	0.8
Bromus ciliatus	0.3	1.2	0.8
Boehmeria cylindrica	0.2	1.2	0.7
Lysimachia ciliata	0.1	1.2	0.6

* includes *Eupatorium maculatum*, *E. fistulosum*, and *E. perfoliatum*

Table 7. Results of the permanent plot sample of the wet prairie, taken September 14, 1981.

Species	Relative Dominance	Relative Frequency	Importance Value
Solidago spp.	46.9	15.6	31.3
Eupatorium spp.*	18.3	13.3	15.8
Carex spp.	8.2	15.6	11.8
Aster spp.	6.7	12.2	9.5
Thelypteris palustris	3.8	14.4	9.1
Calamagrostis canadensis	11.2	6.7	8.9
Iris virginica	0.5	5.6	3.1
Lathyrus palustris	1.0	3.3	2.2
Boehmeria cylindrica	1.1	2.2	1.7
Galium obtusum	0.8	2.2	1.5
Convolvulus sepium	0.3	2.2	1.3
Asclepias syriaca	0.5	1.1	0.8
Agrimonia pubescens	0.2	1.1	0.7
Chelone glabra	0.1	1.1	0.6
Lysimachia ciliata	0.1	1.1	0.6
Oxypolis rigidior	0.1	1.1	0.6
Elymus virginicus	0.1	1.1	0.6

* includes Eupatorium maculatum, E. fistulosum, and E. perfoliatum

season by three families: Asteraceae, Cyperaceae and Poaceae, which shift in their relative importance to each other from May to September and thus provide a dynamic aspect to the structure of the vegetation.

Tamarack Swamp

The results of the sampling of the tamarack swamp show that tamarack (Larix laricina) is the dominant species and Acer rubrum and Fraxinus nigra are subdominant (Table 8). Individuals of Acer rubrum are of smaller size than those of L. laricina although density and frequency for the two taxa in the swamp are similar. Tamarack individuals vary in age from saplings to old trees over 38 cm. in diameter (Figure 13). The swamp also contains several understory species as well as some small individuals typical of southern hardwood forests (Sytsma and Pippen, 1982).

Succession in tamarack forests in southern Michigan leads to a size-structured forest in its later stages of development (Sytsma and Pippen, 1982). Within this structure a relatively few large individuals of tamarack dominate an understory mainly composed of young individuals of Acer rubrum, Toxicodendron vernix and tamarack. The Indian Bowl tamarack swamp appears to be intermediate between the mature and late stages of tamarack forest succession due to the presence of a few large individuals of L. laricina which dominate the swamp and the comparatively low density

Table 8. Results of the point-quarter sample of the tamarack swamp.

Species	Relative Dominance	Relative Density	Relative Frequency	Importance Value
Larix laricina	47.4	28.3	22.9	32.8
Acer rubrum	22.4	11.7	12.1	15.4
Lindera benzoin	1.3	14.6	16.4	10.8
Fraxinus nigra	13.3	7.3	7.9	9.5
Viburnum lentago	1.6	12.2	12.1	8.7
Toxicodendron vernix	2.7	10.2	10.7	7.9
Ulmus americana	4.9	5.4	5.7	5.3
Cornus alternifolia	1.1	3.9	3.6	2.9
Prunus serotina	0.8	1.5	2.1	1.5
Carpinus caroliniana	0.4	2.0	2.1	1.5
Liriodendron tulipifera	2.6	0.5	0.7	1.3
Betula allegheniensis	1.2	1.0	1.4	1.2
Quercus bicolor	0.2	0.5	0.7	0.5
Tilia americana	0.1	0.5	0.7	0.4
Prunus virginiana	0.0	0.5	0.7	0.4

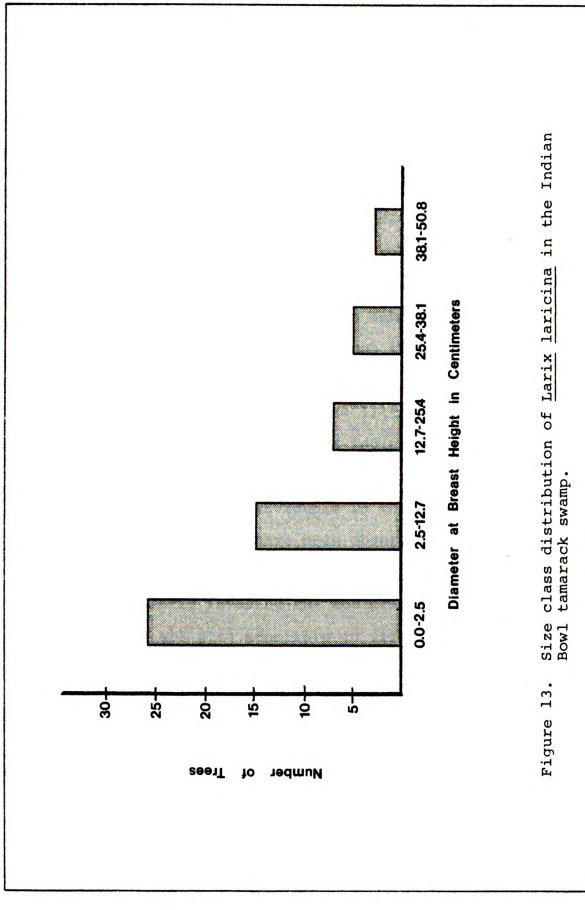

Figure 13. Size class distribution of Larix laricina in the Indian Bowl tamarack swamp.

of L. laricina saplings (Sytsma and Pippen, 1982). However, the importance of Acer rubrum and Fraxinus nigra may indicate the early stages of transition to southern hardwood forest. Transition from tamarack swamp to hardwood forest has been described in its later stages of development (Kurz, 1928; Brewer, 1966), where broad-leaved species dominate and tamarack is of little importance. The transition from tamarack forest to hardwoods is considered rapid in undisturbed situations (Sytsma and Pippen, 1982) but Brewer (1966) states that these forests in southwestern Michigan rarely remain undisturbed long enough to allow succession to hardwood forest to continue.

The Indian Bowl area exhibits little evidence of disturbance by fire or man. This is indicated by the many Larix laricina saplings around the edge of the forest and the presence of large individuals in the middle of the wet prairie. No fire scars have been observed on the trees in the tamarack forest. The thriving Cornus and Viburnum thickets presently invading the wet prairie also support this, as both are also sensitive to fire. The lack of development between the moraine and the tamarack swamp has prevented any significant change in drainage to which tamaracks are highly sensitive. Therefore, the location of the tamarack forest in the Indian Bowl area has allowed the continuing succession of the tamarack swamp.

Spring Flora Sample of the Slopes and Floor of the Bowl

The results of the sampling of the herbaceous spring flora of the slopes and floor of the bowl in May show that Smilacina racemosa and Trillium grandiflorum are the most important species at this time of year. Smilacina is the most important on the north- and south-facing slopes of the bowl (Tables 9 and 11) with Osmorhiza claytonii of secondary importance on the north-facing slope and Hydrophyllum appendiculatum of secondary importance on the south-facing slope. On the floor (Table 12) and the west-facing slope (Table 10) of the bowl Trillium grandiflorum is the most important species with Viola canadensis following in importance on the west-facing slope and Geranium maculatum of secondary importance on the floor of the bowl. Three species were encountered on all three slopes and the floor of the bowl: Trillium grandiflorum, Smilacina racemosa and Polygonatum pubescens.

Comparison of the species found on each slope and the floor of the bowl indicates that north- and south-facing slopes are the least similar, with only three species common to both slopes. The north- and west-facing slopes are most similar with five species common to both slopes. However, each slope aspect has more species in common with the floor of the bowl than with either other slope exposures. This may be because of the larger number of species found on the floor of the bowl due possibly to the greater amount of

Table 9. Results of the plot sample of the herbaceous spring flora of the north-facing slope of the bowl, taken May 1981.

Species	Relative Dominance	Relative Frequency	Importance Value
Smilacina racemosa	50.9	35.7	43.3
Osmorhiza claytonii	21.3	17.9	19.6
Stylophorum diphyllum	4.8	17.9	11.3
Trillium grandiflorum	6.1	7.1	6.6
Caulophyllum thalictroides	9.1	3.6	6.3
Galium aparine	3.5	7.1	5.3
Panax trifolius	2.6	7.1	4.9
Polygonatum pubescens	1.7	3.6	2.6

Table 10. Results of the plot sample of the herbaceous spring flora of the west-facing slope of the bowl, taken May 1981.

Species	Relative Dominance	Relative Frequency	Importance Value
Trillium grandiflorum	35.1	11.1	23.1
Viola canadensis	8.1	19.4	13.8
Smilacina racemosa	13.1	13.9	13.4
Hydrophyllum appendiculatum	11.7	13.9	12.8
Geranium maculatum	13.1	11.1	12.1
Osmorhiza claytonii	9.9	13.9	11.9
Galium aparine	6.7	5.6	6.1
Polygonatum pubescens	1.4	5.6	3.4
Dicentra canadensis	0.5	2.8	1.6
Viola pubescens	0.5	2.8	1.6

Table 11. Results of the plot sample of the herbaceous spring flora of the south-facing slope of the bowl, taken May 1981.

Species	Relative Dominance	Relative Frequency	Importance Value
Smilacina racemosa	33.9	30.8	32.3
Hydrophyllum appendiculatum	29.5	19.2	24.3
Podophyllum peltatum	13.6	11.5	12.5
Asarum canadense	11.8	11.5	11.6
Trillium grandiflorum	6.4	11.5	9.0
Caulophyllum thalictroides	1.3	7.7	4.4
Hepatica acutiloba	2.6	3.9	3.2
Polygonatum pubescens	1.0	3.9	2.5

Table 12. Results of the plot sample of the herbaceous spring flora of the floor of the bowl, taken May 1981.

Species	Relative Dominance	Relative Frequency	Importance Value
Trillium grandiflorum	44.6	16.3	30.4
Geranium maculatum	6.8	16.3	13.5
Voila canadensis	5.3	16.3	10.8
Podophyllum peltatum	13.3	6.1	9.7
Osmorhiza claytonii	5.1	14.3	9.6
Smilacina racemosa	9.4	8.2	8.9
Hydrophyllum appendiculatum	7.7	8.2	7.9
Dicentra canadensis	4.3	6.1	5.2
Galium aparine	1.2	4.1	2.6
Caulophyllum thalictroides	1.5	2.0	1.7
Polygonatum pubescens	1.0	2.0	1.5

light available because of the lack of continuous tree cover.

Trees of the Floor of the Bowl

Twenty-three species were encountered in the sample of the floor of the bowl. In this wet forest typical understory species are more important than upperstory species. Carpinus caroliniana is the most important tree (Table 13) with Lindera benzoin and Ostrya virginiana also very common. Typical canopy species of bottomlands or wet sites, Liriodendron tulipifera, Platanus occidentalis and Populus deltoides (Harlow and Harrar, 1958) are infrequent in the forest and do not form a continuous cover of vegetation above the Carpinus. The wet nature of the forest is also indicated by the presence of Fraxinus nigra, F. pensylvanica, Acer rubrum, and Celtis occidentalis. Over 75 percent of the trees encountered were 2.5 to 12.7 cm. in diameter. None was larger than 50.8 cm. dbh (Figure 14).

The forest on the floor of the bowl has species in common with the tamarack swamp and with the slopes of the bowl. Acer rubrum and Fraxinus nigra are also found in the tamarack swamp (Table 8) but there they are larger in size and more frequent than the floor of the bowl. Ostrya and Carpinus are found on both the slopes and the floor of the bowl but Carpinus is much less frequent on the slopes while Ostrya is an important understory tree but is smaller in

Table 13. Results of the point-quarter sample of the floor of the bowl.

Species	Relative Dominance	Relative Density	Relative Frequency	Importance Value
Carpinus caroliniana	5.5	25.3	20.9	17.2
Lindera benzoin	1.1	15.8	14.8	10.6
Ostrya virginiana	3.7	11.9	11.0	8.9
Liriodendron tulipifera	19.5	2.0	2.8	8.1
Acer saccharum	5.8	7.9	7.7	7.1
Platanus occidentalis	17.0	1.6	1.7	6.7
Tilia americana	4.0	5.5	6.6	5.4
Populus deltoides	10.8	1.6	2.2	4.9
Fraxinus nigra	4.4	4.4	5.0	4.6
Prunus serotina	5.2	4.4	3.9	4.5
Asimina triloba	0.7	4.7	5.0	3.5
Fagus grandifolia	8.2	0.8	1.1	3.4
Ulmus rubra	2.2	4.0	3.9	3.3
Aesculus glabra	2.2	2.4	3.3	2.6
Fraxinus pensylvanica	3.7	1.6	2.2	2.5

Table 13. continued.

Species	Relative Dominance	Relative Density	Relative Frequency	Importance Value
Ulmus americana	2.5	1.2	1.7	1.8
Acer rubrum	1.9	1.2	1.1	1.4
Celtis occidentalis	1.3	0.4	0.6	0.8
Acer negundo	0.3	0.8	1.1	0.7
Crataegus sp.	0.1	0.8	1.1	0.7
Viburnum prunifolium	0.1	0.8	1.1	0.7
Hamamelis virginiana	0.1	0.8	1.1	0.7
Staphylea trifolia	0.1	0.4	0.6	0.3

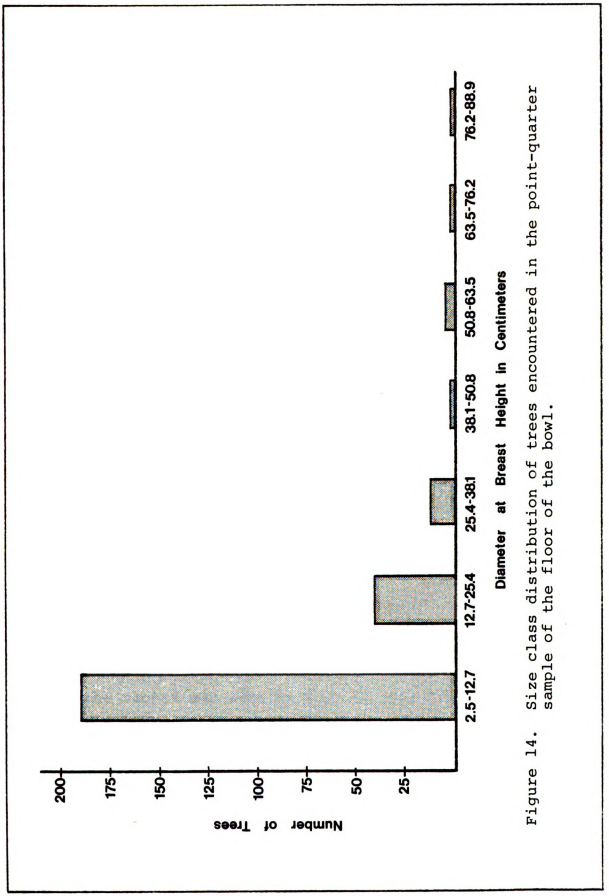

Figure 14. Size class distribution of trees encountered in the point-quarter sample of the floor of the bowl.

size than on the floor of the bowl. Five species occur on the floor of the bowl but were not encountered in either the tamarack swamp or on the slopes of the bowl: Acer negundo, Crataegus sp., F. pensylvanica, Staphylea trifolia, and Aesculus glabra.

Trees on the Slopes of the Bowl

Results of the point-quarter sampling of trees on the slopes of the bowl show differences in the composition and structure of the vegetation depending on the slope aspect. The most important species on the west- and north-facing slopes is Acer saccharum (Tables 14 and 15). On the north-facing slope A. saccharum is generally larger in size than on the west-facing slope. Liriodendron tulipifera is the second most important species on the north-facing slope while Fagus grandifolia is the next most important species on the west-facing slope. On the south-facing slope, however, Quercus alba is the most important species (Table 16). On this slope oaks (Q. alba, Q. rubra and Q. macrocarpa) comprise over 50 percent of the cover. Differences among the slopes may also be seen in the composition and importance of the understory species. Ostrya virginiana is the most important understory tree on both the west- and north-facing slopes but Cornus florida is the most important species on the south-facing slope.

Table 14. Results of the point-quarter sample of the north-facing slope of the bowl.

Species	Relative Dominance	Relative Density	Relative Frequency	Importance Value
Acer saccharum	20.0	31.9	25.9	26.0
Liriodendron tulipifera	25.7	11.1	13.0	16.6
Fagus grandifolia	17.2	6.9	7.4	10.5
Ostrya virginiana	2.5	12.5	14.8	9.9
Fraxinus americana	14.4	5.6	7.4	9.1
Ulmus americana	6.1	6.9	9.3	7.4
Asimina triloba	0.8	9.7	3.7	4.7
Quercus rubra	4.2	2.8	3.7	3.6
Sassafras albidum	3.8	2.8	3.7	3.4
Carya cordiformis	3.8	2.8	1.9	2.8
Hamamelis virginiana	0.1	2.8	3.7	2.2
Tilia americana	1.5	1.4	1.9	1.6
Prunus serotina	0.1	1.4	1.9	1.1
Viburnum prunifolium	0.0	1.4	1.9	1.1

Table 15. Results of the point-quarter sample of the west-facing slope of the bowl.

Species	Relative Dominance	Relative Density	Relative Frequency	Importance Value
Acer saccharum	10.4	41.9	32.5	28.3
Fagus grandifolia	43.9	11.3	8.8	21.3
Prunus serotina	13.7	11.3	11.3	12.1
Fraxinus americana	24.1	4.8	6.2	11.7
Ulmus americana	2.2	9.7	11.3	7.7
Ostrya virginiana	0.4	4.8	7.5	4.3
Quercus alba	2.6	2.4	3.8	2.9
Carpinus caroliniana	0.8	3.2	2.5	2.2
Ulmus rubra	0.1	2.4	3.8	2.1
Viburnum prunifolium	0.1	2.4	3.8	2.1
Cornus florida	0.1	1.6	2.5	1.4
Asimina triloba	0.8	1.6	2.5	1.4
Sassafras albidum	1.3	0.8	1.3	1.1
Liriodendron tulipifera	0.1	0.8	1.3	0.7
Hamamelis virginiana	0.0	0.8	1.3	0.7

Table 16. Results of the point-quarter sample of the south-facing slope of the bowl.

