AN ECOLOGICAL ANALYSIS OF THE ISOLATED PRAIRIES OF NEWAYGO COUNTY, MICHIGAN

Thesis for the Degree of Ph. D.

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Richard S. Hauser

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THESIS

This is to certify that the

thesis entitled

"An Ecological Analysis of the Isolated Prairies of Newaygo County, Michigan"

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Richard Scott Hauser

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of the requirements for

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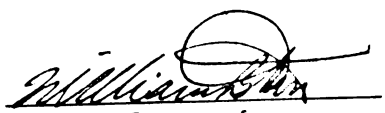

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AN ECOLOGICAL ANALYSIS OF THE ISOLATED PRAIRIES OF NEWAYGO COUNTY, MICHIGAN

By

Richard Scott Hauser

A DISSERTATION

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AN ABSTRACT

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Richard Scott Hauser

Within the limits of four townships in Newaygo County, Michigan, there occurs a group of prairies completely surrounded by forest vegetation, and separated by about 65 miles from the nearest prairies in the southwestern part of Michigan.

The present study has two main objectives. The first is to consider the prairies of Newaygo County in detail with respect to their floristic and ecological characteristics. The second is to consider the factors related to the isolated occurrence of these prairies and to formulate an hypothesis to account for their original occurrence and subsequent persistence within a forest region.

The area is described in detail with respect to its physical features, its history, and the nature of the prairies which occur within it.

The vegetation of the Newaygo prairies is considered from the standpoint of the concept of frequency, interpreting the individual prairie areas as fragments of a large natural stand. Frequency is discussed in terms of 1-square-meter quadrats and 100-square-meter plots. A rapid method for locating ten quadrats within a plot is described. The dominance of the various species in the community is determined on the basis of the amount of ground covered, and is evaluated by means of a "cover index."

Richard Scott Hauser

Relationships between these prairies and their surroundings are investigated and discussed, and their connections with the main body of the prairie peninsula are noted. It has been concluded that the Newaygo prairies, in spite of their isolation, have definite affinities with the prairie peninsula.

Various factors which may be related to the isolation of the Newaygo prairies have been considered. These include climatic, edaphic, biotic, pyric, and anthropeic factors. It is held that the prairie vegetation invaded the forests during a postglacial warm and dry period. Subsequently, as the climate became cooler and more humid, the trees reinvaded the area, surrounding and isolating the prairies of Newaygo county. The persistence of these prairies within the forest cannot be explained by any one factor. It is due, rather, to a delicate balance between many phases of the environment.

It is noted that afforestation activities now in progress threaten to eliminate the prairies completely from Newaygo County.

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INTRODUCTION

Vegetation of Michigan

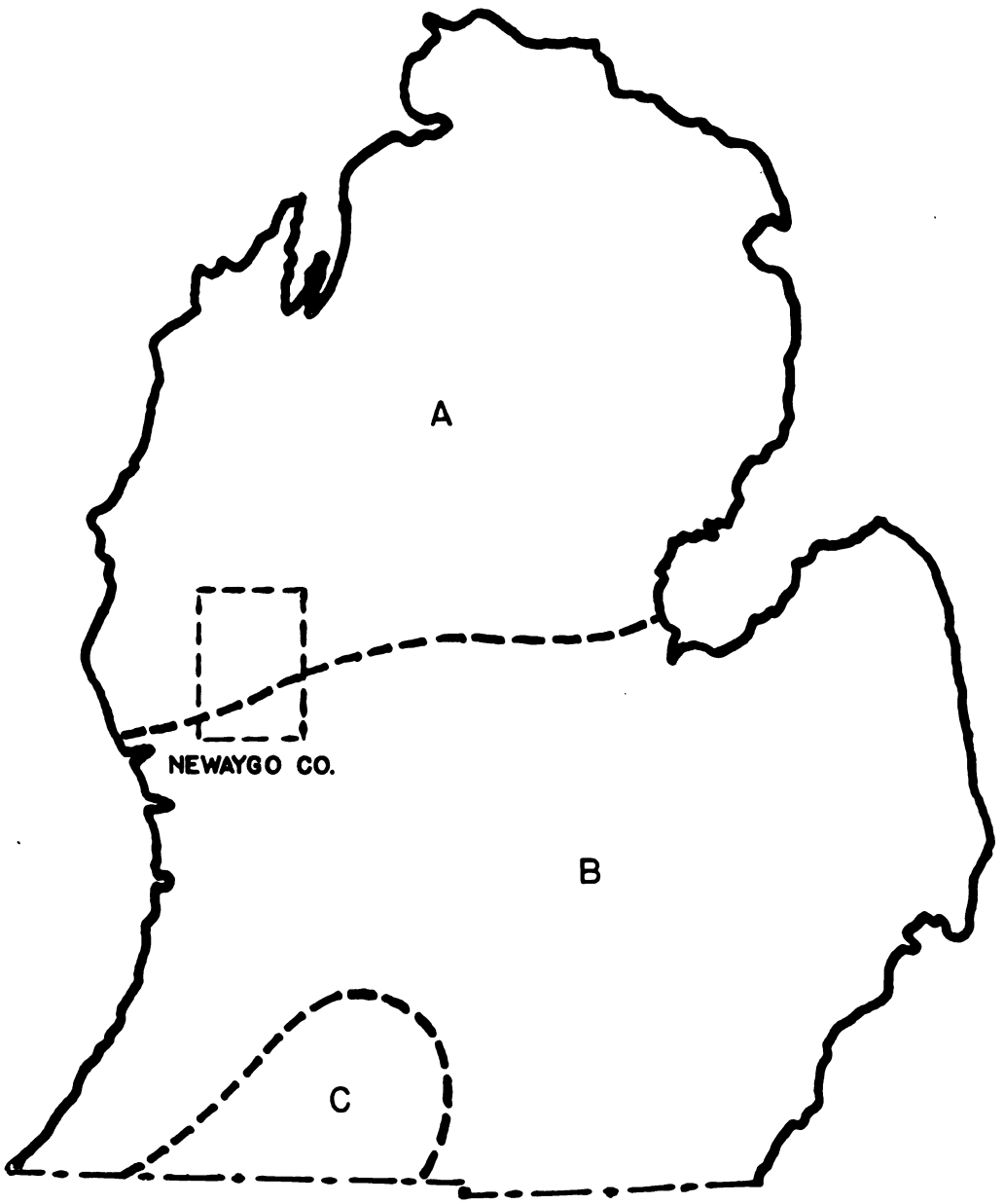
The State of Michigan lies entirely within the Deciduous Forest Formation of eastern North America. The composition of the vegetation within this formation varies greatly from one region to another, but the majority of the most charcteristic woody species are deciduous in habit. Throughout the formation, however, there are various admixtures of evergreen species. North of the Great Lakes region, the deciduous species are gradually eliminated by the increasing rigors of the climate, resulting in the development of the Boreal or Spruce-Fir Forest Formation. Forest species are also gradually eliminated toward the west by the decrease in annual precipitation, leading to the development of the Grassland or Prairie Formation, with wide transition zones in Wisconsin, Illinois, Indiana, and elsewhere. The Deciduous Forest Formation ranges far to the east and south of Michigan, extending to the Atlantic coast and southward into Mississippi, Alabama, Georgia, and the Carolinas (Braun 1950).

Within the Lower Peninsula of Michigan, important differences in the composition of the vegetation are reflected in three major subdivisions, which are called Forest regions by Braun (1950). Extending into the southwestern corner of the State is the Prairie Peninsula section of the Oak-Hickory

Forest region. The southern half of the Lower Peninsula is in the Beech-Maple Forest region, and the northern portion is in the Great Lake section of the Hemlock-White Pine-Northern Hardwoods region. These subdivisions of the vegetation of Michigan have been given various names by different authors, but the nomenclature followed here is that of Braun (1950) (Fig. 1). The boundaries between these areas are not sharply defined but rather consist of transition zones in which there may be a considerable amount of intermixing of the species which are characteristic of each area.

Prairies of Michigan

It is clear that Michigan is primarily a land of forests. In the southwestern part of the State, however, the Prairie Peninsula section mentioned above provides a definite though often interrupted link with the broad prairies which lie to the west. As described by Transeau (1935), the prairie peninsula extends eastward into Indiana and Ohio and just into the southwestern corner of Michigan. Along its border, this Grassland formation loses its continuity and occurs as more and more isolated areas surrounded by forest. In most cases, these small prairie areas are found on the more xeric sites. Most of them are now difficult to recognize because they have been farmed continuously since the arrival of the earliest settlers and because most of the surrounding forest has been cleared. In Michigan, at least, it



A -- Hemlock-White Pine-Northern Hardwoods region, Great Lake section
B -- Beech-Maple Forest region
C -- Oak-Hickory Forest region, Prairie Peninsula section

Fig. 1. Forest regions of the Lower Peninsula of Michigan

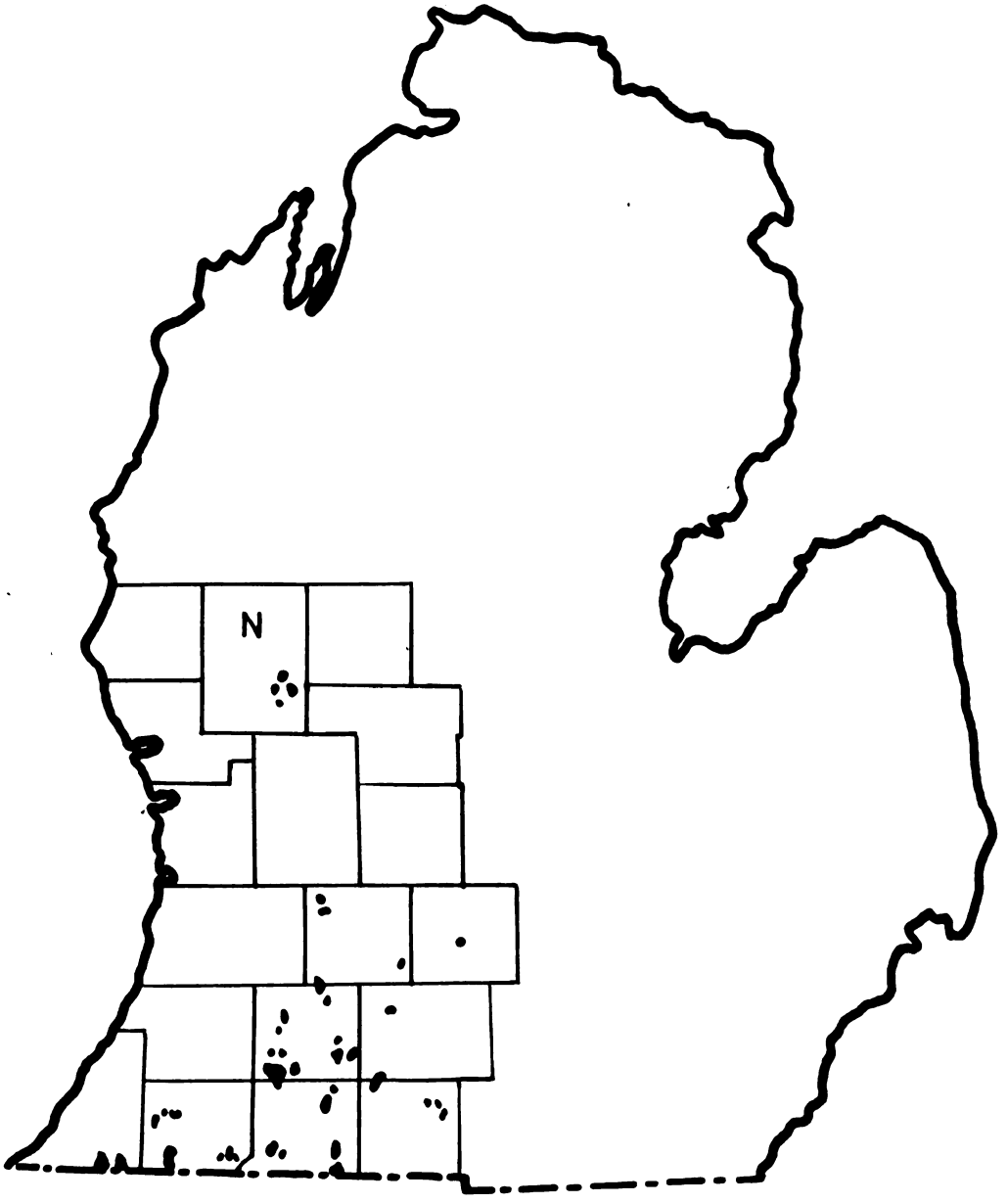
is probably safe to say that no virgin prairies now exist.

According to Veatch (1928) there are about 40 prairies in Michigan, varying in area from 80 acres or less to about 25 square miles. The list has been expanded to 58 by Butler (1947, 1948, 1949). Most of these are located in six counties in the southwestern extremity of the State (Fig. 2). An interesting situation occurs in Newaygo County, however, where a localized group of prairies is found. These are about 65 miles north of the nearest concentration of prairies in the Prairie Peninsula section of the State. In spite of their isolation, these areas in Newaygo County are similar in many respects to the true prairies of the Grassland Formation farther to the west.

From an ecological point of view, it is perhaps unfortunate that these prairies lie completely within the boundaries of the Manistee National Forest (Fig. 4), for they are currently being planted with various species of pines, under the direction of the United States Department of Agriculture, and thus seem to be on their way to extinction.

Objectives of the Study

The present study has two main objectives. The first and most important is to consider the prairies of Newaygo County in detail with regard to their vegetation, soils, physiography, climate, history, and other features. This part of the study is particularly important because of the



N: Newaygo County

Fig. 2. Map of the Lower Peninsula of Michigan showing the location of Newaygo County and the distribution of prairies in the State (Veatch 1928)

ultimate destruction of the prairies which will result from the afforestation project to which reference has been made. It will also be used in a comparison of these areas with the so-called "typical" prairies of the Grassland Formation.

The second objective is to formulate an hypothesis to account for the persistence of these open areas in a region which was formerly covered almost entirely by forest vegetation.

Before proceeding further, it may be well to consider the term prairie as it is used in this study. The early inhabitants of Michigan applied this term to any area nearly or completely devoid of trees. Thus they did not always distinguish clearly between dry and wet areas, such as grasslands and marshes. As used here, the term prairie refers only to the relatively dry, well-drained areas supporting a grassland type of vegetation. It will be shown later that there is a close correlation in Newaygo County between these areas and the distribution of the soil type classified as Sparta loamy sand.

REVIEW OF THE LITERATURE

Prairies of the Central United States

A voluminous amount of literature has been written concerning the Prairie of Grassland Formation which makes up most of the central one-third of the United States. Much of it is irrelevant to the present study, so that only a small fraction of the references will be mentioned. Since the Grassland Formation extends from Indiana westward to the foothills of the Rocky Mountains, with several portions west of the Rockies, and from Canada to Mexico, the variety of climates and habitats to be found within this vast area induce corresponding variations in the floristic composition of the formation. Thus, Weaver and Clements (1938) recognize various subdivisions of the prairie, such as the true prairie, the tall-grass prairie, the coastal prairie, the mixed prairie, and others.

Many of the important studies of the prairie have been made in the central part of the formation, including the States of Missouri, Iowa, Minnesota, South Dakota, Nebraska, and Kansas. Pound and Clements (1898, 1900) were among the earliest of the students of the prairie. Shimek (1911, 1925) discussed the prairies and the persistence of their vegetation. Schaffner (1913) made a floristic study of a Kansas prairie and later (1926) published a study of the grasslands

of the central United States. Steiger (1930) investigated the vegetation and ecology of a virgin prairie in Nebraska. One of the most exhaustive articles on the subject of the prairie was written by Weaver and Fitzpatrick (1934).

Among the many other writings which deal with the prairies of the central United States, a few may be mentioned. The mixed prairie is given a detailed analysis by Albertson (1937). Recent papers on the prairie include a study of the floristic composition of grazed and ungrazed prairie vegetation in Missouri by Drew (1947), a floristic study in Iowa by McDonald (1949), studies on plant succession in grazed Nebraska prairie by Mentzer (1951), and a phytosociological analysis of tall-grass prairie in Oklahoma by Rice (1952).

The Prairie Peninsula

"Prairie Peninsula" is the name used for the region discussed and mapped by Transeau (1935) which, in the words of Braun (1950, p. 185),

> extends eastward from the Mississippi River across Illinois and western Indiana, with outliers as far east as central Ohio, and as far north as southern Wisconsin and southern Michigan. The name is used because of the frequent occurrence of prairie in a peninsula-like projection from the prairies of the Mississippi Valley.

The term "prairie peninsula" was first used by Adams (1902), although it is usually attributed to Transeau, at least by implication. In discussing the migration of certain plants and animals from the west and southwest into

the Great Plains, and from there into the northeastern States, Adams (1902, p. 355) said,

> From the Great Plains east there is a prairie highway reaching as far east as northern Indiana, and forming a sort of peninsula extending east from the Great Plains into a densely forested region. This peninsular highway is composed of parts of northern Iowa and Illinois, and of southern Minnesota and Wisconsin. While the general direction of the prairie peninsula is toward the east, in reality it functions as a southwestern highway, because many of the types of the Great Plains are of distinctly southwestern origin. This is a highway for land forms only, because it does not coincide with any drainage system; in fact, it runs counter to those occurring within its limits.

Forests which occur in the prairie peninsula are predominantly oak-hickory, and Braun (1950) therefore considers the area as a section of the Oak-Hickory Forest region. In the western part, the prairies occupied the majority of the area, particularly the flat to gently rolling areas between ravines or morainic ridges. The forest was generally limited to the slopes of these ravines and ridges. Eastward, the areas of prairie were more and more limited, finally occurring only as small more or less isolated prairies within the forest (Braun 1950, pp. 186-187). Many of the studies of the vegetation of the prairie peninsula are concerned, therefore, with the interactions in this ecotone between prairie and forest.

Transeau (1935) presents a detailed map of the prairie peninsula and lists a series of problems which must be accounted for in any complete interpretation of the origin, development, and maintenance of the prairie peninsula. Two

of the numerous problems which he states are the following:

> The occurrence of a distinctive prairie flora and isolated typical prairie communities as far east as northwestern Pennsylvania, as far north as central Wisconsin and Michigan, and as far south as Kentucky and Tennessee.
>
> The absence of trees and the presence of prairie communities on both uplands and lowlands, on thoroughly drained as well as poorly drained areas from central Ohio to western Iowa. Many of the discussions of the causes of prairie and the absence of trees have dealt with one or the other of these situations. An adequate explanation should account for both.

He also offers a series of comments on the factors involved in the occurrence of the prairie peninsula, but he does not attempt to present solutions to the problems which he has presented.

A number of additional studies have been published which deal with the vegetation and the problems of the prairie peninsula. Sampson (1921) made an ecological survey of the prairie vegetation of Illinois. Bergman (1923) has discussed, rather briefly, the prairie climax in Minnesota. In addition to a listing of the dominant grasses and secondary species, he mentions some of the ecological relations of the vegetation, as well as some of the factors concerned in the maintenance of the prairie. A paper was published by Quick (1923) on the distribution of the climax association in southern Michigan. This paper presents a good discussion of some of the historical and ecological factors involved in the present distribution of prairie within the beech-maple climax of southern Michigan. A detailed consideration of

the competition occurring in the ecotone between prairie and forest has been published by Aikman (1928). A study of relic Wisconsin prairies is a recent contribution by Curtis and Greene (1949). Finally, the relations between forest and prairie in northwestern Indiana have been discussed by Rohr and Potzger (1951).

Prairie Vegetation of Michigan

The literature dealing specifically with prairies in Michigan is very limited, although there are a few general floristic and ecological studies which refer to prairie plants or to the occurrence or distribution of prairies. The principal floristic studies covering the Michigan prairie region are those of Cole (1901), Beal (1904), Pepoon (1907), Hebert (1934), and Hanes and Hanes (1947). Beal included a brief section listing plants peculiar to the prairie region.

Darlington (1945) makes a very brief reference to the prairie vegetation and also provides a few applicable references. In a series of publications, Kenoyer (1930, 1934, 1940, 1943) has attempted to reconstruct the vegetation of the southwestern counties at the time of the original land survey. The maps which he has drawn show many of the original prairie areas that existed before the destructive effects of lumbering and cultivation had become evident.

Reference has been made to the discussion by Quick

(1923) of the historical and ecological factors relating to the beech-maple climax of southern Michigan and its included prairie areas. Gleason (1917) has published a brief discription of a prairie near Ann Arbor, and Veatch (1928) has discussed in detail the pedology of the dry prairies of Michigan.

Two final references will be mentioned which are very interesting from historical, sociological, and economic points of view. Spooner (ca. 1947) published a series of articles in the White Cloud (Newaygo County) Eagle on the history of lumbering in Newaygo County. They have been reprinted in a single volume, and provide a wealth of information regarding the activities of the lumberjacks and early settlers in the county. A few references are made to early settlers on some of the Newaygo prairies, but no information is given concerning the grassland vegetation itself. Butler (1947, 1948, 1949), in a series of four articles, has assembled a vast amount of information concerned with 58 of Michigan's prairies. In very interesting fashion he has described the life of the early settlers, including everything from romance to murder, but without providing much pertinent botanical information.

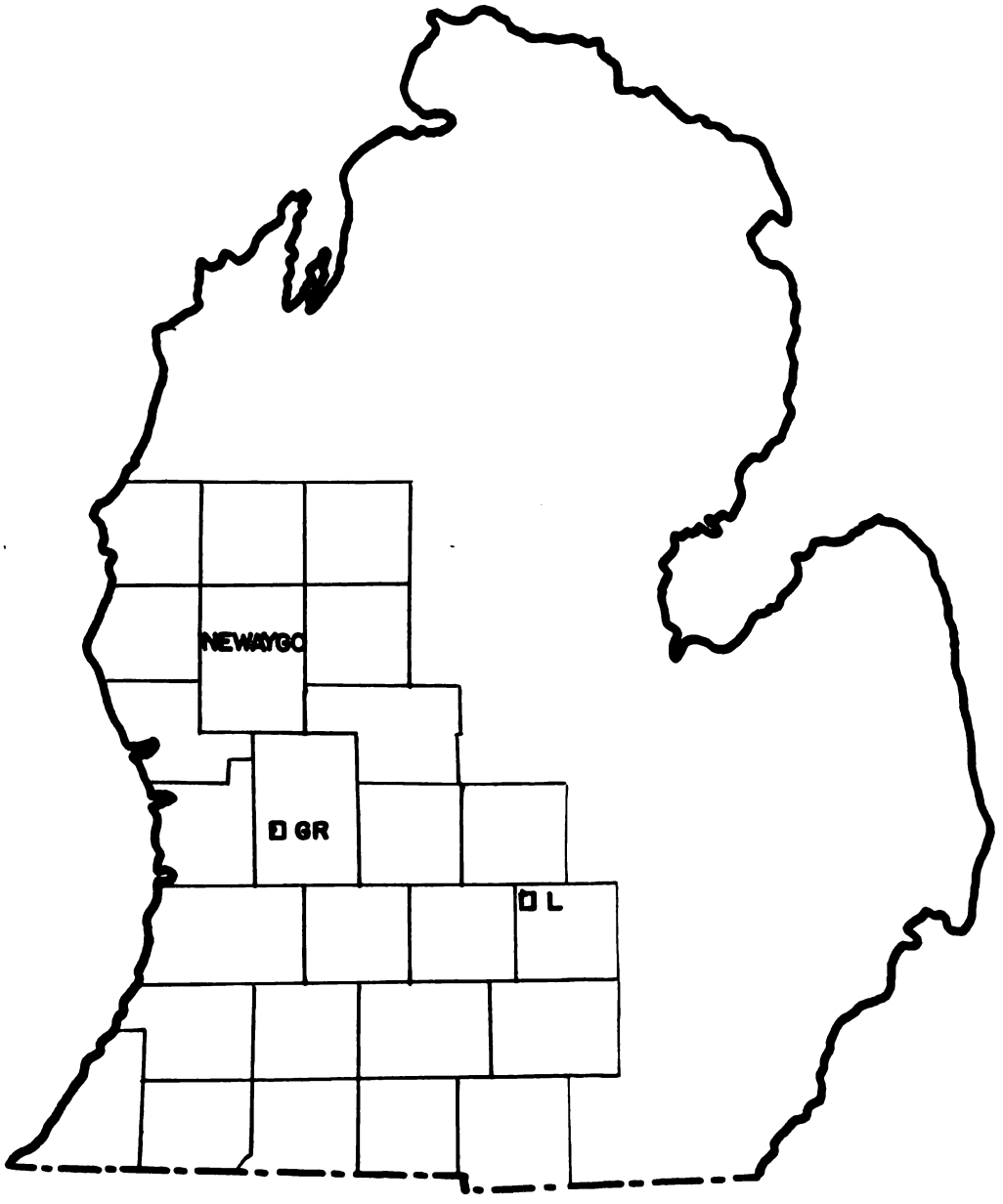
DESCRIPTION OF THE AREA STUDIED

General Description

Location. Newaygo County lies in the west-central part of the Lower Peninsula of Michigan. Its boundaries meet those of Muskegon and Oceana Counties to the west, Lake County to the north, Mecosta and Montcalm Counties to the east, and Kent and Muskegon Counties to the south. The western boundary is about 20 miles from Lake Michigan, and the county lies about 100 miles north of the Indiana border. The city of Lansing is about 70 miles to the southeast (Fig. 3).

The prairies which are the subject of this study are located entirely within four adjoining townships in the southeastern portion of the county. These townships are the following: Everett (T. 13 N., R. 12 W.), Big Prairie (T. 13 N., R. 11 W.), Brooks (T. 12 N., R. 12 W.), and Croton (T. 12 N., R. 11 W.) (Fig. 4).

Physiography, geology, and pedology. The surface features are of glacial origin. They are principally hilly or rolling moraines, and sandy and gravelly outwash plains (Fig. 5). The land surface has not been greatly modified by erosion, for there has been little stream dissection except by the Muskegon and Little Muskegon rivers. The physiographic features are thus largely constructional, and probably have not changed greatly since they were left by the receding



L: Lansing
GR: Grand Rapids

Fig. 3. Map of the Lower Peninsula of Michigan showing the location of Newaygo County

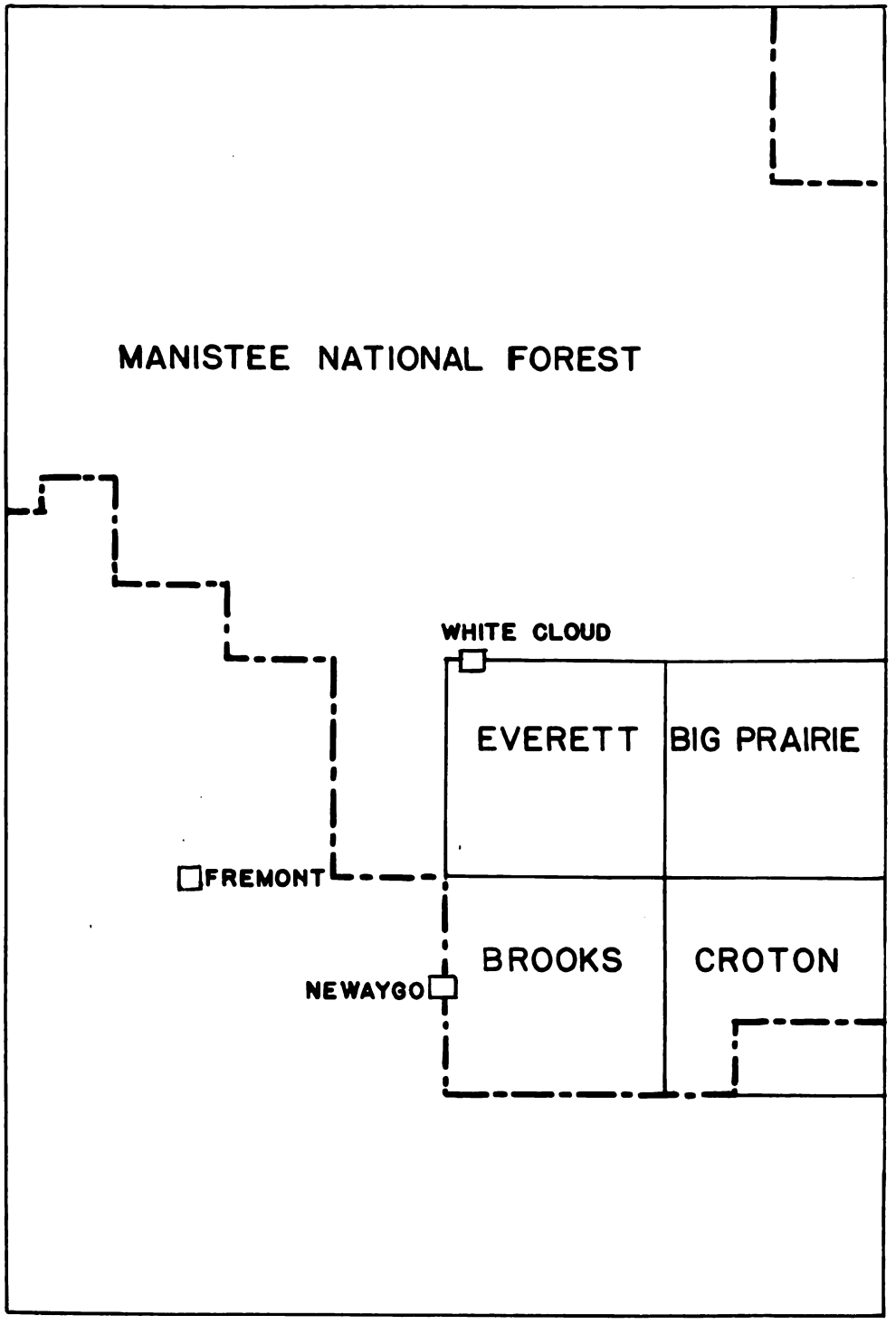


Fig. 4. Map of Newaygo County showing townships which have prairies

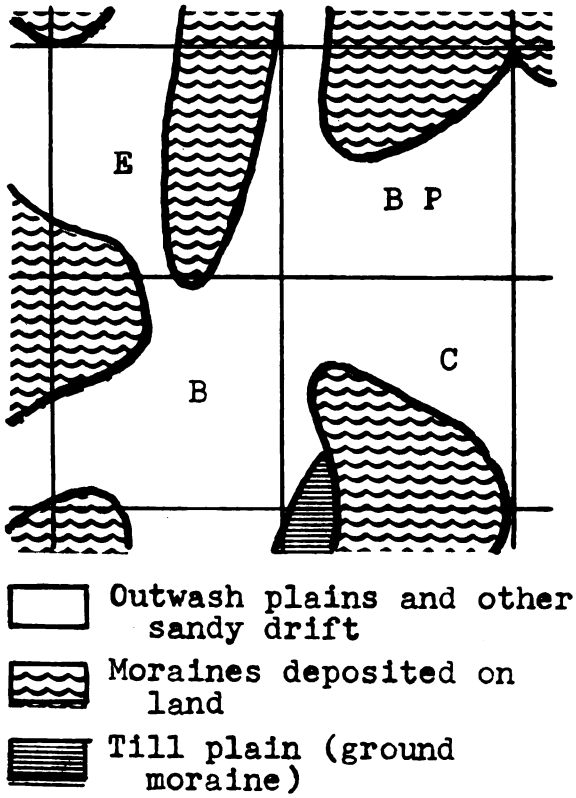


Fig. 5. Surface Geology of Everett, Big Prairie, Brooks, and Croton Townships.

glaciers. The secondary topographic features are characteristic of morainic and outwash areas, and include rounded hills and basins, complex short slopes related to glacial deposition rather than to stream erosion, smooth or pitted dry plains, pot holes, swales, large and small swamps which may be of complex outline, and numerous lakes (Leverett 1924; Mick, et al 1951).

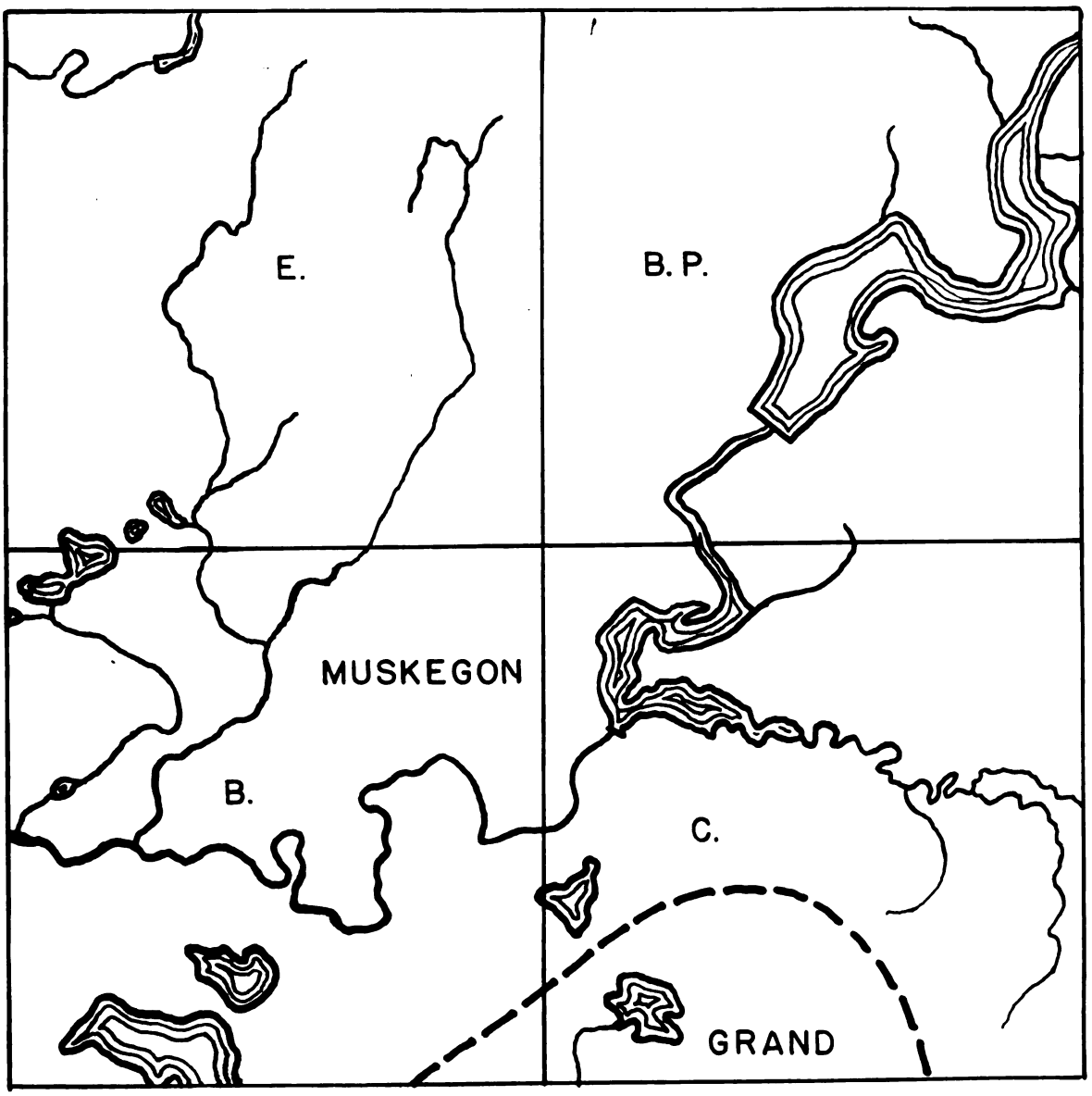
The prairie areas are largely confined to the sandy dry plains. These are in most cases nearly level, but may have slopes with gradients up to seven percent. The slopes are

frequently rounded depressions or potholes, but most of these are well drained because of the sandy and gravelly soil and subsoil.

Surface drainage is mainly into the valley of the Muskegon River, which flows in a southwesterly direction into Lake Michigan. Parts of Brooks and Croton townships belong to the watershed of the Grand River, which also flows into Lake Michigan (Fig. 6) (Beamer, no date).

The soils of Michigan have been divided into groups designated as Natural Land Divisions in a system devised by Veatch and Schneider (Millar 1948, p. 23). In the part of Newaygo County under consideration, the Natural Land Division is number 14, in which the predominant soils are sands and light sandy loams of low fertility. In the Agricultural Land Classification of Michigan compiled by Veatch (1941), the area is considered to be made up predominantly of fourth class land, which is of very low or no value for general farming. A relatively small part of the land is considered to be of the third class, which is of doubtful value for general farming.

The principal soil types associated with the outwash plains are Newton loamy fine sand, Plainfield sand, and Sparta loamy sand. The first of these occupies much of the poorly drained sandy plains and probably supported an original forest cover in which elm, red maple, and black ash were the dominants. The Plainfield sand probably had a

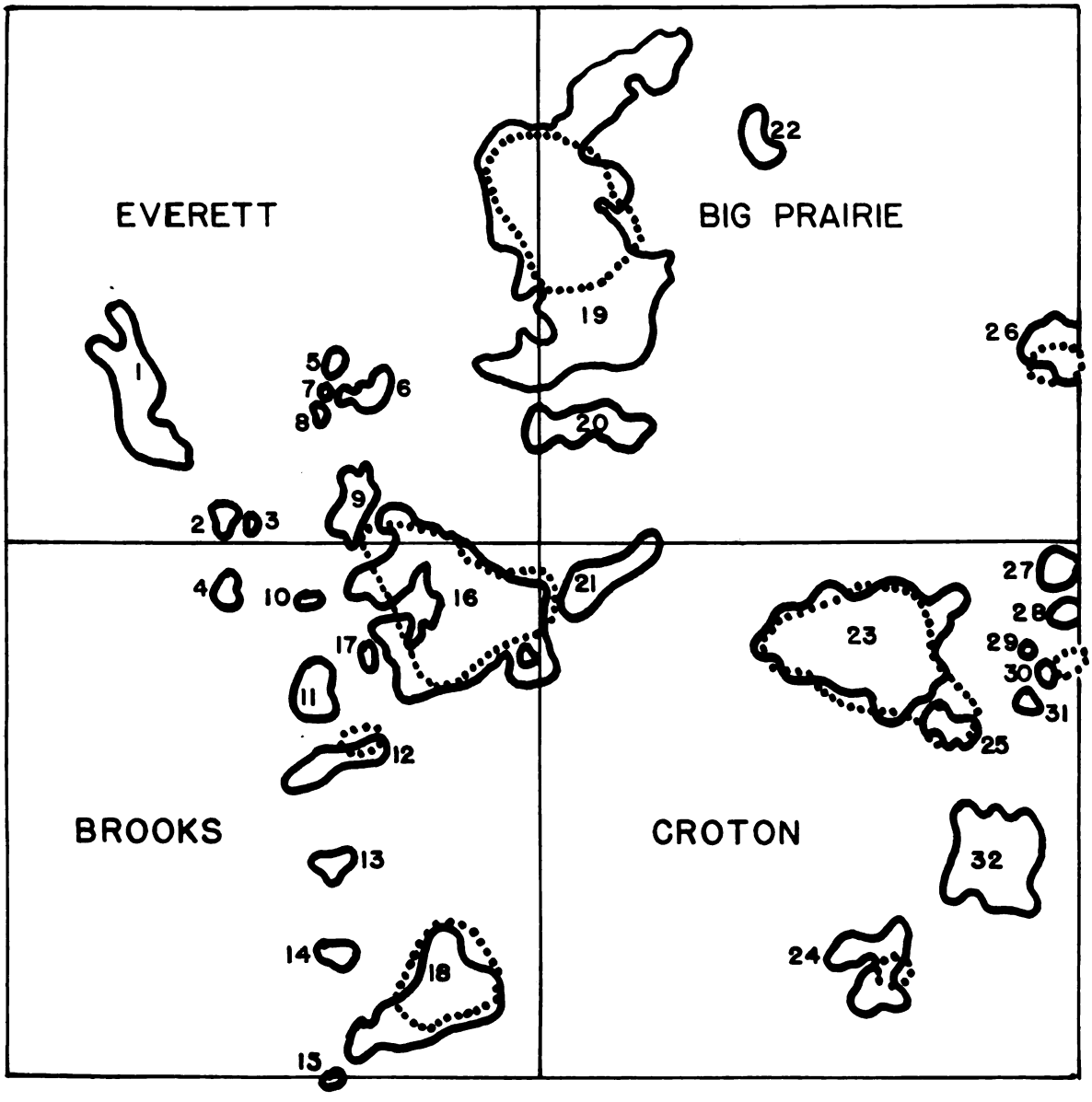


— — — Divide between Muskegon River and Grand River watersheds

Fig. 6. Drainage systems of Everett, Big Prairie, Brooks, and Croton townships

native forest cover of white and red pine, with some oak. It represents the driest soil of the sandy plains. Sparta loamy sand is the soil type associated with the original grassland or prairie vegetation, and occupies a large area of the dry sandy plains (Mick, et al 1951). The 32 areas of this soil type in Newaygo County have been numbered as indicated in Fig. 7.

In general, Sparta loamy sand has a surface layer 6 to 18 inches deep which consists of sand and finely divided, well-decomposed dark-brown organic matter. Following this layer is a brownish transition region of loose sand, grading into a gray or pale-yellow sandy substratum (Mick, et al 1951, p. 57). The sand may reach depths of several feet and may be underlain by fine to coarse gravel. This soil is loose and well drained, acid, and unconsolidated. A detailed study of the profile was made in a gravel pit in Section 15 of Brooks township (Area 12, Fig. 7). In this exposure, the surface layer of dark-brown sand extends to a depth of eight inches. Below this is nine inches of light-brown sand, followed by about two feet of light-yellow medium to coarse sand. Under the sand there is light- to yellow-brown mixed coarse sand and gravel, in which a very slight degree of cementation occurs. Determinations of the acidity were made at four different levels with the following results: at a depth of 2½ inches, pH 6.5; at 6½ inches, pH 5.0; at 14 inches, pH 5.5; and at 31 inches, pH 6.0. A number of small pits were



Sparta loamy sand

Prairies on map of original land survey (1827)

Fig. 7. Map showing distribution of Sparta loamy sand and of the original prairies of Newaygo County

made in other areas of Sparta loamy sand, and in all cases the profiles were similar to the one just described. Figure 8 shows the profile as it appeared in Area 19, in the northern part of Section 13, Everett township.

The organic matter content was determined by the ignition method. It was found that organic matter constituted 2.42 percent of the dry weight of the surface soil.

As an agricultural soil, Sparta loamy sand leaves much to be desired. It was one of the first soils to be farmed in Newaygo County because it did not have to be cleared and was easy to cultivate. Early crops were profitable and some of the early farms were fairly prosperous. Within a few years, however, fertility declined and the moisture-holding capacity of the soil was insufficient in the dry seasons. Most of the farms were abandoned before 1900, and only a few very small areas are at present under cultivation (Mick, et al 1951).

Climate. That the climate of Michigan favors the development of forest vegetation is an obvious conclusion because, except for very limited areas, the State was entirely covered by forests prior to the advent of the lumbering industry. Many factors influence the distribution of vegetation, and all are interrelated, a principle that has been termed that of the holocoenotic environment (Allee and Park 1939; Cain 1944; Billings 1952). It is generally agreed, however,

Fig. 8. Profile of Sparta loamy sand in Area 19.

that climatic control is the primary factor (Cain 1944, p. 11; Darlington 1945, p. 9). Major differences in macroclimatic factors are thus primarily responsible for the distribution of the plant formations. They are not, however, sufficient to explain local variations in plant communities such as those represented by the prairies of Newaygo County (Cain 1944; Darlington 1945; Braun 1950). It follows that the climatic data presented in Table I cannot be used to explain the presence of small prairies in a forest region. These data are presented, however, to give an overall picture of the environment under consideration, and will be used, in part, in a comparison to be made between the Newaygo prairies and those of other regions (U. S. D. A. 1941)

TABLE I

CLIMATIC SUMMARY OF NEWAYGO AND SURROUNDING COUNTIES

County	Station	Temperature				Frost-free Season Ave. No. of Days	Ave. Annual Precip. in Inches
		Jan. Ave. °F.	July Ave. °F.	Max. °F.	Min. °F.		
Newaygo	Croton Dam	22.1	70.3	111	-37	142	31.30
Lake	Luther	20.4	68.9	111	-36	115	32.27
Osceola	Reed City	18.7	69.2	102	-42	125	29.73
Mecosta	Big Rapids	21.6	69.4	103	-36	139	32.10
Montcalm	Greenville	23.5	72.2	108	-26	153	29.68
Kent	Grand Rapids	24.5	72.3	108	-24	169	33.97
Muskegon	Muskegon	24.8	69.5	99	-30	170	28.86
Oceana	Hart	23.4	70.2	104	-35	143	30.17
Mason	Ludington	24.2	68.0	97	-21	161	29.09

Figure 9 shows the monthly averages of temperature and precipitation for Newaygo County (Martin 1936). On the

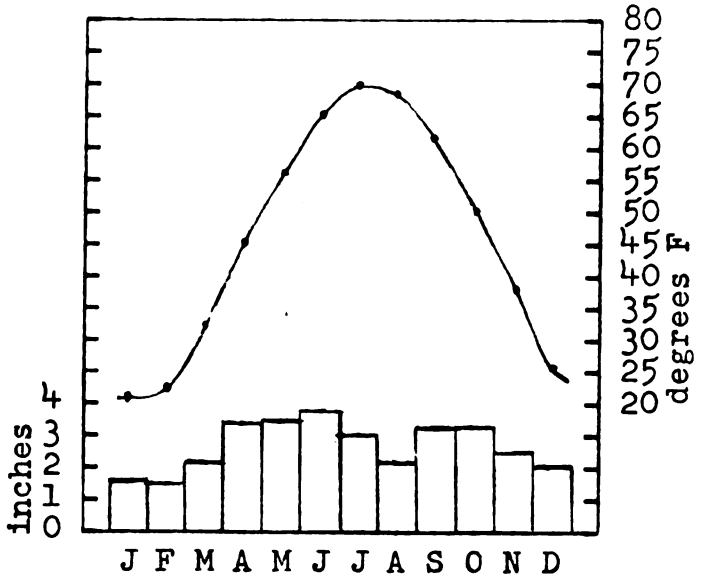


Fig. 9. Monthly averages of temperature and precipitation, Newaygo Co., Michigan

basis of these data, the county can be said to have a humid continental climate with short summers. In the Köppen system of climatic classification, such a climate is indicated by the symbol Dfb. In this instance, D means that the average temperature of the coldest month is under 26.6° F, with the warmest month over 50°. The letter f indicates that the climate is humid throughout the year, and b indicates cool summers with the warmest month under 71.6° but with at least four months over 50°. Newaygo County does not quite fall in the region of humid continental climate with long summers, for which the Köppen symbol is Dfa, with a indicating that

the warmest month is over 71.6°. Kent County, immediately to the south, does fall in this latter classification. The climatic type Dfa includes the southern part of Michigan, other states immediately to the south, and most of the so-called "corn belt" which coincides with the prairie peninsula (Finch and Trewartha 1936).

According to the climatic classification developed by Thornthwaite (1941), which is based on evaluations of precipitation-effectiveness, Michigan lies in the region of Humid climate.

Erosion. Because of the relatively brief extent of geologic time since the Pleistocene glaciation, drainage patterns and stream cutting are little developed in Newaygo County. The principal river, the Muskegon, has cut a deep valley with steep sides, but lateral tributaries are rather infrequent and poorly developed. This lack of dissection is due not only to the youth of the area but also to the porous nature of the sandy and gravelly glacial deposits. In the prairie areas in particular, there is little if any evidence of erosion by water. Conversely, the porosity of the soil leaves it with little water-holding capacity so that wind erosion has assumed serious proportions in areas where the vegetative cover has been removed. Severe wind erosion has taken place in Areas 14, 16, 17, 19 (which includes "The Desert"), 20, and 23 (Figs. 7, 10, and 13). Small blowouts have occurred in many of the other areas (Fig. 12). In some

Fig. 10. Severe wind erosion in Area 16 (Sec. 35, Everett township). Amount of soil removed can be judged by the tree in center

places the topsoil and subsoil have been removed to the extent that a "desert floor" of gravel has been formed. This condition is well shown in Figure 10. Small dunes or hummocks have developed in a few places. On the whole, however, a large percentage of the area of the prairies has not suffered any noticeable degree of erosion (Mick, et al 1951).

History of the Area

Aboriginal population. There is much evidence to show that Newaygo County supported a relatively high Indian population. More village sites have been located in Newaygo than in any other county except Saginaw. Ninety-three mounds have been located, more than in any other county. There were 24 mounds in Brooks township. Many of the mounds were located along the Muskegon River. Hinsdale (1931, p. 31) wrote:

> The size and number of the mounds upon the Muskegon River in Brooks Township indicate a fixed population, whereas the small tumuli of the northwestern part of the county might have been left by transient hunters and fur-gatherers. The forests of the county abounded in a great variety of game animals and water fowl. Corn was cultivated. The Muskegon, at least as far as Croton, afforded a good supply of large fish.

The maps made by the surveyors of the original land survey in 1837 show a number of well-defined Indian trails (Hodgson 1837; Mullett 1837).

Little direct evidence is available regarding the farming and other land-use practices of the Indians. According to Hinsdale (1932), corn was a common Indian crop, and was grown in natural openings, artificial clearings, and areas

opened up by windfalls. According to the notes of the original land survey, both windfalls and burned-over areas were occasionally found in the virgin forest. It is evident that many Indians lived near the Muskegon River, which served as a good source of aquatic plants and animals. Many species of mammals were available, but of the larger animals, apparently only deer and bear were relatively common in Newaygo County. Buffalo were known to enter the forest openings in the southern part of the State, but were never abundant. Elk occurred throughout the Lower Peninsula, but seem to have avoided the areas in which pine was dominant. Moose were common in the Upper Peninsula and the southeastern quarter of the Lower Peninsula, but probably were not very abundant elsewhere (Hinsdale 1932).

Settlement by the white man. The early recorded history of Newaygo County is intimately related to the development of the lumbering industry, and can be said to begin in 1836, the year in which the Indians had given up title to the lands in the county. The first persons to establish squatters' rights arrived that year. The first sawmill was built in 1837 where Pennoyer Creek joins the Muskegon River, and marked the beginning of the village of Newaygo, the first permanent white settlement in the county. The original land survey for what are now Everett, Big Prairie, Brooks, and Croton townships was made during that year. The land came onto the market in 1839, and the first claim filed was for land at Muskegon

Forks, which is now Croton. By 1848, the population of the county had increased considerably. Although most of the people were connected with the lumbering industry, some settlers were taking up homesteads. A number of these were located on the open prairies. The prairies mentioned in the early accounts were named Marengo, Little Sherrar, Stearns, and Big Prairie. They are shown in Figure 7 as Areas 16, 18, 23, and 19, respectively.

The United States census of 1850 credits Newaygo County with a population of 510 persons, concentrated mostly at Newaygo, Stearns' Mill (another name for Croton), and Bridgeton. In 1884, lumbering was still the most important industry, but agriculture had developed extensively. There were at that time 1,770 farms in the county, having an average improved area of 43½ acres per farm (Anonymous 1884, p. 489; Butler 1947, p. 284; 1948, p. 36; 1949, pp. 118, 223; Spooner ca. 1947).

The majority of the farms in the townships under consideration, and practically all of those which were located on the prairies, have now been abandoned for a long time. It is difficult to say just how long ago they were given up, but there are several lines of evidence which may be used. One is the fact that very few dwellings or other structures remain, although old wells, basements, fragments of timber and old-fashioned nails, old apple trees and lilac bushes, remains of fence lines, etc., attest to the early agricultural

activities of the region. In Area 15, for example, there is a blowout in the northeastern part, next to which is an aggregation of old apple trees, lilac bushes, and irises, which would certainly indicate the former location of a residence. Not the slightest fragment of a building remains, however, and there is not even a trail or road leading to the spot. Other bits of agricultural evidence, however, include a few faint furrows and several straight boundaries between forest and prairie, which would indicate that there had been some clearing and enlargement of the original open area.

Another type of evidence concerning the period of abandonment is afforded by old cemeteries, particularly those in or near the prairies. Figure 11 shows the dates of burial to be found on tombstones in several of these cemeteries. The earliest date is 1853, and the latest is 1897, but most of the deaths recorded occurred between 1853 and 1882. It would thus appear that most of the prairies have been abandoned for at least 70 years.

Description of the Prairies

Original condition of the prairies. The notes and maps of the original land survey (Hodgson 1837; Mullett 1837) show a total of eight treeless areas listed as prairies, in Everett, Big Prairie, Brooks, and Croton townships (Figs. 7 and 19). Four of these are relatively large, and the remaining four are quite small. Inasmuch as the surveyors traver-

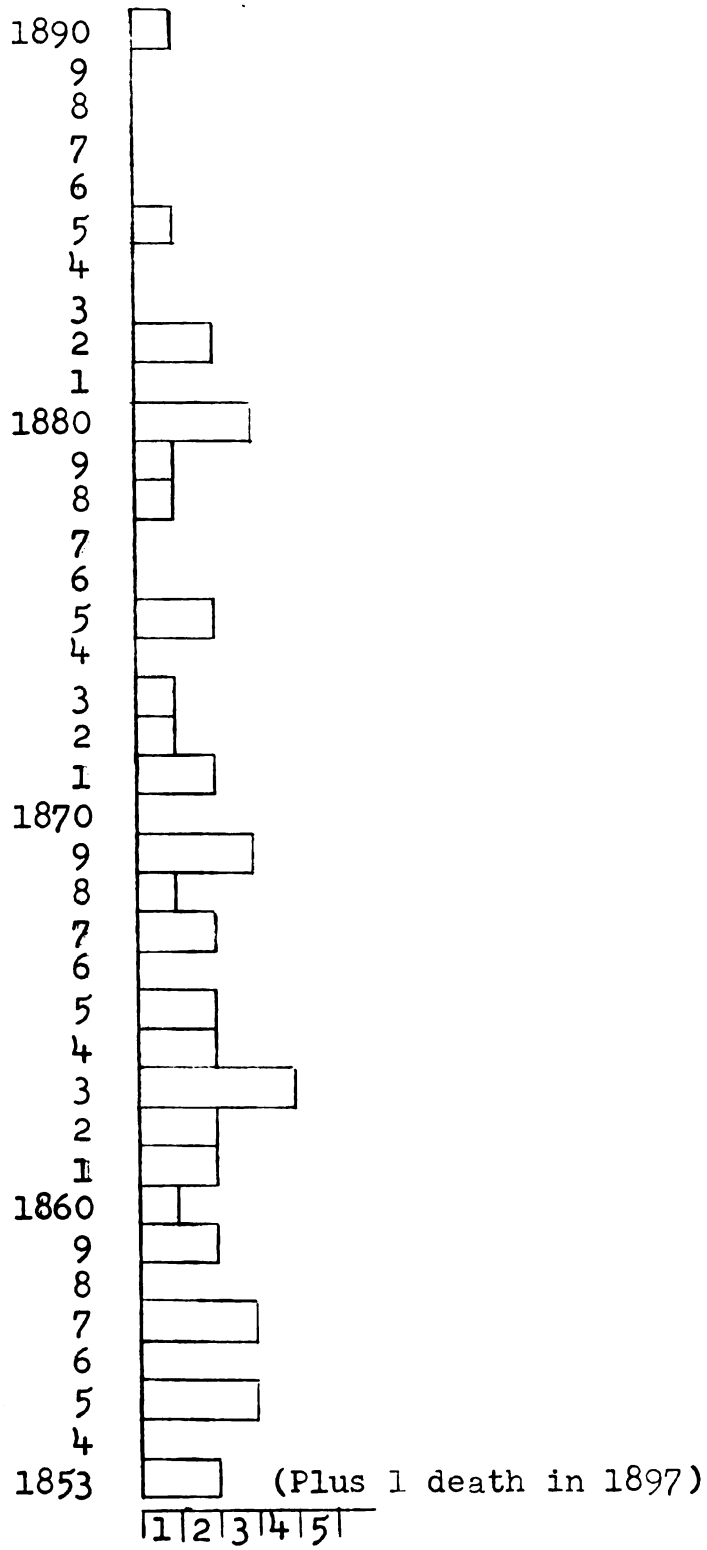


Fig. 11. Dates and number of burials in cemeteries in the Newaygo prairie region

sed only the section lines, which run at intervals of a mile, it is quite possible that there were other areas that they did not see. It is quite clear from the surveyors' notes that these prairies were distinctive. On a number of occasions it was necessary for the surveyors to set up corner posts because of a lack of nearby trees. A few direct quotations from the surveyors' notes will show some of the observations recorded by them (Hodgson 1837; Mullett 1837).