Species	Relative Dominance	Relative Density	Relative Frequency	Importance Value
Quercus alba	25.1	10.5	10.5	15.4
Cornus florida	0.6	15.8	14.0	10.2
Hamamelis virginiana	0.5	14.5	14.0	9.7
Quercus rubra	21.7	2.6	3.5	9.3
Acer saccharum	7.9	7.9	8.8	8.2
Fagus grandifolia	6.2	9.2	8.8	8.1
Sassafras albidum	3.0	7.9	8.8	6.6
Quercus macrocarpa	12.5	2.6	3.5	6.2
Fraxinus americana	14.8	1.3	1.8	6.0
Acer rubrum	5.1	4.0	3.5	4.2
Celtis occidentalis	1.0	5.3	5.3	3.9
Lindera benzoin	0.1	5.3	3.5	3.0
Ostrya virginiana	0.2	4.0	3.5	2.5
Viburnum prunifolium	0.1	4.0	3.5	2.5

Table 16. continued.

Species	Relative Dominance	Relative Density	Relative Frequency	Importance Value
Ulmus rubra	0.1	2.6	3.5	2.1
Robinia pseudo-acacia	1.0	1.3	1.8	1.4
Liriodendron tulipifera	0.1	1.3	1.8	1.0

The results of the line-intercept sample of the slopes of the bowl (Table 17) generally indicate the same species composition as the results of the point-quarter sample. The major difference appears in the dominance of the species in each sample. The line-intercept sample results indicate that Fagus grandifolia and Acer saccharum are co-dominant on the south-facing slope, while the point-quarter sample indicates that Q. alba, Q. rubra and Q. macrocarpa are the important species. The difference in the sampling results may be due to the placement of the transects and to the line-intercept methods of sampling which would emphasize species with broad canopies but not necessarily correspondingly large basal areas.

Using Sorensen's index of similarity based on the presence or absence of species (Mueller-Dombois and Ellenberg, 1974) the west- and north-facing slopes of the bowl were the most similar (Table 18) and the north- and south-facing slopes were the least similar according to the point-quarter data. The index of similarity for the line-intercept data indicates that all slopes are very similar in species composition. The index of similarity between the point-quarter sample and the line-intercept sample is 89.36, indicating a high level of similarity between the results of the two different sampling methods.

Differences in composition and structure of the vegetation among slopes of varying aspects have often been studied (Shanks and Norris, 1950; Spurr, 1964; Geiger,

Table 17. Relative dominance of species encountered in the line-intercept sample of the north-, west-, and south-facing slopes of the bowl.

Species	North-facing	West-facing	South-facing
Acer rubrum	2.2	----	----
Asimina triloba	----	0.6	13.9
Acer saccharum	15.3	29.3	13.9
Carpinus caroliniana	----	0.4	----
Carya cordiformis	0.1	12.6	10.8
Celtis occidentalis	----	3.6	----
Cornus alternifolia	----	----	0.7
Cornus florida	9.1	4.6	10.2
Fagus grandifolia	8.8	1.5	26.1
Fraxinus americana	8.1	3.0	3.3
Hamamelis virginiana	7.1	----	2.7
Juglans nigra	----	----	0.5
Lindera benzoin	----	1.0	7.0
Liriodendron tulipifera	20.0	1.8	----
Ostrya virginiana	15.0	14.2	5.6
Prunus serotina	2.2	10.1	4.2
Platanus occidentalis	----	----	0.9
Quercus alba	----	----	0.5
Quercus macrocarpa	----	----	1.7
Quercus prinus	----	----	1.3
Quercus rubra	9.6	----	2.1

Table 17. continued.

Species	North-facing	West-facing	South-facing
Robinia pseudo-acacia	----	0.9	----
Sassafras albidum	----	----	2.8
Tilia americana	2.6	----	4.0
Ulmus americana	----	10.5	2.0

Table 18. Index of similarity values for the north-, west-, and south-facing slopes of the bowl.

Sampling Method	West-facing/ North-facing	North-facing/ South-facing	South-facing/ West-facing
Point-quarter	75.86	58.06	68.75
Line-intercept	61.54	64.52	60.61

1964; Armesto and Martinez, 1978). In eastern North America studies comparing north-facing and south-facing slopes have included vegetational differences as well as differences in insolation and soil temperature (Shanks and Norris, 1950; Cantlon, 1953; Cooper, 1961; Pearson, 1971). The Indian Bowl depression with its steeply-sloping sides offers another example of differences in the composition and structure of the vegetation based on topography. One of the most important differences between the north- and south-facing slopes is the amount of insolation each receives during the day. The northern exposure receives the least amount of direct sunlight and is therefore cooler and moister than the south-facing slope which receives a greater amount of direct sunlight and is dryer and warmer (Geiger, 1975). This difference in the microclimate is also reflected in the composition and structure of the vegetation. In the Indian Bowl site the species composition is very similar on all slopes (Table 18) but the structure; i.e., dominance, density and frequency varies according to slope aspect.

The greater importance of Liriodendron tulipifera on the north-facing slope of the bowl than on the south-facing slope indicates the cooler, moister nature of the northern exposure. Liriodendron tulipifera does better on moist sites (Harlow and Harrar, 1958). The greater importance of Liriodendron on the north-facing slope has also been documented in other eastern North American studies (Shanks and

Norris, 1950; Cantlon, 1953; Pearson, 1971). The dominance of oaks on the south-facing slope of the bowl and the importance of Cornus florida as an understory species is typical of south-facing slopes in eastern North America (Shanks and Norris, 1950; Cantlon, 1953; Pearson, 1971). Thus the bowl-formation exhibits typical differences in species composition and vegetational structure due to slope exposure when compared to other studies of the effect of slope aspect on the vegetation in eastern North America.

Soils

The soils of the study area were analyzed in order to determine variations in the nutrient content from one community to another within the Indian Bowl tract. The samples were analyzed for potassium, phosphorus, calcium, magnesium and zinc, iron, manganese and copper by the Michigan State University Soil Testing Service. According to the soil survey of Berrien County (Larson, 1980) the study area may be divided into six major soil categories: Houghton and Kerston mucks, Udorthents, Udipsamments, Morocco loamy sand, Oshtemo sandy loam and Oakville fine sand. Udipsamments and Udorthents are found on the west side of the moraine. Oakville fine sand occurs in one area on the west-facing slope.

The wet prairie, tamarack swamp and much of the wet forest of the floor of the bowl occur on Houghton and

Houghton-Kerston mucks. These soils are aquic Histosols of gently sloping to level sites. The pH of these areas is slightly acid to nearly neutral (Table 19). The most noticeable results are the high amounts of calcium and magnesium present in these areas. The prairie, however, has considerably less calcium than either the tamarack swamp or the wet forest. The presence of calceophilic species such as Filipendula rubra and Cypripedium reginae in the prairie and Thuja occidentalis in the wet forest also indicate the high calcium content of the soils of these areas.

The slopes of the bowl are primarily composed of Oshtemo sandy loam. This is an inorganic soil classified as coarse, loamy, mixed mesic, typic Hapludalfs. The pH of the slopes is slightly more acidic than the pH of the prairie or tamarack swamp (Table 20). The calcium and magnesium content of the slopes is markedly less than in the wet forest, tamarack swamp or praire. These figures indicate the leaching out of the calcium and magnesium from the slopes to the floor of the bowl and the tamarack swamp. Because the tamarack swamp impedes the flow of groundwater to the prairie, less calcium and magnesium have been deposited there than in the floor of the bowl and the tamarack swamp. Among the slopes of the bowl, the south-facing slope has much less calcium and magnesium than the north- or west-facing slopes. This may be due to the difference in leaf litter composition as the south-facing slope has more oaks present than either the north- or west-facing

Table 19. Concentrations of eight macro- and micro-nutrients of the soils of the wet prairie, tamarack swamp, and the floor of the bowl.

		MACRO-NUTRIENTS			
Community	pH	Phosphorus (P) kg/ha	Potassium (K) kg/ha	Calcium (Ca) kg/ha	Magnesium (Mg) kg/ha
wet prairie	6.8	6.7	62.6	8049.6	1403.1
tamarack swamp	6.9	7.8	98.4	10221.9	1508.2
floor of the bowl	6.3	11.8	152.1	10221.9	1456.8

	MICRO-NUTRIENTS			
	Iron (FE) ppm	Zinc (Zn) ppm	Manganese (Mn) ppm	Copper (Cu) ppm
wet prairie	8	6	24	6
tamarack swamp	4	6	30	6
floor of the bowl	12	24	67	7

Table 20. Concentrations of eight macro- and micro-nutrients in the soils of the north-, west-, and south-facing slopes of the bowl.

		MACRO-NUTRIENTS			
Community	pH	Phosphorus (P) kg/ha	Potassium (K) kg/ha	Calcium (Ca) kg/ha	Magnesium (Mg) kg/ha
north-facing slope	6.2	31.3	161.0	3465.8	488.6
west-facing slope	6.2	64.8	251.6	3465.8	578.0
south-facing slope	6.5	102.9	161.0	1900.6	345.5

	MICRO-NUTRIENTS			
	Iron (Fe) ppm	Zinc (Zn) ppm	Manganese (Mn) ppm	Copper (Cu) ppm
north-facing slope	16	8	40	1
west-facing slope	20	8	43	1
south-facing slope	16	7	38	3

slopes. The high amount of potassium on the west-facing slope may be due to runoff from Hochberger Road and from surrounding fields which have been fertilized.

Threatened and Special Concern Plants

Rare species are an interesting aspect of our native flora as they are important in the maintenance of species diversity (Whittaker, 1974). In Michigan the greatest number of rare species occurs in palustrine situations (Beaman, 1977). The fact that many rare species have been reported from the Indian Bowl area emphasize the importance of this tract in the preservation of our native species in Michigan. Although a few of the reported species were documented by herbarium specimens collected by other investigators, most had not previously been collected. Therefore a careful search for these species was made in the spring and summer of 1980 and 1981. Eight of the thirteen threatened and special concern plants previously reported from the area by Schaddalee (1980) were found during the course of this study. One species, Cryptogramma stelleri, which was not previously reported, was also found.

About half of the species reported from the study area were in the wet prairie and half were reported from the bowl. Polemonium reptans and Trillium recurvatum were found in greater abundance than previously reported (Schaddalee, 1980). Cypripedium candidum appears in

decline as only one individual was located by the author in 1981 and Schaddalee (1980) had reported a larger number of plants from one location the previous year. The distribution of each state threatened or special concern plant (except Corydalis flavula, since there is no available data on its distribution in the study area) in the study area can be seen in Figures 15 through 27. One of the species (Dryopteris celsa) has a distribution which is generally southern with a disjunct population in southwestern Michigan (Mickel, 1979). The distribution of other species is generally eastern North American (Fernald, 1970). Within the Indian Bowl tract, there is a high concentration of the threatened species Polemonium reptans and Trillium recurvatum throughout the study area. Prairie species which are threatened in the state but are widespread and common in the Indian Bowl prairie are Filipendula rubra and Silphium integrifolium. The habitat of each threatened or special concern plant reported for the study area is generally typical for that species in North America (Table 21). With the exception of coastal plain disjunct sites such as Grand Beach on Lake Michigan, the concentration of threatened and special concern species in the Indian Bowl tract is higher than any other area of similar or smaller size in the state. This is due partially to the diversity of the habitat types found within the tract, and also the area's minor history of disturbance.

Figure 15. Reported distribution of Aristolochia serpentaria in the Indian Bowl study area

Figure 16. Distribution of Berula pusilla in the Indian Bowl study area.

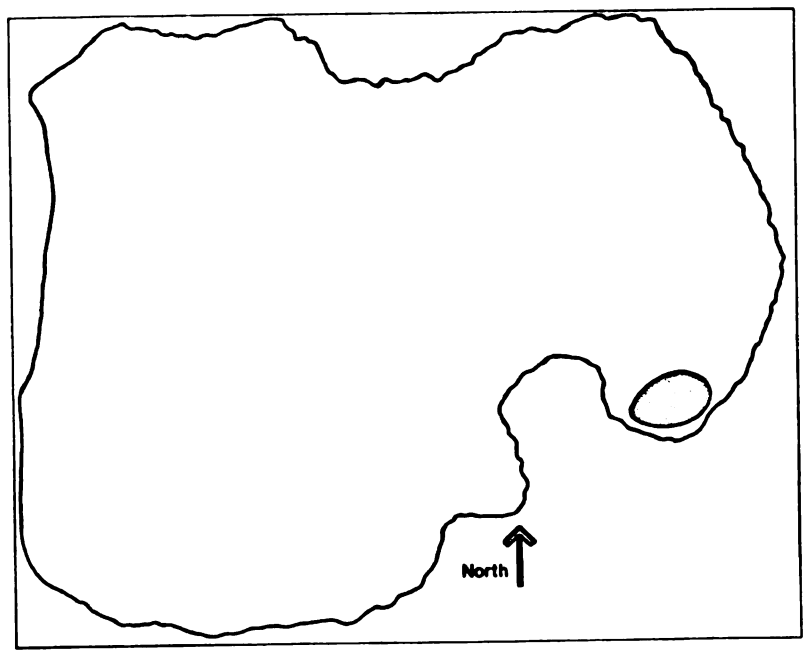

Figure 15.

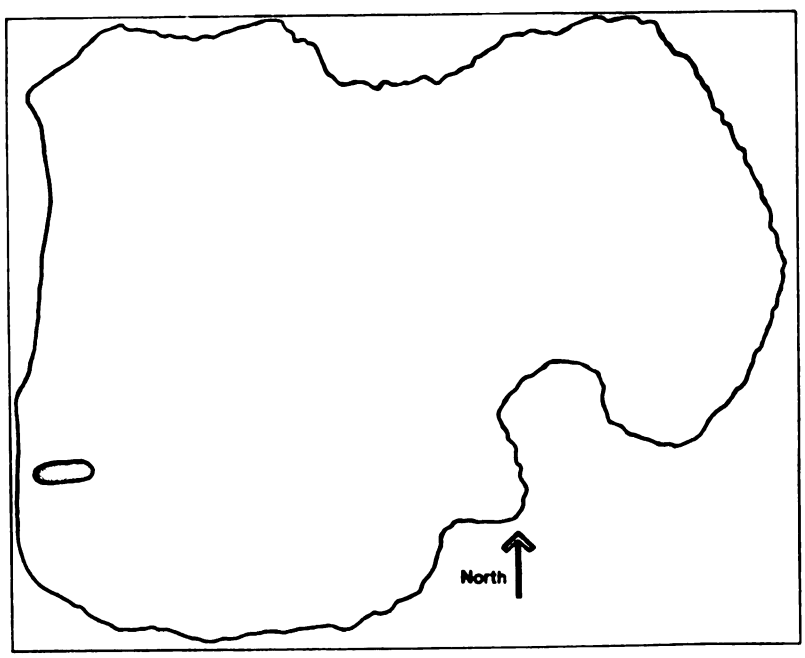

Figure 16.

Figure 17. Reported distribution of Carex trichocarpa in the Indian Bowl study area.
Figure 18. Distribution of Cryptogramma stelleri in the Indian Bowl study area.

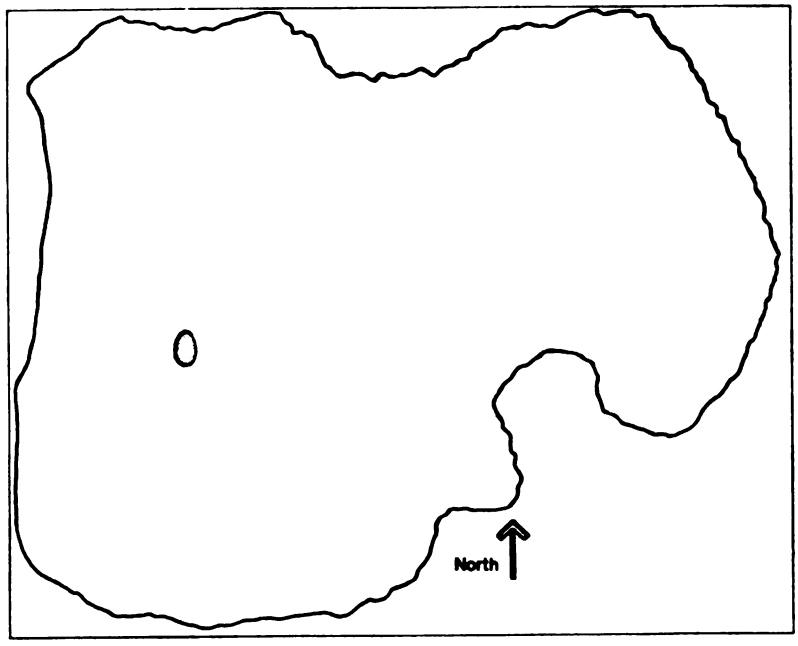

Figure 17.

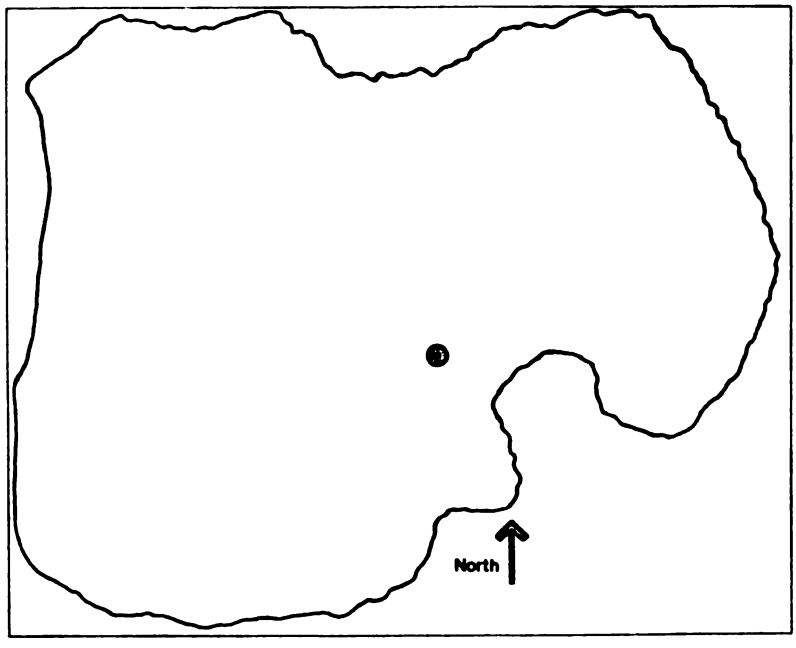

Figure 18.

Figure 19. Distribution of Cypripedium candidum in the Indian Bowl study area.
Figure 20. Distribution of Dryopteris celsa in the Indian Bowl study area.

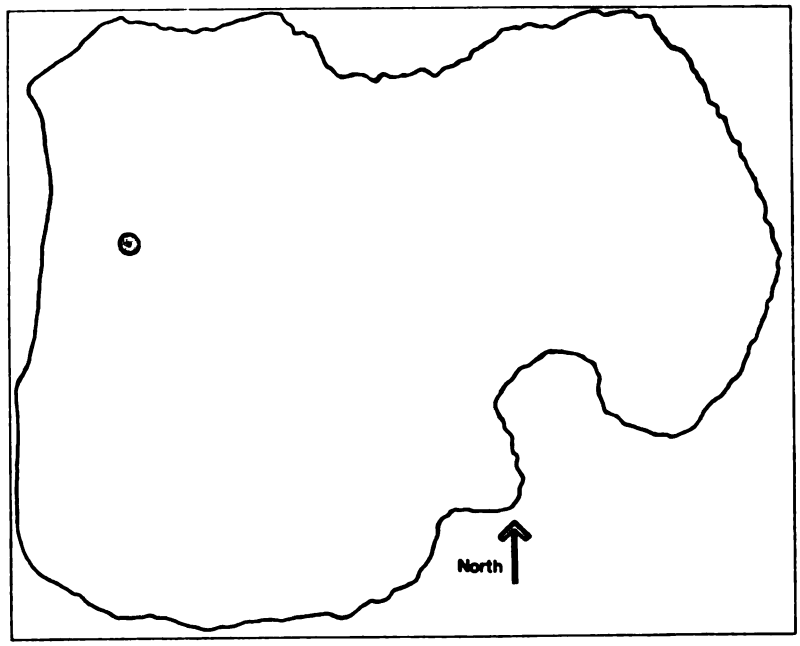

Figure 19.

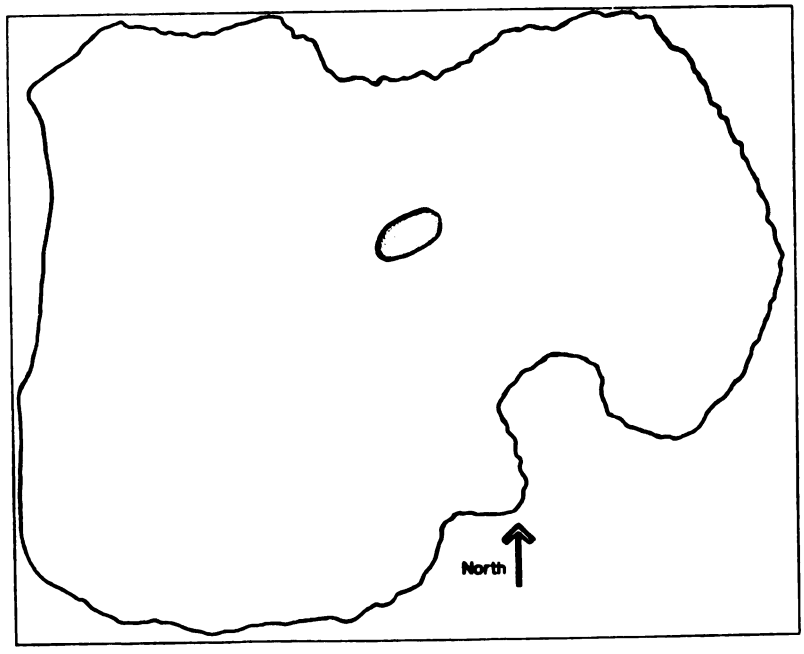

Figure 20.

Figure 21. Distribution of Filipendula rubra in the Indian Bowl study area.

Figure 22. Reported distribution of Gymnocladus dioica in the Indian Bowl study area.

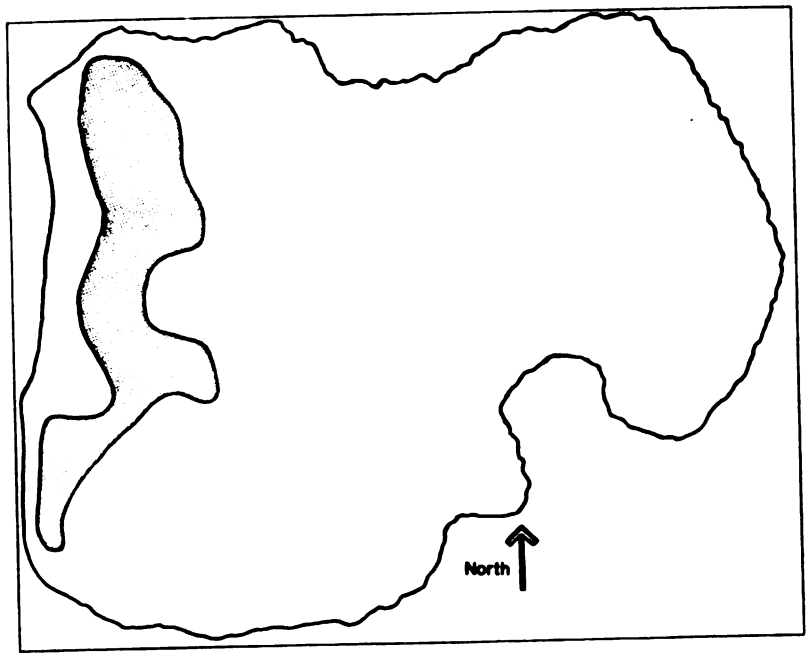

Figure 21.

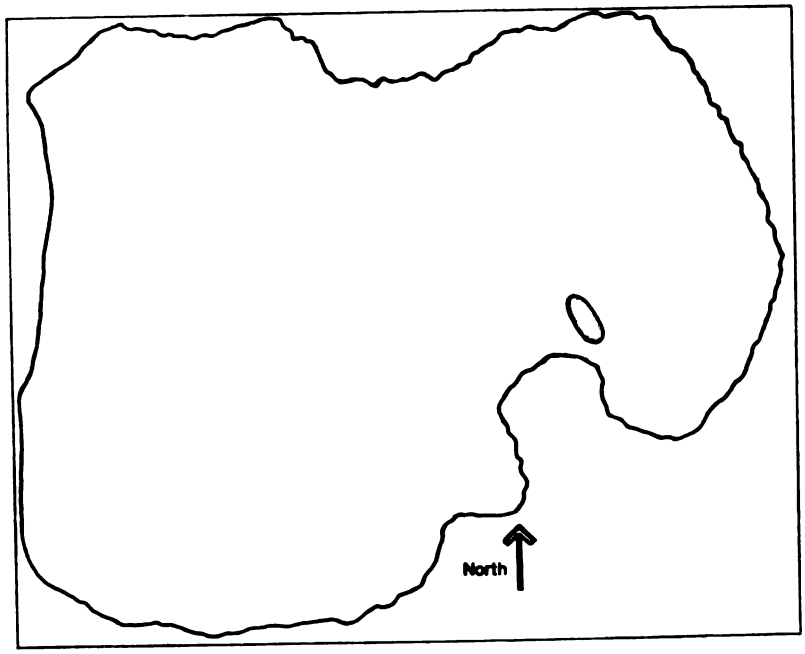

Figure 22.

Figure 23. Reported distribution of Hydrastis canadensis in the Indian Bowl study area.
Figure 24. Distribution of Polemonium reptans in the Indian Bowl study area.

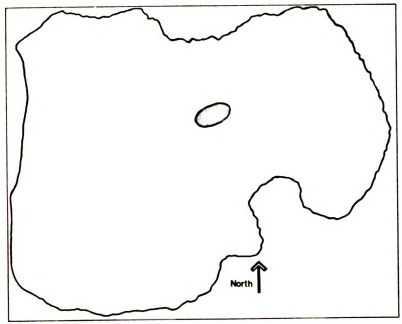

Figure 23.

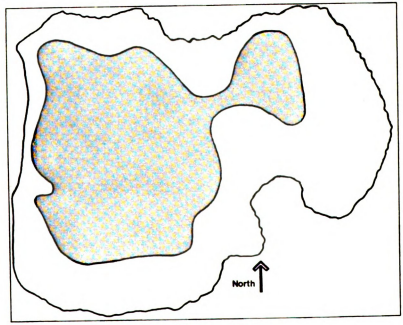

Figure 24.

Figure 25. Distribution of Rudbeckia sullivantii in the Indian Bowl study area.
Figure 26. Distribution of Silphium integrifolium in the Indian Bowl study area.

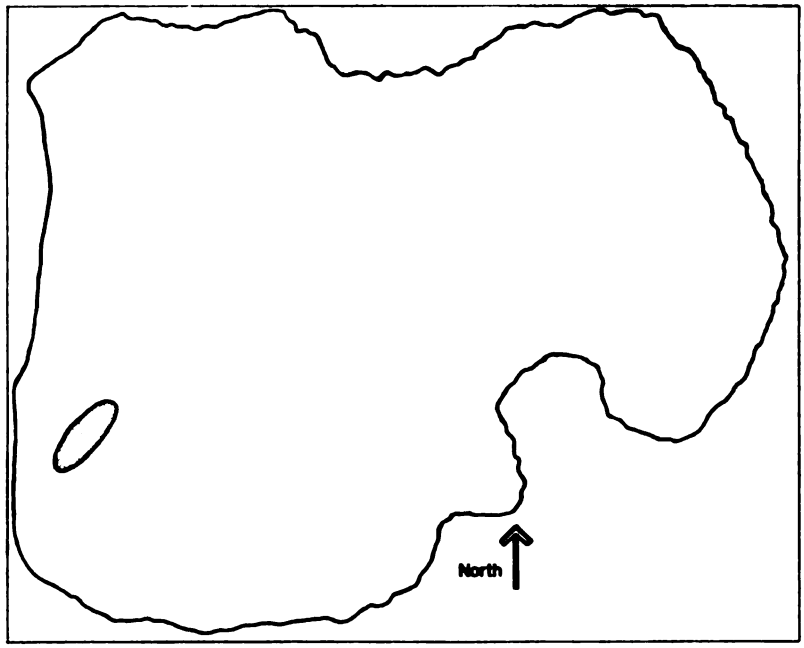

Figure 25.

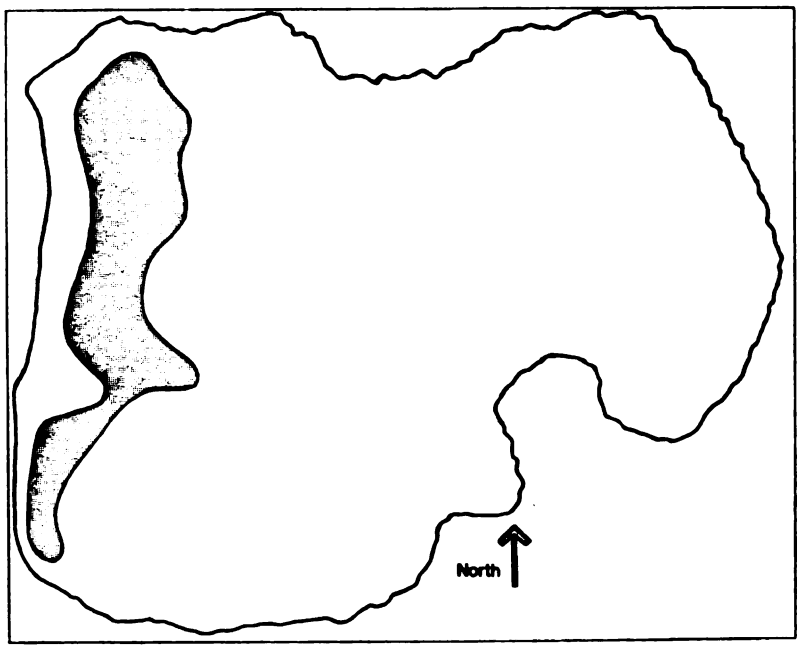

Figure 26.

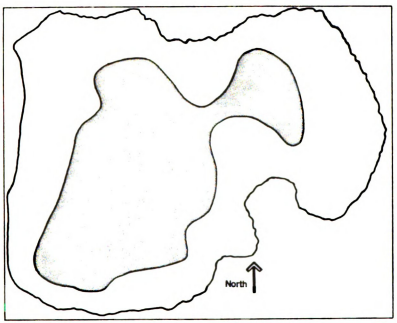

Figure 27. Distribution of Trillium recurvatum in the Indian Bowl study area.

Table 21. Distribution and status of state threatened and special concern species reported from the Indian Bowl study area.

Species	Michigan Status**	General Habitat***	Distribution in North America***
Aristolochia serpentaria	Threatened*	Rich, often calcareous woods, (Swink, 1974)	Florida to Texas, north to southwest Connecticut, southeastern New York, Ohio, Indiana, southern Illinois, central Missouri and southeastern Kansas.
Berula pusilla	Threatened	Swamps and streams, (Holte and Thorne, 1962; Moyer, 1900)	New York and southern Ontario to Minnesota and British Columbia, south to Florida and Mexico.
Carex trichocarpa	Special concern*	Calcareous swales, marshes and bottomlands, (Swink, 1974; Wolden, 1971; Costello, 1936)	Southwest Quebec and Vermont to Ontario and Minnesota, south to Connecticut, Delaware, Pennsylvania, Ohio, Indiana, northern Iowa.
Corydalis flavula	Threatened	Moist soil	Eastern New York to southern Ontario, southern Michigan and South Dakota, south to North Carolina, Louisiana, and Oklahoma.
Cryptogramma stelleri	Special concern	Calcareous rocks and moist shady slopes	Southeast Labrador peninsula to Alaska, south to Newfoundland and locally to New Brunswick, north and west New England, Pennsylvania, West Virginia, Michigan, northern Illinois, northeast Iowa, Colorado, Utah and Washington.

Table 21. continued.

Species	Michigan Status**	General Habitat***	Distribution in North America***
Cypripedium candidum	Threatened*	Calcareous meadows, prairie, and mossy glades, (Holte and Thorne, 1962; Moyer, 1900; Gleason, 1917; Thompson, 1975)	West central New York to North Dakota, south to northern New Jersey, eastern Pennsylvania, Kentucky and Missouri.
Dryopteris celsa	Threatened	Inundated acid swamps, cypress-swamps, cypress-knees and -logs, and wet woods	On or near the Coastal Plain, Louisiana, to South Carolina, north to southeast Virginia and locally to southeast Pennsylvania.
Filipendula rubra	Threatened	Fens, meadows and prairies, (Swink, 1974; Betz, 1976; Freisner and Potzger, 1946; Jones, 1944)	Pennsylvania to Michigan and Iowa, south to Georgia, Kentucky and Illinois.
Gymnocladus dioica	Special concern*	Rich moist woods	New York to southern Ontario, southern Wisconsin and eastern Nebraska, south to West Virginia, Alabama, Arkansas, and Oklahoma.
Hydrastis canadensis	Threatened*	Rich woods, (Swink, 1974)	Minnesota to Nebraska and south to Alabama.

Table 21. continued.

Species	Michigan Status**	General Habitat***	Distribution in North America***
Polemonium reptans	Threatened	Rich woods and bottomlands occasionally in fens and prairies (Swink, 1974; Freisner and Potzger, 1946; Thompson, 1975)	New York to Minnesota and south to interior Georgia, Alabama, Mississippi, Missouri, and Oklahoma.
Rudbeckia sullivantii	Special concern	Prairies, swamps and damp shores, (Jones, 1944; Swink, 1974; Thompson, 1975)	Ohio and Michigan to Missouri, south to Alabama, and Arkansas.
Silphium integrifolium	Threatened	Wet to dry prairies, (Gould, 1941; Curtis and Greene, 1949; Green, 1950; Drew, 1947; Sorensen, 1962; Shimek, 1900; Sampson, 1921; Vestal, 1914; Bushey and Moran, 1978; Bliss and Cox, 1964; Freisner and Potzger, 1946; Peattie, 1930; Thompson, 1975; Scharrer, 1971; Weaver and Fitzpatrick, 1934)	Indiana to eastern Kansas, and Mississippi.

Table 21. continued.

Species	Michigan Status**	General Habitat***	Distribution in North America***
Trillium recurvatum	Threatened	Rich woods, pastures, and thickets, (Swink, 1974; Peattie, 1930)	Ohio to Iowa, south to Alabama, Mississippi, and Arkansas.

* Species not documented from the Indian Bowl study area by a herbarium specimen.
** Wildlife Div. DNR (1982)
*** Fernald 1970

LITERATURE REVIEW

Various descriptions and definitions of fens and prairies have been published. The classification of these community types has often been based on different criteria in different papers. Some of this confusion may be due to the original usage of the terms prairie and fen. Prairie is a European expression which was used by the French explorers to describe the grasslands of the Midwest. This was a commonly used word in France which meant grassy park (Conard, 1952). Fen is also originally European. In Britain fens are described by Tansley (1939) as peatlands with somewhat or decidedly alkaline, nearly neutral or slightly acid pH. The application of these European terms to North American communities was based primarily on the first impression of the settlers and only later investigated in any botanical detail. Therefore definitions of these two communities vary throughout the literature.

The broadest definition of fen may be that of Jeglum et al. (1974), which includes any wetland that is enriched by mineral soil water. In a more restricted sense fen is defined by them as an open sedge-rich site, high in organic matter and generally alkaline. Often these are peatlands with a dominance of sedges and Sphagnum subordinate or absent, but with a continuous cover of mosses of the brown moss group (Drepanocladus spp.). These areas usually develop in places with restricted or very slow internal

drainage or seepage. The graminoid fen is one of two categories listed by Jeglum et al. under open fen. The graminoid fen is distinguished from a low shrub fen by the dominance of sedges and grasses rather than shrubs or small trees. This type of fen often has a peat substrate but this may also be muck or even a mineral soil. The surface of the soil does not float but may often be covered by water due to flooding. Mosses form a continuous ground layer in the graminoid fen. Jeglum et al. also recognize a tree fen under which there are two basic types: the graminoid-rich fen with Larix as an important component and the Sphagnum-rich tree fen. Another term Jeglum et al. use is meadow. This community type has a closed graminoid cover with little or no standing water. Sedges or grasses are dominant although shorter in height than in a fen; broad-leaved herbs are often very conspicuous.