> Land all Dry Rolling Prairie good 2 rate Prickly Pears Grass Creeping Vines &c
>
> Land Rolling West ½ 2d Rate Scattering Pine and Oak Last ½ rolling Prairie good 2 Rate
>
> Land first Part rolling 2d Rate Pine W & B Oak-- Oak Brush Last Part Dry Rolling Prairie Sandy Soil
>
> Land mostly dry Rolling Prarie Second Rate thinly coverd with grass & weeds
>
> Land mostly dry Rolling Prarie poor Soil -- not much grass &c
>
> Set Post Cor Sects 1, 2, 11 & 12 in Prairie. No trees raised mound Land Rolling all good 2d Rate Scattering W & B Oak -- Prickly Pear Grass Vines &c

Spelling and punctuation have been kept as they were in the original notes.

Virgin areas. If "virgin areas" be defined as those which were never farmed by the white man, it is probably safe to assert that none of the prairies in Newaygo County fall within this category. A primary reason for this assumption is that prairie lands in any part of Michigan were usually the first to be settled and farmed because they were clear

and easy to plow, at least after the sod had been broken for the first time. Furthermore, most of the prairies show definite evidence of human occupancy. It is possible, however, that a few of the very small prairies were cultivated for a short time only.

Relationships between prairies and soil types. In this study, particular attention was directed to the distribution of Sparta loamy sand because of the close relationship between this soil type and a grassland type of vegetation. Reference to Figure 7 will show the close correlation between the eight original prairies shown on the map of the original land survey, and the distribution of Sparta loamy sand. Many of the small areas of this soil type are not mentioned as prairies in the survey, but in some instances at least, this is due to the fact that they were remote from the section lines and thus were not seen by the surveyors.

An examination of the 32 tracts of Sparta loamy sand shows that there is a very close correlation between the occurrence of this soil type and the absence of forest cover. The boundaries, however, do not always match very closely because of the extensive amount of clearing which has taken place at various times in the past. Nevertheless, an examination of aerial photographs taken by the Production and Marketing administration of the U. S. Department of Agriculture shows that there is often a great deal of similarity between the outlines of the original prairies, of Sparta

loamy sand, and of the present open areas.

Present land use. Most of the area of Everett, Big Prairie, Brooks, and Croton townships lies within the boundaries of the Manistee National Forest (Fig. 4). Many private holdings still remain, however, and these include numerous farms, but very little farming is being done on Sparta loamy sand. The few farms that are in operation on the prairies do not appear to be very prosperous. The following areas are currently being farmed: a small part of Area 1, most of Area 12, a very small proportion of Area 16, a few small parts of Areas 19, 20, and 21, most of Areas 24 and 26, and a small part of Area 32. In addition, a few acres have been cultivated within the past five years in Areas 18 and 23 (Fig. 7).

The United States Department of Agriculture has been doing an extensive amount of afforestation in the prairies during recent years. The earliest part of this work was done primarily in the areas most affected by serious wind erosion. Recent work is continuing into areas unaffected by erosion, and if the present rate of planting is maintained, it will be only a few more years until the prairies of Newaygo County will have disappeared completely.

A final kind of land use which may be considered is that for recreation. In Newaygo County as a whole there are many tourist attractions such as winter sports, archery, hunting, fishing, swimming, camping, and summer homes. It must be

admitted, however, that the prairies have little to offer as recreational areas. The severely eroded area known as "The Desert," which is located in Area 19, has been a scenic attraction in the past, but the afforestation of that area is now nearly complete so that little remains that is of interest to the sightseer. A skeet range maintained on Area 23 is the only other recreational feature worthy of mention.

VEGETATION OF THE NEWAYGO PRAIRIES

Field Methods

Selection of areas for study. The occurrence of prairies in Newaygo County has been observed since the early days of the settlement of the county, as has been discussed in an earlier section of this work. The close correlation between these prairies and Sparta loamy sand has been noted in the Soil Survey of Newaygo County (Mick, et al 1951), and has been observed by various persons, including Professors Jethro O. Veatch and William B. Drew of Michigan State College. As a starting point in this study, therefore, an attempt was made to examine all areas of Sparta loamy sand for the presence of vegetation which might be considered to be characteristic of prairies. Every area of this soil type in Newaygo County is located in the four townships of Everett, Big Prairie, Brooks, and Croton, with the sole exception of two small portions in Bridgeton township, in the southeastern corner of the county. These latter areas were never definitely located because of the absence of distinctive landmarks, confusing trails and roads, and lack of agreement among various maps of the region. They are therefore not included in this study.

There are 32 areas of Sparta loamy sand in the four

townships to which reference has been made. They vary greatly in size, from some which cover only a few acres, to one which has an area of over 2,600 acres and includes parts of 12 different sections of land. For convenience, the tracts of Sparta loamy sand have been designated as "Areas" and have been numbered as is shown in Figure 7. The areas in which a detailed study was made of the vegetation are the following: 1, 2, 4, 6, 7, 8, 11, 12, 14, 15, 16, 17, 18, 19, 20, 21, 23, 25, 26, and 31. The remaining areas include one which was not definitely located, a few which are actively farmed, and several in which there has been so much disturbance of the vegetation that they have very little similarity to other prairie areas.

Figure 7 also shows the close correlation between the prairies shown on the maps of the original land survey and areas of Sparta loamy sand.

Cultural disturbances have of course altered the original pattern of vegetation in great measure, but there remains a fairly close relationship between present-day open areas and forest boundaries, and the distribution of Sparta loamy sand. The selection of "typical" tracts of prairie vegetation is made difficult by the clearing and farming of the former residents, by the encroachment of forest vegetation, whether by planting or natural succession, and by the present-day afforestation activities of the U. S. Department of Agriculture. The selection of a specific area for

study is thus necessarily subjective in many cases.

The final selection of a prairie area for detailed study was based on the following criteria: (a) it was located on Sparta loamy sand, (b) it was an open area, that is, not forested, (c) obvious disturbance was at a minimum, and (d) there was an assemblage of at least some characteristic prairie species. For this latter criterion, no specific a priori list of species was formulated, but the selection of an area was influenced by the presence of such dominant species as Andropogon gerardi, A. scoparius, and Sorghastrum nutans, as well as other characteristic grasses and forbs, such as Koeleria cristata, Eragrostis pectinacea, Liatris aspera, and Hieracium longipilum. Typical aspects of a few of these areas are shown in Figures 12, 13, 14, and 15.

Method of obtaining data. The vegetation was studied in detail in plots, each 10 x 10 meters, which were distributed throughout the areas under consideration. In some of the smaller areas, only one plot was used, and more were located in the larger areas. A total of 50 plots was set out in the 20 areas which were used in the study.

Within each plot 10 quadrats, each one meter square, were used for studies of frequency and percentage of cover of the various species. Thus a total of 500 quadrats was used throughout the range of the Newaygo prairies. It was originally decided to distribute the quadrats at random within

Fig. 12. Northeastern corner of Area 15, showing blowout which marks the location of a former dwelling

Fig. 13. Central portion of Area 23. White pines at left indicate the location of a former dwelling. Andropogon gerardi in foreground

Fig. 14. Northern part of Area 16. Andropogon scoparius, Carex pensylvanica and Liatris aspera in foreground. Extensive wind erosion in background

Fig. 15. View of Area 30. Extensive colony of Carex pensylvanica in foreground, Andropogon gerardi and Liatris aspera in middle distance

each plot, but a method was devised of locating the quadrats according to a definite pattern which provided a well-distributed series of samples, and which, at the same time, resulted in a great saving of effort and time. This pattern is shown in Figure 16.

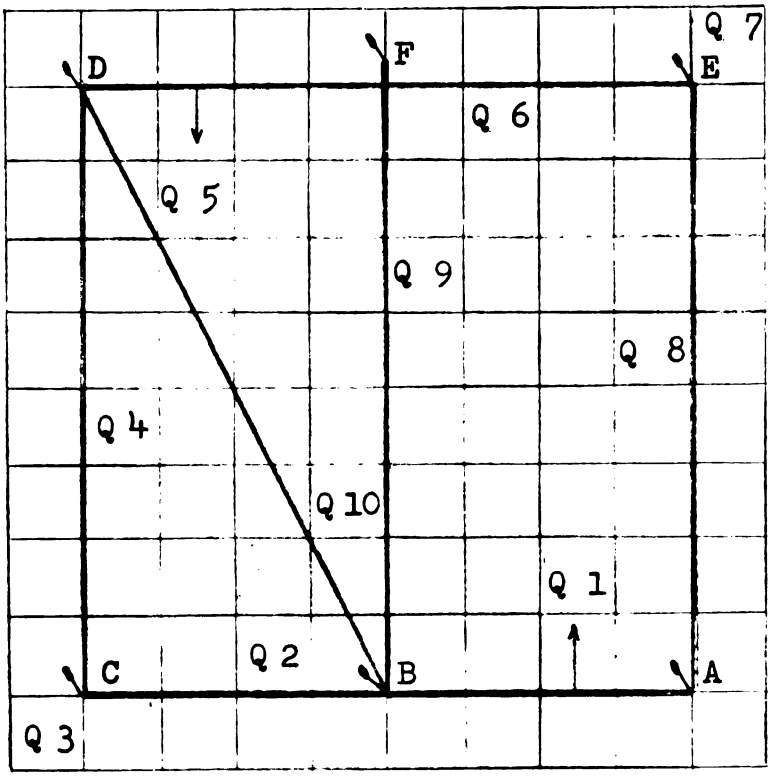


Fig. 16. One-hundred square meter plot showing arrangement of cords and location of quadrats.

The mechanics involved in outlining the plot and locating the quadrats within it were simplified by the construction of an arrangement of cords and pegs which could be set up very rapidly. A stout cord was tied to form a square 8 x 8 meters, with small wooden tent pegs fastened permanently

at points A, B, C, D, and E, as shown in Figure 16. Another cord was tied permanently between B and D. In use, peg A was pushed into the ground, and then peg B was pushed into place after stretching the cord between them until it was taut. The same procedure was followed with peg C, first making certain that the three pegs formed a straight line. The position of peg D was automatically found when portions B--D and C--D of the square were pulled taut. Finally, peg E was pushed into the position that was indicated by the lengths A--E and D--E of the cord. A separate cord, slightly over 8 meters in length had a small loop at one end and a tent peg attached to the other. The loop was placed over peg B, and the location of peg F was determined by stretching the cord until it was directly over a mark on the square midway between D and E.

The locations of the quadrats were indicated by markers of colored thread applied to the cords. The quadrats were outlined by a rigid square made from four 1-meter quadrat sticks bolted together. It can be seen from the diagram that there were only two quadrats which did not touch one of the cords. These two, numbers one and five, were accurately located by placing the quadrat square next to the cord and then flipping it over once. Although the cords outlined a plot of 8 x 8 meters, the use of the quadrat square made it easy to determine the boundaries of a plot 10 x 10 meters, as is shown in Figure 16. In practice, this system of locat-

ing quadrats was very efficient and rapid. It would not work, of course, in shrubby vegetation.

Forms were made up listing the species of the Newaygo prairies, and the species that occurred in each quadrat were recorded, using numbers from one to five to indicate the cover class to which they belonged, following the nomenclature of Braun-Blanquet (1932) and Oosting (1948). These cover classes are as follows:

1. covering less than 5 percent of the ground surface
2. covering 5 to 25 percent of the ground surface
3. covering 25 to 50 percent of the ground surface
4. covering 50 to 75 percent of the ground surface
5. covering 75 to 100 percent of the ground surface

A check mark was placed on the form for any species which occurred in the plot but not in a quadrat. Notations were also made concerning species which occurred in the areas but not in the plots.

Analysis of Data

General discussion. An investigation in plant ecology can be carried out in many ways and various interpretations can be given to the data obtained. Many factors affect the objectives and the results of such an investigation, such as the type of vegetation involved, the size of the stands, the amount of interference by man, the time available for the study, and the interests of the investigator.

Generally speaking, however, it may be said that one of the principal objectives in most studies of plant communities is the determination of the species of which the community is composed and of the relative importance of each species within it. This is particularly important if the community is to be compared to similar ones elsewhere. Another principal objective is to determine the regularity of distribution or the commonness of the species which are characteristic of the community.

The distributional concept which has been used in this study is frequency, a term which has been interpreted in different ways by various authors, but which is generally defined as the number of samples in which a species occurs, expressed as a percentage of the total number of samples examined (Oosting 1948, p. 58; Curtis and McIntosh 1950, p. 435). It is often interpreted as an analytical character, in which case the samples should be from a single stand. Not all authors limit the term in this way however (Drew 1947).

The concept of frequency has been employed as defined above, by considering the entire group of Newaygo prairies as a single stand. This is a logical approach inasmuch as these prairies form a relatively compact natural area, separated by about 65 miles from any other prairies. The individual groupings of prairie vegetation are thus considered

as fragments of one large stand. In this study, frequency has been investigated in two ways. First,it has been determined in terms of all the samples studied in the entire stand. In this case it has been determined both as plot frequency (Fp) based on 50 100m^2 plots, and as quadrat frequency (Fq) based on 500 1m^2 quadrats. Secondly, frequency has been considered separately for six of the most representative soil areas, in which case it has been determined in terms of quadrat frequency.

Equal in value to the concepts regarding the distribution of species, are the concepts relating to the actual importance of the species in the community, or its dominance. Dominance may be determined in various ways, but usually includes measurements of size, volume of space occupied, or amount of ground covered (Oosting 1948, p. 61). The kind of measurement to be used depends in large part upon the type of vegetation. In grassland studies, the counting of individuals is a laborious process and is often of questionable value because of the variations in size, form, and habit of growth of grasses. For this reason, estimates or measurements of cover are very useful. In this study, estimates of the percentage of ground area covered by the various species have been used as an expression of their relative dominance. Cover has been recorded according to the five cover classes referred to on page 45. The application of the data recorded for cover will be discussed in a succeeding section.

Occurrence of species in terms of frequency. The data recorded in the field notes have been summarized in Table II. Species have been listed alphabetically under the headings of grasses, sedges and rushes, and forbs, including a few arborescent species. The total number of plots in which each species was found is recorded in the first column. In the second column, plot frequency (Fp) is shown, in terms of the percentage of 50 plots in which the species occurred. The third column summarizes the number of quadrats in which the species was found, and the last column shows this figure converted to quadrat frequency (Fq), which is the percentage of 500 quadrats which contained the species.

Frequencies may be grouped into five classes, as follows:

1--19, class A

20--39, class B

40--59, class C

60--79, class D

80--100, class E

Class A tends to be very large because of the many sporadic species occurring with low frequency in most stands. Class E tends to be relatively large because it includes the dominant plants of the community. If the sample size is increased, classes A and E tend to increase, with a corresponding decrease in classes B, C, and D. It follows that frequency classes can be compared only when they are based on samples of the same size (Costing 1948, p. 61). The accomp-

TABLE II

FREQUENCY PERCENTAGES OF SPECIES OCCURRING ON THE NEWAYGO PRAIRIES

	Plots		Quadrats	
	No.	F_p[1] (%)	No.	F_q[2] (%)
GRASSES				
Agrostis scabra	1	2	1	0.2
Andropogon gerardi	30	60	137	27.4
Andropogon scoparius	36	72	228	45.6
Aristida purpurascens	22	44	62	12.4
Danthonia spicata	15	30	47	9.4
Eragrostis pectinacea	20	40	44	8.8
Koeleria cristata	37	74	219	43.8
Panicum depauperatum	27	54	77	15.4
Panicum pseudopubescens	31	62	66	13.2
Panicum scribnerianum	5	10	6	1.2
Panicum virgatum	1	2	7	1.4
Poa compressa	7	14	22	4.4
Poa pratensis	11	22	41	8.2
Sorghastrum nutans	15	30	46	9.2
Sporobolus cryptandrus	1	2	10	2.0
Stipa spartea	1	2	2	0.4
SEDGES AND RUSHES				
Carex pensylvanica	47	94	445	89.0
Cyperus filiculmis	26	52	56	11.2
Juncus greenei	1	2	7	1.4
Bulbostylis capillaris	2	4	-	-
Equisetum sp.	1	2	1	0.2
FORBS (AND ARBORESCENT SPECIES)				
Ambrosia psilostachya var. coronopifolia	43	86	292	58.4
Anemone cylindrica	5	10	16	3.2
Arenaria stricta	7	14	41	8.2
Apocynum cannabinum	3	6	2	0.4
Artemisia caudata var. calvens	15	30	31	6.2
Asclepias viridiflora	1	2	2	0.4
Aster azureus	7	14	13	2.6
Aster ericoides	4	8	11	2.2
Aster sericeus	1	2	1	0.2
Blephilia ciliata	1	2	2	0.4
Convolvulus spithamaeus	2	4	6	1.2
Coreopsis lanceolata	7	14	26	5.2
Crataegus sp.	1	2	-	-
Erigeron canadensis	2	4	6	1.2
Erigeron strigosus	8	16	8	1.6
Euphorbia corollata	39	78	119	23.8
Euphorbia cyparissias	1	2	7	1.4
Geum triflorum	1	2	10	2.0

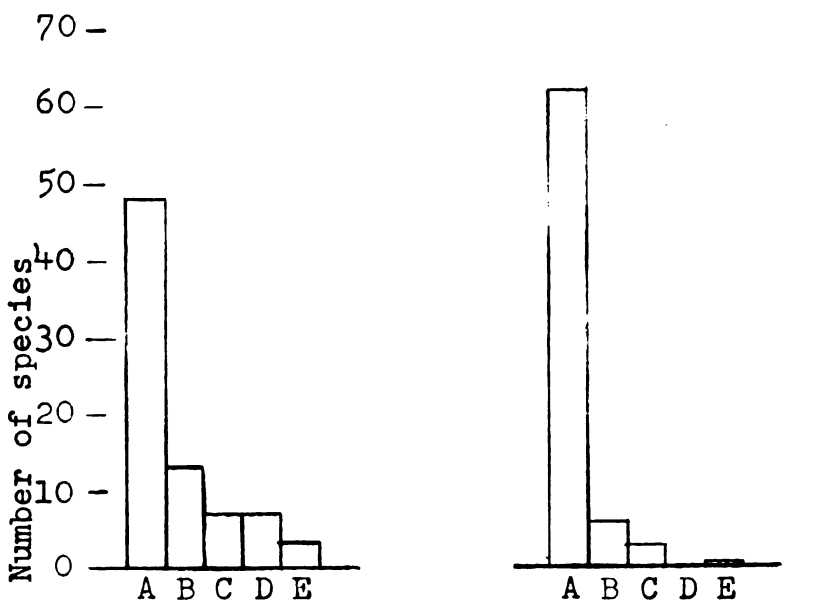
TABLE II (continued)

	Plots		Quadrats	
	No.	Fp[1] (%)	No.	Fq[2] (%)
Gnaphalium obtusifolium	10	20	11	2.2
Helianthemum canadense	8	16	19	3.8
Helianthus hirsutus	1	2	3	0.6
Helianthus occidentalis	14	28	73	14.6
Hieracium longipilum	28	56	41	8.2
Hypericum perforatum	9	18	11	2.2
Krigia virginica	16	32	25	5.0
Lactuca canadensis	1	2	1	0.2
Lespedeza capitata	3	6	7	1.4
Liatris cylindracea	4	8	8	1.6
Liatris aspera var. intermedia	37	74	114	22.8
Linaria canadensis	16	32	44	8.8
Linum sulcatum	12	24	45	9.0
Lithospermum croceum	5	10	6	1.2
Lupinus perennis	1	2	-	-
Melilotus alba	1	2	1	0.2
Mollugo verticillata	3	6	4	0.8
Monarda punctata var. villicaulis	14	28	34	6.8
Opuntia humifusa	2	4	2	0.4
Oenothera sp.	5	10	6	1.2
Penstemon hirsutus	6	12	5	1.0
Physalis virginiana	1	2	6	1.2
Polygala polygama var. obtusata	40	80	129	25.8
Polygonella articulata	17	34	22	4.4
Potentilla arguta	3	6	4	0.8
Prunus serotina	1	2	-	-
Prunus virginiana	1	2	-	-
Rosa carolina	7	14	27	5.4
Rubus spp.	25	50	123	24.6
Rudbeckia serotina	4	8	5	1.0
Rumex acetosella	26	52	109	21.8
Silene antirrhina	1	2	1	0.2
Solidago graminifolia	1	2	2	0.4
Solidago missouriensis	3	6	3	0.6
Solidago nemoralis	36	72	87	17.4
Specularia perfoliata	2	4	1	0.2
Tephrosia virginiana	14	28	51	10.2
Viola pedata var. linearíloba	16	32	55	11.0

[1]Plot frequency (Fp) based on 50 100m^2 plots

[2]Quadrat frequency (Fq) based on 500 1 m^2 quadrats.

anying graphs (Fig. 17) show the numbers of species in each of the frequency classes, on a plot basis and on a quadrat basis. It can be seen that class E increases with increase in size of the sample, but class A has not shown the expected increase.



Plot frequency Quadrat frequency

Fig. 17. Frequency diagrams for all prairie areas

The shape of the plot frequency diagram bears a strong resemblance to a typical constance diagram in that the two lowest classes (A and B) show a distinct maximum, class E is small, and class A is smaller than it is in the case of quadrat frequency (Braun-Blanquet 1932, p. 57; Oosting 1948, p. 71). This pattern indicates that the plot frequency

observations may possibly be considered as constance, in which case the stand would have to be defined as the general area immediately surrounding the plot. This is not considered, however, to be a satisfactory definition of a stand.

The frequency classes, first used by Raunkiaer (1934), and later by numerous other investigators, are often used as a measure of the homogeneity of a stand. If classes B, C, and D are relatively large, the stand is considered to be less homogeneous than one in which class E is large. On the other hand, Curtis and McIntosh (1950, p. 454) consider that the frequency distribution curve is of no value as a measure of homogeneity. In any case, if these frequency graphs are held to indicate some measure of homogeneity, they tend to show that the Newaygo prairies, as a whole, are little homogeneous as to the distribution of their vegetation. This is not surprising in view of the large number of weeds and other introduced plants which can be noted in Table II, as well as the many other kinds of evidence of the disturbance to which these areas have been subjected.

To clarify the relative importance of species in terms of their distribution, Table III includes all species having plot frequencies of 20 percent or more, in order of decreasing frequency. Table IV includes the species having quadrat frequencies of 10 percent or more, also in order of decreasing frequency.

TABLE III

RELATIVE PLOT FREQUENCY (Fp) OF SPECIES OCCURRING IN AT LEAST 20 PERCENT OF THE PLOTS

	Fp (%)
GRASSES	
Koeleria cristata	74
Andropogon scoparius	72
Panicum pseudopubescens	62
Andropogon gerardi	60
Panicum depauperatum	54
Aristida purpurascens	44
Eragrostis pectinacea	40
Danthonia spicata	30
Sorghastrum nutans	30
Poa pratensis	22
SEDGES	
Carex pensylvanica	94
Cyperus filiculmis	52
FORBS	
Ambrosia psilostachya var. coronopifolia	86
Polygala polygama var. obtusata	80
Euphorbia corollata	78
Liatris aspera var. intermedia	74
Solidago nemoralis	72
Hieracium longipilum	56
Rumex acetosella	52
Rubus spp.	50
Polygonella articulata	34
Krigia virginica	32
Linaria canadensis	32
Viola pedata var. lineariloba	32
Artemisia caudata var. calvens	30
Helianthus occidentalis	28
Monarda punctata var. villicaulis	28
Tephrosia virginiana	28
Linum sulcatum	24
Gnaphalium obtusifolium	20

TABLE IV

RELATIVE QUADRAT FREQUENCY (Fq) OF SPECIES OCCURRING IN AT LEAST 10 PERCENT OF THE QUADRATS

	Fq (%)
GRASSES	
Andropogon scoparius	46
Koeleria cristata	44
Andropogon gerardi	27
Panicum depauperatum	15
Panicum pseudopubescens	13
Aristida purpurascens	12
SEDGES	
Carex pensylvanica	89
Cyperus filiculmis	11
FORBS	
Ambrosia psilostachya var. coronopifolia	58
Polygala polygama var. obtusata	26
Rubus spp.	25
Euphorbia corollata	24
Liatris aspera var. intermedia	23
Rumex acetosella	22
Solidago nemoralis	17
Helianthus occidentalis	15
Viola pedata var. lineariloba	11
Tephrosia virginiana	10

The frequency diagrams for Areas 12, 15, 16, 18, 19, and part of 23, expressed in terms of quadrat frequency for each area are shown in Figure 18. These areas were selected as representatives of the entire group. With the exception of Area 15, they coincide with the prairies shown on the map of the original land survey. It can be seen that homogeneity varies from area to area, being greatest in Areas 12, 15, 19, and 23.

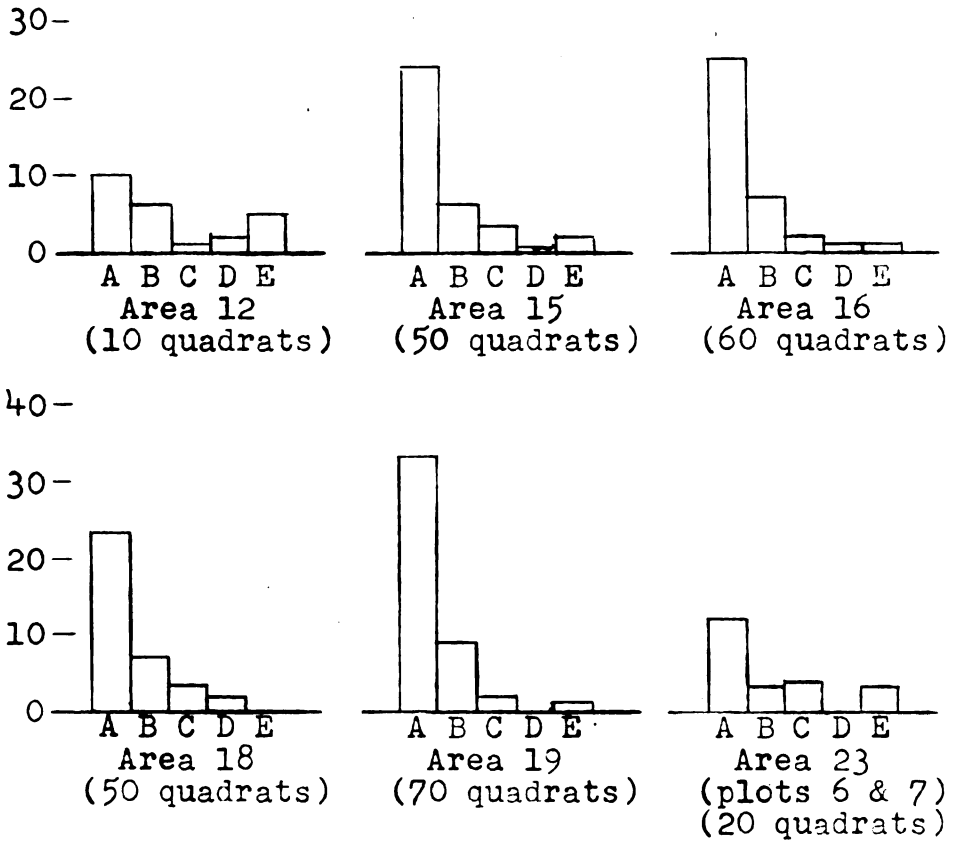


Fig. 18. Quadrat frequency diagrams for six selected prairie areas

Dominance of species in terms of cover. Reference has been made in the section on field methods to the use of five cover classes to indicate the percentage of ground surface covered or shaded by each species. The cover classes were recorded in the field notes (Appendix B) using numbers from one to five for each quadrat in which a species occurred. Cover is considered to be an important measure of dominance for grassland vegetation. In this study, dominance has been determined on a relative basis for the more important species in Areas 12, 15, 16, 18, 19, and 23 (in part). Instead of trying to obtain averages of cover classes for large numbers of quadrats, each species in an area has been given a figure which is called the Cover Index (CI). The cover index is merely the sum of the cover classes (p. 45) of the species. For example, a species covering less than five percent of the ground surface (cover class 1) in each of five quadrats would have a cover index of 5. Another species, with cover class 1 in two quadrats, cover class 2 in another two quadrats, and not occurring in the fifth quadrat, would have a cover index of 6. Table V includes the 18 species of greatest dominance, indicating their cover indices and relative rank in each of the six areas selected for consideration. The cover indices for the six areas have been added and used to determine the overall ranking of the species with regard to relative dominance.