Shaw and Fredine (1979) do not use the terms fen or wet prairie but the term Inland Fresh Meadow. This community type is described as having soil without standing water during most of the year but is waterlogged within at least a few inches of its surface. The vegetation is composed of grasses, sedges, rushes and various forbs. In northern areas Carex, rushes, prairie cordgrass (Spartina pectinata) and mints are common components.

Curtis (1959) considers a fen to be a hybrid community where the unusual combination of environmental factors has sorted out and retained suitably adapted species from each

of the major community formations that developed in the post-glacial period. He considers the wet prairie and the sedge meadow to be floristically very closely associated with the fen.

Hayden (1943) describes fen in the context of a hydrosere origin of the prairie in the Iowa Lake region of Clay and Palo Alto Counties, Iowa. In this hydrosere can be seen three major stages: the early hydrosere which may be swamp, marsh, or fen; the late hydrosere of either wet meadow or sedge meadow; and the prairie climax. Hayden regards the swamp, marsh or fen as intermediate between aquatic life forms and terrestrial life forms. The swamp has the water level above the soil surface through the summer with Phragmites and Scirpus dominant. The marsh has a waterlogged soil which is inorganic in composition and has a water table at or below the surface most of the year. Usually a marsh occurs around or along a permanent body of water. Phalaris arundinaceae, Alopecurus aequalis and Ranunculus cymbalaria are important components. A fen has waterlogged soil but has an organic base and is anywhere from very alkaline to nearly neutral to very slightly acidic. The vegetation of the marsh and the fen are quite similar although in the fen the plants tend to form a structureless black peat. As the depth of the water decreases, a sedge meadow forms with a dense sod of Carex, Juncus and Eleocharis. The soil is still saturated due to spring and early summer flooding and supports Mentha,

Teucrium, Stachys, Lycopus, Caltha and Cicuta, among others. As the sod is established grasses such as Spartina pectinata, Calamagrostis canadensis, Andropogon gerardii, Elymus virginicus and Panicum virgatum occur. Phlox, Anemone, Thalictrum and Zygadenus also become more important. Developing from this is the prairie climax; as drainage increases and organic material increases species such as Stipa spartea, Andropogon scoparius, Bouteloua curtipendula with Helianthus, Solidago, Liatris, Lespedeza and Petalostemon increase in dominance.

The prairie is a community which is characterized as dominated by grasses (Weaver, 1954). It has been described from Illinois (Sampson, 1921) and from west of the Mississippi River (Weaver and Fitzpatrick, 1934; Weaver, 1954). While Sampson considers Illinois to be the prairie state, Weaver only considers the prairie west of the Mississippi. The prairie peninsula was described by Transeau (1935) as an area which extended in part into southwestern Michigan from the western prairie. While the definition of mesic prairie is fairly consistent (Weaver, 1954; Sampson, 1921; Green, 1950; Curtis, 1959), wet prairie is not as consistently described.

In a description of the prairie of Indiana, Betz (1976) notes black silt-loam prairies as being mesic, wet and alkaline fens. The list of characteristic species for wet prairie and fen mainly differ in the presence of calceophilic species such as Filipendula rubra in the fen.

Betz uses forbs as indicators with dominant grasses to distinguish among the different types of Indiana prairies.

Holte and Thorne (1962) describe fens as often occurring in wet prairies in Iowa. However, Weaver (1954) does not describe wet or lowland prairies as anything but dominated by grasses (often Spartina pectinata) and makes no mention of fen as a type of prairie.

In a northern Indiana prairie, Bliss and Cox (1964) describe a mosaic of communities including wet prairie, marsh, swamp forest and bog. The greatest cover in the prairie was Andropogon gerardii, with Spartina pectinata dominant in the wetter places. Species listed as important in the Andropogon areas include Solidago nemoralis, Aster ericoides, Silphium integrifolium and Saxifraga pensylvanica. In the poorly drained areas where Spartina pectinata is dominant, mainly along streams within the prairie, they found Helianthus grossiserratus, Stachys tenuifolia, Pychanthemum and Aster novae-angliae important. Other areas within the prairie are dominated by Carex and Calamagrostis canadensis.

Friesner and Potzger's (1946) study of Cabin Creek Raised Bog in Indiana described an area of high alkalinity with an absence of Sphagnum and ericads. Prairie grasses are an important element. The soil is a peat moss built up on the floodplain from a high water table and hydrostatic pressure. The raised bog or fen is located between Cabin Creek and a moraine with several streams flowing from the

base of the moraine into the creek. In the more elevated portions of the bog, prairie species become more important. Among these are Andropogon gerardii, Sorghastrum nutans, Filipendula rubra and Dodecatheon media. Also important are Cypripedium reginae and Aster umbellatus.

Baker (1972) describes a fen, using Tansley's (1939) definition, from the California coast with a dominant cover of almost pure Carex and Eleocharis. Other species Baker considered typical of a fen are Calamagrostis and Menyanthes trifoliata. Baker includes the statement that often fens are successional stages in hydroseres leading to a forest climax. In this fen there are also some patches of Sphagnum with Ledum growing on them.

In his study of the bogs of northern lower Michigan, Gates (1942) does not distinguish between fen and bog. His definition of bog is quite broad: an area of vegetation developing in undrained or poorly drained situations which by the development of a mat invades open water forming covering over the body of water. The water may be acid or alkaline. The vegetation progresses through a series of associations beginning with mat-forming sedges and passing through shrub and Sphagnum stages to coniferous forest.

In her study of Bakertown Fen in Berrien County, Michigan, Kohring (1982) describes a fen as an area dominated by sedges with a continuous flow of spring water which has percolated through calcareous deposits; many calceophiles and nonericaceous shrubs are present. Bakertown

Fen is dominated by Carex and Eleocharis. Kohring also describes a sedge meadow from the area dominated by Carex aquatilis with scattered Solidago, Thalictrum dasycarpum and Sambucus canadensis. Thelypteris palustris and Iris virginica occur in the wetter areas of the sedge meadow.

In 1917 Gleason described a prairie in Ann Arbor, Michigan which was mainly dominated by Carex lasiocarpa but in other places by Sorghastrum nutans and Sporobolis heterolepis. Gleason notes the conglomeration of types of plants which occur together in the prairie. Gleason indicates that bog species such as Sarracenia purpurea and Parnassia glauca and wet prairie species such as Gentiana procera, Liatris spicata and Oxypolis rigidior occur together in this site. Other prairie species present include Zizia aurea, Helianthus grosseserratus, Muhlenbergia mexicana and Cypripedium candidum. Gleason considers this site a relict colony of prairie plants.

A wet prairie near Ann Arbor along the floodplain of the Huron River is described by Thompson (1970). This site has nine indicator species of the wet prairie (Curtis, 1959) and seven of the wet-mesic prairie indicator species. However, there is no description of the soil type of dominant cover.

A wet prairie in southwestern Michigan was studied by Brewer (1965). In this prairie the soil moisture was very high, as was the replaceable calcium. Species occurring most frequently were Spartina pectinata, Geranium maculatum,

Galium boreale, Cicuta maculata, Pycnanthemum virginianum and Fragaria virginiana.

In conclusion, while fens may be well-defined in Britain and prairies well-defined west of the Mississippi River, in the prairie peninsula region (Transeau, 1935) the concepts of fen and wet prairie often overlap. The overlap or confusion can be seen in the difference of opinion of what species indicate a wet prairie, fen or bog (c.f. Curtis, 1959; Gleason, 1917; Betz, 1976; Freisner and Potzger, 1946). It can also be seen in the approach to the community; whether by its physical attributes, i.e., soil and water, or by its floristic composition. Fens tend to be described first by their soil and water characteristics, secondly by the composition of the vegetation, whereas prairies are primarily described by their vegetation and may occur on a variety of soil types.

DISCUSSION

A community can be described as a population or assemblage of organisms in a designated habitat (Whittaker, 1975). This assemblage of organisms is not always a discreet entity but rather one part of a continuum of combinations of populations occurring in various habitats (Whittaker, 1975; Curtis, 1955). The Indian Bowl graminoid-composite dominated community is an example of part of the continuous spectrum of community types called fen, southern sedge

meadow, wet and wet-mesic prairie. These community types are described by Curtis (1959) using a series of indicator species characterizing each type.

The Indian Bowl community does not fit precisely into one community category. Instead it exhibits characteristics of all of the above communities as described by Curtis (1959). It has the soil properties commonly found in fens and sedge meadows. In the early summer the vegetation is similar to a sedge meadow, but by the end of the summer it is more characteristic of a wet prairie. Many species indicative of wet-mesic prairies are also found in the community.

In order to better evaluate the vegetation of the Indian Bowl site the species lists of twelve other similar communities were studied. These twelve communities occur in Michigan (Thompson, 1970; Hayes, 1964; Cain and Slater, 1948), Illinois (Anderson and Van Valkenburg, 1977; Bushey and Moran, 1978; Sherff, 1913), Indiana (Freisner and Potzger, 1946), Iowa (Sorensen, 1964; Holte and Thorne, 1962), Wisconsin (Stout, 1914) and in Canada at Windsor, Ontario (Rogers, 1966) and at Winnipeg, Manitoba (Levin and Keleher, 1969). From the list of species for each site, including the Indian Bowl site, a tally of indicator species (sensu Curtis, 1959) was made for each community type: fen, southern sedge meadow, wet prairie, wet-mesic prairie and mesic prairie. Using a modified method of Curtis (1955) each indicator type was weighted so that

scores from 100 to 500 were obtained. The community which most closely resembled a fen according to Curtis' indicator species would have a score of 100, while a community which was mesic prairie would have a score of 500. While Curtis' indicator species are based primarily on Wisconsin studies this does not exclude the usefulness of them as a means of comparison on a general basis.

The results (Figure 28) indicate that ten of the 13 communities tallied lie between the sedge meadow and wet prairie categories. The Indian Bowl site lies in the middle portion of these ten communities. However, its score indicates that it is probably best called a wet prairie. Skokie Marsh, in northeastern Illinois appears also as a wet prairie. The proximity of the Indian Bowl site to Skokie Marsh and their possible connection to the old Lake Chicago (Sampson, 1921) would suggest their similarity of development, and therefore similar vegetational composition.

The Indian Bowl site may also be evaluated in terms of change from fen or sedge meadow to wet prairie to wet-mesic prairie. This change has been postulated by Hayden (1943) and Sampson (1921), who call this a hydrarch or hydrosere succession. In the Indian Bowl site this type of succession may be seen on a large and small scale. Due to the physical position of the wet prairie and the tamarack in the Indian Bowl tract, it is possible that there is a barrier to groundwater flow between the prairie and the

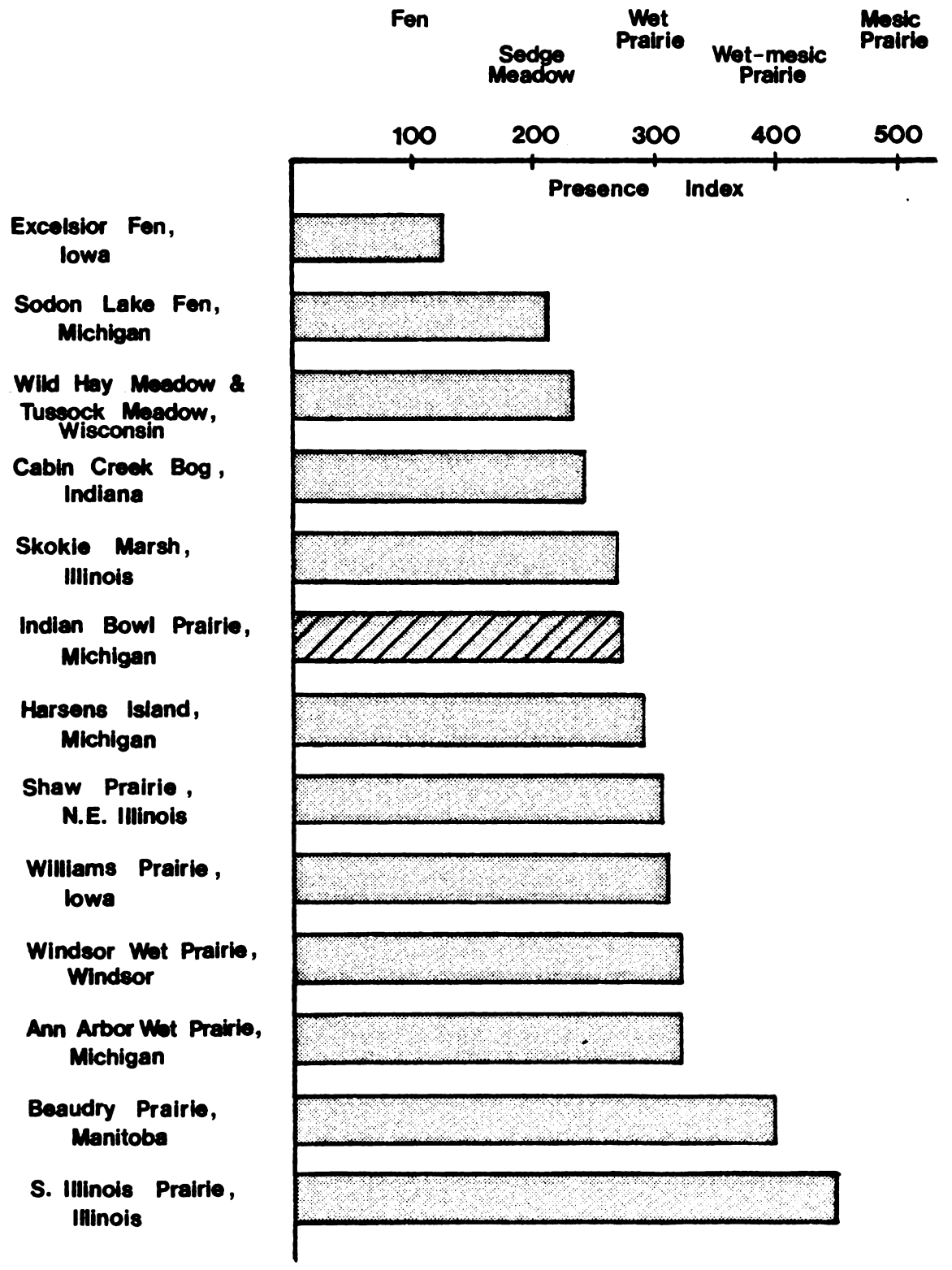

Figure 28. Presence index of 13 communities using Curtis (1959) indicator species.

moraine (initially allowing the development of the tamarack swamp). This can be seen not only by the fact that the soil between the tamarack swamp and the moraine is considerably wetter than in the prairie but also by the distribution of the amount of calcium and magnesium leached from the moraine (Tables 19 and 20). If the tamarack swamp continues to develop and further groundwater seepage through the prairie decreases, the site will become drier, and existing prairie plants may become more important (Sampson, 1921; Hayden, 1943). Because of its location on the floodplain of the St. Joseph River, it is unlikely that it will become dry enough to be considered a mesic prairie, however.

On a smaller scale, the micro-topography presently has some effect on the types of plants which occur in the Indian Bowl site. The habit of Carex stricta, which is very common in the prairie, is to form tussocks (Costello, 1936). The tussocks, as well as anthills and slight differences in general elevation, are emphasized by normal changes in water level in the prairie from spring to fall. Thus, high spots in the prairie provide a suitable opening for the establishment of wet-mesic and mesic prairie species. The source for the mesic prairie species was, prior to settlement, Wolf's Prairie, a mesic prairie of 1000 acres on the present site of Berrien Springs (Butler, 1947).

The change to wet-mesic prairie, with Andropogon gerardii a more important component of the prairie than at present, would take a longer period of time than the average

of 10 to 20 years suggested by Whittaker (1975) for an old-field to become Andropogon dominated. The drying of the prairie would not be a constant event because it is subject to occasional flooding by the St. Joseph River. The introduction of new species or the spreading of species already present in the prairie by seeds would be slowed by the abundant vegetative cover and the great amount of dead grasses and sedges which shade the soil surface. Most of the species in the wet prairie are perennials, a small percentage of which flower during the growing season. Controlled burning of the prairie would be important for three reasons. First it would remove the mat of dead grasses and sedges and therefore open up new spaces for seed germination. Secondly, the burning would inhibit the spread of Cornus and Viburnum and other shrubs presently invading the prairie. Lastly, the effect of burning often increases the percentage of individuals which flower (Kohring, 1982). The effect of this on the succession of the wet prairie would be to deter the development of the prairie into shrub carr, and to increase the possibility of further establishment of wet-mesic and mesic prairie species as the site dries.

Bray - Curtis Multidimensional Ordination

Homogeneity of the distribution and cover of the species of the wet prairie was examined using

multidimensional polar ordination (Bray and Curtis, 1957). The plots taken in the July sample were analyzed separately from the plots taken in the August sample of the prairie. Using Sorensen's index of similarity (Mueller-Dombois and Ellenberg, 1974) where percent cover is the quantitative value, 102 plots were compared in the July sample and 83 plots were compared in the August sample. Coordinates for the x, y, and z dimensions were obtained and plotted three-dimensionally by the CALCOMP plotter implemented on the Michigan State University CDC Cyber 750 computer. End points of each of the dimensions plotted were determined using the least similar plot pair which had more than three index of similarity values of 50.00 or higher (Mueller-Dombois and Ellenberg, 1974). The resulting distribution of plots on the figure shows relationship by geometric proximity. These relationships are based on species composition and percent cover within each plot.

Ordination of the July sample showed a high level of homogeneity with a few outlying plots (Figure 29). Three groups may be distinguished from this plot. Based on the mean percent cover of the dominant species in the plots in each group a trend from wet to dry may be observed (Figure 30). A look at the plot sample data of the prairie shows a very high frequency of Carex and Solidago (Table 1). The high dominance of these taxa as well as the consistency with which they appear throughout the 102 plots supports

Figure 29. Multidimensional polar ordination results for the July sample of the wet prairie.