TABLE V

RELATIVE DOMINANCE OF EIGHTEEN SPECIES IN SELECTED PRAIRIE AREAS, AS INDICATED BY COVER INDEX

	Individual Areas												Summary	
	12[1]		15		16		18		19		23		Total of CI's	Over-all Rank
	CI[2]	Rank	CI	Rank	CI	Rank	CI	Rank	CI	Rank	CI	Rank		
Carex pensylvanica	11	3	81	1	104	1	51	2	136	1	49	1	432	1
Andropogon scoparius	8	6	62	2	62	2	87	1	45	3	20	4	284	2
Ambrosia psilostachya	9	4	46	3	44	3	25	4	39	4	22	3	185	3
Koeleria cristata	9	4	39	5	24	6	25	4	20	8	34	2	151	4
Andropogon gerardi	13	1	0	18	35	4	14	9	61	2	0	14	123	5
Rubus spp.	0	13	44	4	1	17	26	3	21	7	18	5	110	6
Rumex acetosella	0	13	6	13	16	9	21	6	28	5	2	11	83	7
Polygala polygama v. obt.	3	8	25	7	19	8	14	9	15	12	6	7	82	8
Liatris aspera v. interm.	1	10	18	8	25	5	13	11	20	8	2	11	79	9
Helianthus occidentalis	12	2	29	6	0	18	21	6	15	12	0	14	77	10
Euphorbia corollata	0	13	8	11	22	7	11	12	16	11	11	6	68	11
Panicum depauperatum	1	10	16	9	11	11	19	8	10	14	2	11	59	12
Solidago nemoralis	0	13	6	13	7	14	5	16	22	6	3	8	43	13
Aristida purpurascens	0	13	3	16	10	12	10	13	19	10	0	14	42	14
Cyperus filiculmis	4	7	6	13	7	14	8	15	4	18	3	8	32	15
Panicum pseudopubescens	0	13	11	10	5	16	2	17	9	15	3	8	30	16
Hieracium longipilum	1	10	7	12	16	9	1	18	5	17	0	14	30	16
Eragrostis pectinacea	2	9	1	17	10	12	9	14	7	16	0	14	29	18

[1]Numbers of quadrats per area are as follows: Area 12, 10 quadrats; Area 15, 50 quadrats; Area 16, 60 quadrats; Area 18, 50 quadrats; Area 19, 70 quadrats; Area 23, 20 quadrats (from plots 6 and 7 only).

[2]CI: Cover Index. See page 56 for explanation of the term.

Relationships to the Surrounding Forest

Natural vegetation at the time of the original land survey. Everett, Big Prairie, Brooks, and Croton townships were surveyed in 1837 by Hodgson and Mullett. Their work was checked later by the examiner of surveys (Brewer 1854), and found to be essentially correct. Kenoyer (1930, 1934, 1940, 1943), who has reconstructed the vegetation of a number of Michigan counties from the notes made by the surveyors, describes the method as follows (1934, p. 107):

> The surveyor blazed two trees at each station corner and at the midpoint of each section boundary line, stating in his field notes the kind, size, and location with reference to the stake. When records of the species are inserted in their proper locations on a county map it is easy to outline the area occupied by each plant association. Since the located points are in general a half-mile from one another it is possible to draw the boundary line of the association within a half-mile of the exact location.

In addition to the section corners and midpoints of section lines, the surveyors noted the occurrence of trees which were found elsewhere along the section lines. They also noted the points along the section lines at which they entered or left prairies and marshes and where they crossed streams. A reconstruction of the vegetation of the townships under consideration , based on the notes and the method just described, is shown in Figure 19. It is evident that the principal forest association was that of White Pine, which covered approximately half the area. It is,of course,the forest type which was most in demand by the early lumbering

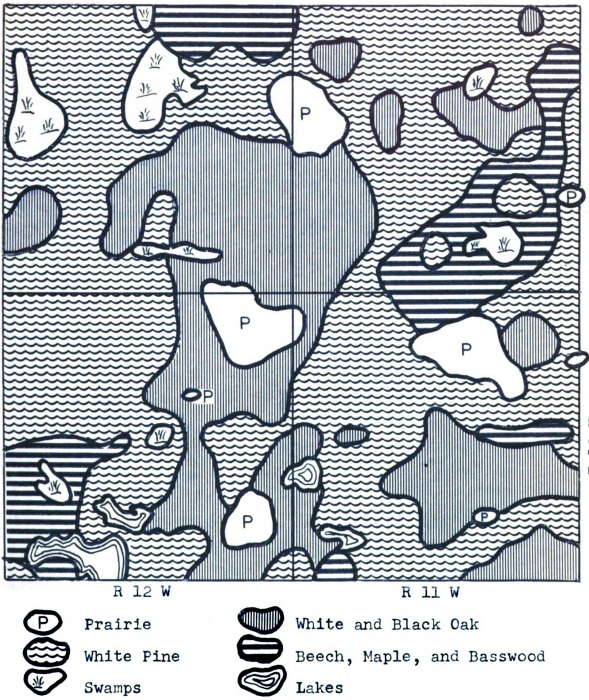


Fig. 19. Reconstruction of the original vegetation of a part of Newaygo County, based on the notes of the original land survey (1827)

industry. The White and Black Oak association appears to have been second, in terms of area. Beech, Maple, and Basswood formed the third association characteristic of the region. There were numerous swamps and marshes, but only the larger ones are shown on the map. The areas listed as prairies are also shown. In addition, mention was made of several burned areas which are not shown on the map.

An examination of the prairies on this map (Fig. 19) does not disclose any consistent relationship between prairies and any particular forest association. Two of the areas are entirely surrounded by oak forest, one is surrounded by white pine forest, and the remainder are bounded by more than one forest association.

Present prairie-forest boundaries. It is difficult to make any generalizations regarding the present-day relationships between the prairies and their surrounding forest, because of the many disturbances which have occurred during the past century. These include the practically complete removal of the forest cover by the early lumbering operations, the cultivation of the land, whether prairie or cleared forest, and the enlargement of prairie areas by removing trees and shrubs along their edges. The latter activity is indicated in a number of places where the prairie-forest boundary is a straight line.

In general, however, it is evident that the forest is

invading the prairies. The evidence is contradictory, however, as to the rate at which this movement is proceeding. In some instances the boundary is very abrupt, the trees giving way to the prairie with practically no transitional region. This may, of course, be due to former clearing, but since most of the areas have been abandoned for many decades, the rate of invasion must be, in these cases, very slow. In other instances there is a fairly broad zone in which oaks can be found in all stages from seedlings to large trees, along with a few other species of trees and shrubs. In these cases it would appear that the rate of invasion has been much more rapid. In addition, as has been pointed out in an earlier section, a great deal of tree planting is done, so it appears to be only a matter of time before these prairies will have disappeared altogether.

Connections with the Prairie Peninsula

The portion of the prairie peninsula associated with Michigan is generally considered to extend into the southwestern corner of the State. Nowhere in Michigan, however, does there occur the broad expanse of prairie that is characteristic of the main body of the prairie peninsula. The prairie vegetation is to be found as a number of separate tracts dispersed throughout the forest. It is impossible to determine how many of these existed in the past, but Butler (1947, 1948, 1949) has used historical references in compiling

a list of 58 prairies. Most of these were concentrated in Berrien, Cass, St. Joseph, Branch, Kalamazoo, and Calhoun Counties (Fig. 2), which form the western part of the two southern tiers of counties in Michigan. Very few known prairies occur north of these counties except for the group concentrated in Newaygo County. This does not mean, however, that the isolation of the Newaygo prairies was complete. There are frequent references in the early literature to the occurrence of numerous "oak openings" which were probably much too small to merit the name of prairies. It is probable that these oak openings contained members of the prairie flora, and thus provided a degree of continuity to this vegetation type throughout the southern part of Michigan.

Although a considerable amount of collecting has been done in the region of the prairies and a number of floras have been published (Cole 1901; Beal 1904; Pepoon 1907; Hebert 1934; Hanes and Hanes 1947), practically nothing has been written regarding the overall distribution of the prairie species.

Occasional roadside and cemetery groupings of prairie species have been noted by various persons. Such groupings, particularly in Ingham, Clinton, and Ionia Counties, have been observed by W. B. Drew, C. L. Gilly, and G. W. Parmelee of Michigan State College, and by the writer. For example, the following characteristic species were collected from a

small prairie-like area in Ionia County[1] by Gilly and Parmelee:

Comandra richardsiana
Heuchera richardsoni
Penstemon sp.
Solidago rigida
Aster laevis
Asclepias tuberosa
Rudbeckia serotina
Silphium terebinthinaceum
Stipa spartea

Similar groupings of prairie species occur with increasing frequency toward the southwestern portion of the State. Appendix A includes a series of maps that show the distribution of representative prairie species throughout the Lower Peninsula of Michigan.

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[1]Lyons Township (T. 7 N., R. 5 W.), NW ¼ of Section 18, along North Maple River bluff and Grand Trunk Railroad. Collected on June 21st, 1949.

COMPARISONS WITH PRAIRIES OF OTHER REGIONS

General Discussion

Specific qualitative and quantitative comparisons between different ecological studies are usually very difficult to make because of the lack of uniformity in the use of terms, the use of various sizes and numbers of sample areas, differences in objectives, and for many other reasons. The present study is no exception. An effort will be made, however, to point out some of the similarities and differences between the prairies of Newaygo County and those of other regions. Only a very generalized comparison can be made because of the wide extent of the grassland formation. The consequent variations in climate and topography result in great differences in the plant cover.

Vegetation

Prairies are variously classified according to the dominant vegetation, topography, or moisture relations. Weaver and Clements (1938) have classified the prairies with respect to the stature of the dominant grasses. The true prairie is dominated by grasses of medium height. The other major prairie types are the tall-grass prairie and the mixed prairie, which is composed of both medium-sized and short grasses.

Mainly on the basis of soil moisture relations, prairies are also considered as high (or dry) prairies, and low (or wet) prairies. Soil factors may also be taken into account, such as in the case of sand prairies and dry lime prairies (Curtis and Greene 1949). The Newaygo prairies are to be considered as dry prairies because of the excessive drainage occasioned by the very sandy nature of the soil, rather than by marked differences in topography. Likewise, they may be considered as sand prairies. On the basis of floristic composition, they are related most closely to the tall-grass prairies because of the occurrence of three of the dominants, Andropogon gerardi, Sorghastrum nutans, and Panicum virgatum. The tall-grass prairie is also the kind usually found along or within the margin of the deciduous forest (Weaver and Clements 1938, p. 520).

Plants occurring in the Newaygo prairies which are considered as more or less important constituents of the prairies of South Dakota, Nebraska, Kansas, Missouri, and Iowa by Weaver and Fitzpatrick (1934), and Drew (1947), include the following grasses and related plants: Andropogon scoparius, Andropogon gerardi, Poa pratensis, Stipa spartea, Sorghastrum nutans, Panicum virgatum, P. scribnerianum, Koeleria cristata, and Carex pensylvanica. Similarly included are the following forbs: Erigeron strigosus, Euphorbia corollata, Liatris aspera, Lespedeza capitata, Linum sulcatum, Anemone cylindrica, Hieracium longipilum, Aster azureus,

Aster sericeus, Lithospermum croceum, Solidago graminifolia, and S. nemoralis. Schaffner (1913) and Steiger (1930), in studies made in Kansas and Nebraska, respectively, are in essential agreement with the list of species just mentioned. A study by Bergman (1923) in Minnesota adds Geum triflorum and Potentilla arguta to the list of characteristic prairie plants; both of these are also found in the Newaygo prairies. An investigation in Oklahoma by Rice (1952) includes Sporobolus cryptandrus. Cain, Nelson and McLean (1937) have found Aster ericoides (= A. pilosus) and Viola pedata with high constancy in a prairie on Long Island.

On the basis of the foregoing list of species, it can be seen that the Newaygo prairies include a fairly high number of plants which are considered to be typical prairie species. On the other hand, it must be noted that a number of plants considered as important constituents of prairie vegetation elsewhere have not been found in the prairies under consideration. Among these are Sporobolus asper,* S. heterolepis, Agropyron smithii, Bouteloua curtipendula, B. gracilis, Elymus canadensis,* Buchloe dactyloides, Amorpha canescens,* Helianthus rigidus, Antennaria campestris, Solidago missouriensis var. fasciculata, Psoralea argophylla, Baptisia leucophaea,* Viola pedatifida,* and others.

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*Collected, however, from prairie areas in southern Michigan (M. S. C. herbarium).

Climate

Because of the vast expanse of the prairie formation any brief discussion of its climate must be in very general terms. Within the United States as a whole, there is a general decrease in rainfall from east to west, and a decrease in temperature from south to north. Reference to Table VI will show that average summer temperatures are distinctly lower in Michigan than they are in the main body of the prairie region. July temperatures are on the average 10 degrees higher in Missouri and Kansas than in Newaygo County, Michigan. Michigan also has a shorter growing season than do most other sections of the prairie region. The table also shows a decrease in average annual rainfall from

TABLE VI

COMPARISONS OF CLIMATIC FACTORS OF NEWAYGO COUNTY WITH SELECTED STATIONS WITHIN THE PRAIRIE REGION

State	Station	Temp. °F July ave.	Growing Season, days	Ave. Annual Precip. inches
Michigan	Croton Dam (Newaygo Co.)	70.3	142	31.3
Illinois	Peoria	76.4	188	35.0
Iowa	Guthrie Center	75.5	156	31.1
S. Dakota	Yankton	75.4	161	24.0
Nebraska	Lincoln	78.0	180	27.3
Missouri	St. Joseph	80.0	186	33.9
Kansas	Manhattan	80.0	171	31.9

Illinois westward, but the precipitation of Newaygo County is very close to the average for the stations shown. In terms of Thornthwaite's (1941) precipitation-effectiveness index, however, Michigan is found in the region of humid climate, while most of the prairie region lies within the zones of moist subhumid and dry subhumid climate. This is a direct reflection of the differences in temperature. In western lower Michigan, the lower summer temperatures are due not only to latitude, but also to the influence of Lake Michigan.

In summary, it may be noted that the Newaygo prairies lie beyond the limits of the subhumid climate with relatively warm summers which is generally associated with grassland regions.

Soils

A map showing the general distribution of the "great soil groups" (U. S. D. A. 1938; Millar and Turk 1943) will show that the Newaygo prairies are located near the boundary between the gray-brown podzolic soils and the podzol soils. On the other hand, most of the prairie region is characterized by soils of the prairie, chernozem, chestnut, and planosol groups. Furthermore, Sparta loamy sand, a podzolized soil, contains only extremely small amounts of the silt and clay separates, while the major soil series of the prairie region have, in general, a high percentage of these separ-

ates, with a consequently finer, heavier texture and a greater water-holding capacity. They also have, in most cases, a high percentage of organic matter.

Summary of Comparisons

From the foregoing consideration of the various characteristics of the Newaygo prairies and their comparison with other regions, it is apparent that they are similar to other prairies in general to a limited extent only. They are least similar to the prairies of the central United States, but seem to be more closely comparable with the high prairies and sand prairies of Wisconsin (Curtis and Greene 1949). The greatest differences are in respect to climate and soils. On the basis of their vegetation, they are much like other prairies in having a considerable number of the dominants and other plants which are considered to be characteristic of grassland regions. They are dissimilar, however, in the fact that they lack a number of the species which are regarded as important constituents of prairie vegetation. This is not surprising in view of their isolated situation and the disturbances to which they have been subjected. The high incidence of Carex pensylvanica is not typical of other prairies, and neither is the frequency with which weedy plants occur, such as Ambrosia psilostachya, Rubus spp., Rumex acetosella, and others. This weedy nature of the Newaygo prairies is not to be ascribed entirely to exploitation

by the early settlers. The notes of the surveyors of the original land survey, some of which were quoted in an earlier section (p. 32), clearly indicate that the prairies in their original state did not have the lush cover of grasses that so impressed the early migrants to the western states.

FACTORS RELATED TO THE ISOLATED OCCURRENCE OF THE NEWAYGO PRAIRIES

Climatic Factors

Postglacial climatic fluctuations. The importance of climate in determining the nature of climax formations has long been recognized. Other factors may alter, modify, or temporarily control the nature of the vegetation, but climate, in the long run, is the primary factor controlling the development of a plant formation. Present-day correlations between vegetation and climate are obvious.

Marked fluctuations of climate have occurred in the past, with consequent changes in the nature of the vegetation. In studies of the vegetation of Michigan and of the prairie peninsula, the only climatic fluctuations of immediate importance are those which occurred in the post-glacial period, that is, after the retreat of the ice of the Wisconsin stage of the Pleistocene epoch. In an interpretation of the origin, development, and maintenance of the prairie peninsula, Transeau (1935) has stated that: "Prehistoric factors are at least as important as present day measurable factors when dealing with the geographic phases of this problem . . ."

The methods of approach to the study of past climates

are rather limited. Veatch (1938) has shown pedologic evidence of changes of climate in Michigan. Gleason (1923) has used relic communities as an indication of past climates. Most studies of prehistoric climates are based on evidence provided by plant fossils. A few of these are concerned with fragments of plants, but the majority of studies have been based on the identification of pollen deposits in bogs of the glaciated regions. In many cases, genera can be identified from their pollen, and a knowledge of the environmental requirements of each genus will throw light on the probable climatic conditions which characterized the periods when various genera predominated. One of the foremost students of pollen analysis is Sears (1935a, 1935b, 1942a, 1942b, 1948), who has been followed by many others, including Cain (1939), Potzger (1946, 1948), Parmelee (1947), Potter (1947), and Cain and Slater (1948).

After studying pollen profiles from many bogs in the glaciated region, Sears (1942a) has developed an outline of five climatic periods of post-glacial time, which are the following, as listed by Braun (1950):

V. The present -- probably cooler and with more available moisture than in IV.

IV. A warm dry period -- oaks and hickories, with some beech.

III. A more humid, also warm, period -- maximum of beech, and hemlock in some places.

II. A dry, probably warmer, period -- maximum of pine, often with oak.

I. A moist cool period -- maximum of fir and spruce.

The warm-dry period, IV, is of the greatest interest in studies of grassland vegetation in the region of the prairie peninsula. It has been called the "xerothermic" period by Gleason (1923), Sears (1942b), and others. Gleason postulated the existence of this xerothermic period on the basis of evidence provided by relic colonies of plants. Sears and others have assumed the existence of this warm dry period on the basis of the pollen record which shows a maximum of oak, frequently accompanied by Carya. Furthermore, in Iowa and other midwestern areas there is also an increase in grass pollen.

From period IV to the present there are indications of a shift in climate to one which is cooler and more moist. This climatic shift has been marked by a westward migration of deciduous forests, a decrease in the amount of grassland vegetation in the eastern part of the prairie peninsula, a decrease of oak, and a general increase of the mesic genera of trees. The actual floristic composition varies greatly from one region to another, so that no concise generalizations can be made regarding the vegetation of the prairie peninsula and surrounding areas (Braun 1950).

It is interesting to consider the length in years of post-glacial time and of the climatic periods within it.

Flint (1947) has discussed the problems of postglacial chronology. Any estimate of postglacial time can apply to only one locality, because the ice uncovered different places at different times as it receded slowly northward. Various methods have been used in attempts to determine the length of postglacial time. One has been the rate of recession of waterfalls, such as Niagara Falls. There are so many variable factors which cannot be evaluated that this kind of estimate is completely unreliable. Another method that holds some promise is the counting of varve layers in glacial lakes, but they must be correlated southward from the limits of glaciation, a feat which has not yet been accomplished in North America. These and other equally unreliable methods have given estimates of postglacial time in the southern Great Lakes region varying from less than 10,000 to more than 30,000 years. Gordon (1940) mentions attempts to date the xerothermic period which place it at about 3,100 to 3,400 years ago.

A new method of great promise is that of the determination of the radiocarbon (C^{14}) content of plant remains and sea shells. It has been checked stratigraphically and with samples of known age, and seems to be a reliable method (Libby, Anderson, and Arnold 1949; Arnold and Libby 1949, 1951; Flint 1951; Flint and Deevey 1951; Godwin 1951). With regard to the dating of the postglacial climatic periods, Flint and Deevey (1951) state:

> . . . in round numbers the Mankato maximum in Wisconsin probably was attained 11,000 years ago. The postglacial spread of forests, and of Mesolithic cultures adapted to forests, took place in England about 9,000 years ago. The time of attainment of the Boreal type of climate, i. e. the time of the pine zone, differed appreciably according to the latitude of the locality. The pine zone is about 9,000 years old in West Virginia, about 8,000 years old in Connecticut, and about 6,000 years old in Maine; it is about 8,000 years old in southern Minnesota and about 7,000 years old in northern Minnesota. The age of the thermal maximum ("climatic optimum") has not been precisely fixed, but several samples from horizons not far from it give ages ranging from about 6,000 to about 3,000 years ago.

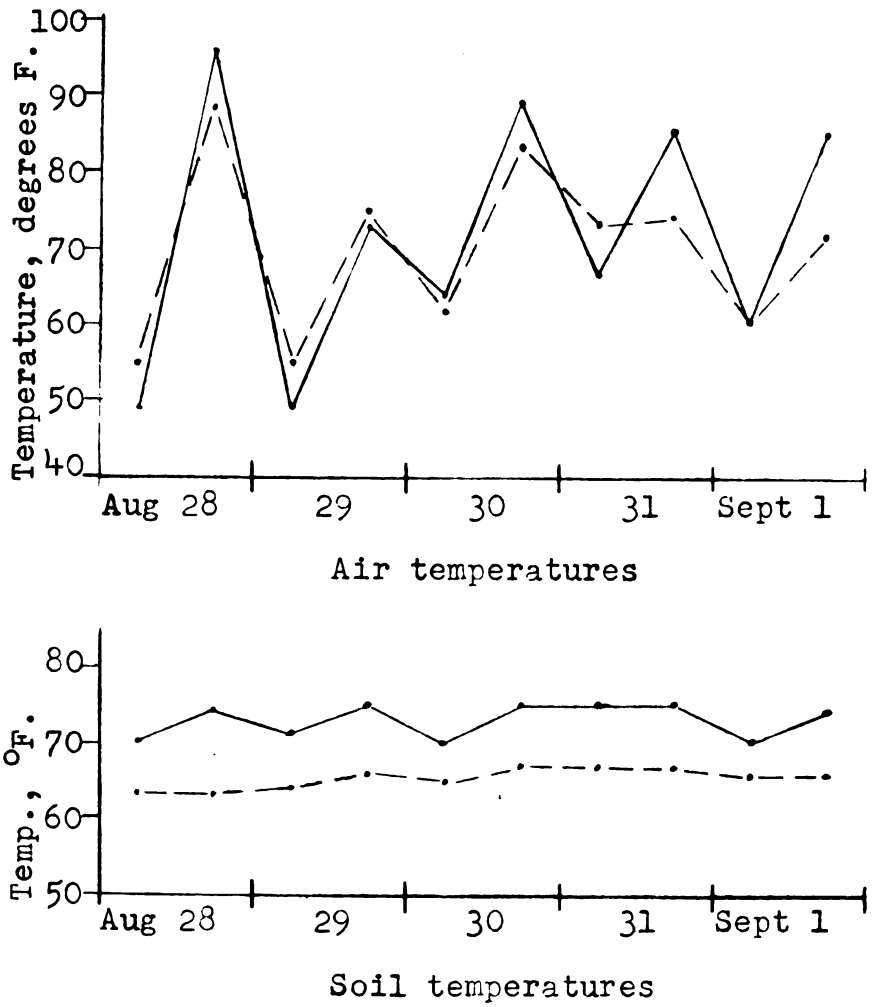
It would appear, then, that the prairie peninsula reached its maximum eastward extension at least 3,000 years ago, probably extending into the middle of the Lower Peninsula of Michigan. Subsequently, as the climate has gradually become cooler and more humid, the forests have encroached southward and westward upon the prairie, leaving behind the prairie remnants which are the subject of this study. A few students of the pollen record, however, are not in complete agreement with this theory. Fuller (1935) sees no evidence of alternating moist and dry periods during postglacial time, on the basis of pollen records from the Lake Michigan region. He also feels that there has been very little change in the vegetation of the Lower Peninsula of Michigan during the last half of postglacial time. Potzger (1943) sees no indication of decided cooling of climate during recent post-Pleistocene times in Lower Michigan, but feels that the pollen record suggests a drier climate.

Macroclimatic factors. These factors have been discussed on pages 21 to 25 and are not considered to be of any significance in explaining local variations in plant communities.

Microclimatic factors. For various reasons it was not possible, in the course of this study, to make an extended number of microclimatic observation. For purposes of comparison between prairie and woodland, however, measurements of temperature, precipitation, and evaporation were made during the five-day period from August 28 to September 1, 1952. The stations selected were near the southern edge of Area 25 (Fig. 7). Three boundaries are in agreement at that point: the one shown on the map made at the time of the original land survey, the boundary between Sparta loamy sand and Plainfield sand shown by Mick, et al (1951), and the present dividing line between prairie and forest vegetation. The prairie station was located about 30 yards from the boundary, and the forest station was about 50 yards in from the edge of the woods.

Two maximum-minimum thermometers were used at each station. One was encased in a copper can and buried in a vertical position with the top of the can a few inches below the surface of the soil. The other was protected from the direct rays of the sun by an aluminum shield, and attached to a stake about two feet above the surface of the soil.