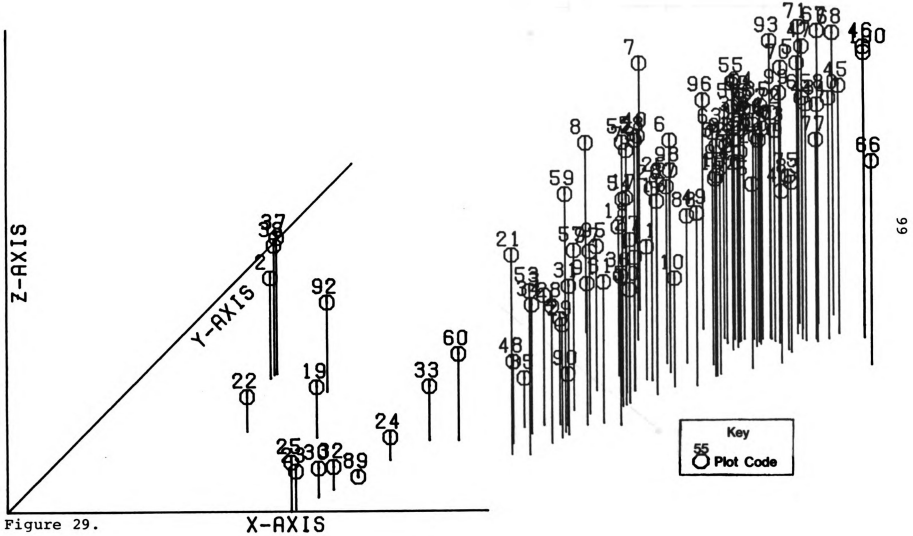

Figure 29.

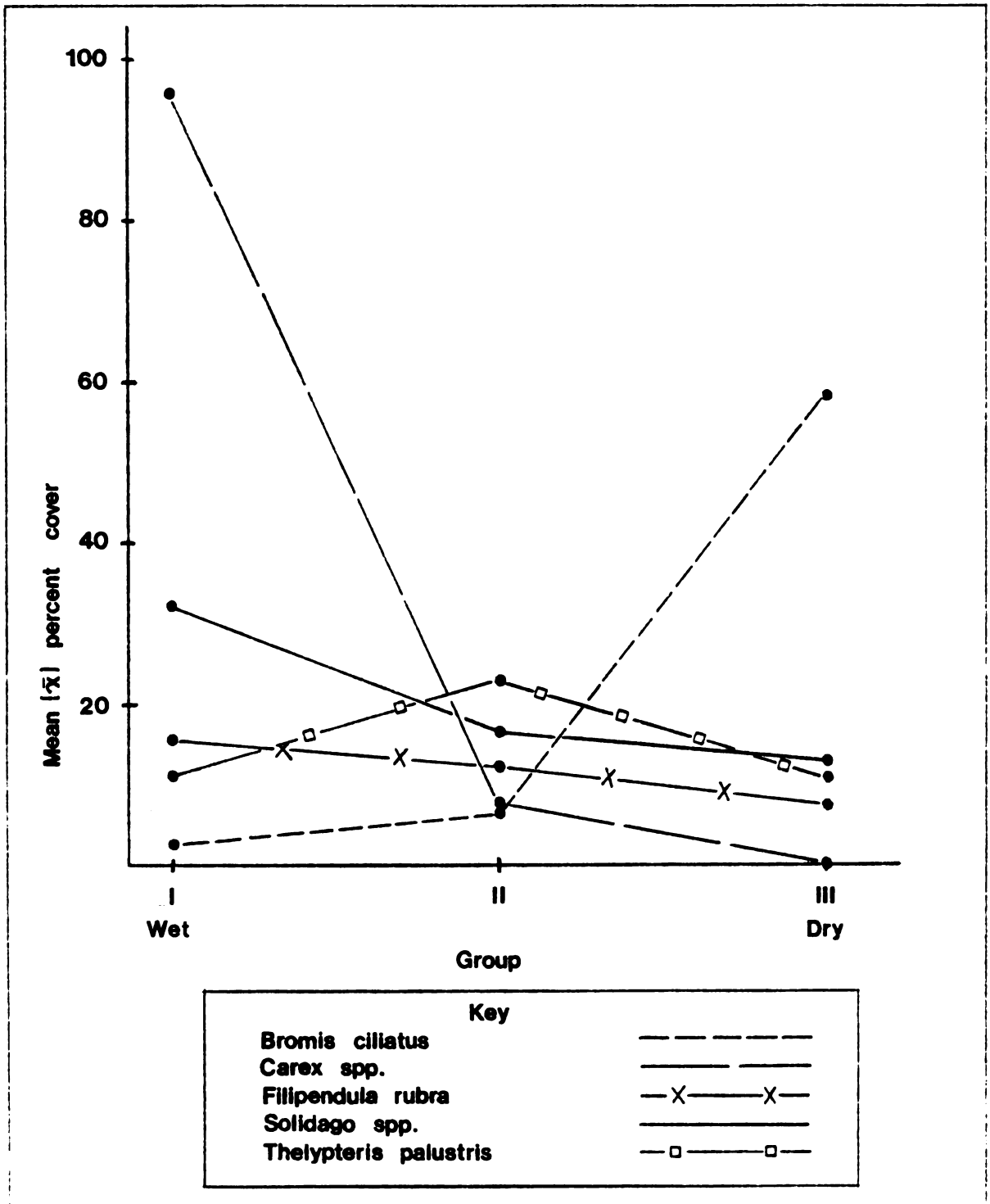

Figure 30. Difference in mean percent cover in the three groups indicated by the July ordination results.

the ordination results of a relatively homogeneous community at this time of the season.

The August sample showed four groupings of plots after ordination (Figure 31). The groups can be classified as dry (I) and wet (IV) with two intermediate groups (II and III). Group I had the fewest number of plots and is characterized by a high mean percent cover of Sorghastrum nutans and a lack of Carex (Figure 32). Eupatorium maculatum and E. perfoliatum are lacking in these plots also. Less than five percent of the plots fell into the second group. This group has much less Sorghastrum nutans than Group I but more so than Group III. Carex spp. and Eupatorium maculatum and E. perfoliatum are present in relatively small amounts in these plots, indicating an increase in moisture. Group III contained over 40 percent of the plots. Whereas Sorghastrum nutans has decreased in its cover in this group, taxa which occur in wetter environments such as Carex stricta, Calamagrostis canadensis and Eupatorium spp. have increased in cover. About 20 percent of the plots fall into the wettest category (Group IV). In these plots there is no Sorghastrum nutans present. Eupatorium shows a definite increase in cover which indicates the high moisture content of the soil. The taxa which show a wide range of tolerance to the wet and dry conditions are Thelypteris palustris, which shows almost no change in cover from one group to the next, and Solidago,

Figure 31. Multidimensional polar ordination results for the August sample of the wet prairie.

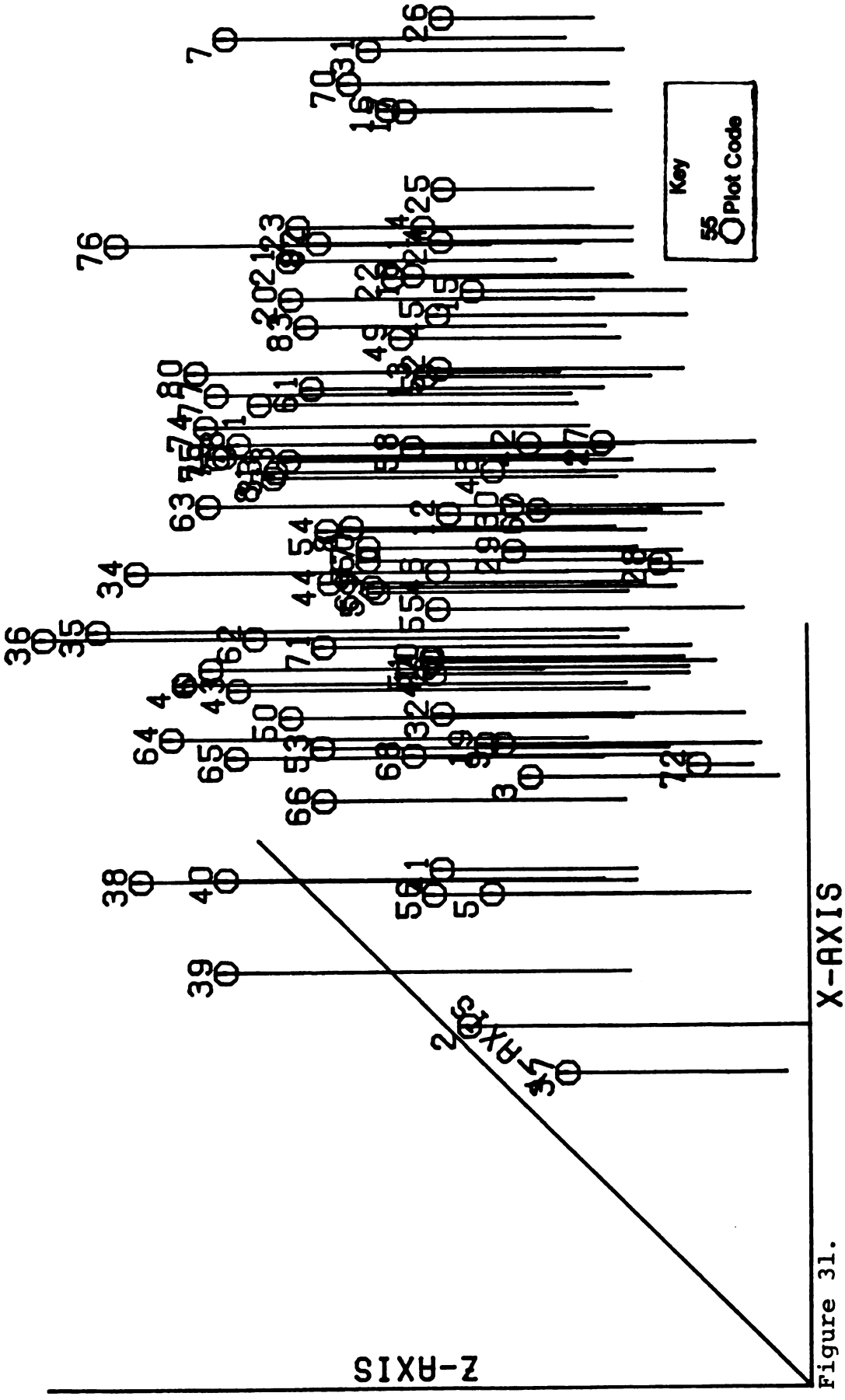

Figure 31.

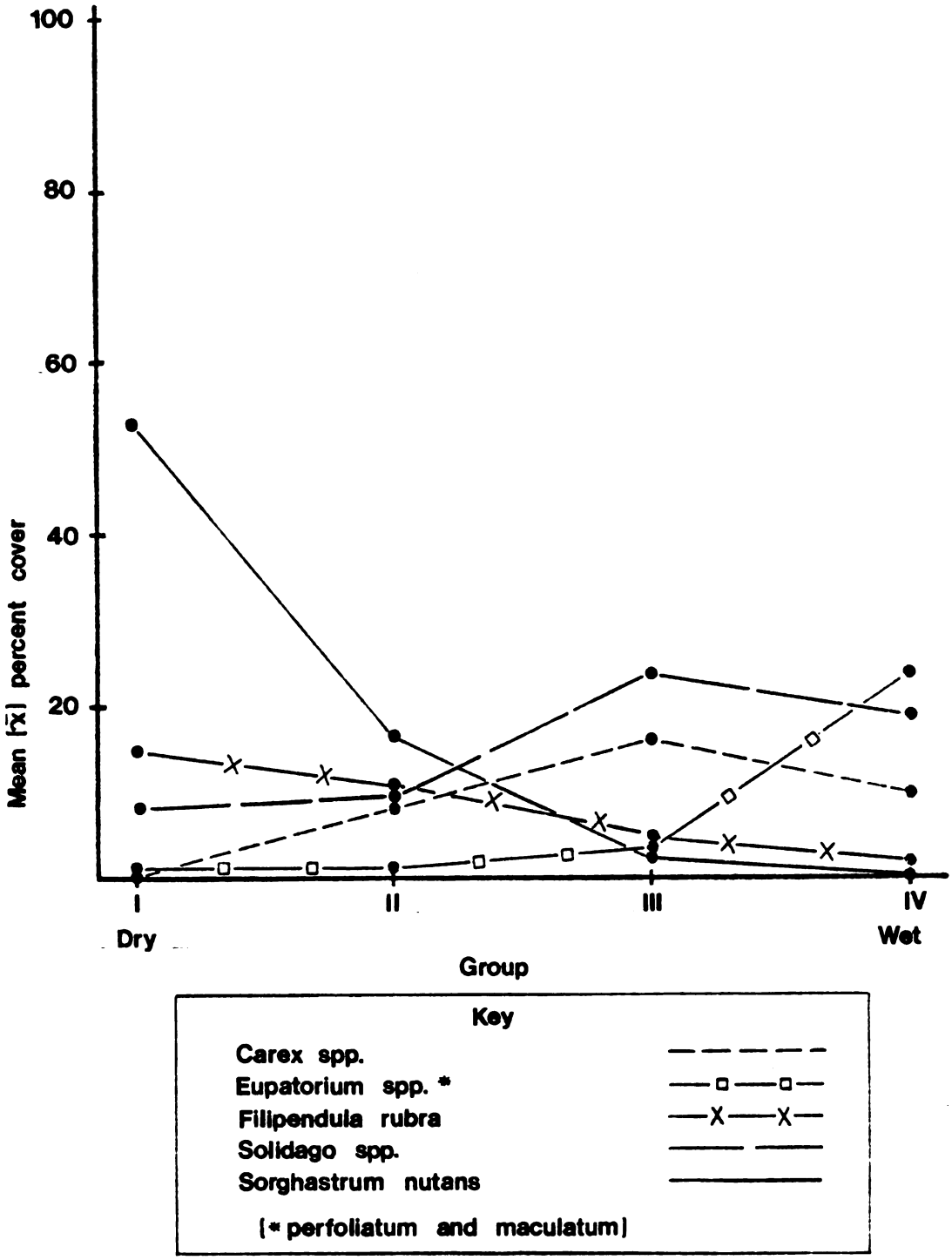

Figure 32. Difference in mean percent cover of the four groups indicated by the August ordination results.

which increases slightly in Group III but is present in similar amounts in all of the groups.

The difference in the ordination results from July to August may be explained by the seasonal changes of the community. In July the wet prairie is usually quite wet throughout as spring flooding and rainfall are just over. By August the amount of rainfall has decreased, and so the slight changes in elevation would be emphasized. Species which mature later in the season such as Aster spp. and Sorghastrum nutans and occur on relatively drier sites, would be more prominent than in July. This would appear in the ordination plot as a less homogeneous series of plots than the July ordination. Composition of these plots involves not only species diversity but also elevation. Thus, plots which happened to have a large amount of higher ground due to tussocking of grasses and sedges would show up in the drier group in the ordination plot. While the August ordination may appear to reveal four groups within the wet to dry gradient, closely placed plots in the prairie are not necessarily geometrically close in the ordination plot. This is most likely caused by the varying elevations which affect the soil moisture and therefore the species composition. Thus the sample plots are actually a mosaic of small patches of relatively high and low elevations. A study of the micro-topography within several of these plots and any correlation between soil moisture and

species composition would be valuable in further understanding of the structure of the prairie vegetation.

CHECKLIST OF VASCULAR PLANTS

The checklist has voucher specimens deposited in the University of Michigan Herbarium (MICH), Beal-Darlington Herbarium of Michigan State University (MSC), and the Herbarium of Andrews University (AUB), in Berrien Springs, Michigan. Species recorded in this checklist are documented by previous collections or were collected by the author during the spring, summer and fall of 1980-1981, and the spring of 1982. Although more species have been previously listed from this area (Medley, 1972), part of the difference in number is due to the size of the study area which is somewhat smaller than the area originally inventoried. Thus many weedy species found along the stream and field to the south of Love Creek are not included in the checklist. Two of the species previously listed should be noted: Phlox maculata has been reported but investigation by the author indicates that no one has yet seen it in the area, and Cypripedium calceolus var. parviflorum is reported for the woods at the base of the moraine. This is not a usual habitat for this variety (Fernald, 1970) and it was not found during the course of this study.

The checklist is arranged phylogenetically using Cronquist's (1981) system of classification for the dicotyledons and the monocotyledons. The pteridophytes and gymnosperms are arranged according to Gleason and Cronquist (1963). Nomenclature follows that of Voss (1972) for the monocots and gymnosperms, and Gleason and Cronquist (1963) for the dicots. Nomenclature for Dryopteris celsa and Rudbeckia sullivantii follows that of Fernald (1970).

The checklist includes 85 families and 210 genera. There are 315 species; 301 are native, 14 are introduced. Eight families had ten or more species in them. The Asteraceae have the highest number of species with 42, and the Poaceae have the next highest with 26. The largest genus is Solidago with 11 species. Carex has 10 species. Most of the introduced species were found along the path through the prairie or along the road that follows the base of the slopes of the bowl.

CHECKLIST OF VASCULAR PLANTS OF INDIAN BOWL WET PRAIRIE AND ITS ADJACENT COMMUNITIES

LYCOPODIOPHYTA

LYCOPODIACEAE

Lycopodium lucidulum Michx. Shining clubmoss. *KRON* 869 (MICH, MSC, AUB), along bank of north-facing slope of the bowl.

SELAGINELLACEAE

Selaginella apoda (L.) Spring. Spike moss. *KRON* 652 (MICH, MSC, AUB), along foot path in wet prairie.

POLYPODIOPHYTA

OPHIOGLOSSACEAE

Botrychium virginianum (L.) Sw. Grape fern. *KRON* 815, 958 (MICH, MSC, AUB), common on floor of bowl.

OSMUNDACEAE

Onoclea sensibilis L. Sensitive fern. *KRON* 873 (MICH, MSC, AUB), common in wet prairie and in thickets.

Osmunda regalis L. Royal fern. *KRON* 820 (MICH, MSC, AUB), in tamarack swamp between wet prairie and the bowl.

POLYPODIACEAE

Adiantum pedatum L. Maidenhair fern. *KRON* 814 (MICH, MSC, AUB), south end of bowl, wooded slope.

Athyrium felix-femina (L.) Roth. Ladyfern. *KRON* 799, 842 (MICH, MSC, AUB), at eastern end of the bowl, rich wooded slopes.

Cystopteris bulbifera (L.) Bernh. Bulblet fern. *KRON* 835 (MICH, MSC, AUB), wooded slopes at base of the moraine, south of the gap in the bowl.

Cryptogramma stelleri (Gmel.) Prantl. Slender cliff-brake. *KRON* 950 (MICH, MSC, AUB), on limestone boulder imbedded in moraine.