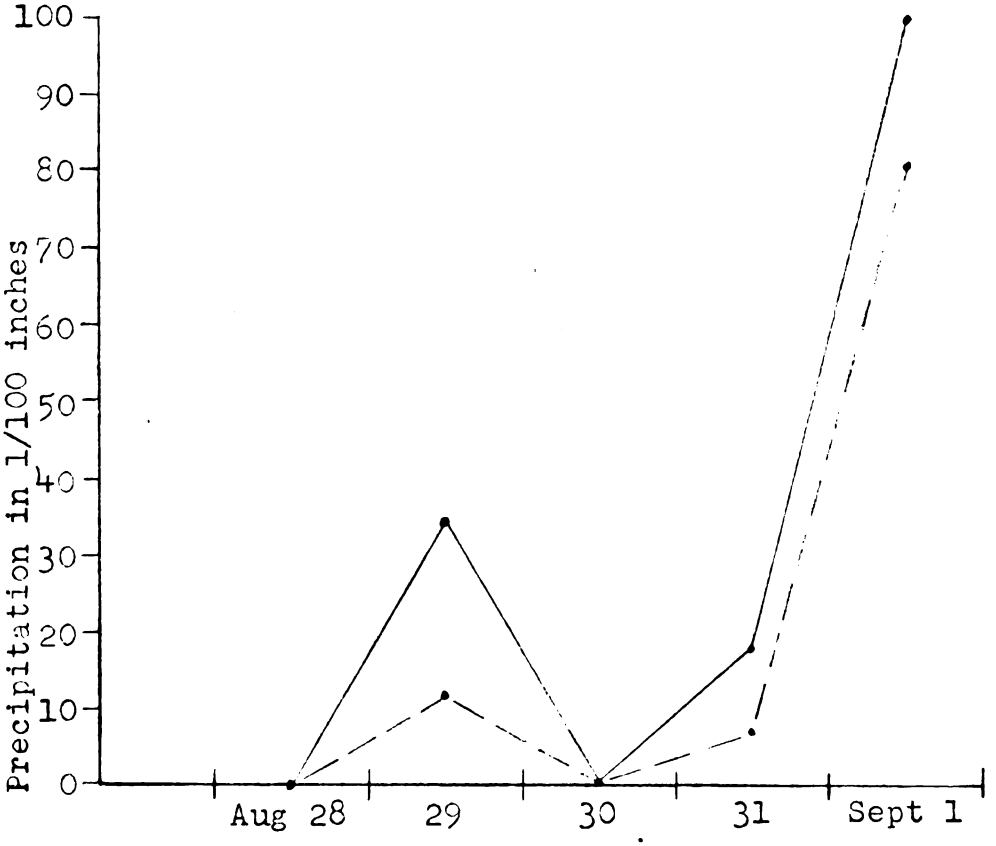
The results of the daily temperature readings are shown in Figure 20. It is readily observable that air temperatures in the prairie are generally more extreme than those in the forest. Daily maxima averaged 7.4 degrees higher in the prairie. Soil temperatures did not fluctuate as much, but were consistently higher in the prairie.



Solid line: prairie; broken line: forest

Fig. 20. Maximum and minimum air and soil temperatures in Prairie Area 25 and in adjoining forest

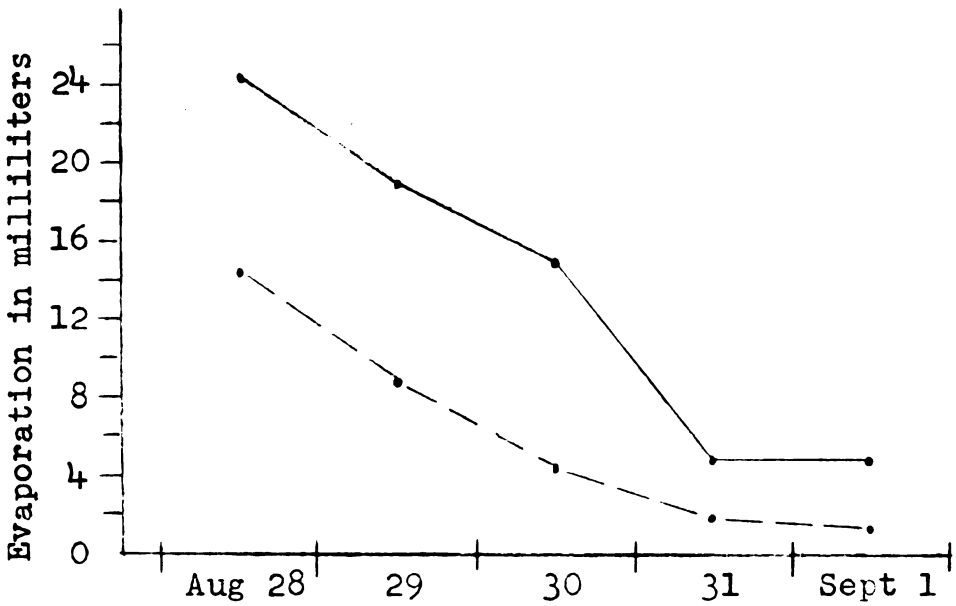
A rain gage was located at each station. The first day was sunny, the second was overcast with some precipitation. The third day was again sunny. The fourth day was cloudy in the morning with some precipitation, and was sunny in the afternoon. On the fifth day there was a severe thunderstorm with a large amount of rainfall. The results of the precipitation record for the prairie and forest stations are shown in Figure 21. It can be seen that less water reached the surface of the ground in the forest than did in the prairie.



Solid line: prairie; broken line: forest

Fig. 21. Precipitation in Prairie Area 25 and adjoining forest

Two Livingston atmometers were placed at each station, with the bottle placed on the ground and the bulb about 18 inches above the surface of the soil. Water loss was measured daily. White porous porcelain bulbs were used and the correction factor for each bulb was applied to the figures which were obtained. The results indicated for each station are the average for both atmometers at the station. The average amount of water lost per bulb at each station is shown in Figure 22. The graph shows that the rate of evaporation was considerably higher in the prairie.



Solid line: prairie; broken line: forest

Fig. 22. Evaporation from Livingston atmometers in Prairie Area 25 and adjoining forest

Geologic and Edaphic Factors

Topography. It has been noted (p. 13) that the prairie areas are found principally on the nearly level sandy outwash plains. No consistent relationship has been found, however, between topography and the prairie boundaries.

Characteristics of the soil. Livingston (1905) has held that climate is less important than the size of the soil particles in determining forest distribution. He also states that the sorting of the soil particles dates back almost entirely to the close of the last glacial stage. The similarity of particle size in Sparta loamy sand and the Plainfield sand which adjoins it in most places appears to limit the value of Livingston's theory, insofar as the distribution of the Newaygo prairies is concerned.

Mick, et al (1951), offer an interesting theory regarding the development of Sparta loamy sand and of the vegetation associated with it:

> Sparta loamy sand . . . although underlain by the yellow dry sandy substratum of the well-drained plains, possesses also the deep organic surface characteristics of poorly drained soils. Several highland marl deposits associated with Sparta loamy sand are proof of an ancient wet or marshy condition. It appears that the organic layer of this soil developed when the area was not so excessively drained as at present. A sudden lowering of the water table exposed the marsh surface to soil-forming forces. The original organic accumulation was deep enough to persist through the degradational processes that have operated on it since the recession of the water table. This theory of a sudden change from excessively wet to excessively dry conditions also

affords an explanation of the failure of the forest to advance rapidly over the grass-covered Sparta plains. The grasses, of course, aided in preserving the organic matter in the surface layer.

In most places, Plainfield sand is the soil type which adjoins Sparta loamy sand. Both of these soils have surface layers composed of sand or loamy sand. Both are acid throughout the profile, and are loose, pervious, and unconsolidated (Mick, et al 1951). They differ, however, in color and organic matter content. Sparta loamy sand has a surface soil which is black to dark brown, with a brownish subsoil. Plainfield sand is light grayish yellow in the surface soil, with grayish brown to pale brownish yellow subsoil.

Organic matter content, water content, and field capacity of the two soils were compared, using samples collected at the same stations near the boundary of Area 25 that were used for microclimatic studies (p. 76)

Organic matter content of the two soils was determined by the ignition method. The soils were oven dried at about 120 degrees F. for 48 hours, and then were baked in an electric oven at about 800 to 1000 degrees F. for 24 hours. Determinations were made on two samples of each soil, and the results were averaged. Sparta loamy sand showed an organic matter content of 2.42 percent of the weight of the dry soil. In Plainfield sand, organic matter constituted 1.76 percent of the dry weight of the soil. These figures show a decided increase of organic matter in Sparta loamy

sand as compared with Plainfield sand. In a study of prairie vegetation in Missouri, Drew (1947) found that the associated soil, Putnam silt loam, had an organic matter content of about 3.9 percent as determined by the digestion method, and 6.6 percent by the ignition method.

The moisture content of the soils at the time they were collected was determined by drying them in an oven at about 120 degrees F. for 48 hours. The water content of Sparta loamy sand was 1.3 percent, expressed in terms of percentage of the dry weight of the soil. On the same basis, Plainfield sand had a water content of 1.4 percent. The difference between these two samples is insignificant.

Field capacity of the soils was measured by saturating them with water and drying them in an oven as mentioned above (Gates 1949). The results are expressed as percentage of water in terms of the dry weight. Sparta loamy sand had a field capacity of 27.3 percent; Plainfield sand, 33.3 percent. The difference shown here is not great. Normally, a loamy sand with rather high organic matter content would be expected to hold more water than a sand with little organic matter.

Biotic Factors

Plant competition. In the ecotone between prairie and forest, competition between the members of the two formations is an important factor in determining the stability of the

boundary between them. Transeau (1935) has stated: "Tall prairie grasses once established exclude forest seedlings . . ." This is a belief well substantiated in many places. On the other hand, there is evidence of past and present encroachment of forest upon prairie, or vice versa. Ewing (1924) and Aikman (1928) have recognized situations in which the forest is encroaching on the prairie. Buell and Cantlon (1951) have studied a well-established forest which

> . . . has every appearance of being a first generation which has invaded en masse a previously unforested area, either a prairie community or a shrub community that had become established on prairie. On the basis of ring counts of a few cut stumps available, the mature trees appear to be 130--140 years of age. This suggests an approximate date for the invasion.

Others have seen evidence of a bidirectional encroachment of prairie and forest. This type of succession has been studied in Iowa by McComb and Loomis (1944), Loomis and McComb (1946), and McDonald (1949).

In the Newaygo prairies there is evidence of invasion by trees, but evidence regarding the rate of invasion is very contradictory, as has been pointed out in an earlier section (pages 60, 61).

Effects of grazing animals. No direct evidence is available regarding the effects of animals, particularly of the buffalo, in maintaining or extending the range of the prairies. In a recent study of the buffalo, Roe (1951) states that they had little effect in deforestation, although by grazing they

would prevent regeneration, so that the forest would eventually die.

According to Hinsdale (1932), deer and bear were apparently the only large mammals which were relatively common in Newaygo County, and they would not be likely to have any effect on the extent of the prairies.

Pyric and Anthropeic Factors

Much has been written concerning the effects of fire on the extent of the prairie. The early writers believed that fires were the primary cause of prairies. Smith (1859, p. 117) states categorically:

> The prairies were unquestionably produced by the agency of man. . . . There is no rational explanation of the existence of the prairies, other than their annual exposure, for many ages, to running fires, set by savage men, to facilitate their hunting, as the Indians have been accustomed to do, till the timber has been eradicated from them.

Gleason (1912) does not believe prairie fires were the cause of prairies, but he does maintain (1923) that the westward migration of deciduous forests after the xerothermic period was followed by an eastward migration of prairies resulting from the prairie fires set by the Indians. In a recent publication, Sauer (1950) maintains that fire, aided by man, is more important than climate in determining grassland vegetation.

Most recent authors, however, follow the more conservative view that fires have undoubtedly had some effect on

the prairie boundaries, but that climate is still the major factor in determining the distribution of the grassland vegetation. There is evidence that the present-day rate of invasion of forest into prairie is due in large part to the cessation of prairie fires because of the cultivation of the former prairies. Buell and Cantlon (1951) have studied this factor carefully and conclude that the rate of invasion of trees into prairie has increased since the cessation of fires, but that climatic control is still the more important factor. Bergman (1923) considers insufficient moisture as the limiting factor to the expansion of forests into western Minnesota, but thinks also that soil conditions and burning have contributed to the extension of the prairie in some places.

No evidence is available concerning the probability of fires having contributed significantly to the present extent of the Newaygo prairies. There was, however, a large Indian population in the county, and they may have burned off the prairies at intervals. The maps of the original land survey show a number of burned areas, but none are associated with the prairies. It is also probable that the Indians did some clearing to increase the size of their fields, inasmuch as they raised a number of crops (Hinsdale 1932).

Conclusions Regarding the Isolated Occurrence of the Newaygo Prairies

A number of factors have been discussed which play an important part in the development of the vegetation of southern Michigan. Some of these may have had a specific effect leading to the isolated occurrence of the prairie vegetation of Newaygo County. An attempt will be made to formulate an hypothesis which will account for the distribution of these prairie relics.

There is abundant evidence, particularly from the studies of pollen spectra in and near the glaciated region, that there have been well-defined long-range climatic fluctuations during postglacial time. Concurrently with the climatic changes, there have been changes in the composition of the vegetation brought about by migrations in response to the alterations of the climate. Several thousand years ago there was a xerothermic period during which there was a northward migration of forests and during which the prairie peninsula reached its greatest extent, reaching probably to the central part of the Lower Peninsula of Michigan. This will account for the prehistoric invasion of Michigan by prairie species.

Subsequently, a return to a more mesic climate reversed the direction of migration of the vegetation, so that the forests encroached on the prairie peninsula. Numerous relics of the prairie have remained as evidence of this movement.

One feature which must be accounted for in the Newaygo prairies is the persistence of these areas over what appears to have been a long period of time with a very slow rate of invasion by the forest. This assumption is based on the close coincidence between edaphic and vegetational boundaries which can be observed in many places, and by the occurrence of Sparta loamy sand, a prairie--type soil which would require a grassland cover for a long period of time in order to develop its characteristic profile. This persistence of prairies within a forest climate cannot be explained by reference to any individual factors. The holocoenotic nature of the environment must be considered, in which there is an interaction of many factors and the vegetation.

Of the factors which have been investigated, macroclimate appears to be of little importance in explaining the persistence of the Newaygo prairies. Microclimatic factors have probably been of some importance, along with certain edaphic factors such as the developmental history of the soil and its organic matter content. Topographic factcrs seem to be of little importance, with a larger part being played by the geological origin of the parent materials of the soil. Factcrs of plant competition have probably played a very important part. Pyric and anthropeic factors are difficult to evaluate for lack of direct evidence, but they may also have been important.

To summarize the problem, the original occurrence of

prairies in Newaygo County was occasioned by prehistoric postglacial climatic fluctuations, and the persistence of these prairies is due to a delicate balance among a large number of variable factors.

In conclusion, it may be noted that this balance has been disturbed within historic times by cultivation of the prairies and lumbering of the forests, and currently by the afforestation of prairie areas. This has resulted in an increase in the rate of invasion of forest vegetation which will probably result in the eventual extinction of these isolated prairies.

SUMMARY AND CONCLUSIONS

A study has been made of a prairie region which is confined to four townships in Newaygo County, Michigan. This region consists of a number of prairie fragments surrounded by forest, which formerly was made up of white pine, white and black oak, and beech-maple-basswood communities.

Various features of the prairies of Newaygo County have been described, such as their geology, pedology, and climate. The influence of man on the area has been investigated.

The vegetation was studied intensively by the use of 1-square-meter quadrats and 100-square-meter plots. The data obtained were interpreted in terms of frequency for an appraisal of the distribution of the various species. The dominance of each species was evaluated in terms of cover. It was found that, while there is a considerable degree of similarity between the vegetation of the Newaygo prairies and those of other regions, a number of the plants which are considered to be important prairie species are absent from Newaygo County. Thus, although the Newaygo prairie flora has many affinities with that of other prairies, it is nevertheless comparatively weedy and impoverished as to characteristic prairie species.

The relationships of these prairies to the surrounding forests have been discussed. The notes of the original

land survey were examined, and used to prepare a map showing the original distribution of forests and prairies in the area.

A number of factors which may be related to the occurrence of the prairies as relics within the forest have been studied, but no one factor can be said to be responsible.

Finally, it may be concluded that the prairies of Newaygo County constitute a relic grassland area having distinct relationships to the prairie peninsula in spite of being isolated from the main body of the Grassland Formation. Furthermore, it is apparent that the prairie vegetation originally arrived in the area which it now occupies in response to a postglacial period of warm dry climate. Subsequent change to a cooler and more humid climate brought a southward advance of the forests and retreat of the grasslands, portions of which remained isolated within the forest. The persistence of these prairie relics is due to a delicate balance of microclimatic, edaphic, and biotic factors.

It has been noted that a current program of afforestation, if continued, will lead to the ultimate disappearance of these isolated prairies.

APPENDIX

A. Distribution of Selected Prairie Species in the Lower Peninsula of Michigan 92

B. Plot and Quadrat Data 108

C. List of Species Found in the Prairies of Newaygo County 159

A. Distribution of Selected Prairie Species in the Lower Peninsula of Michigan

This section of the appendix consists of Figures 23 to 37, inclusive, which are maps indicating the distribution of certain prairie species in the Lower Peninsula of Michigan. Most of the data shown on the maps were obtained from specimens in the herbaria of Michigan State College, of the University of Michigan, and of Mr. G. W. Parmelee. Some of the distributions shown for Newaygo County are based on the collections of the writer, which will be deposited in the Michigan State College herbarium. The paper by Thompson[1] on the Violaceae of Michigan was a source of additional information on the distribution of Viola pedata.

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[1]Thompson, B. E. 1921. Distribution of the Violaceae of Michigan. Papers Mich. Acad. Sci., Arts, and Letters. The Macmillan Co. New York.

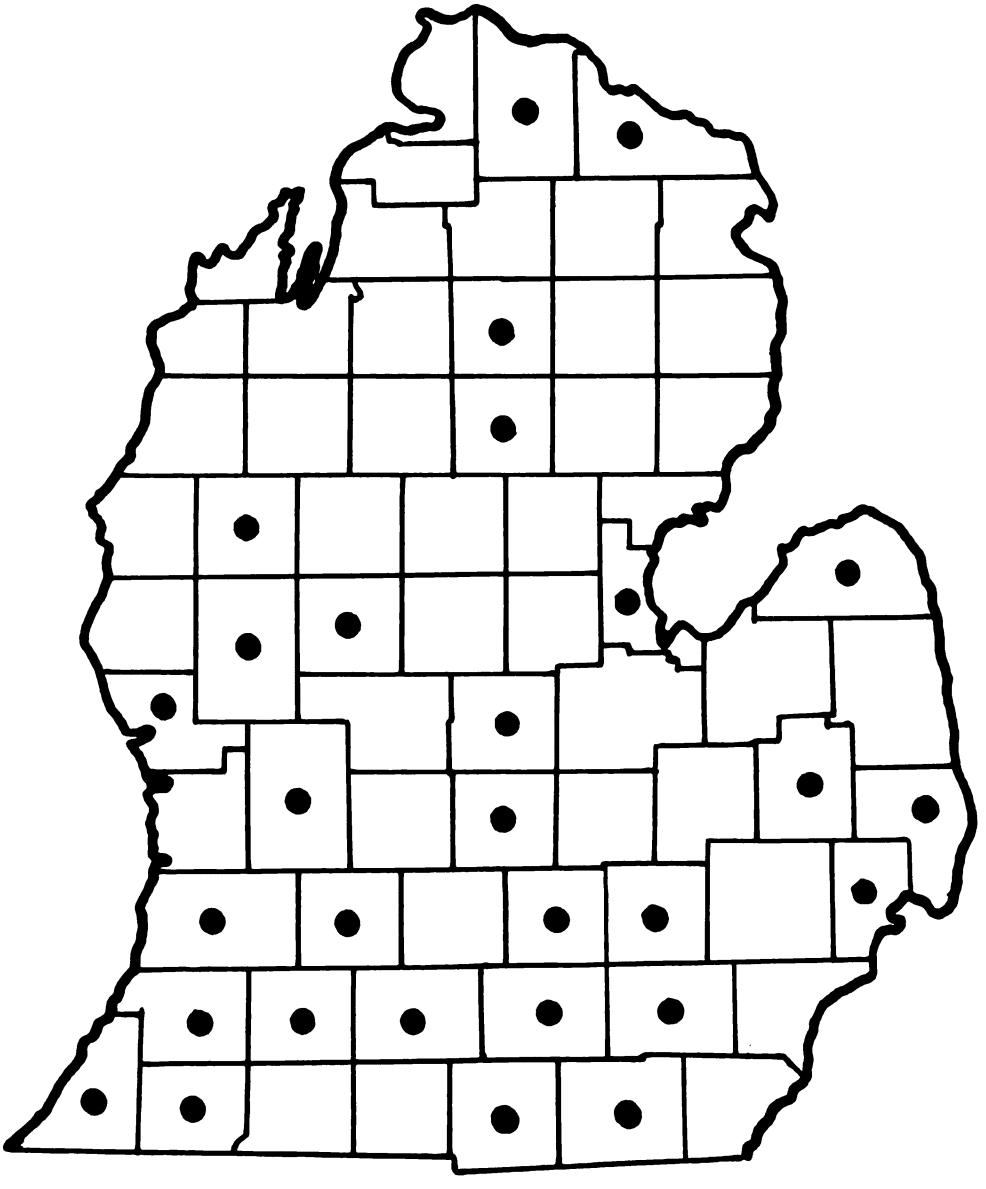

Fig. 23. Map of the Lower Peninsula of Michigan showing the distribution of **Andropogon gerardi**

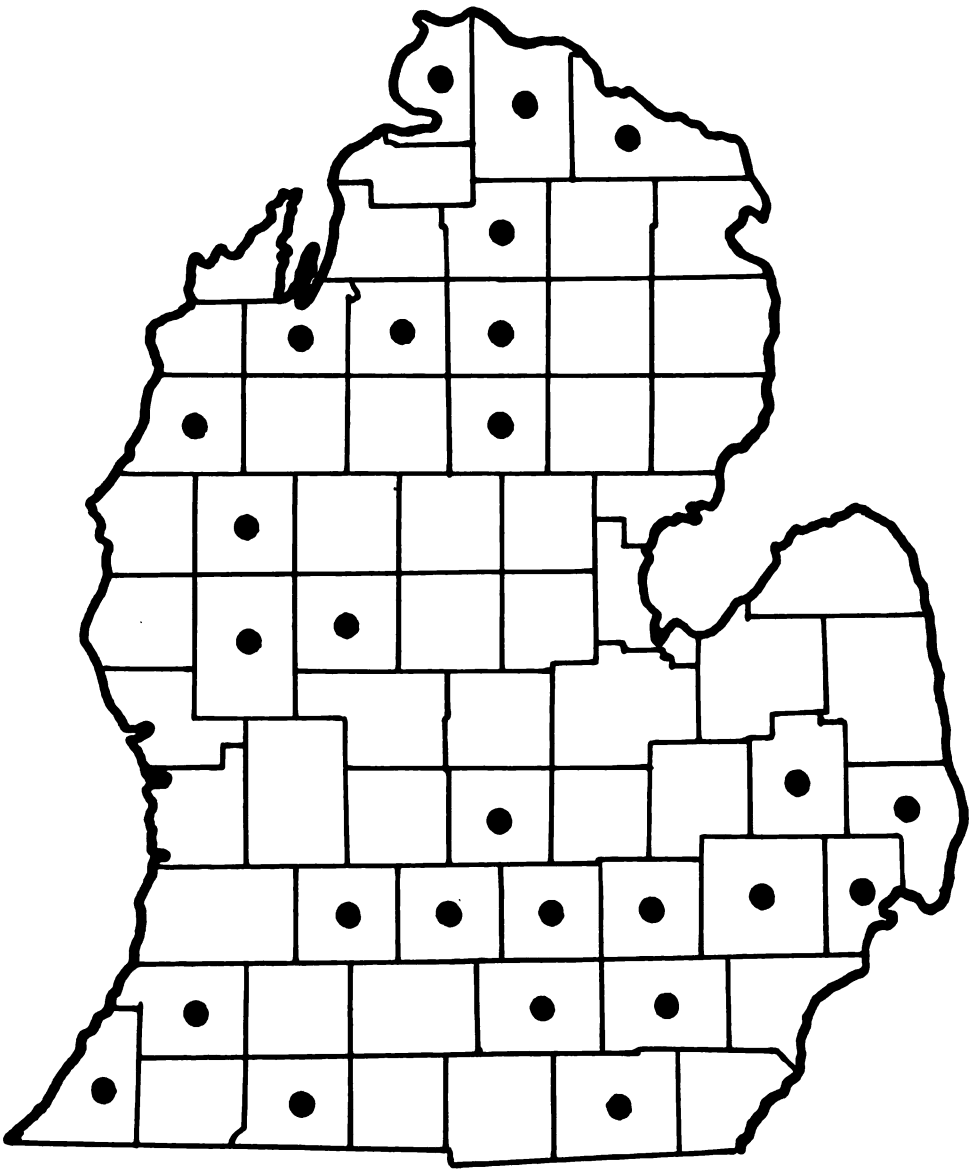

Fig. 24. Map of the Lower Peninsula of Michigan showing the distribution of **Andropogon scoparius**

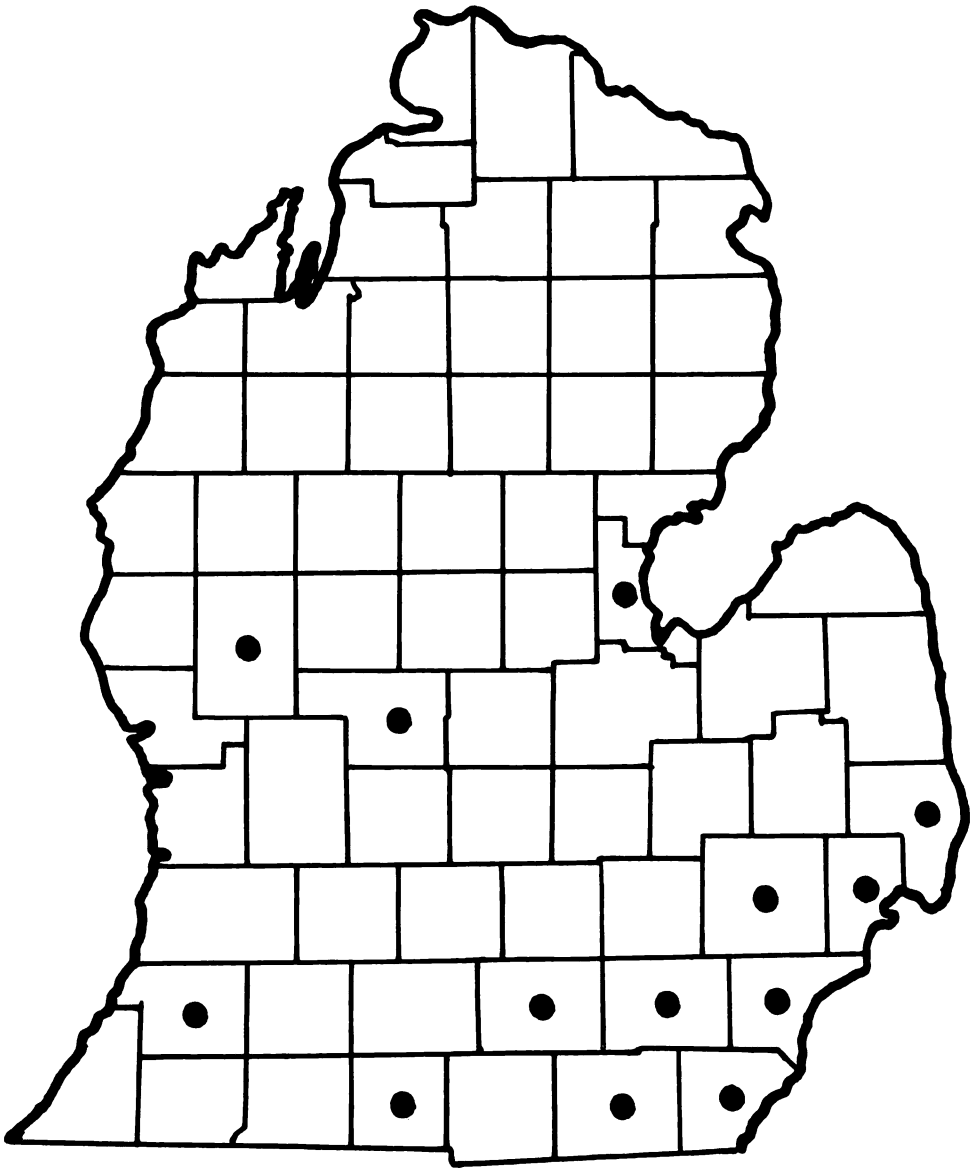

Fig. 25. Map of the Lower Peninsula of Michigan showing the distribution of **Aster ericoides**

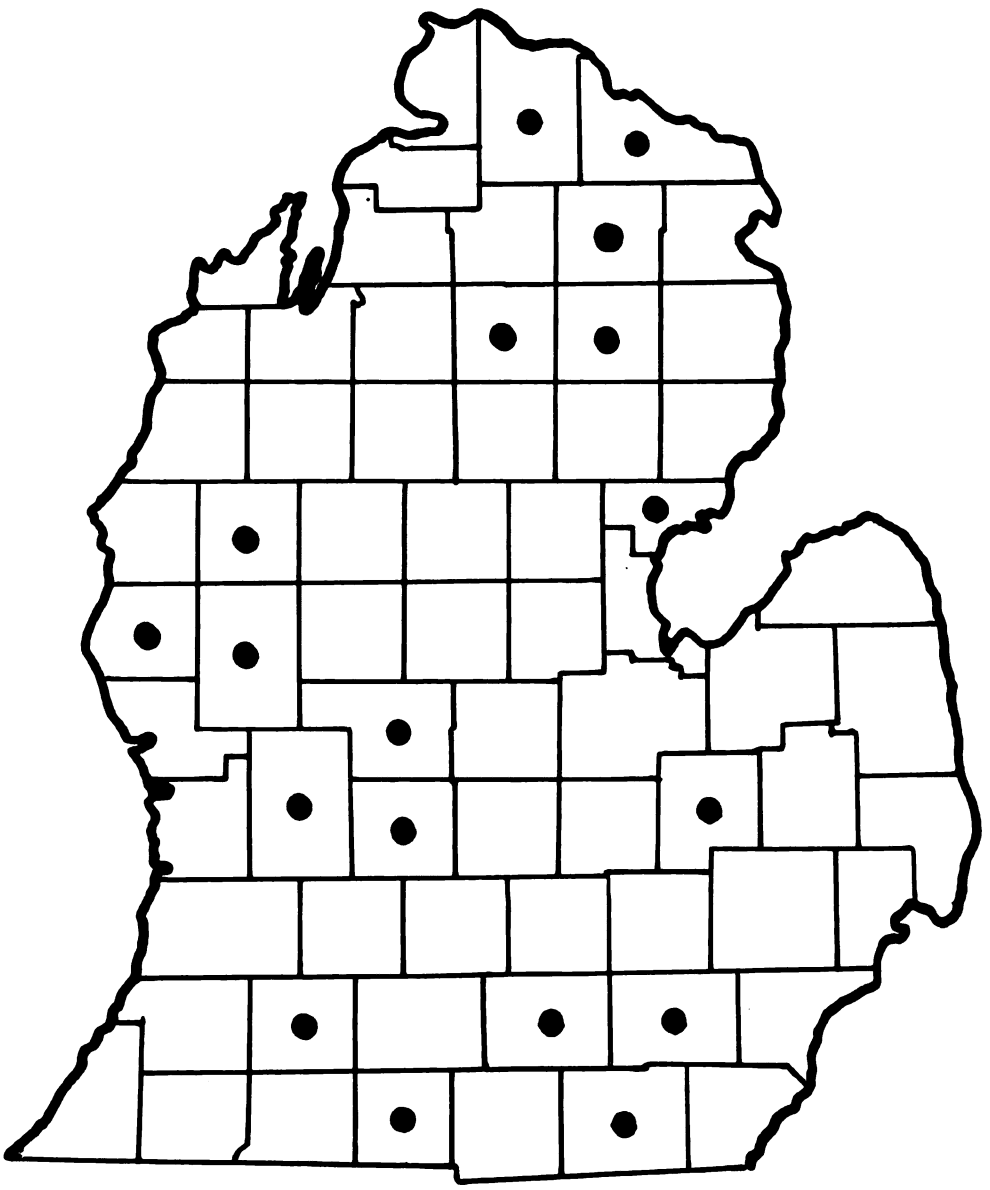

Fig. 26. Map of the Lower Peninsula of Michigan showing the distribution of *Helianthus occidentalis*

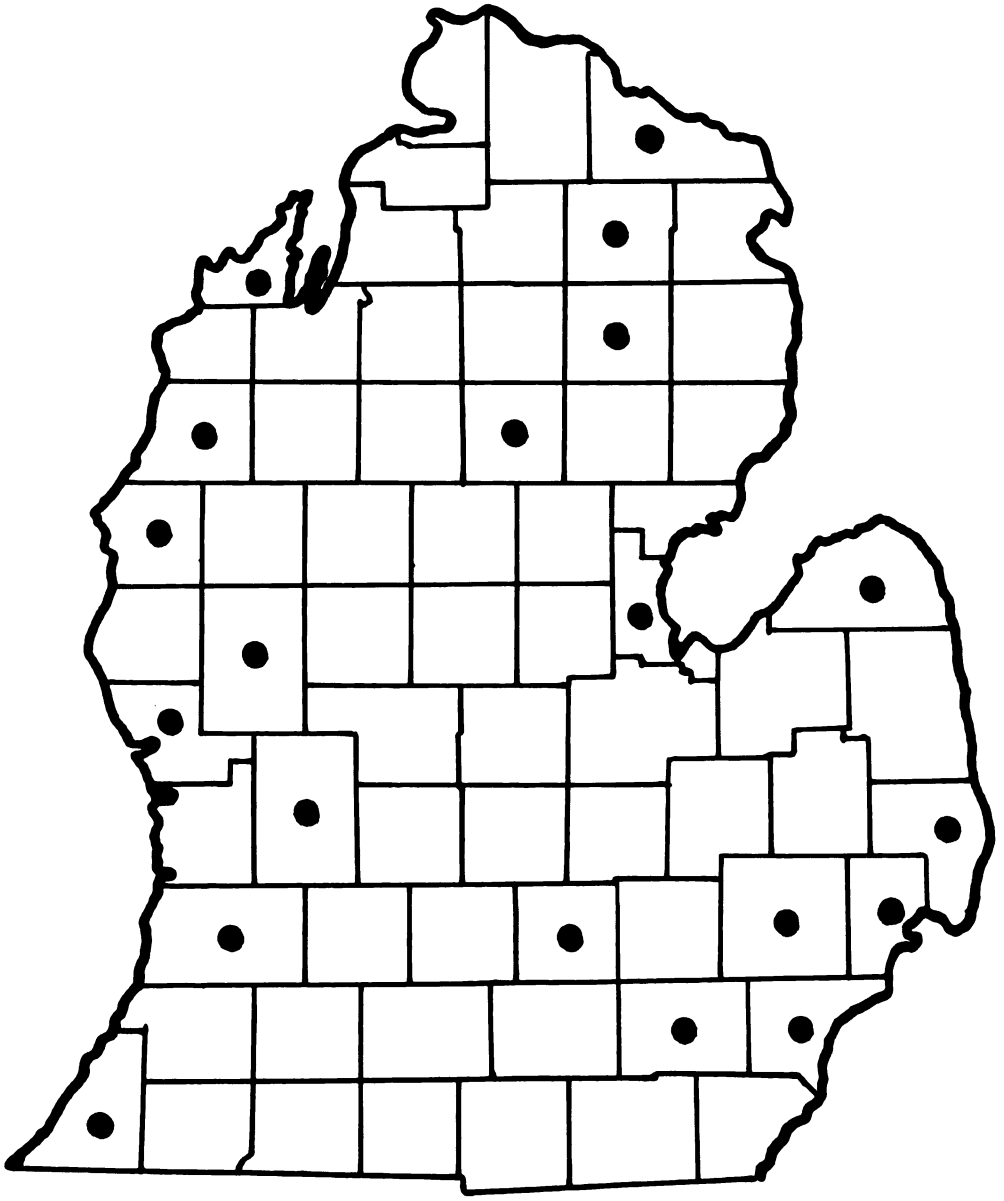

Fig. 27. Map of the Lower Peninsula of Michigan showing the distribution of *Koeleria cristata*

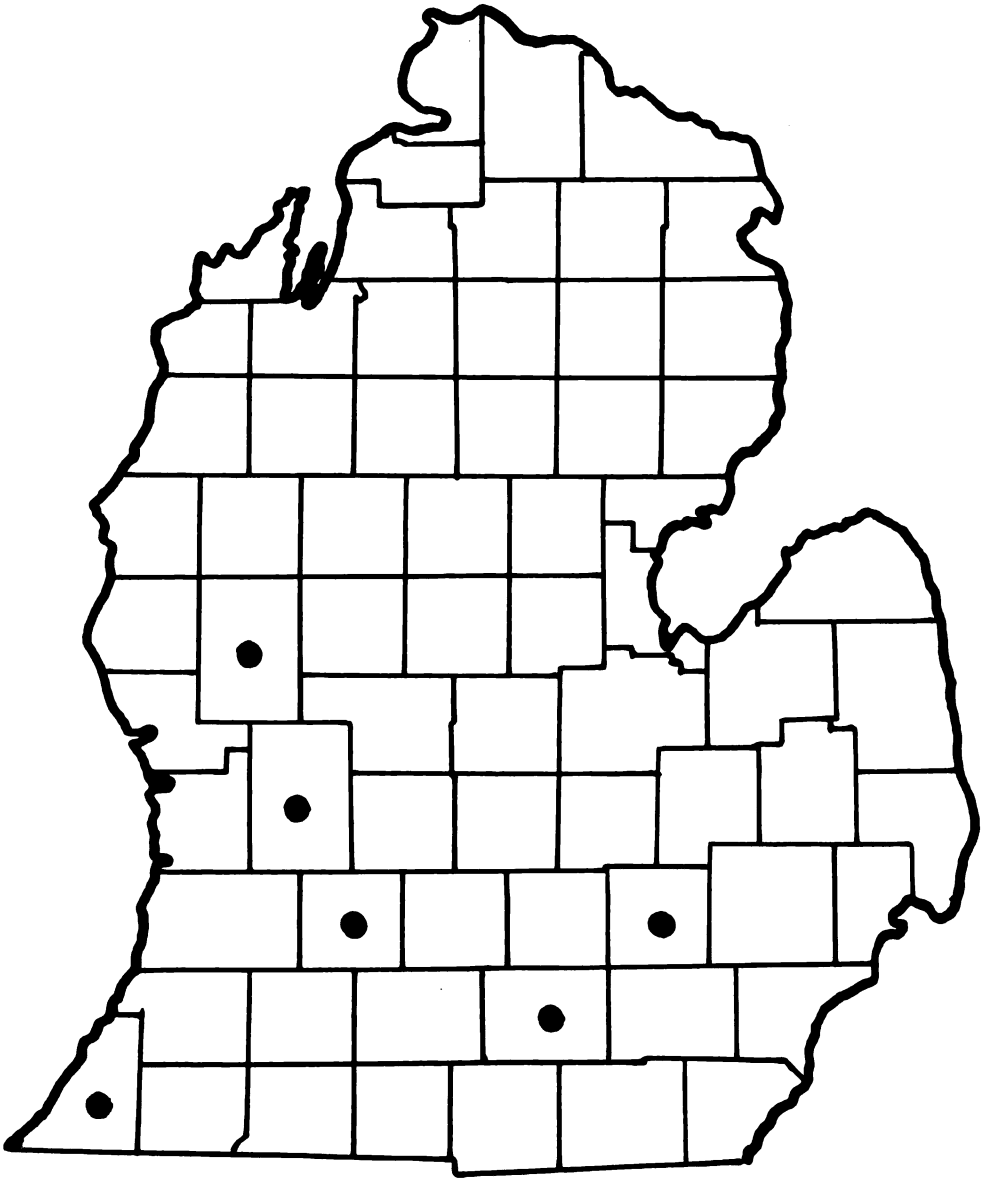

Fig. 28. Map of the Lower Peninsula of Michigan showing the distribution of **Kuhnia eupatorioides**

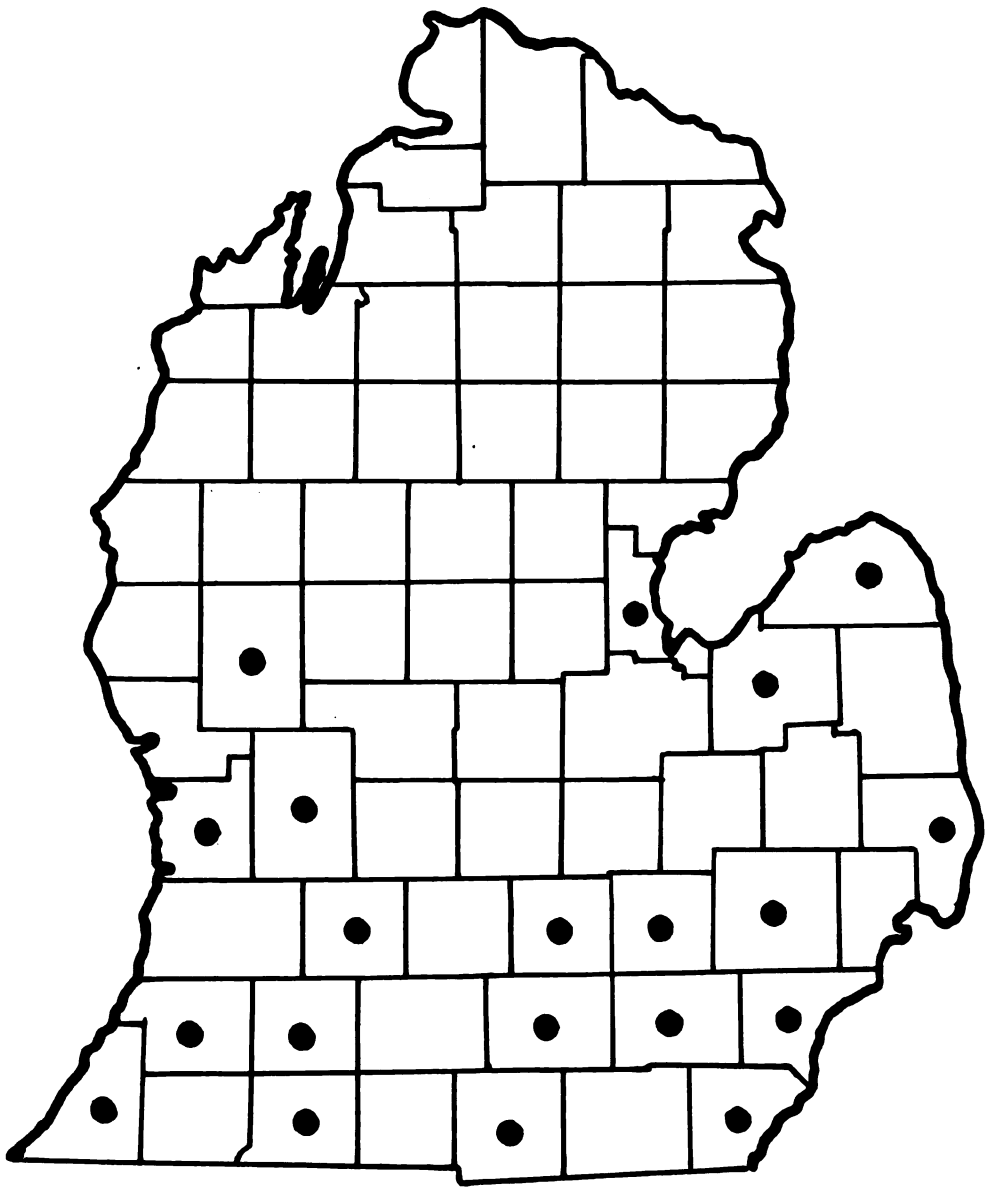

Fig. 29. Map of the Lower Peninsula of Michigan showing the distribution of Lespedeza capitata.
Data in large part from: Hauser, R. S. 1947. The taxonomy and phytogeography of the Leguminosae of Michigan. Unpublished M. S. thesis. Michigan State College

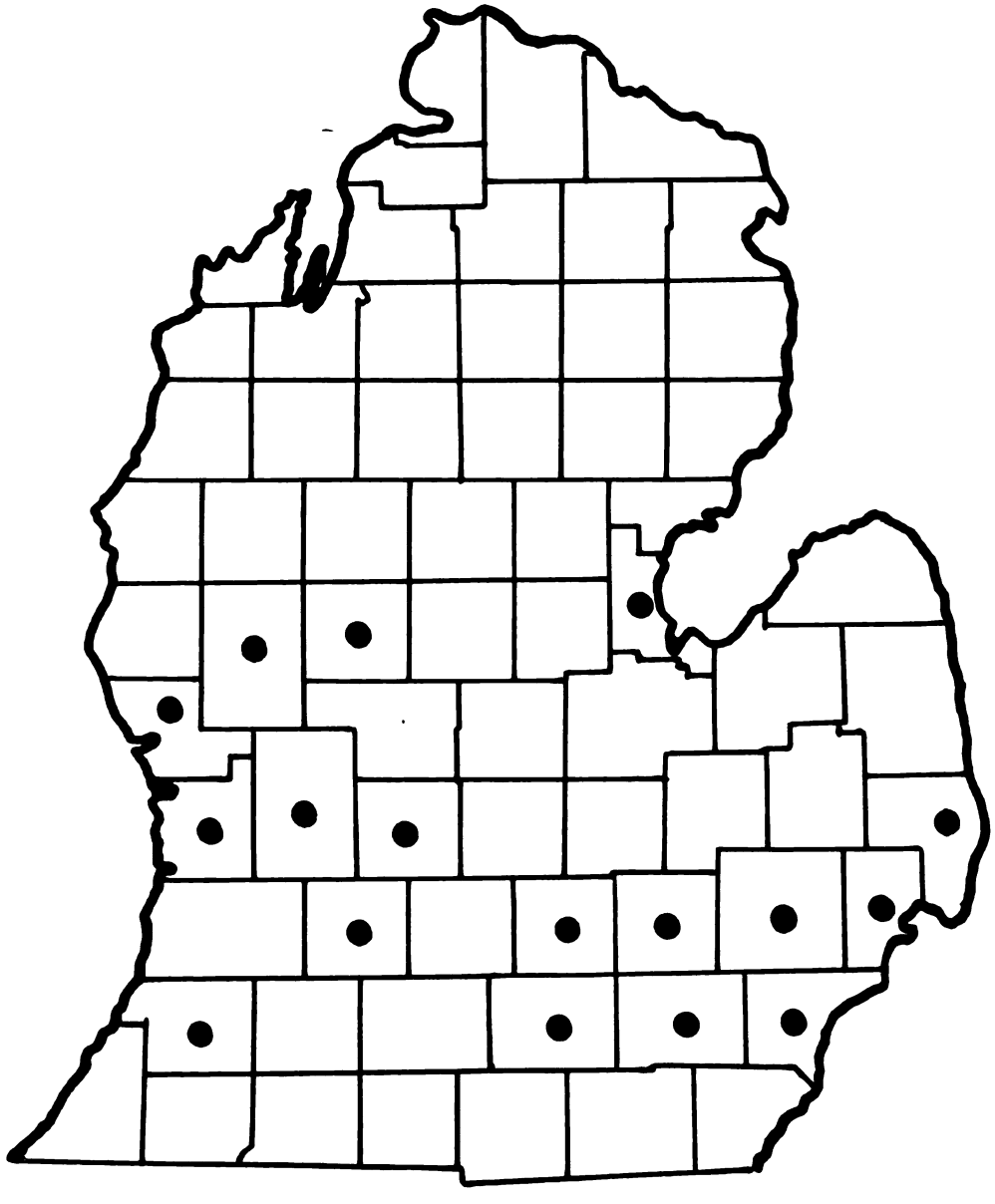

Fig. 30. Map of the Lower Peninsula of Michigan showing the distribution of **Liatris aspera var. intermedia**

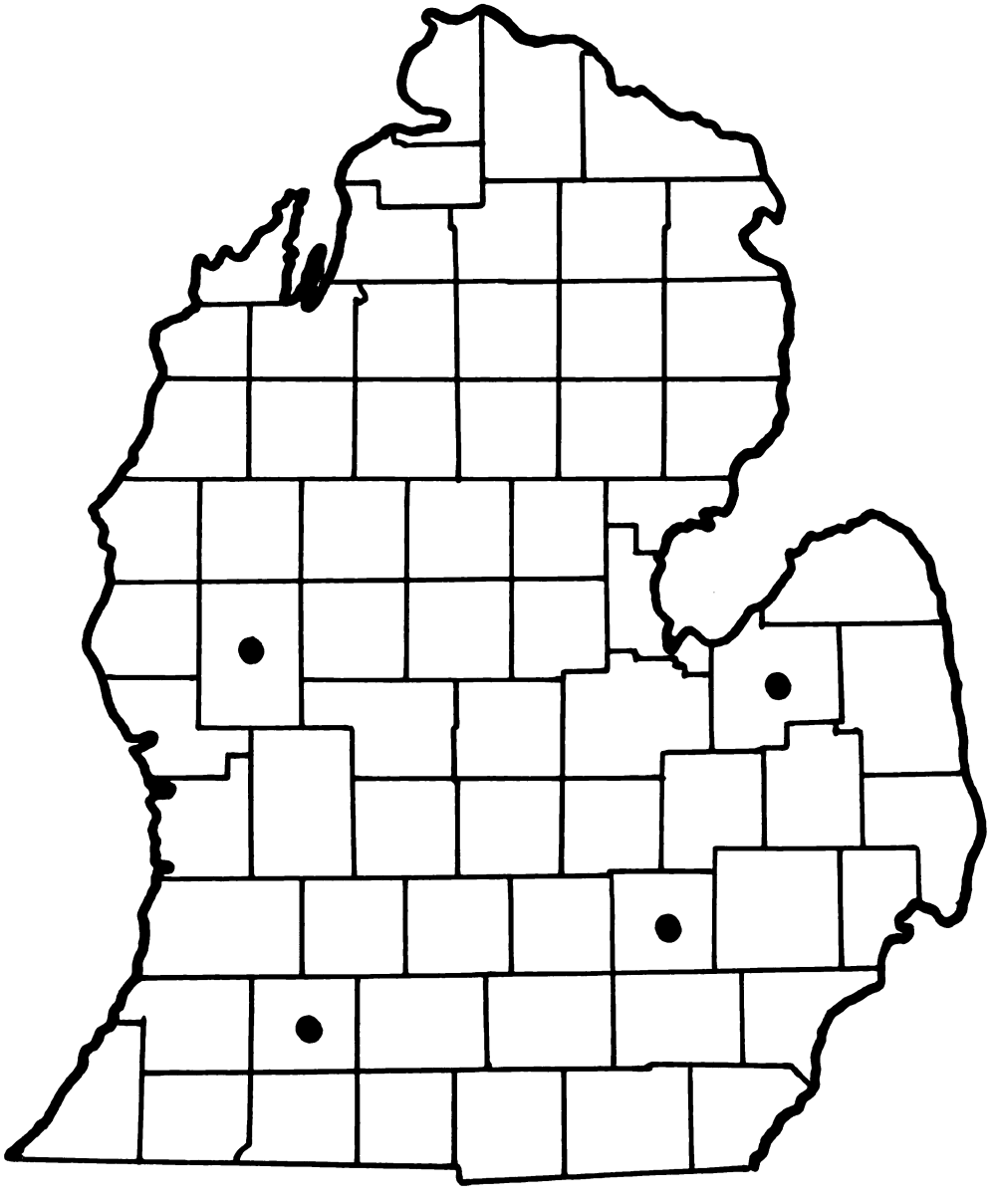

Fig. 31. Map of the Lower Peninsula of Michigan showing the distribution of **Linum sulcatum**

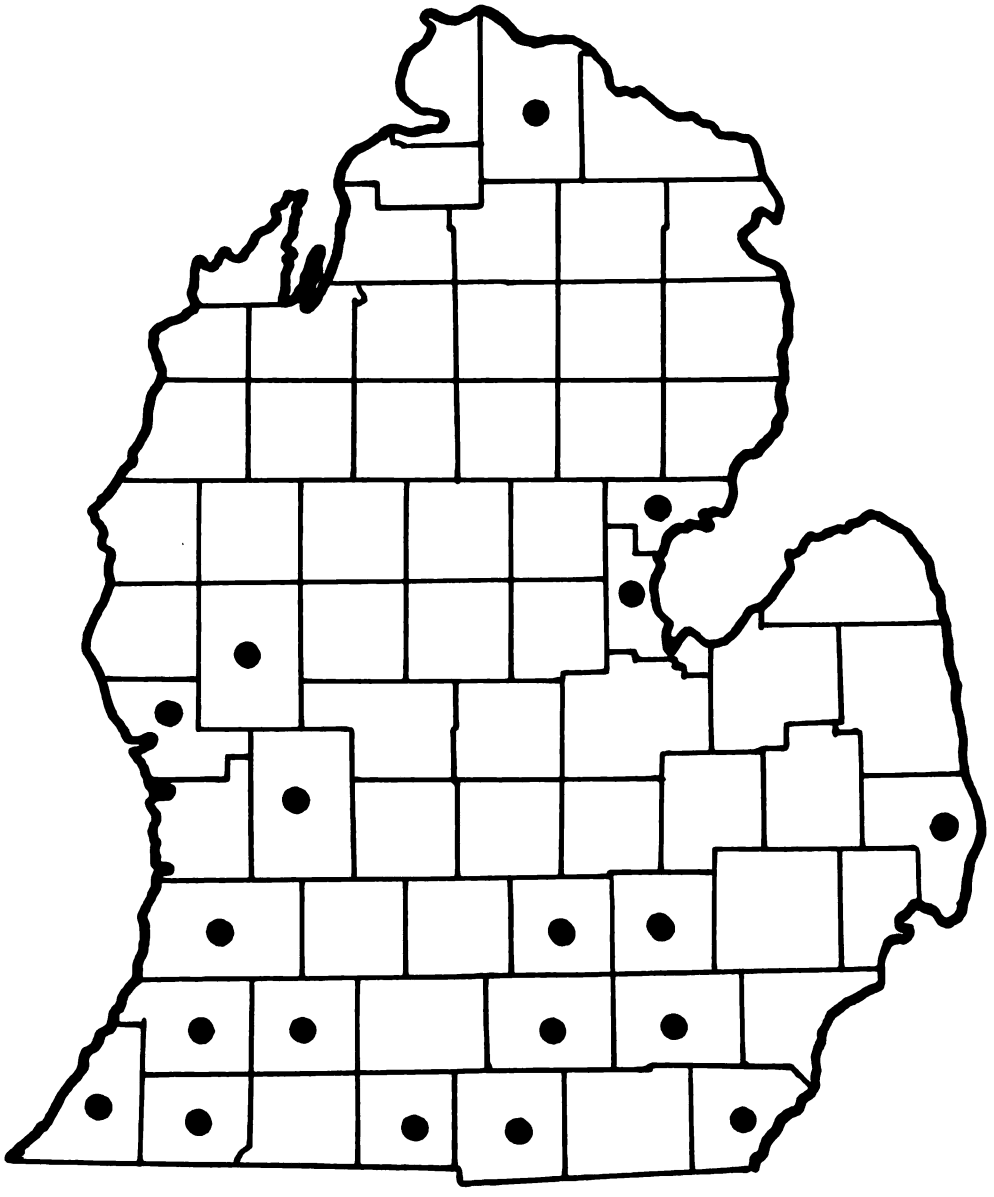

Fig. 32. Map of the Lower Peninsula of Michigan showing the distribution of **Panicum virgatum**