Dryopteris celsa (Wm. Palmer) Small. Log fern. *WAGNER* 74233 (MICH), *MEDLEY* s.n. (MICH), near gap of bowl.

Polystichum acrostichoides (Michx.) Schott. Christmas fern. *KRON* 808 (MICH, MSC, AUB), south end of bowl, wooded slope.

Thelypteris palustris Schott. Marsh fern. *KRON* 687, 841 (MICH, MSC, AUB), common throughout wet prairie.

PINOPHYTA

CUPRESSACEAE

Thuja occidentalis L. Arbor vitae. *KRON* 959 (MICH, MSC, AUB), in gap of the bowl, along stream.

PINACEAE

Larix laricina (DuRoi) K. Koch. Tamarack. *KRON* 618 (MICH, MSC, AUB), tree to 60 ft., forming dominant in swamp.

MAGNOLIOPHYTA
MAGNOLIOPSIDA
MAGNOLIIDAE

MAGNOLIACEAE

Liriodendron tulipifera L. Tulip poplar. *KRON* 966 (MICH, MSC, AUB), common in floor of bowl and on the north- and west-facing slopes of the bowl.

ANNONACEAE

Asimina triloba (L.) Dunal. Paw paw. *KRON* 749 (MICH, MSC, AUB), small tree, common on slopes of the bowl, in thickets between the tamarack swamp and the bowl.

LAURACEAE

Lindera benzoin (L.) Blume. Spicebush. *KRON* 715 (MICH, MSC, AUB), small tree, common in thicket between tamarack swamp and the bowl.

Sassafras albidum (Nutt.) Nees. Sassafras. *KRON* 953 (MICH, MSC, AUB), tree to 15 meters, on slope of bowl.

ARISTOLOCHIACEAE

Asarum canadense L. Wild ginger. *KRON* 812 (MICH, MSC, AUB), south end of bowl, wooded slope.

RANUNCULACEAE

Actaea pachypoda Ell. Baneberry. *KRON* 761, 954 (MICH, MSC, AUB), floor of bowl.

Anemone canadensis L. Windflower. *KRON* 600 (MICH, MSC, AUB), throughout wet prairie.

Anemonella thalictroides (L.) Spach. Rue anemone. *KRON* 724 (MICH, MSC, AUB), rich woods, loamy soil at base of moraine.

Aquilegia canadensis L. Columbine. *KRON* 748 (MICH, MSC, AUB), along road at base of moraine, sandy.

Caltha palustris L. Marsh marigold. *KRON* 713 (MICH, MSC, AUB), common along creeks.

Clematis virginiana L. Virgin's bower. *KRON* 690 (MICH, MSC, AUB), twining vine, southern part of prairie.

Hepatica acutiloba DC. Hepatica. *KRON* 733 (MICH, MSC, AUB), on steeply sloping sides of bowl, loamy sand.

H. americana (DC.) Ker. Round-lobed hepatica. *KRON* 738 (MICH, MSC, AUB), south-facing slope of bowl, steeply sloping, sandy.

Isopyrum biternatum (Raf.) T & G. False rue anemone. *KRON* 719 (MICH, MSC, AUB), in very wet soil in thickets at edge of wet prairie.

Ranunculus abortivus L. Kidneyleaf-crowfoot. *KRON* 969 (MICH, MSC, AUB), floor of bowl.

R. parviflorus L. Crowfoot. *KRON* 970 (MICH, MSC, AUB), base of slope eastern end, along road, introduced from Europe.

R. recurvatus Poir. Buttercup. *KRON* 757 (MICH, MSC, AUB), slope of bowl, eastern end.

R. repens L. Creeping buttercup. *KRON* 753 (MICH, MSC, AUB), floor of bowl at gap, introduced from Europe.

R. septentrionalis Poir. Buttercup. *KRON* 599, 717 (MICH, MSC, AUB), in very wet areas, thickets.

Thalictrum dasycarpum Fisch. & Lall. Meadow rue. *KRON* 605 (MICH, MSC, AUB), common in wet prairie.

T. dioicum L. Early meadow rue. *KRON* 737 (MICH, MSC, AUB), south-facing slope, sandy soil.

BERBERIDACEAE

Caulophyllum thalictroides (L.) Michx. Blue cohosh. *KRON* 734 (MICH, MSC, AUB), south side of bowl, steep slope, loamy sand.

Podophyllum peltatum L. Mayapple. *KRON* 760 (MICH, MSC, AUB), floor of bowl.

PAPAVERACEAE

Chelidonium majus L. Rock poppy. *KRON* 762 (MICH, MSC, AUB), along road through south end of bowl, introduced from Europe.

Sanguinaria canadensis L. Bloodroot. *KRON* 709 (MICH, MSC, AUB), rich loamy sand, south side of bowl.

Stylophorum diphyllum (Michx.) Nutt. Wood poppy. *KRON* 727 (MICH, MSC, AUB), very steeply sloping, south side of bowl, loamy sand.

FUMARIACEAE

Corydalis flavulus (Raf.) DC. Yellow fumewort. *SMITH* s.n. (AUB), uncommon.

Dicentra canadensis (Goldie) Walp. Squirrel corn. *KRON* 728 (MICH, MSC, AUB), south side of bowl on a very steep slope, loamy sand.

D. cucullaria (L.) Bernh. Dutchman's breeches. *KRON* 730 (MICH, MSC, AUB), south side of bowl on steep slope, loamy sand.

HAMAMELIDACEAE

Hamamelis virginiana L. Witch hazel. *KRON* 951 (MICH, MSC, AUB), slopes of the bowl.

CANNABACEAE

Humulus lupulus L. Hops. *KRON* 837 (MICH, MSC, AUB), climbing vine in thickets between tamarack swamp and bowl, from Europe.

URTICACEAE

Boehmeria cylindrica (L.) Sw. Bog hemp. *KRON* 668, 632 (MICH, MSC, AUB), in wet prairie.

Laportea canadensis L. Wood nettle. *KRON* 899 (MICH, MSC, AUB), wooded floor of the bowl.

Pilea pumila (L.) Gray. Clearweed. *KRON* 849 (MICH, MSC, AUB), along road south end of bowl, base of steep slope.

FAGACEAE

Fagus grandifolia Ehrh. Beech. *KRON* 952 (MICH, MSC, AUB), on slopes of bowl.

JUGLANDACEAE

Carya cordiformis (Wang.) K. Koch. Bitternut hickory. *KRON* 967 (MICH, MSC, AUB), on slopes of bowl.

BETULACEAE

Betula pumila L. Swamp birch. *KRON* 617 (MICH, MSC, AUB), small shrub in wet prairie.

Carpinus caroliniana Walt. Blue beech. *KRON* 961 (MICH, MSC, AUB), floor of bowl.

Ostrya virginiana (Mill.) K. Koch. Ironwood. *KRON* 968 (MICH, MSC, AUB), slopes of bowl.

CARYOPHYLLIDAE

PHYTOLACCACEAE

Phytolacca americana L. Pokeweed. *KRON* 875 (MICH, MSC, AUB), along path through bowl, sandy soil.

PORTULACEAE

Claytonia virginica L. Spring beauty. *KRON* 720 (MICH, MSC, AUB), in wet soil along edge of thickets, and the wet prairie.

POLYGONACEAE

Polygonum natans Eat. Smartweed. *KRON* 850 (MICH, MSC, AUB), stream running through prairie.

Polygonum virginianum L. Knotweed. *KRON* 870 (MICH, MSC, AUB), south end of bowl, base of slope.

Rumex orbiculatus Gray. Dock. *KRON* 641, 673 (MICH, MSC, AUB), edge of creek running through prairie.

DILLENIIDAE

CLUSIACEAE

Hypericum cf. denticulatum Walt. St. John's wort. *KRON* 847 (MICH, MSC, AUB), open spot floor of bowl.

TILIACEAE

Tilia americana L. Basswood. *KRON* 974 (MICH, MSC, AUB), scattered through bowl.

VIOLACEAE

Viola arvensis Murr. Violet. *KRON* 756 (MICH, MSC, AUB), slope of bowl, eastern end.

V. cucullata Ait. *KRON* 722 (MICH, MSC, AUB), wet soil edges of thickets and prairie.

V. odorata L. *KRON* 723 (MICH, MSC, AUB), rich woods, loamy sand at base of moraine.

V. rotundifolia Michx. *KRON* 711 (MICH, MSC, AUB), south-facing slope of bowl, loamy sand.

V. striata Ait. *KRON* 731 (MICH, MSC, AUB), south side of bowl, steep slope.

CUCURBITACEAE

Echinocystis lobata L. Wild cucumber. *KRON* 683 (MICH, MSC, AUB), climbing vine in woods along river.

SALICACEAE

Salix humilis Marsh. Small pussy willow. *KRON* 708 (MICH, MSC, AUB), along bank of Love Creek.

S. sericea Marsh. Silky willow. *KRON* 642, 653, 927 (MICH, MSC, AUB), forming thickets with Cornus.

Salix sp. *KRON* 754 (MICH, MSC, AUB), floor of bowl at gap.

BRASSICACEAE

Arabis laevigata (Muhl.) Poir. Rock cress. *KRON* 790 (MICH, MSC, AUB), eastern end of bowl, rich wooded slopes.

Cardamine bulbosa (Schreb.) BSP. Bittercress. *KRON* 718, 781 (MICH, MSC, AUB), wet soil in thickets, and scattered through prairie.

Dentaria diphylla Michx. Toothwort. *KRON* 747 (MICH, MSC, AUB), south side of bowl, at base of slope.

Nasturtium officinale R. Br. Watercress. *KRON* 597 (MICH, MSC, AUB), rooted in bottom of sluggish stream in prairie, introduced from Europe.

PRIMULACEAE

Lysimachia ciliata L. Loosestrife. *KRON* 670, 801 (MICH, MSC, AUB), wet prairie.

L. nummularia L. Moneywort. *KRON* 630, 666 (MICH, MSC, AUB), along edge of stream in prairie, from Europe.

L. quadriflora Sims. Loosestrife. *KRON* 654 (MICH, MSC, AUB), in prairie.

L. thyrsiflora L. Tufted loosestrife. *KRON* 649 (MICH, MSC, AUB), wet prairie, from Europe.

ROSIDAE

GROSSULARIACEAE

Ribes cynosbatii L. Dogberry. *KRON* 710 (MICH, MSC, AUB), shrub, rich woods, floor of bowl.

SAXIFRAGACEAE

Mitella diphylla L. Bishop's cap. *KRON* 626, 726 (MICH, MSC, AUB), tamarack swamp, thickets, slopes of the bowl.

Parnassia glauca Raf. Grass-of-Parnassus. *KRON* 914 (MICH, MSC, AUB), southern portion of prairie.

Saxifraga pensylvanica L. ssp. interior Burns. Swamp saxifrage. *KRON* 604, 783 (MICH, MSC, AUB), along streams running through the prairie.

ROSACEAE

Agrimonia gryposepala Wallr. Agrimony. *KRON* 640 (MICH, MSC, AUB), wet prairie.

A. parviflora Ait. Agrimony. *KRON* 700 (MICH, MSC, AUB), occasional in wet prairie.

A. pubescens Wallr. Agrimony. *KRON* 853 (MICH, MSC, AUB), floor of bowl, wooded.

Amelanchier laevis Wieg. Juneberry. *KRON* 714 (MICH, MSC, AUB), small tree, at edge of tamarack swamp and prairie.

Aronia prunifolia (Marsh.) Rehder. *KRON* 776, 957 (MICH, MSC, AUB), southeast prairie at edge of tamarack swamp.

Filipendula rubra (Hill) Robins. Queen-of-the-prairie. *KRON* 645 (MICH, MSC, AUB), *GILLIS* 13935 (MSC), abundant in prairie.

Fragaria vesca L. Woodland strawberry. *KRON* 771 (MICH, MSC, AUB), southeast portion of prairie.

F. virginiana Duchesne. Strawberry. *KRON* 964 (MICH, MSC, AUB), thicket between tamarack swamp and bowl.

Geum canadense Jacq. Avens. *KRON* 809 (MICH, MSC, AUB), south end of bowl, wooded slope.

G. rivale L. Purple avens. *KRON* 778 (MICH), in shade under Cornus, one seen.

Potentilla fruticosa L. Shrubby cinquefoil. *KRON* 696 (MICH, MSC, AUB), shrub, southeastern prairie.

P. recta L. Cinquefoil. *KRON* 791 (MICH, MSC, AUB), eastern end of bowl.

Prunus serotina Ehrh. Black cherry. *KRON* 777 (MICH, MSC, AUB), in tamarack swamp and bowl.

Rubus allegheniensis Porter. Raspberry. *KRON* 960 (MICH, MSC, AUB), thicket between tamarack swamp and bowl.

R. pubescens Raf. Dwarf raspberry. *KRON* 774 (MICH, MSC, AUB), edge of tamarack swamp and prairie.

CAESALPINIACEAE

Cercis canadensis L. Redbud. *KRON* 751 (MICH, MSC, AUB), small tree, floor of bowl.

FABACEAE

Amphicarpa bracteata (L.) Fern. Hog peanut. *KRON* 905 (MICH, MSC, AUB), thickets, twining vine.

Apios americana Michx. Ground nut. *KRON* 681 (MICH, MSC, AUB), twining vine in wet prairie.

Desmodium glutinosum (Muhl.) Wood. Tick-trefoil. *KRON* 887 (MICH, MSC, AUB), slopes of bowl.

D. nudiflorum (L.) DC. Tick-trefoil. *KRON* 833 (MICH, MSC, AUB), thickets.

D. paniculatum (L.) DC. Tick-trefoil. *KRON* 891 (MICH, MSC, AUB), wooded slopes of the bowl.

Lathyrus palustris L. Vetchling. *KRON* 619 (MICH, MSC, AUB), twining herb, throughout prairie.

Robinia pseudo-acacia L. Black locust. *KRON* 962 (MICH, MSC, AUB), occasional on floor of bowl, and slopes.

LYTHRACEAE

Lythrum alatum Pursh. Loosestrife. *KRON* 828 (MICH, MSC, AUB), central prairie, south portion.

ONAGRACEAE

Circaea quadrisulcata (Maxim.) Franch ex. Sav. Enchanter's nightshade. *KRON* 807 (MICH, MSC, AUB), south end of bowl, base of wooded slope.

Epilobium coloratum Biehler. Willow herb. *KRON* 680, 880 (MICH, MSC, AUB), in wetter spots in prairie.

Gaura biennis L. Gaura. *KRON* 675 (MICH, MSC, AUB), along creek running through prairie.

Oenothera biennis L. Evening-primrose. *KRON* 885 (MICH, MSC, AUB), along road at base of moraine, south of gap in bowl.

CORNACEAE

Cornus florida L. Flowering dogwood. *KRON* 745 (MICH, MSC, AUB), small tree, floor of bowl.

Cornus purpusii Koehne. Dogwood. *KRON* 608, 638 (MICH, MSC, AUB), shrub to 7 ft., forming thickets along edge of prairie.

C. racemosa Lam. Dogwood. *KRON* 872 (MICH, MSC, AUB), forming thickets along stream banks.

C. stolonifera Michx. Red osier. *KRON* 956 (MICH, MSC, AUB), occasional spreading shrub in prairie.

RHAMNACEAE

Rhamnus alnifolia L'Her. Buckthorn. *KRON* 620 (MICH, MSC, AUB), small shrub, occasional in prairie.

VITACEAE

Vitis riparia Michx. Frost grape. *KRON* 976 (MICH, MSC, AUB), leaning, twining vine on Cornus in prairie.

POLYGALACEAE

Polygala senega L. Seneca snakeroot. *KRON* 595 (MICH, MSC, AUB), wet prairie.

STAPHYLEACEAE

Staphylea trifolia L. Bladdernut. *KRON* 764 (MICH, MSC, AUB), floor of bowl.

HIPPOCASTANACEAE

Aesculus glabra Willd. Ohio buckeye. *KRON* 750 (MICH, MSC, AUB), common throughout bowl, and in thickets.

ACERACEAE

Acer negundo L. Box-elder. *KRON* 974 (MICH, MSC, AUB), eastern end of bowl, slopes, and on floor.

A. nigrum Michx. Black maple. *KRON* 975 (MICH, MSC, AUB), occasional in thickets and in woods along base of moraine.

A. saccharum Marsh. Sugar maple. *KRON* 955 (MICH, MSC, AUB), in bowl where forms important component of woods.

ANACARDIACEAE

Toxicodendron vernix (L.) Ktze. Poison sumac. *KRON* 935 (MICH, MSC, AUB), prairie, tamarack swamp and thickets, often very large.

RUTACEAE

Ptelea trifoliata L. Hop-tree. *KRON* 832 (MICH, MSC, AUB), thickets between tamarack swamp and moraine.

OXALIDACEAE

Oxalis stricta L. Wood sorrel. *KRON* 800 (MICH, MSC, AUB), along road, east end of bowl.

GERANIACEAE

Geranium maculatum L. Wild geranium. *KRON* 765 (MICH, MSC, AUB), floor of bowl.

LIMNANTHACEAE

Floerkia proserpinacoides Willd. False mermaid. *KRON* 735 (MICH, MSC, AUB), forming mats on north-facing slope of bowl.

BALSAMINACEAE

Impatiens capensis Meerb. Jewel weed. *KRON* 805 (MICH, MSC, AUB), south end of bowl, base of steep slope.

I. pallida Nutt. Jewel weed. *KRON* 854 (MICH, MSC, AUB), southeast end of bowl, and floor.

ARALIACEAE

Panax trifolium L. Dwarf ginseng. *KRON* 712 (MICH, MSC, AUB), along road through the floor of bowl.

APIACEAE

Angelica atropurpurea L. Alexanders. *KRON* 616 (MICH, MSC, AUB), large herb to 6 ft., wet prairie.

Berula pusilla (Nutt.) Fern. Water parsnip. *KRON* 858 (MICH, MSC, AUB), *MEDLEY* s.n. (MOR), *SCHADDALEE* 59-80 (MSC), decumbent, emergent from sluggish stream in prairie.

Chaerophyllum procumbens (L.) Crantz. *KRON* 767 (MICH, MSC, AUB), western edge of prairie, near St. Joseph river.

Cicuta maculata L. Water hemlock. *KRON* 664 (MICH, MSC, AUB), occasional in prairie.

Cryptotaenia canadensis (L.) DC. Honewort. *KRON* 864 (MICH, MSC, AUB), thickets between prairie and bowl.

Osmorhiza claytonii (Michx.) C. B. Clarke. Sweet jarvil. *KRON* 784 (MICH, MSC, AUB), thickets on edge of prairie.

O. longistylis (Torr.) DC. Anise root. *KRON* 759, 843 (MICH, MSC, AUB), slope of bowl, eastern end.

Oxypolis rigidior (L.) Raf. Cowbane. *KRON* 635, 693 (MICH, MSC, AUB), common in wet prairie.

Sanicula marilandica L. Black snakeroot. *KRON* 813 (MICH, MSC, AUB), south end of bowl, wooded slope.

Zizia aurea (L.) Koch. Golden alexanders. *KRON* 593 (MICH, MSC, AUB), abundant in wet prairie.

ASTERIDAE

GENTIANACEAE

Gentiana andrewsii Griseb. Bottle gentian. *KRON* 703, 949 (MICH, MSC, AUB), wet prairie.

G. procera Holm. Fringed gentian. *KRON* 705, 706, 948 (MICH, MSC, AUB), wet prairie.

Swertia caroliniensis (Walt.) Kuntze. American columbo. *KRON* 785 (MICH, MSC, AUB), south-facing slope at gap of bowl, base of slope, sandy.

APOCYNACEAE

Apocynum sibiricum Jacq. Indian hemp. *KRON* 627 (MICH, MSC, AUB), wet prairie north of main creek.

ASCLEPIADACEAE

Asclepias incarnata L. Swamp milkweed. *KRON* 650 (MICH, MSC, AUB), occasional in wet prairie.

A. purpurescens L. Purple milkweed. *KRON* 644, 817 (MICH, MSC, AUB), occasional in south end of prairie.

A. syriaca L. Common milkweed. *KRON* 665 (MICH, MSC, AUB), occasional in prairie.

SOLANACEAE

Solanum dulcamara L. Bittersweet. *KRON* 816 (MICH, MSC, AUB), along edge of creek, prairie.

S. dulcamara f. albiflorum House. *KRON* 614 (MICH, MSC, AUB), along edge of creek, prairie, from Europe.

CONVOLVULACEAE

Convolvulus sepium L. Bindweed. *KRON* 607 (MICH, MSC, AUB), climbing vine, prairie.

CUSCUTACEAE

Cuscuta cuspidata Engelm. Dodder. *KRON* 679 (MICH, MSC, AUB), parasitic herb growing on Nasturtium, in creek in prairie.

POLEMONIACEAE

Phlox divaricata L. Blue phlox. *KRON* 752 (MICH, MSC, AUB), floor of bowl at gap and in thickets between the tamarack swamp and the bowl.

Polemonium reptans L. Jacob's ladder. *KRON* 601, 755 (MICH, MSC, AUB), throughout the wet prairie, in thickets and floor of bowl.

HYDROPHYLLACEAE

Hydrophyllum appendiculatum Michx. Waterleaf. *KRON* 971 (MICH, MSC, AUB), slope of bowl.

H. canadense L. Waterleaf. *KRON* 806 (MICH, MSC, AUB), south end of bowl, wooded slope.

H. virginianum L. John's cabbage. *KRON* 977 (MICH, MSC, AUB), slope of bowl.

BERBENACEAE

Phryma leptostachya L. Lopseed. *KRON* 830, 902 (MICH, MSC, AUB), wooded slopes of bowl.

Verbena hastata L. Blue vervain. *KRON* 698 (MICH, MSC, AUB), wet prairie.

V. urticifolia L. White vervain. *KRON* 865 (MICH, MSC, AUB), woods and floor of bowl.

LAMIACEAE

Ajuga genevensis L. Bugleweed. *KRON* 793 (MICH, MSC, AUB), eastern end of bowl, base of wooded slope, along road.

Blephila hirsuta (Pursh) Benth. Wood mint. *KRON* 851 (MICH, MSC, AUB), floor of bowl

Glechoma hederacea L. Ground ivy. *KRON* 770 (MICH, MSC, AUB), west edge of prairie, along St. Joseph river, from Europe.

Lamium amplexicaule L. Dead nettle. *KRON* 769 (MICH, MSC, AUB), western edge of prairie, along St. Joseph river, near thin woods, from Europe.

Leonurus cardiaca L. Motherwort. *KRON* 795 (MICH, MSC, AUB), eastern end of bowl, base of wooded slope, along road, Eurasian.

Lycopus americana Muhl. Water horehound. *KRON* 689 (MICH, MSC, AUB), wet prairie.

L. virginicus L. Water horehound. *KRON* 697 (MICH, MSC, AUB), wet prairie.

Mentha arvensis L. Mint. *KRON* 859, 922 (MICH, MSC, AUB), prairie.

Monarda fistulosa L. Horsemint. *KRON* 663 (MICH, MSC, AUB), north side of creek, prairie.

Prunella vulgaris L. Heal-all. *KRON* 655 (MICH, MSC, AUB), along footpath, prairie, introduced from Europe.

Pycnanthemum muticum (Michx.) Pers. Mountain mint. *KRON* 677 (MICH, MSC, AUB), south portion of prairie.

Scutellaria galericulata L. Skullcap. *KRON* 648, 684 (MICH, MSC, AUB), prairie.

S. laterifolia L. Skullcap. *KRON* 848 (MICH, MSC, AUB), along road through south end of bowl.

Stachys tenuifolia Willd. Hedge nettle. *KRON* 915 (MICH, MSC, AUB), prairie.

Teucrium canadense L. Wood sage. *KRON* 838 (MICH, MSC, AUB), edge of floor of bowl.

OLEACEAE

Fraxinus americana L. White ash. *KRON* 973 (MICH, MSC, AUB), large tree in floor and slopes of bowl.

SCROPHULARIACEAE

Chelone glabra L. Turtlehead. *KRON* 917 (MICH, MSC, AUB), prairie, throughout.

Gerardia aspera Dougl. Gerardia. *KRON* 916 (MICH, MSC, AUB), prairie.

Pedicularis canadensis L. Lousewort. *KRON* 746 (MICH, MSC, AUB), floor of bowl.

P. lanceolata Michx. Lousewort. *KRON* 921 (MICH, MSC, AUB), throughout prairie.

Scrophularia marilandica L. Figwort. *KRON* 852 (MICH, MSC, AUB), along path around base of bowl.

Veronica officinalis L. Speedwell. *KRON* 846 (MICH, MSC, AUB), south edge of floor, open spot, wet soil, introduced from Europe.

Veronicastrum virginicum (L.) Farw. Culver's root. *KRON* 678 (MICH, MSC, AUB), south of main creek, prairie.

OROBANCHACEAE

Conopholis americana (L.) Wallr. Cancer root. *KRON* 787 (MICH, MSC, AUB), south-facing slope of bowl, sandy soil, parasitic.

Epifagus virginiana (L.) Bart. Beech drops. *KRON* 938 (MICH, MSC, AUB), wooded slope of bowl, parasitic.

CAMPANULACEAE

Campanula aparinoides Pursh. Marsh bellflower. *KRON* 651 (MICH, MSC, AUB), wet prairie.

C. rotundifolia L. Harebell. *KRON* 811 (MICH, MSC, AUB), base of moraine, steep slope.

Lobelia inflata L. Indian tobacco. *KRON* 845 (MICH, MSC, AUB), base of slopes, north end of bowl.

L. siphilitica L. Great blue lobelia. *KRON* 694 (MICH, MSC, AUB), prairie.

RUBIACEAE

Galium aparine L. Bedstraw. *KRON* 768 (MICH, MSC, AUB), along St. Joseph river.

G. circaezans Michx. Bedstraw. *KRON* 868 (MICH, MSC, AUB), prairie.

G. obtusum Bigel. Bedstraw. *KRON* 606 (MICH, MSC, AUB), prairie.

G. parisiene L. *KRON* 782, 878 (MICH, MSC, AUB), prairie.

G. lanceolatum Torr. *KRON* 789 (MICH, MSC, AUB), central prairie.

CAPRIFOLIACEAE

Lonicera sempervirens L. Trumpet honeysuckle. *KRON* 779 (MICH, MSC, AUB), climbing vine on Cornus, wet prairie.

Sambucus canadensis L. Elderberry. *KRON* 667 (MICH, MSC, AUB), tall shrub, south of main creek, prairie.

S. pubens Michx. Red-berried elder. *KRON* 729 (MICH, MSC, AUB), very steep slope, north-facing.

Viburnum acerifolium L. Maple leaf viburnum. *KRON* 786 (MICH, MSC, AUB), north end of bowl, small shrub in sandy soil.

ASTERACEAE

Antennaria plantaginifolia (L.) Richards, pussy toes. *KRON* 740 (MICH, MSC, AUB), north slope, sandy.

Aster cordifolius L. Aster. *KRON* 936 (MICH, MSC, AUB), prairie.

A. lucidulus (Gray) Wieg. Aster. *KRON* 944 (MICH, MSC, AUB), prairie.

A. macrophyllus L. Aster. *KRON* 890, 892 (MICH, MSC, AUB), floor of bowl.

A. novae-angliae L. New England aster. *KRON* 946 (MICH, MSC, AUB), prairie.

A. prenanthoides Muhl. Aster. *KRON* 894 (MICH, MSC, AUB), prairie.

A. puniceus L. Aster. *KRON* 939, 947 (MICH, MSC, AUB), wooded slopes of bowl.

A. simplex Willd. Aster. *KRON* 923, 941 (MICH, MSC, AUB), prairie.

A. umbellatus Mill. Aster. *KRON* 912, 919 (MICH, MSC, AUB), prairie.

Cirsium muticum Michx. Swamp thistle. *KRON* 671 (MICH, MSC, AUB), prairie.

Erigeron pulchellus Michx. Fleabane. *KRON* 797 (MICH, MSC, AUB), eastern end of bowl.

Eupatorium fistulosum Baratt. Joe-pye weed. *KRON* 686 (MICH, MSC, AUB), throughout prairie.

E. maculatum L. Joe-pye weed. *KRON* 910 (MICH, MSC, AUB), prairie.

E. perfoliatum L. Boneset. *KRON* 701 (MICH, MSC, AUB), wet prairie.

E. rugosum Houtt. White snakeroot. *KRON* 844, 893 (MICH, MSC, AUB), south edge, floor of bowl.

Helenium autumnale L. Sneezeweed. *KRON* 707, 913 (MICH, MSC, AUB), wet prairie.

Helianthus decapetalus L. Sunflower. *KRON* 659 (MICH, MSC, AUB), semi-shaded area along creek, prairie.

H. gigantea L. Sunflower. *KRON* 882, 920 (MICH, MSC, AUB), prairie.

H. laetiflorus Pers. Sunflower. *KRON* 907 (MICH, MSC, AUB), prairie.

Hieracium paniculatum L. Hawkweed. *KRON* 888 (MICH, MSC, AUB), in sandy path through floor of bowl.

Lactuca canadensis L. Lettuce. *KRON* 861 (MICH, MSC, AUB), sandy soil in path of bowl.

Liatris spicata (L.) Willd. Blazing star. *KRON* 691 (MICH, MSC, AUB), southeast prairie.

Polymnia canadensis L. Leaf cup. *KRON* 836 (MICH, MSC, AUB), along road through south end of bowl.

Prenanthes alba L. White lettuce. *KRON* 896 (MICH, MSC, AUB), prairie.

P. racemosa Michx. Rattlesnake root. *KRON* 943 (MICH, MSC, AUB), wet prairie.

Rudbeckia hirta L. Black-eyed Susan. *KRON* 656 (MICH, MSC, AUB), southernmost portion of prairie.

R. sullivantii Boynton & Beadle. Showy black-eyed Susan. *KRON* 682 (MICH, MSC, AUB), common in southern portion of prairie.

Senecio obovatus Muhl. Groundsel. *KRON* 596, 741 (MICH, MSC, AUB), edges of creeks in wet prairie and floor of bowl.

Silphium integrifolium Michx. Rosinweed. *KRON* 661 (MICH, MSC, AUB), *GILLIS* and *KOHRING* 14167 (MSC), scattered throughout prairie.

Solidago canadensis L. Goldenrod. *KRON* 881, 883, 909, 925, 926, 934 (MICH, MSC, AUB), prairie.

S. caesia L. Bluestem goldenrod. *KRON* 903 (MICH, MSC, AUB), wooded slopes at base of moraine.

S. flexicaulis L. Goldenrod. *KRON* 937 (MICH, MSC, AUB), prairie.

S. gigantea Ait. Goldenrod. *KRON* 688, 900 (MICH, MSC, AUB), wet prairie.

S. graminifolia (L.) Salisb. Goldenrod. *KRON* 908 (MICH, MSC, AUB), prairie.

S. hispida Muhl. Goldenrod. *KRON* 895, 898 (MICH, MSC, AUB), prairie.

S. puberula Nutt. Goldenrod. *KRON* 932, 933 (MICH, MSC, AUB), prairie.

S. riddellii Frank. Riddell's goldenrod. *KRON* 940 (MICH, MSC, AUB), prairie.

S. rugosa Mill. Wrinkled goldenrod. *KRON* 924 (MICH, MSC, AUB), prairie.

S. uliginosa Nutt. Marsh goldenrod. *KRON* 942, 945 (MICH, MSC, AUB), prairie.

Verbesina alternifolia (L.) Britt. Wingstem. *KRON* 879 (MICH, MSC, AUB), prairie.

Vernonia missurica Raf. Ironweed. *KRON* 636, 676 (MICH, MSC, AUB), prairie.

LILIOPSIDA
ALISMATIDAE

ALISMATACEAE

Sagittaria latifolia Willd. Arrowleaf. *KRON* 702, 911 (MICH, MSC, AUB), wetter spots of prairie and thickets.

JUNCAGINACEAE

Triglochin maritima L. *KRON* 860 (MICH, MSC, AUB), small pool about 1 meter wide in prairie.

ARECIDAE

ARACEAE

Arisaema triphyllum (L.) Schott. Jack-in-the-pulpit. *KRON* 736 (MICH, MSC, AUB), north-facing slope of bowl.

Symplocarpus foetidus (L.) Nutt. Skunk cabbage. *KRON* 978 (MICH, MSC, AUB), tamarack swamp.

LEMNACEAE

Lemna minor L. Duckweed. *KRON* 884 (MICH, MSC, AUB), slowly moving to still water in stream, prairie.

COMMELINIDAE

COMMELINACEAE

Tradescantia ohiensis Raf. Dayflower. *KRON* 615 (MICH, MSC, AUB), prairie.

JUNCACEAE

Juncus brachycephalus (Englm.) Buch. *KRON* 657 (MICH, MSC, AUB), prairie.

J. effusus L. *KRON* 823 (MICH, MSC, AUB), prairie.

J. greeneii Oakes & Tuckerman. *KRON* 658 (MICH, MSC, AUB), prairie.

Juncus sp. *KRON* 646 (MICH, MSC, AUB), prairie.

Juncus sp. *KRON* 804 (MICH, MSC, AUB), eastern end of bowl, base of slope.

Luzula acuminata Raf. *KRON* 742 (MICH, MSC, AUB), floor of bowl.

CYPERACEAE

Carex bebbii (Bailey) Fern. *KRON* 624 (MICH, MSC, AUB), prairie.

C. crinita Lam. *KRON* 662 (MICH, MSC, AUB), prairie.

C. exilis Dewey. *KRON* 819 (MICH, MSC, AUB), prairie.

C. howeii MacKenzie. *KRON* 623 (MICH, MSC, AUB), prairie.

C. hystericina Willd. *KRON* 827 (MICH, MSC, AUB), prairie.

C. pensylvanica Lam. *KRON* 739, 744 (MICH, MSC, AUB), north slope, steep, sandy.

C. plantaginea Lam. *KRON* 743 (MICH, MSC, AUB), floor of bowl.

C. sartwellii Dewey. *KRON* 775 (MICH, MSC, AUB), prairie, edge of tamarack swamp.

C. stricta Lam. *KRON* 610, 965 (MICH, MSC, AUB), prairie.

C. tetanica Schk. *KRON* 773 (MICH, MSC, AUB), southeast portion of prairie.

Eleocharis intermedia (Muhl.) Schultes. *KRON* 772 (MICH, MSC, AUB), southeast portion of prairie.

Scirpus atrovirens Willd. *KRON* 825 (MICH, MSC, AUB), wet prairie.

POACEAE

Agrostis gigantea Roth. Redtop. *KRON* 826 (MICH, MSC, AUB), prairie.

Agrostis perennans (Walt.) Tuckerman. Upland bent grass. *KRON* 897 (MICH, MSC, AUB), prairie.

Alopecurus pratensis L. Foxtail grass. *KRON* 798 (MICH, MSC, AUB), eastern end of bowl.

Andropogon gerardii Vitm. Big bluestem. *KRON* 685 (MICH, MSC, AUB), prairie.

Brachyelytrum erectum (Roth) Beauv. *KRON* 839 (MICH, MSC, AUB), eastern end of bowl, wooded slope.

Bromus ciliatus L. Fringed brome. *KRON* 629, 633 (MICH, MSC, AUB), prairie.

B. latiglumis (Shear) Hitchc. *KRON* 874, 904 (MICH, MSC, AUB), prairie.

B. pubescens Muhl. Canada brome. *KRON* 611, 831, 901 (MICH, MSC, AUB), prairie.

Calamagrostis canadensis (Michx.) Beauv. Blue joint. *KRON* 609, 647 (MICH, MSC, AUB), prairie.

Cinna arundinacea L. Wood reed grass. *KRON* 855 (MICH, MSC, AUB), along path through bowl.

Glyceria striata (Lam.) Hit. Fowl manna grass. *KRON* 628, 834 (MICH, MSC, AUB), prairie.

Elymus villosus Willd. Wild rye. *KRON* 871 (MICH, MSC, AUB), thickets between prairie and bowl.

E. virginicus L. Wild rye. *KRON* 796, 877, 906 (MICH, MSC, AUB), eastern end of bowl.

Hystrix patula Moench. Bottle brush grass. *KRON* 810 (MICH, MSC, AUB), south end of bowl, wooded slope.

Leersia virginica Willd. White grass. *KRON* 840 (MICH, MSC, AUB), eastern end of bowl, wooded.

Milium effusum L. *KRON* 631 (MICH, MSC, AUB), along Love Creek, woods.

Muhlenbergia frondosa (Poiret) Fern. *KRON* 928 (MICH, MSC, AUB), prairie.