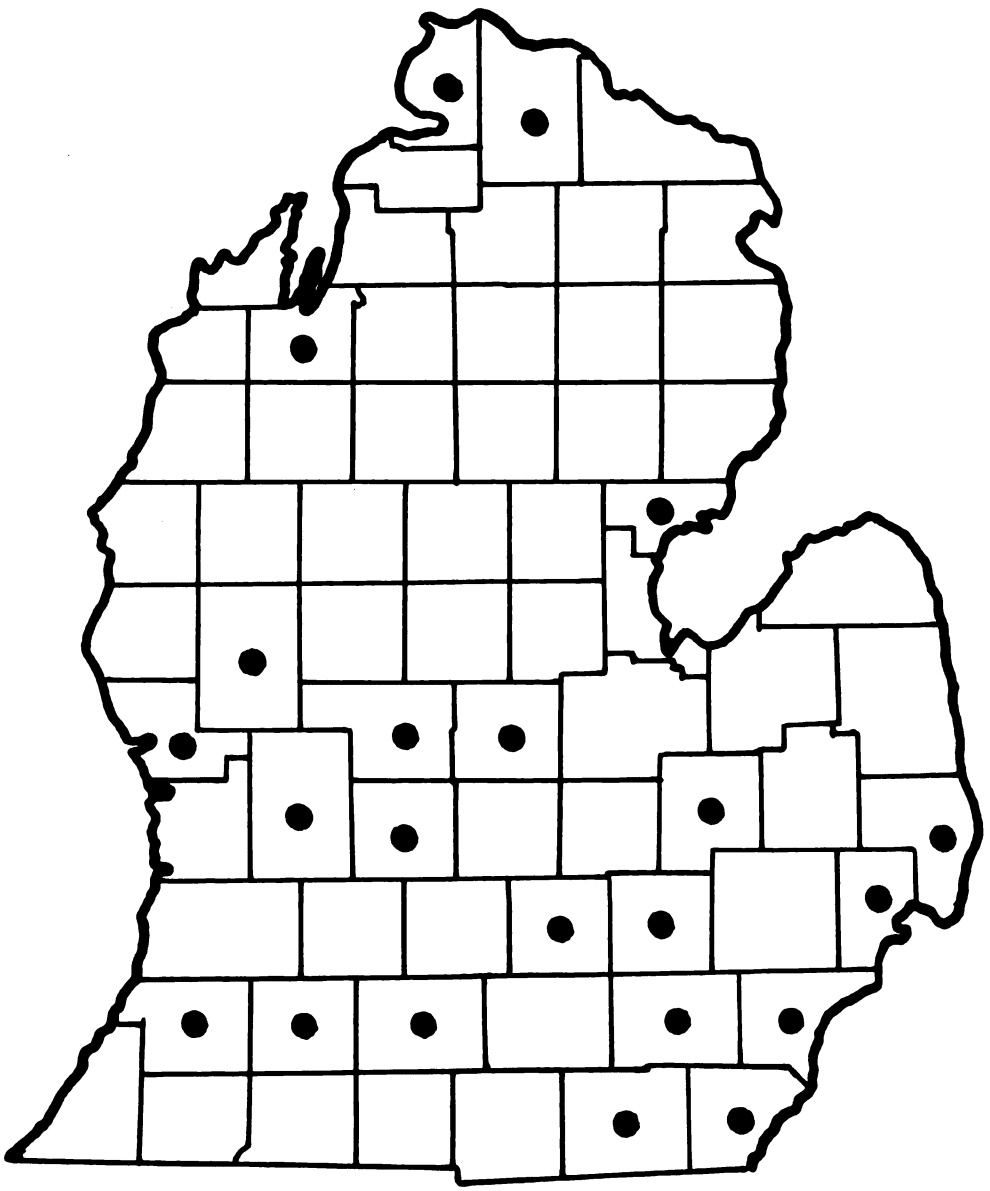

Fig. 33. Map of the Lower Peninsula of Michigan showing the distribution of **Rudbeckia serotina**

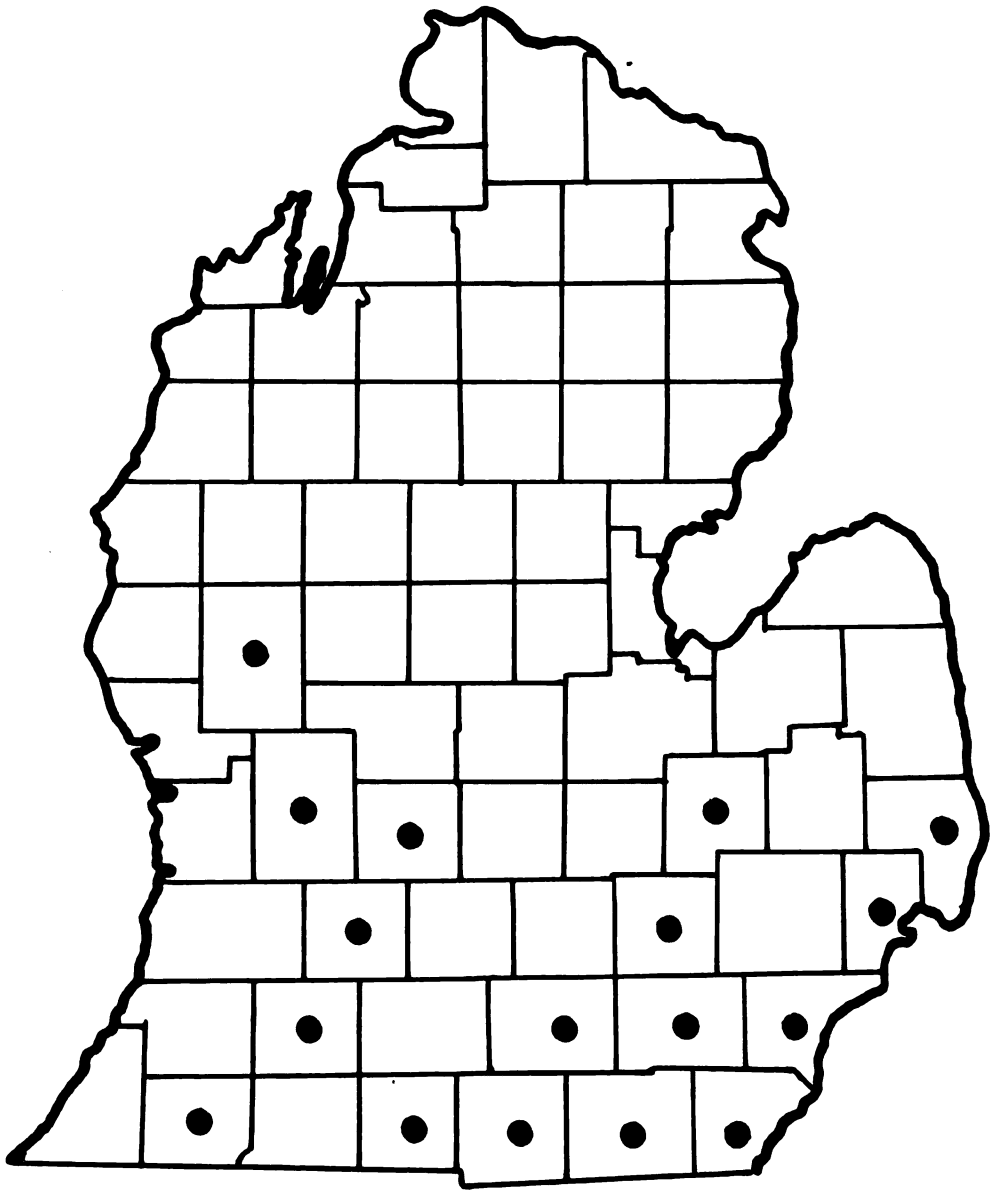

Fig. 34. Map of the Lower Peninsula of Michigan showing the distribution of *Solidago rigida*

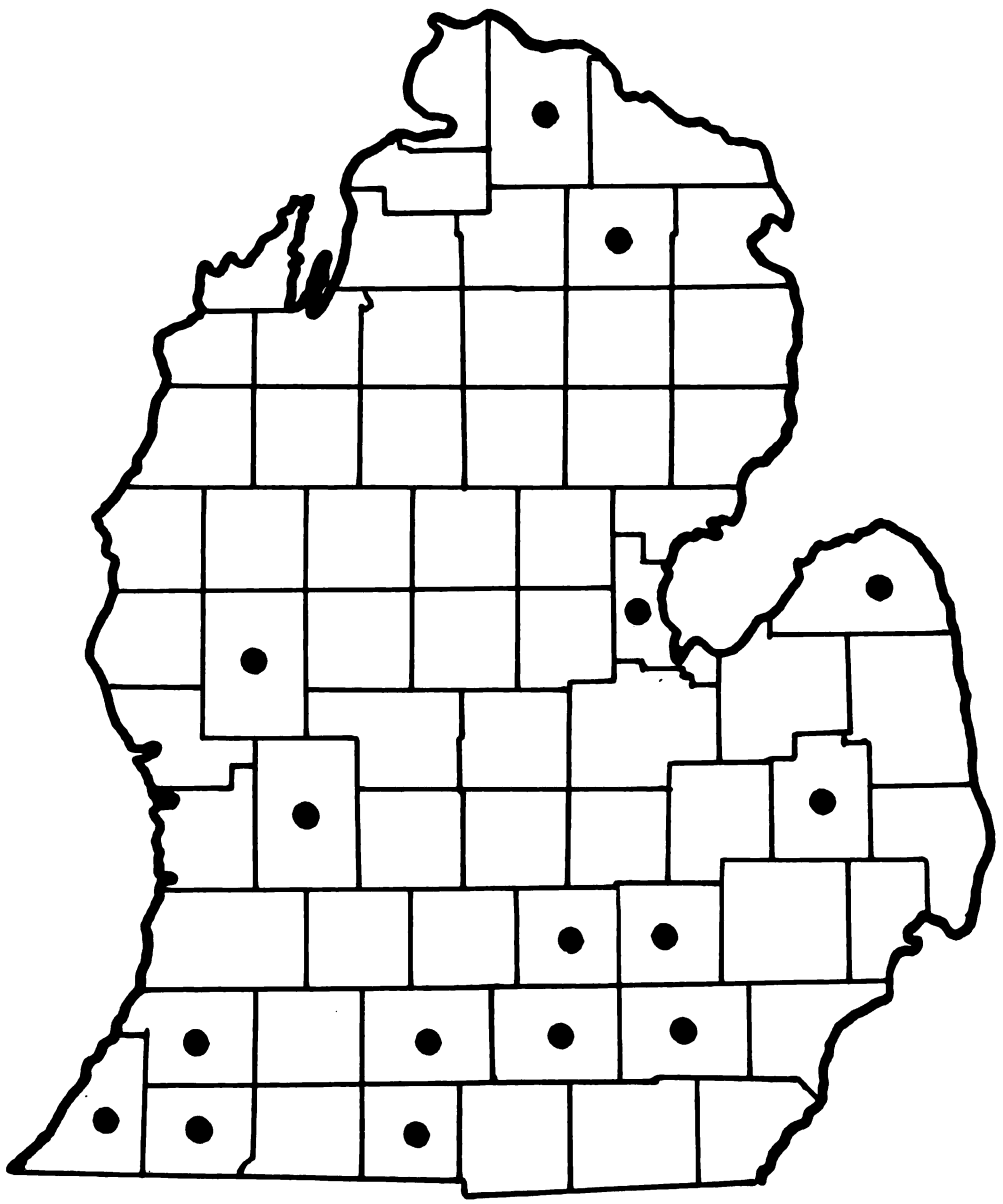

Fig. 35. Map of the Lower Peninsula of Michigan showing the distribution of Sorghastrum nutans

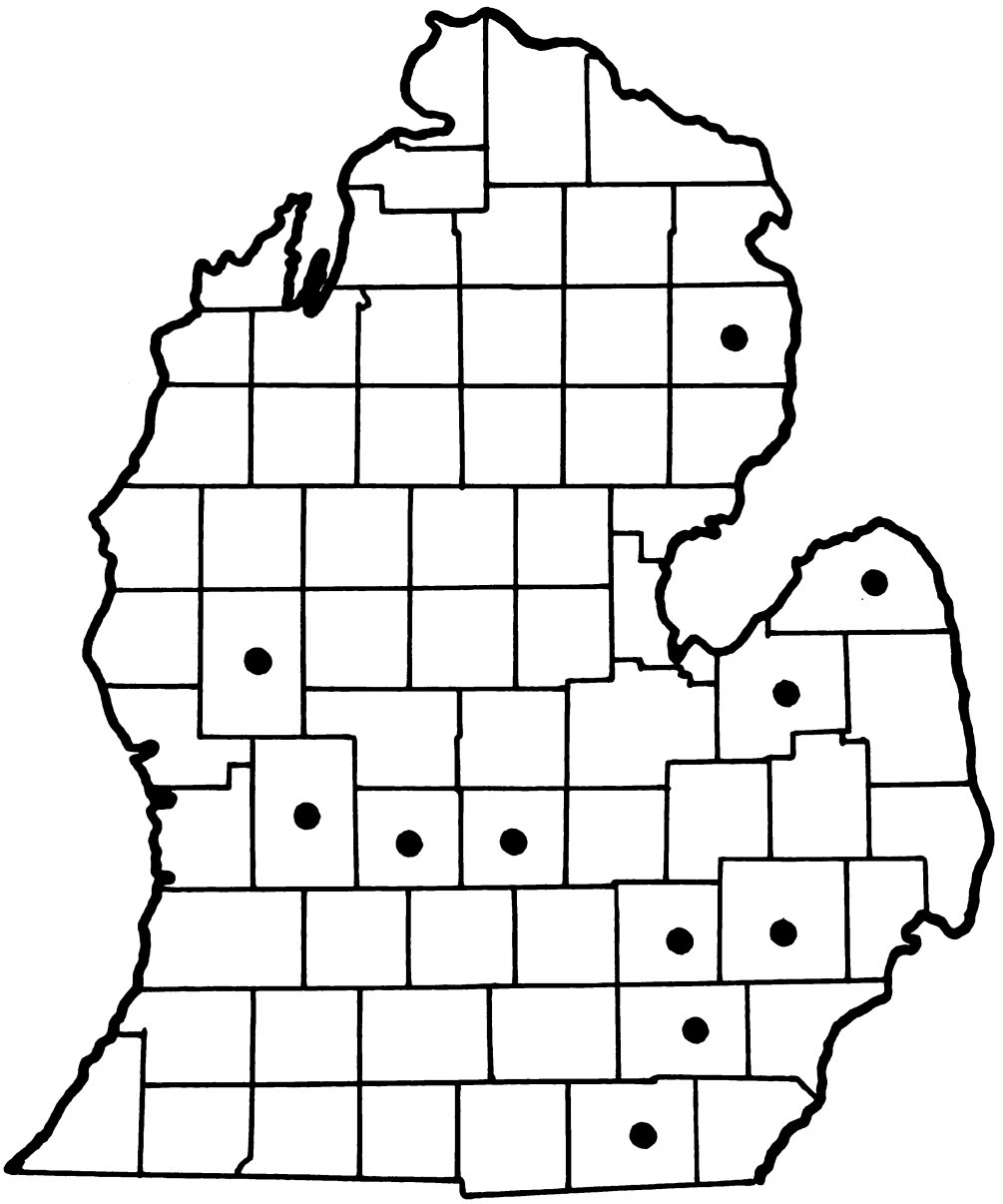

Fig. 36. Map of the Lower Peninsula of Michigan showing the distribution of **Stipa spartea**

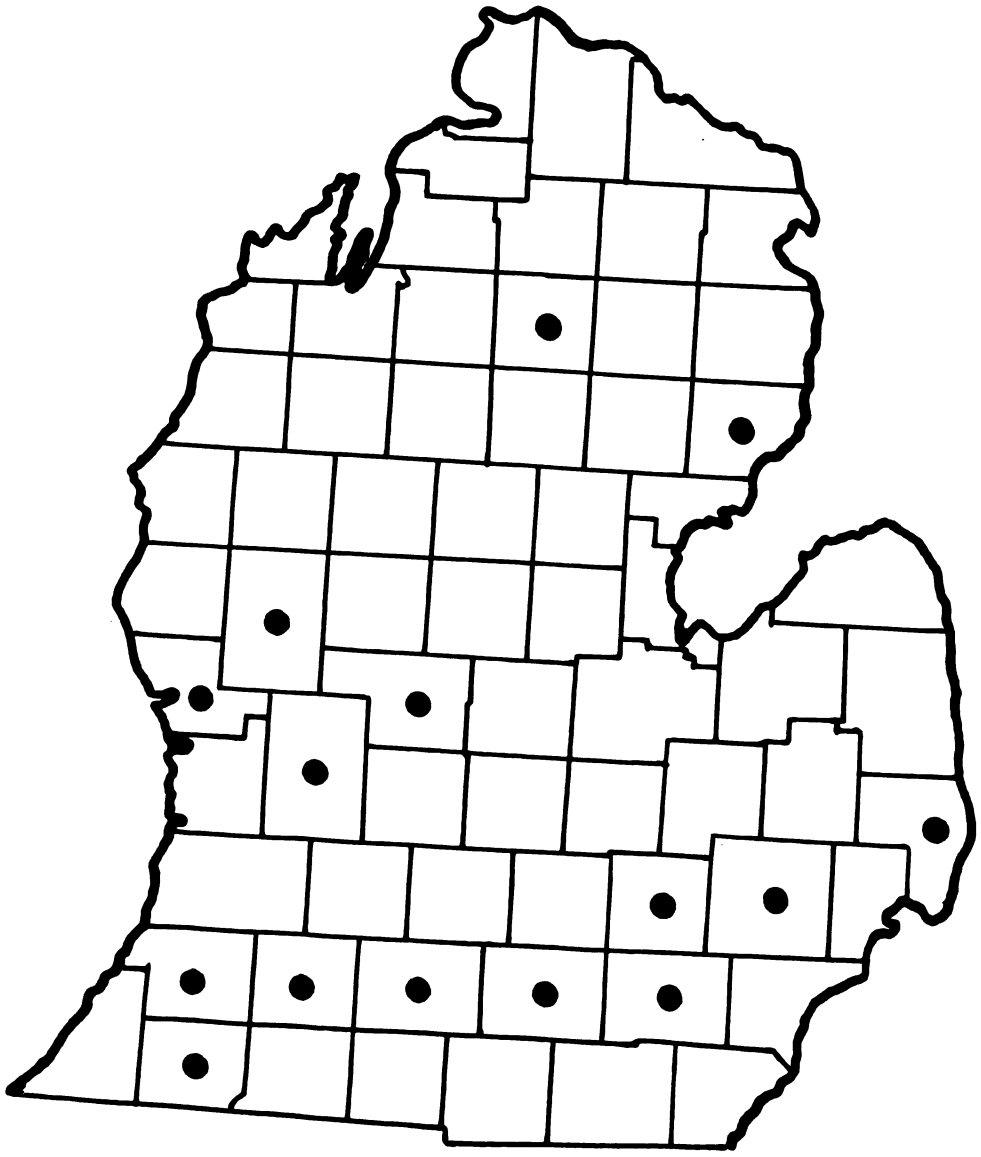

Fig. 37. Map of the Lower Peninsula of Michigan showing the distribution of **Viola pedata**

B. Plot and Quadrat Data

The field notes obtained in the plot and quadrat studies are reproduced on pages 109 to 158, inclusive. A column in provided for each of the 10 quadrats studied in every plot. The occurrence of a species in a given quadrat is indicated by a number from one to five. These numbers represent the cover classes discussed on page 45. In the last column, an x indicates that the species occurred within the 100 m^2 plot but not in any of the 10 quadrats. Varietal designations have been eliminated from the species lists. The complete nomenclature is given in Appendix C (page 159).

Area 1, Plot I

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Danthonia spicata											x
Koeleria cristata	1	2	1	2		2	2	2	2	2	
Panicum pseudopubescens			1	1			1			1	
Poa pratensis					1						
Carex pensylvanica	5	4	3	4	5	4	3	4	4	5	
Cyperus filiculmis				1							
Ambrosia psilostachya	2	1	2	2	1	2	2	2	2	3	
Gnaphalium obtusifolium				1							
Hieracium longipilum											x
Liatris aspera											x
Linaria canadensis	1		1								
Monarda punctata			1								
Polygonella articulata			1				1				
Rubus spp.		1					1				
Solidago nemoralis											x
Viola pedata						1					

Area 1, Plot II

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon scoparius		1			2		1	1	2		
Koeleria cristata	1	1	2	1	2	2	1	2	2	2	
Panicum depauperatum	1										
P. pseudopubescens		1		1	1						
Poa pratensis						2	2		2		
Carex pensylvanica	4	3	2	3	2	3	2	3	2	3	
Ambrosia psilostachya	3	2	2	2	3	2	1	2	3	2	
Artemisia caudata	1							1			
Erigeron strigosus	1										
Linaria canadensis	1	1		1	1	1		1			
Rubus spp.						1					
Solidago nemoralis				1							
Tephrosia virginiana		1	2	2	1	3	4		2	2	
Specularia perfoliata											x

Area 1, Plot III

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi	2	1	1	1	2	2	2	4	2	2	
Andropogon scoparius			1								
Koeleria cristata	2	1	1	2	1	1	2	2	1	2	
Panicum scribnerianum	1										
Carex pensylvanica	2	4	2	2	2	2	2	1	2	2	
Cyperus filiculmis							1			1	
Ambrosia psilostachya	1	1	1	2	2	1	1	1	1	1	
Artemisia caudata										1	
Coreopsis lanceolata											x
Liatris aspera								1			
Linaria canadensis					1	1	1		1		
Monarda punctata											x
Polygonella articulata										1	
Rubus spp.	1	3	3	4	3	1	2			1	
Rumex acetosella	1	1	2		2		2	2			
Solidago nemoralis						1					
Tephrosia virginiana							1				

Area 1, Plot IV

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi				3	1	1					
A. scoparius						1	1	1	1		
Eragrostis pectinacea	1		1		1		1	2		1	
Koeleria cristata	2	1	2	2		3	2	2	2	3	
Panicum depauperatum	1										
Carex pensylvanica	3	1	2	1	2	2	2	2	2	2	
Cyperus filiculmis						1					
Ambrosia psilostachya	2	2	2	1	2	2	2	1	3	2	
Euphorbia corollata		1									
Liatris aspera							1				
Linaria canadensis	1	1			1						
Mollugo verticillata		1			1						
Polygala polygama	1									1	
Solidago nemoralis	1									1	

Area 2, Plot I

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi	1		1		1	2					
A. scoparius	1			2				1		1	
Aristida purpurascens			1	1	1	1	3	2	1	1	
Panicum depauperatum				1							
P. pseudopubescens									1		
Sorghastrum nutans	1				2	1	1	1	2	2	
Carex pensylvanica	4	5	4	1	1	4	1	1	1	4	
Polygala polygama								1			
Rumex acetosella	1	1	2	1	1	1	1		1		

Area 4, Plot I

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi	3	2	1	1	2	2		2	2	2	
A. scoparius	1	1	2	2	1					1	
Aristida purpurascens			1	1		1			1		
Koeleria cristata						1					
Panicum depauperatum		1		1							
P. pseudopubescens	1				1	1	1	1	1		
Sorghastrum nutans	2						2	2	1	1	
Carex pensylvanica	1	1	1	1	1	1	2	1	1	1	
Ambrosia psilostachya						1	1		1		
Artemisia caudata	1						1				
Liatris aspera				1							
Polygala polygama	1	1		1	1						
Solidago nemoralis	1	1	1		1			1	2	1	
Polygonella articulata	1	1			1	1	1			1	
Viola pedata		1		1						1	

Area 6, Plot I

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi			4					1	2	1	
A. scoparius		2			2	2	1			1	
Panicum pseudopubescens						1					
P. virgatum				1	1	1	1	1	1	1	
Sorghastrum nutans											x
Carex pensylvanica	5	2	1	4	1	3	4	4	3	2	
Gnaphalium obtusifolium									1		
Polygonella articulata		1									
Tephrosia viginiana	2	2	1	3	1		2	2	1	1	

Area 6, Plot II

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi		1		2	1	2	1		1		
Andropogon scoparius	1	1	1	1	1	1	1	1	1	2	
Danthonia spicata											x
Koeleria cristata	1	1	2	1	1	1	1	1	1	2	
Panicum pseudopubescens		1	1								
P. depauperatum		2	1					1		1	
Sorghastrum nutans	1						1	1			
Carex pensylvanica	1	1	1	1	3	3	2	2	2		
Ambrosia psilostachya	1		1				1	1	1		
Gnaphalim obtusifolium											x
Hypericum perforatum											x
Linaria canadensis			1								
Polygala polygama		1	1		1			1		1	
Rumex acetosella	1										
Solidago nemoralis				1							
Tephrosia virginiana		1	1							1	
Viola pedata		1			1		1	1	1	1	

Area 7, Plot I

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi		2	1		2			3		2	
A. scoparius		1	1	1		1	1	1	1		
Eragrostis pectinacea										1	
Koeleria cristata	2	1	1	1	1	2		2	1	1	
Panicum pseudopubescens	1		1	1		1	1	1	1	2	
Sorghastrum nutans	1					1		1			
Carex pensylvanica	2	1	2	3	4	2	3	1	1	1	
Cyperus filiculmis								1			
Gnaphalium obtusifolium					1				1	1	
Polygala polygama							1	1		1	
Polygonella articulata	1										
Solidago nemoralis			1	1							
Tephrosia virginiana			1	2	1	3		1	3	1	
Viola pedata	1			1							

Area 8, Plot I

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi									1		
A. scoparius	2	1	1	1	1			1	1	1	
Koeleria cristata	1	1	2	1	1				1	1	
Panicum depauperatum		1									
P. pseudopubescens	1	1			1	1					
Sorghastrum nutans			1								
Carex pensylvanica	3	3	3	2	4	4	4	2	3	2	
Gnaphalium obtusifolium											x
Polygonella articulata											x
Rumex acetosella	1	1		1	1	1	1	1		1	
Solidago nemoralis										1	
Tephrosia virginiana					2	2	1		1		
Viola pedata	1	1	1	1						1	

Area 11, Plot I

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Aristida purpurascens		1									
Eragrostis pectinacea									1		
Poa compressa	1	1	1	3		3	2	1	1	1	
P. pratensis			1								
Sporobolus cryptandrus	1	1	1	1	2	1	1	1	1	1	
Cyperus filiculmis		1			1	1	1				
Ambrosia psilostachya	1	1	1	1		1		1	1	1	
Anemone cylindrica										1	
Erigeron strigosus										1	
Euphorbia corollata						1	1	1	1		
Helianthemum canadense			1								
Hieracium longipilum								1			
Hypericum perforatum					1		1	1			
Liatris aspera		1								1	
Linum sulcatum		1	1		1				1	1	
Lithospermum croceum								1			
Monarda punctata						1					
Oenothera sp.			1	1						1	
Polygala polygama		1	1					1			
Polygonella articulata	1		1								
Rubus spp.		1									
Rudbeckia serotina						1				1	
Solidago nemoralis	1	1	1	1	1		1	1			

Area 12, Plot I

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi	1	1	1	1	1		2	1	1	4	
A. scoparius		2	2	1	1				2		
Eragrostis pectinacea						1	1				
Koeleria cristata	1	1	1	1	1	1	1		1	1	
Panicum depauperatum	1										
Sorghastrum nutans	1		1				1				
Stipa spartea	1							1			
Carex pensylvanica	1	1	1	1	1	1	1	2	1	1	
Cyperus filiculmis	1		1			1	1				
Ambrosia psilostachya	1	1	1	1	1	1	1		1	1	
Arenaria stricta	1	1	1	1	1	1	1	1	1	1	
Artemisia caudata		1		1		1					
Aster ericoides	1			1					1		
A. sericeus*											
Blephilia ciliata					1					1	
Coreopsis lanceolata					1				1		
Erigeron ramosus											x
Euphorbia corollata											x
Helianthus occidentalis	2	2	1	2		1	1	2	1		
Hieracium longipilum						1					
Kuhnia eupatorioides*											
Liatris cylindracea		1	1	1						1	
Liatris aspera						1					
Linaria canadensis						1				1	
Lithospermum croceum											x
Penstemon hirsutus		1									
Polygala polygama	1				1					1	
Rosa carolina	1	1		1	1	1		1	1		
Viola pedata		1				1					

*Aster sericeus was frequent throughout the area, although not found in the plot. Kuhnia eupatorioides was found along the road, a few yards south of the area.