M. glomerata (Willd.) Trin. Marsh wild timothy. *KRON* 856 (MICH, MSC, AUB), prairie.

M. mexicana (L.) Trin. *KRON* 930, 931 (MICH, MSC, AUB), prairie.

M. schreberi J. F. Gmelin. Nimblewill. *KRON* 889 (MICH, MSC, AUB), in sandy path through bowl.

M. tenuiflora (Willd.) BSP. *KRON* 866 (MICH, MSC, AUB), slope of bowl, north-facing.

Panicum dichotomum L. *KRON* 867, 886 (MICH, MSC, AUB), along path through bowl.

Panicum virgatum L. Switchgrass. *KRON* 821, 876 (MICH, MSC, AUB), prairie.

Phragmites communis Trin. Reed. *KRON* 863 (MICH, MSC, AUB), prairie.

Poa alsodes Gray. *KRON* 766 (MICH, MSC, AUB), floor of bowl.

Sorghastrum nutans (L.) Nash. Indian grass. *KRON* 695 (MICH, MSC, AUB), prairie.

Spartina pectinata Link. Prairie cordgrass. *KRON* 672 (MICH, MSC, AUB), prairie, south of main creek.

TYPHACEAE

Typha angustifolia L. Narrow-leaved cattail. *KRON* 625 (MICH, MSC, AUB), wetter places in prairie.

LILIIDAE

LILIACEAE

Allium cernuum Roth. Nodding wild onion. *KRON* 643, 699 (MICH, MSC, AUB), petals white to pink, prairie.

A. tricoccum Ait. Wild leek. *KRON* 829 (MICH, MSC, AUB), wooded slope between tamarack swamp and bowl.

Asparagus officinalis L. Asparagus. *KRON* 612 (MICH), one seen in prairie, European.

Erythronium americanum L. Trout lily. *KRON* 732 (MICH, MSC, AUB), south side of bowl steep slopes, loamy sand.

Hypoxis hirsuta (L.) Cov. Yellow star grass. *KRON* 594 (MICH, MSC, AUB), prairie.

Lilium superbum L. Turk's cap lily. *KRON* 660 (MICH, MSC, AUB), prairie.

Polygonatum pubescens (Willd.) Pursh. Solomon's seal. *KRON* 758 (MICH, MSC, AUB), slope of bowl, east end.

Smilacina racemosa (L.) Desf. Large false Solomon's seal. *KRON* 763 (MICH, MSC, AUB), common on slopes of bowl.

S. stellata (L.) Desf. Small false Solomon's seal. *KRON* 613, 780 (MICH, MSC, AUB), prairie.

Trillium flexipes Raf. Nodding trillium. *KRON* 963 (MICH, MSC, AUB), wooded slope between tamarack swamp and bowl.

T. grandiflorum (Michx.) Salisb. Large-flowered trillium. *KRON* 716 (MICH, MSC, AUB), thicket between prairie and bowl.

T. recurvatum Beck, Prairie wake-robin. *KRON* 721 (MICH, MSC, AUB), throughout tamarack swamp, thicket and floor of bowl.

Uvularia grandiflora Sm. Bellwort. *KRON* 725 (MICH, MSC, AUB), rich woods at base of moraine, loamy soil.

Zygadenus glaucus Nutt. White camas. *KRON* 692 (MICH, MSC, AUB), prairie.

IRIDACEAE

Iris virginica L. Blue flag. *KRON* 598 (MICH, MSC, AUB), in wetter spots in prairie.

Sisyrinchium graminoides Bickn. Blue-eyed grass. *KRON* 794 (MICH, MSC, AUB), eastern end of bowl, wooded slopes.

SMILACACEAE

Smilax herbacea var. lasioneura (Hooker) DC. Carrion flower. *KRON* 621, 622 (MICH, MSC, AUB), twining vine on north side of main creek through prairie.

DIOSCOREACEAE

Dioscorea villosa L. Yam. *KRON* 669, 818 (MICH, MSC, AUB), climbing vine, north of creek running through prairie.

ORCHIDACEAE

Cypripedium calceolus L. var. pubescens (Willd.) Correll. Large yellow lady's slipper. *KRON* 603, 788 (MICH, MSC, AUB), tamarack swamp and south prairie.

Cypripedium reginae Walt. Showy lady's slipper. *KRON* 602 (MICH, MSC, AUB), wet prairie.

Habenaria lacera (Michx.) Lodd. Ragged orchis. *KRON* 874 (MICH), prairie, one seen.

H. psycodes (L.) Sprengel. Small purple fringed orchis. *KRON* 862 (MICH, MSC, AUB), prairie between tamarack swamp and bowl.

Liparis loeselii (L.) Richard. Bog twayblade. *KRON* 822 (MICH, MSC, AUB), wet prairie.

Spiranthes romanzoffiana Cham. Hooded lady's tresses. *KRON* 704, 918 (MICH, MSC, AUB), prairie.

APPENDIX

APPENDIX

Criteria for endangered, threatened, and special concern plants in Michigan as described by the Plant Technical Committee of the Wildlife Division of the Michigan Department of Natural Resources (1982) and Wagner et al. (1977).

Criteria for endangered:

A. Extreme rarity in Michigan (less than or equal to two known viable populations) and at least one of the following conditions:

B. Endemism or near-endemism to Michigan;

OR

C. Rarity throughout North America;

OR

D. Rarity in the Great Lakes drainage basin with demonstrable threat to state populations;

OR

E. Special factors causing unusual vulnerability (e.g., disease, highly specialized requirements, exceptional danger of exploitation).

Criteria for threatened:

A. Extreme rarity in Michigan, but not meeting secondary endangered criteria;

OR

B. Endemism or near-endemism to Michigan;

OR

C. State rarity (less than or equal to ten known viable populations, or if no current population data are available, occurrence in less than or equal to five counties and less than or equal to 20 collection localities with known decline) and at least one of the following:

1. Rarity in the Great Lakes region;

or

2. Demonstrable threat to all or most state populations;

or

3. Disjunction or phytogeographic significance;

or

4. Unusual habitat vulnerability (e.g., prairie, fen, lakeshore);

or

5. Extremely localized state distribution (less than or equal to two counties);

or

6. Special factors (scientific importance, absence of recent records);

OR

D. No populations known extant or recently reported.

Criteria for rare or special concern species (not protected under Michigan law):

A species or lower taxa that is extremely uncommon in Michigan although not fitting the criteria of "endangered" or "threatened" which deserves further study and monitoring. Peripheral species, not listed as "threatened" may be included in this category along with those species which were once "threatened" or "endangered" but now have increasing or protected, stable populations.

Definitions:

Rarity: Nowhere common; limits given on numbers of populations are guidelines only and are not intended to be rigid, artificial cut-offs.

Viable population: An actively reproducing population large enough to maintain itself indefinitely in a natural community with minimal disturbance.

LITERATURE CITED

LITERATURE CITED

Anderson, R. C. and C. VanValkenburg. 1977. Response of a southern Illinois grassland community to burning. Trans. Ill. State Acad. Sci. 69:399-414.

Armesto, J. J. and J. A. Martinez. 1978. Relations between vegetation structure and slope aspect in the Medittera-nean region of Chile. J. Ecol. 66:881-889.

Baker, H. 1972. A fen on the northern California coast. Madrono 21:405-416.

Barnes, C. R. and M. A. Kohring. 1978. Indian Bowl wet prairie and area site plan and environmental impact assessment. Prepared for the Berrien County Parks and Recreation Commission. Unpublished.

Beaman, J. H. 1977. Commentary on endangered and threatened plants in Michigan. Mich. Bot. 16:110-122.

Betz, R. F. 1976. The prairies of Indiana. Proc. Fifth Mid-west Prairie Conf. pp. 25-31.

Bliss, L. C. and G. W. Cox. 1964. Plant community and soil variation within a northern Indiana prairie. Amer. Mid. Nat. 72:115-128.

Bray, J. R. and J. T. Curtis. 1957. An ordination of the upland forest communities of southern Wisconsin. Ecol. Monog. 27:325-349.

Brewer, R. 1965. Vegetational features of a wet prairie in southwestern Michigan. Occas. Papers Adams Ctr. Ecol. Studies 13:1-16.

_____ 1966 Vegetation of two bogs in southwestern Michigan. Mich. Bot. 5:36-46.

Brower, J. E. and J. H. Zar. 1977. Field and laboratory methods for general ecology. Wm. C. Brown Co., Dubuque, Iowa. 193 pp.

Bushey, C. L. and R. C. Moran. 1978. Vascular flora of Shaw prairie, Lake county, Illinois. Trans. Ill. State Acad. Sci. 71:427-435.

Butler, A. F. 1935. Rediscovering Michigan's prairies. Michigan History Magazine. 31:267-286, 33:220-231.

Cain, S. and J. V. Slater. 1948. The vegetation of Sodon Lake. Amer. Mid. Nat. 40:741-762.

Cantlon, J. E. 1953. Vegetation and microclimates on north and south slopes of Cushetunk Mountain, New Jersey. Ecol. Monog. 23:241-270.

Caton, J. D. 1870. The last of the Illinois, and a sketch of the Pottawattomi. Fergus' Historical Series #3. 15 pp.

Champion, E. 1926. Berrien's beginnings. Berrien County Publ. 37 pp.

Conard, H. S. 1952. The vegetation of Iowa: an approach toward a phytosociologic account. State Univ. Iowa Studies in Nat. Hist. 19:1-164.

Coolidge, O. W. 1906. A twentieth century history of Berrien County, Michigan. Lewis Publ. Co. Chicago. 1007 pp.

Cooper, A. W. 1961. Relationships between plant life-forms and microclimate in southeastern Michigan. Ecol. Monog. 31:31-58.

Costello, D. F. 1936. Tussock meadows in southeastern Wisconsin. Bot. Gaz. 97:610-649.

Cottam, G. and J. T. Curtis. 1956. The use of distance measures in phytosociological sampling. Ecology. 37:451-460.

Cox, G. W. 1976. Laboratory manual of general ecology. Wm. C. Brown Co., Dubuque, Iowa. 232 pp.

Cronquist, A. 1981. An integrated system of classification of flowering plants. Columbia University Press. 1262 pp.

Curtis, J. T. 1955. A prairie continuum in Wisconsin. Ecology. 36:558-566.

_____ 1959. The vegetation of Wisconsin: an ordination of plant communities. Univ. Wisc. Press, Madison, Wisc. 658 pp.

_____ and H. C. Greene. 1949. A study of relic Wisconsin prairies by the species presence method. Ecology. 30: 83-92.

Drew, W. B. 1947. Floristic composition of grazed and ungrazed prairie vegetation in north-central Missouri. Ecology. 28:26-41.

Ellis, F. 1880. History of Berrien and VanBuren counties, Michigan. Lippincott Press, Philadelphia. 548 pp.

Fernald, M. L. 1970. Gray's manual of botany. D. Van Nostrand Co. Cincinnati. 1632 pp.

Friesner, R. C. and J. E. Potzger. 1946. The Cabin Creek raised bog, Randolph county, Indiana. Butler Univ. Bot. Studies. 8:24-43.

Gates, F. C. 1942. The bogs of northern lower Michigan. Ecol. Monog. 12:213-254.

Geiger, R. 1950. Climate near the ground. Harvard Univ. Press, Cambridge, Mass. 494 pp.

Gleason, H. A. 1917. A prairie near Ann Arbor, Michigan. Rhodora. 19:163-165.

_____ and A. Cronquist. 1963. Manual of vascular plants of northeastern United States and adjacent Canada. Van Nostrand Reinhold Co. Cincinnati. 810 pp.

Gould, F. W. 1941. Plant indicators of original Wisconsin prairies. Ecology. 22:427-429.

Green, P. A. 1950. Ecological composition of high prairie relics in Rock county, Wisconsin. Wisc. Acad. Sci. Arts Lett. 40:159-172.

Harlow, W. M. and E. S. Harrar. 1958. Textbook of dendrology. McGraw Hill Co., Inc. New York. 512 pp.

Hayden, R. 1943. A botanical survey in the Iowa Lake region of Clay and Palo Alto counties. Iowa St. Coll. Jour. Sci. 17:277-416.

Hayes, B. N. 1964. An ecological study of a wet prairie on Harsen's Island, Michigan. Mich. Bot. 3:71-82.

Hinsdale, W. B. 1931. Archaeological atlas of Michigan. Michigan Handbook Series #4. Univ. Mich. Press. Ann Arbor, Michigan.

Holte, K. E. and R. F. Thorne. 1962. Discovery of a calcareous fen complex in northwest Iowa. Proc. Iowa Acad. Sci. 69:54-60.

Jeglum, J. K., Boissonneau, A. N., and V. F. Haavisto. 1974. Toward a wetland classification for Ontario. Canadian Forestry Service, Dept. of the Environment, Info. Report O-X-215.

Jones, C. H. 1944. Studies in Ohio floristics-III. Vegetation of Ohio prairies. Bull. Torr. Bot. Club. 71:536-548.

Kenoyer, L. A. 1934. Forest distribution in southwestern Michigan as interpreted from the original land survey. Papers Mich. Acad. Sci. Arts and Lett. 19:107-111.

Kohring, M. A. 1982. Ecological and floristic analysis of Bakertown fen. M.S. thesis. Michigan State University.

Kurz, H. 1923. Hydrogen ion concentration in relation to ecological factors. Bot. Gaz. 76:1-69.

Lake, D. J. 1873. Atlas of Berrien county, Michigan. C. O. Titus Publ.

Larson, J. D. 1980. Soil survey of Berrien county, Michigan. U. S. Dept. Agric., Soil Conservation Service.

Levin, M. H. and G. M. Keleher. 1969. Vegetation of a prairie near Winnipeg, Manitoba. Canad. Field Nat. 83:113-122.

Medley, M. 1972. United for survival natural area report: Indian Bowl wet prairie and swamp forest. Michigan Natural Areas Council Reconnaissance Reports Vol. 1:206-212.

Mickel, J. T. 1979. How to know the ferns and fern allies. The pictured key nature series. Wm. C. Brown Co. Publ. 229 pp.

Moyer, L. R. 1900. The prairie flora of southwestern Minnesota. Bull. Minn. Acad. Sci. 4:357-372.

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley and Sons, New York. 547 pp.

Pearson, P. R., Jr. 1971. Woodland vegetation of Fort Washington State Park, Pennsylvania. Bull. Torr. Bot. Club. 101:101-104.

Peattie, D. C. 1930. Flora of the Indiana dunes. Field Museum of Natural History, Chicago. 432 pp.

Rogers, C. M. 1966. A wet prairie community at Windsor, Ontario. Canad. Field Nat. 80:195-199.

Sampson, H. C. 1921. An ecological survey of the prairie vegetation of Illinois. Bull. Ill. Nat. Hist. Surv. 13:519-577.

Schaddalee, L. 1980. Potential preserve site summary: Indian Bowl. Unpublished.

Scharrer, E. M. 1971. Current evidence of tall grass prairie remnants in southwestern Michigan. M.S. Thesis Michigan State University.

Shanks, R. E. and F. H. Norris. 1950. Microclimatic variation in a small valley in eastern Tennessee. Ecology. 31:532-539.

Shaw, S. P. and C. G. Fredine. 1979. Wetlands of the United States--Their extent and their value to waterfowl and other wildlife. Office of River Basin Studies. Circ. 39, Fish and Wildlife Service, U. S. Dept. of Interior.

Sherff, E. E. 1913. Vegetation of Skokie Marsh. Bull. Ill. State Lab. Nat. Hist. 9:575-615.

Shimek, B. 1900. The prairies. Bull. Lab. Nat. Hist. Univ. Iowa. 6:169-240.

Sorensen, P. D. 1962. The Williams prairie: a prairie relict in Johnson county. Proc. Iowa Acad. Sci. 69:45-54.

Spurr, S. H. 1964. Forest ecology. Ronald Press, Co. New York. 352 pp.

Stout, A. B. 1914. A biological and statistical analysis of the vegetation of a typical wild hay meadow. Trans. Wisc. Acad. Arts Lett. 17:405-469.

Swink, F. 1974. Plants of the Chicago region. 2nd edition The Morton Arboretum, Lisle, Illinois. 474 pp.

Sytsma, K. J. and R. W. Pippen. 1982. The Hampton Creek wetland complex in southwestern Michigan. II. Structure and succession of tamarack forests. Mich. Bot. 21:67-74.

Tansley, A. G. 1939. The British islands and their vegetation. Cambridge Univ. Press, Cambridge. 930 pp.

Thompson, P. W. 1970. A wet prairie community in Ann Arbor, Michigan. Mich. Academ. 2:87-94.

_____ 1975. Floristic composition of prairie stands in southern Michigan. in Wali, ed. Prairie: a multiple view. Univ. North Dakota Press, Grand Forks, N.D.

_____, Medley, M. and W. H. Wagner, Jr. 1976 Indian Bowl tract reconnaissance report. Michigan Natural Areas Council Reconnaissance Reports. Vol. 1:198-205.

Transeau, E. N. 1935. The prairie peninsula. Ecology. 16: 423-437.

Turner, T. G. 1867. Turner's gazeteer of the St. Joseph valley in Michigan and Indiana. Hazlett and Reed Printers, Chicago. 168 pp.

Vestal, A. 1914. A black-soil prairie station in northeastern Illinois. Bull. Torr. Bot. Club. 41:351-364.

Voss, E. G. 1972. Michigan flora. Part I: gymnosperms and monocots. Cranbrook Inst. of Sci. and the University of Michigan Herbarium. 488 pp.

Wagner, W. H., Jr., Voss, E. G., Beaman, J. H., Bourdo, E. A., Case, F. W., Churchill, J. A., and P. W. Thompson. 1977. Endangered, threatened and rare vascular plants in Michigan. Mich. Bot. 16:99-110.

Weaver, J. E. 1954. North American prairie. Johnson Publ. Co. Lincoln, Nebraska. 348 pp.

Weaver, J. E. and T. J. Fitzpatrick. 1934. The prairie. Ecol. Monog. 4:231-258.

Whittaker, R. H. 1975. Communities and ecosystems. MacMillan Pub. Co., Inc. 2nd edition. 385 pp.

Wildlife Division, Michigan Dept. Natural Resources. 1982. Proposed endangered and threatened species list. Second biennial review. Photocopy.

Wolden, B. O. 1971. Flora of Island Grove and adjacent Iowa prairies before 1908. Proc. Iowa Acad. Sci. 78:2-8.