Area 14, Plot I

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon scoparius	4	3	2	2	3			1	2	1	
Aristida purpurascens									1		
Panicum depauperatum										1	
P. pseudopubescens											x
Carex pensylvanica	2	2	4	3	3	3	5	3	3	2	
Cyperus filiculmis						1					
Euphorbia corollata					1					1	
Helianthus occidentalis						1			2		
Hieracium longipilum											x
Krigia virginica				1							
Liatris aspera		1									
Linaria canadensis	1		1	1		1		1			
Mollugo verticillata				1							
Polygala polygama		1						1	1		
Rubus spp.			1				2				
Rumex acetosella						1					
Solidago nemoralis						1	1	1			

Area 14, Plot II

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi	1	1	1	2							
A. scoparius		1			1	2	2	1	2	1	
Eragrostis pectinacea	1		1		1						
Koeleria cristata	1	1	2	2	1	1	1	1	1	1	
Panicum depauperatum	1		1	1	1			1	1		
Panicum pseudopubescens		1									
Carex pensylvanica	1	1		1	1	1	1	1	1	1	
Cyperus filiculmis	1	1	1	1		1		1	1	1	
Ambrosia psilostachya	1	1	1		1			1	1		
Anemone cylindrica	1	1	1		1						
Artemisia caudata	1								1		
Aster azureus				1						1	
Convolvulus spithamaeus			1						1		
Euphorbia corollata	1	1	1	1	1	1	1		1		
Helianthemum canadense					1	1		1	1		
Helianthus hirsutus			1	1						1	
H. occidentalis	1	2	2	2	2	2	1	1	1	1	
Hieracium longipilum					1	1		1	1		
Hypericum perforatum		1	1								
Lespedeza capitata											x
Liatris aspera	1					1	1	1	1		
Linaria canadensis		1									
Linum sulcatum	1		1	1	1		1	1	1	1	
Monarda punctata						1					
Polygala polygama	1			1		1	1				
Polygonella articulata									1		
Potentilla arguta										1	
Rubus sp.							1				
Solidago nemoralis	1								1	1	
Specularia perfoliata									1		
Viola pedata	1	1	1			1	1	1	1		

Area 15, Plot I

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Koeleria cristata	2	1	1	2	1	2	2	2	2	1	
Panicum depauperatum	1	1	1	1	1	1	1	2	1	1	
P. pseudopubescens		1	1	1		1	1				
Carex pensylvanica	1	1	1	1	1	1	1	1	1		
Cyperus filiculmis	1	1		1	1			1			
Ambrosia psilostachya	1	1	1	1	1	1	1	1	1	1	
Artemisia caudata		1	1		1						
Aster azureus									1		
Coreopsis lanceolata	1	1	1	1	1	1	1	1	1	1	
Erigeron strigosus											x
Euphorbia corollata	1	1	1	1						1	
Euphorbia cyparissias			1	3	2	1	1	1	2		
Helianthemum canadense	1			1	1		1	1	1		
Helianthus occidentalis	1	2	3							2	
Hieracium longipilum								2	2		
Lespedeza capitata		1					1			1	
Liatris aspera	1	1					1		1		
Linum sulcatum	1	1	1	1	1	1	1	1	1	1	
Lithospermum croceum											x
Monarda punctata	1		1	1	1						
Oenothera sp.					1						
Polygala polygama		1	1	1	1		1	1	1	1	
Rubus sp.				1	1						
Solidago nemoralis						1	1	1	1		

Area 15, Plot II

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon scoparius	3	3	2	3	2	2	2	3	2	3	
Koeleria cristata	1		1								
Panicum pseudopubescens		1									
Carex pensylvanica	2	2	2	2	2	2	1	1	1	2	
Ambrosia psilostachya		1	1	1					1		
Euphorbia corollata			1								
Helianthemum canadense								1			
Helianthus occidentalis			2			1					
Hieracium longipilum							1				
Krigia virginica					1	1			1		
Liatris aspera	1	1	1	1	1	1		1	1	1	
Polygala polygama		1						1			
Rubus sp.					1	1	1	1	1		

Area 15, Plot III

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon scoparius	2	1	1	1		2	2	2	2	2	
Eragrostis pectinacea		1									
Koeleria cristata	2	1	1	1	2	1	1	2	1	1	
Panicum depauperatum				1				1	1		
P. pseudopubescens								1		1	
P. scribnerianum	2										
Poa compressa							1				
Carex pensylvanica		1	1	4	3		1		1	4	
Cyperus filiculmis											x
Ambrosia psilostachya	1	1	1	1	2	1	1	1	1	1	
Euphorbia corollata		1						1			
Helianthemum canadense											x
Helianthus occidentalis		2				2			2		
Krigia virginica		1						1			
Liatris aspera							1				
Linaria canadensis	1	1			1	1	1				
Monarda punctata									1		
Oenothera sp.											x
Polygala polygama	1	1		1	1	1		1		1	
Rubus sp.							1				
Rumex acetosella	1				1	1	1	1	1		
Viola pedata					1	1					

Area 15, Plot IV

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon scoparius	3	2	1	3	3	2	3	3	2	2	
Danthonia spicata		1	1	1		1	1			1	
Koeleria cristata		1	1				1	1		1	
Panicum depauperatum	1										
P. Pseudopubescens			1								
P. scribnerianum			1								
Carex pensylvanica	1	2	1	1	1	2	1	1	1	1	
Cyperus filiculmis			1								
Ambrosia psilostachya	1	1	1			1	1	1		1	
Artemisia caudata			1				1	1			
Erigeron strigosus			1								
Euphorbia corollata											x
Helianthemum canadense											x
Helianthus occidentalis				1	2	2			2	1	
Hieracium longipilum						1			1	1	
Krigia virginica										1	
Liatris aspera							1	1	1	1	
Polygala polygama				1	1	1			1	1	
Rubus sp.	2	3	3	1			1	2	1	2	
Solidago nemoralis										1	

Area 15, Plot V

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Aristida purpurascens			1	1				1			
Koeleria cristata				1			1			1	
Panicum depauperatum					1						
P. pseudopubescens	1								1		
P. scribnerianum				1							
Carex pensylvanica	4	2	2	4	3	3	2	3	3	2	
Ambrosia psilostachya	2	2	1	1	2	1	1	1	2	1	
Euphorbia corollata										1	
Helianthus occidentalis		1	2	1							
Hieracium longipilum				1							
Krigia virginica										1	
Linaria canadensis										1	
Penstemon hirsutus											x
Polygala polygama						1				1	
Prunus serotina											x
P. virginiana											x
Rubus sp.	2		2		2	3	4	4	2	1	
Solidago nemoralis	1										
S. missouriensis								1	1		

Area 16, Plot I

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi						1		3	2		
A. scoparius	2		1	2	1	1	3		1		
Aristida purpurascens						1					
Koeleria cristata		1	1	1							
Sorghastrum nutans		2	2	1					1	1	
Carex pensylvanica	3	4	2	2	3	4	2	4	2	3	
Cyperus filiculmis										1	
Ambrosia psilostachya					1						
Arenaria stricta			1								
Euphorbia corollata											x
Hieracium longipilum											x
Liatris aspera	1		1								
Opuntia humifusa	1										
Solidago nemoralis											x
Tephrosia virginiana				1				1	1	1	
Viola pedata					1			1			

Area 16, Plot II

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi					3		2				
A. scoparius			1				1				
Eragrostis pectinacea				1				1			
Koeleria cristata	1			1		1	1	1	1	1	
Panicum pseudopubescens		1									
Sorghastrum nutans	1	1		1		1		1		1	
Poa pratensis						1	1		1		
Carex pensylvanica	3	2	1	2	3		1	1	2	1	
Cyperus filiculmis							1				
Ambrosia psilostachya	1	1	1	1		1	1	1	1	1	
Arenaria stricta						1	1	1	1		
Aster azureus											x
A. ericoides								1			
Euphorbia corollata										1	
Hieracium longipilum						1					
Liatris aspera	1	1									
Linum sulcatum							1				
Penstemon hirsutus				1							
Polygala polygama	1		1								
Polygonella articulata						1					
Tephrosia virginiana					1				1		
Viola pedata						1					

Area 16, Plot III

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi						1					
Eragrostis pectinacea	1								1		
Koeleria cristata		1	1	2	1	2	1	2	2	1	
Panicum depauperatum	1		1		1				1	1	
P. pseudopubescens					1						
Poa pratensis	1	1					1	1			
Carex pensylvanica				1							
Cyperus filiculmis	1			1		1		1			
Equisetum sp.	1										
Ambrosia psilostachya	2	1	1	1	1	2	1	2	1	1	
Artemisia caudata										1	
Asclepias viridiflora	1				1						
Coreopsis lanceolata			2		1					1	
Euphorbia corollata	1	1	1	1	1	1	1	1	1		
Hieracium longipilum			1	1	1			1			
Lactuca canadensis					1						
Liatris aspera	1	1	1	2	1	1	1	2	1	1	
Linum sulcatum		1		1	1	1	1	1		1	
Lithospermum croceum	1					1		1			
Monarda punctata	1	1	1	1			1		1	1	
Oenothera sp.										1	
Polygala polygama			1					1	1		
Polygonella articulata	1	1									
Rubus sp.			1								
Solidago nemoralis				1						1	

Area 16, Plot IV

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi	1	4		2	2	1	4		3	1	
A. scoparius	3		2	2	2	2	1	3	1	2	
Aristida purpurascens		1		1							
Panicum pseudopubescens			1			1			1		
Carex pensylvanica	1	1	1		1	1	1	1	1	1	
Ambrosia psilostachya		1	1	1						1	
Euphorbia corollata	1	1		1	1	1	1	1	1	1	
Hieracium longipilum		1	1	1	1	1		1	1		
Liatris aspera										1	
Polygala polygama			1	1	1	1		1	1	1	
Polygonella articulata			1								
Rumex acetosella				1							
Solidago nemoralis			1							1	

Area 16, Plot V

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon scoparius	1	2	1	2		2	3	3	2	3	
Aristida purpurascens		1			1	1	1	1	1		
Eragrostis pectinacea		1									
Koeleria cristata										1	
Panicum depauperatum				1	2	1		1		1	
Carex pensylvanica	4	3	5	4	1	1	1	1	1	1	
Cyperus filiculmis										1	
Ambrosia psilostachya	1	1	1	2	1				1	1	
Euphorbia corollata	1	1		1							
Liatris aspera	1	1				1	1	1	1		
Polygala polygama		1				1	1	1	1		
Rumex acetosella				1	1	1		1	1	1	

Area 16, Plot VI

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi	1						3			1	
A. scoparius	2	2		2	1			1	1	3	
Aristida purpurascens						1					
Eragrostis pectinacea			1	1			1	1	1		
Koeleria cristata		1	3	1		1	1		1		
Sorghastrum nutans	1		1								
Carex pensylvanica	2	1	2	4	5	1	4	4	2	2	
Ambrosia psilostachya	1	1	1	1	1	1	1	1	1		
Hieracium longipilum			1	1					1	1	
Liatris cylindracea									1		
Liatris aspera			1							1	
Polygala polygama	1	1									
Rumex acetosella	1	1	1	1	1	1		1	1	1	
Solidago nemoralis	1	1	1								
Viola pedata	1				1	1	1		1		

Area 17, Plot I

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi								4			
A. scoparius		1									
Eragrostis pectinacea				1				1		1	
Koeleria cristata	1			1		1		1	1		
Poa compressa									1		
P. pratensis					1	1					
Sorghastrum nutans											x
Carex pensylvanica	2	3	2	3	3	4	4	1	2	3	
Cyperus filiculmis							1				
Ambrosia psilostachya		1		1	1	2	1	1	1		
Arenaria stricta	1	1		1	1	1	1	1	1	1	
Aster azureus						1					
A. ericoides					1						
A. sericeus						1					
Euphorbia corollata				1	1	1		1	1	1	
Gnaphalium obtusifolium								1			
Helianthus occidentalis				1	2	1	2	1	2	1	
Hieracium longipilum				1			1	1			
Krigia virginica	1										
Opuntia humifusa		1									
Polygala polygama								1	1		
Rosa carolina					1						
Solidago nemoralis							1	1			
Tephrosia virginiana	1		1							1	
Viola pedata		1								1	

Area 18, Plot I

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi	2								2		
A. scoparius	3	2	1	1	2	2	3	3	1	2	
Aristida purpurascens			1	1	1	1		1	1	1	
Koeleria cristata			1								
Panicum depauperatum			1				1	1			
P. pseudopubescens						1					
Carex pensylvanica	1	2	2	2	2	1	1	1	1	1	
Hieracium longipilum											x
Krigia virginica			1	1	1	1					
Liatris aspera	1	1								1	
Polygala polygama						1			1	1	
Rubus sp.	1	2	2	3	2	2		1	1	2	
Rumex acetosella	1						1				
Solidago graminifolia		1	1								
S. nemoralis		1				1					
Tephrosia virginiana								1			

Area 18, Plot II

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon scoparius		3	2	4	4	3	4	4	4	3	
Aristida purpurascens	1		1								
Eragrostis pectinacea		1									
Sorghastrum nutans	2									1	
Carex pensylvanica	2	3	2	2	2	1	1	2	1	1	
Cyperus filiculmis	1										
Bulbostylis capillaris	2			1		1	1				
Ambrosia psilostachya			1								
Euphorbia corollata											x
Hieracium longipilum									1		
Krigia virginica	1										
Liatris aspera					1						
Linaria canadensis	1						1				
Mollugo verticillata	1										
Polygala polygama				1	1	1	1				
Rumex acetosella	1		1				1	1	1		
Solidago nemoralis					1					1	
Tephrosia virginiana		2	2								

Area 18, Plot III

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Eragrostis pectinacea	1	1	1	1	1		1	1			
Koeleria cristata	1	1	1	2	1	1	1	1	1	1	
Panicum depauperatum	1	1	1		1	1	2	2		1	
P. pseudopubescens	1										
Poa compressa							1				
P. pratensis									1		
Cyperus filiculmis	1					1	1	1	1		
Ambrosia psilostachya	1	1	2	2	1	1	1	2	2	1	
Euphorbia corollata	1			1	1	1	1	1	1	1	
Helianthus occidentalis		1	1	2	2	1	1			3	
Liatris aspera	1			1		1	1	1		1	
Linaria canadensis		1	1						1	1	
Lithospermum croceum				1						1	
Polygala polygama			1	1					1	1	
Rumex acetosella	1	1	1		1	1		1	1	1	
Solidago nemoralis				1							

Area 18, Plot IV

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi	1	2	1	2			1	1		2	
A. scoparius	1	2	1							1	
Eragrostis pectinacea						1					
Koeleria cristata	1	1	1	1	1	1	2	1	1	1	
Panicum depauperatum		1	1		1			1			
Poa pratensis	1	1		1					1	1	
Carex pensylvanica	1	1	1			1	1	1	1		
Cyperus filiculmis					1		1				
Ambrosia psilostachya	1	1	1	1	1	1	1	1	1	1	
Artemisia caudata		1									
Arenaria stricta	1		1	1	1	1	1	1	1		
Aster ericoides				1	1	1	1		2	1	
Euphorbia corollata				1	1					1	
Helianthus occidentalis	1	1	1	2	1	1	1	1	1		
Liatris cylindracea						1	1				
Liatris aspera					1					1	
Linum sulcatum							1				
Polygala polygama	1		1								
Potentilla arguta	1										
Rosa carolina	1	1	1		1				1	1	
Rubus sp.						3	1	2	4		
Tephrosia virginiana			2								

Area 18, Plot V

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi											x
A. scoparius	3	3	3	2	3	4	3	3	3	4	
Aristida purpurascens									1		
Koeleria cristata					1			1			
Panicum depauperatum			1		1						
Sorghastrum nutans	1										
Carex pensylvanica	2	2	1	2	1	1	1	1	1	1	
Liatris aspera									1		
Linaria canadensis	1						1				
Polygala polygama		1									
Rumex acetosella	1			1	1	1		1	1		

Area 19, Plot I

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi	1	2	2	4	4		3	3	2	4	
A. scoparius	1	2	3			3	2	2	2		
Aristida purpurascens					1	1					
Danthonia spicata											x
Panicum depauperatum	1										
Carex pensylvanica	1	1	1	1	1	1	2	1	1	1	
Ambrosia psilostachya		1		1	1					1	
Hieracium longipilum											x
Hypericum perforatum				1							
Liatris aspera	1	1				1	1		1	1	
Polygala polygama	1										
Rumex acetosella		1	1	1						1	
Solidago nemoralis		1									

Area 19, Plot II

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi	4										
Aristida purpurascens		2	1		1		1				
Danthonia spicata			1								
Eragrostis pectinacea							1				
Koeleria cristata			1	1	1	1				1	
Panicum depauperatum				1							
Poa compressa					1						
Carex pensylvanica	2	3	2	2	2	2	2	2	4	3	
Ambrosia psilostachya		1		1						1	
Coreopsis lanceolata		1					1	1	1	1	
Erigeron strigosus					1						
Euphorbia corollata	1	1	1		1	1	1	1	1	1	
Helianthemum canadense	1	1	1				1				
Helianthus occidentalis	1	1	3	2	2	1	2	1	1	1	
Hieracium longipilum		1									
Liatris aspera				1		1	1	1	1		
Monarda punctata					1						
Polygala polygama	1		1	1		1		1			
Potentilla arguta					1				1		
Rosa carolina	1				1	1	1	1		1	

Area 19, Plot III

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi	3			2		1	1	2			
Danthonia spicata	1			1	1		1				
Eragrostis pectinacea	1							1			
Koeleria cristata	1	2	1	1	1	1	1	1	1	1	
Poa pratensis				1							
Carex pensylvanica	2	4	2	2	3	4	5	2	4	4	
Cyperus filiculmis	1										
Ambrosia psilostachya	1	2	1	2	2	2	1	1	2	2	
Erigeron canadensis				1	1	1	1		1		
Gnaphalium obtusifolium			1							1	
Hieracium longipilum										1	
Krigia virginica					1						
Liatris aspera								1			
Melilotus alba	1										
Monarda punctata	1					1		1			
Oenothera sp.										1	
Polygala polygama	1										
Rubus sp.			3	1							
Rumex acetosella		2								1	
Solidago nemoralis	1		2		1		1	1	1		

Area 19, Plot IV

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi	2	2	2	1							
A. scoparius		2									
Danthonia spicata					1	4	3				
Eragrostis pectinacea	1				1	1		1			
Koeleria cristata							7				
Panicum pseudopubescens	1	1									
Poa compressa	1			1							
Poa pratensis	1	1	2	3	3	1	1	2	2	3	
Carex pensylvanica	1	1	1	1	3	2	2	4	4	2	
Juncus greenei	1	1		1		1		1	1	2	
Ambrosia psilostachya						1	1				
Aster azureus	1										
Erigeron canadensis			1								
Euphorbia corollata				1		1					
Hieracium longipilum						1					
Hypericum perforatum	1										
Liatris aspera		1									
Monarda punctata		1									
Polygala polygama	1										
Rudbeckia serotina	1										
Rumex acetosella	1										
Solidago nemoralis	1			1						1	

Area 19, Plot V

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi				1				3			
A. scoparius	2	3				3	1	2	2	2	
Agrostis scabra					1						
Aristida purpurascens							1				
Koeleria cristata									1	1	
Panicum pseudopubescens	1						1	1		1	
Carex pensylvanica	2	2	5	4	5	2	2	2	3	3	
Ambrosia psilostachya	2										
Gnaphalium obtusifolium				1							
Hieracium longipilum											x
Krigia virginica							1				
Polygonella articulata	1										
Rumex acetosella	1	1		1	1		1		1	1	
Solidago nemoralis	1	1		1				1			
Tephrosia virginiana						4	3	1	2	1	
Viola pedata	1										

Area 19, Plot VI

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi			2								
A. scoparius		1	2	3	3	1		1	2		
Aristida purpurascens	1	1	1		1		1		1	1	
Panicum depauperatum	2	1		1				1	1	2	
Panicum pseudopubescens	1					1					
Sorghastrum nutans								2	1	2	
Carex pensylvanica	1	1	1	1	3	3	4	2	1	1	
Cyperus filiculmis						1					
Ambrosia psilostachya						1	1	1	1		
Euphorbia corollata							1	1			
Hieracium longipilum				1					1		
Polygala polygama	1			1			1		1		
Rubus sp.						1	3	1	1		
Rumex acetosella	1		1	1		1			1	1	
Solidago nemoralis	1	1		1	1		1	1			

Area 19, Plot VII

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi	3	2	2	1	1					1	
Aristida purpurascens	1	1			1		1				
Koeleria cristata									1		
Panicum pseudopubescens							1				
Cyperus filiculmis			1			1					
Ambrosia psilostachya	1	1	1	1	1	1		1		1	
Anemone cylindrica								1			
Artemisia caudata				1		1	1			1	
Convolvulus spithamaeus		1			1			1		1	
Coreopsis lanceolata		1	1	1	2	1		2	1	1	
Euphorbia corollata	1	1					1				
Gnaphalium obtusifolium									1		
Helianthemum canadense		1		1	1						
Hypericum perforatum							1				
Krigia virginica	1		1								
Lespedeza capitata	1			1	1	1					
Liatris aspera		1	1	1	1	1	1			1	
Linum sulcatum		1		1	1		1	1		1	
Monarda punctata							1	1			
Polygonella articulata						1					
Polygala polygama	1	1								1	
Rubus sp.			1	1	2	2	1	1	2	1	
Rumex acetosella	1		1		1	1		1	1	1	
Solidago nemoralis								1			

Area 20, Plot I

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon scoparius	1	2	3	1	1	1	1	1	1	3	
Panicum depauperatum					1						
Carex pensylvanica	1	1		1	1	1	2	1	1	1	
Ambrosia psilostachya	1	1	1	1	1					1	
Euphorbia corollata	1	1	1	1	1			1		1	
Hieracium longipilum			1		1						
Krigia virginica			1								
Liatris aspera	1	1						1	1		
Linum sulcatum	1		1								
Monarda punctata	1	1									
Penstemon hirsutus	1										
Polygala polygama		1	1	1	1			1	1	1	
Polygonella articulata					1						
Rubus sp.	1	1		1	2	1	1	1	2	1	
Rumex acetosella		1	1								
Solidago nemoralis									1	1	

Area 21, Plot I

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi	2	2		3	3	2	1	2	3	1	
A. scoparius	2		2			2	1	3		1	
Koeleria cristata							1				
Poa pratensis	1	2	1	1	1	1	1	1	1	2	
Carex pensylvanica	2	1	1	1	1	1	1	1	1	1	
Ambrosia psilostachya		1	1	1	1	1	1		1	1	
Anemone cylindrica		1	1	1	1	1	1	1	1	1	
Arenaria stricta	1		1	1	1	1		1	1	1	
Artemisia caudata							1				
Euphorbia corollata									1	1	
Helianthus occidentalis							1				
Linum sulcatum	1				1		1				
Monarda punctata	1	1	1		1	1	1	1	1	1	
Physalis virginiana			1	1		1	1		1	1	
Rosa carolina		1	1						1	1	
Rudbeckia serotina							1	1			
Tephrosia virginiana	2										

Area 23, Plot I

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Aristida purpurascens				1							
Danthonia spicata									1		
Panicum scribnerianum									1	1	
Carex pensylvanica	5	3	2	2	2	5	5	5	1	2	
Cyperus filiculmis									1		
Ambrosia psilostachya			1	1	1					1	
Apocynum cannabinum											x
Euphorbia corollata					1						
Krigia virginica					1				1	1	
Liatris aspera				1					1		
Polygala polygama				1							
Polygonella articulata											x
Rubus sp.		4	4	3	3	2	2	1	4	4	
Rumex acetosella	1				1				1		
Solidago nemoralis										1	

Area 23, Plot II

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon scoparius											x
Aristida purpurascens							1				
Danthonia spicata	1	3	3	3	2	1		2	3	2	
Panicum pseudopubescens					1						
Carex pensylvanica	4	2	4	3	5	3	4	3	3	3	
Ambrosia psilostachya	1		1	1	1	1	1				
Apocynum cannabinum											x
Euphorbia corollata											x
Hieracium longipilum											x
Liatris aspera									1		
Rubus sp.	2	2	1			1	1	2	2	2	
Rumex acetosella						1	1				
Solidago nemoralis								1	1	1	
S. missouriensis											x

Area 23, Plot III

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Aristida purpurascens							1				
Danthonia spicata	3	1	1				1			1	
Panicum pseudopubescens	1	1									
Carex pensylvanica	3	5	5	5	4	4		5	5	5	
Ambrosia psilostachya	1	1	1	1		1	1	1	1	1	
Apocynum cannabinum				1					1		
Euphorbia corollata							1				
Hieracium longipilum							1				
Krigia virginica											x
Liatris aspera										1	
Linaria canadensis									1		
Polygala polygama				1							
Rubus sp.					3	2	2				
Rumex acetosella	1	1	1							1	

Area 23, Plot IV

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Aristida purpurascens				1	1						
Danthonia spicata			1								
Koeleria cristata			1								
Panicum depauperatum		1	1		1						
P. pseudopubescens			1				1				
Poa compressa				1		1					
Carex pensylvanica	5	5	4	4	3	4	4	5	4	5	
Ambrosia psilostachya	1		1	1	2	2		1	2		
Euphorbia corollata	1	1	1	1	1	1	1		1		
Gnaphalium obtusifolium				1							
Krigia virginica				1	1		1				
Liatris aspera	1	1		1	1		1	1	1		
Linaria canadensis	1			1	1		1		1		
Polygala polygama	1			1	1		1		1		
Solidago nemoralis										1	

Area 23, Plot V

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Danthonia spicata	1		2				1				
Panicum pseudopubescens											x
Carex pensylvanica	5	4	3	4	5	4	4	5	5	5	
Ambrosia psilostachya						1	2	1	1		
Hieracium longipilum											x
Liatris aspera											x
Linaria canadensis											x
Rubus sp.	1	2	2	1	1	3	4	3	1	1	
Rumex acetosella											x
Solidago nemoralis						1					

Area 23, Plot VI

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon scoparius	2	2	2	2	1	1	2	2	2	3	
Danthonia spicata	1	1	2	2					1	2	
Koeleria cristata	1	2		1	3	3	3	2	2	1	
Panicum pseudopubescens			1						1		
Carex pensylvanica	2	1	2	1	2	3	3	2	2	3	
Cyperus filiculmis		1					1				
Ambrosia psilostachya	2	1		1	1	1	1	1	1	1	
Artemisia caudata							1				
Erigeron strigosus						1					
Euphorbia corollata			1	1		1	1			1	
Hieracium longipilum											x
Hypericum perforatum					1						
Liatris aspera		1			1						
Linum sulcatum							1				
Polygala polygama	1		1								
Rubus sp.	1		1	1		1	2	2			
Rumex acetosella	1		1								
Solidago nemoralis				1							

Area 23, Plot VII

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon scoparius	1										
Danthonia spicata		1		1						2	
Koeleria cristata	1		2	2	1	2	2	2	3	1	
Panicum depauperatum	1								1		
P. pseudopubescens				1							
Carex pensylvanica	4	5	3	2	2	2	2	2	2	4	
Ambrosia psilostachya	1	1	1	1	1	1	2	2	2		
Aster azureus				1	1		1	1	1	1	
Erigeron strigosus	1						1				
Euphorbia corollata		1			1	1	1	1	1		
Krigia virginica				1		1	1				
Linum sulcatum										1	
Polygala polygama						1	1	1	1		
Rubus sp.			2	1	3	1	3				
Rudbeckia serotina											x
Solidago nemoralis	1				1						
S. missouriensis									1		
Viola pedata				2	2	2	1	1	1		

Area 25, Plot I

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi	3										
Danthonia spicata		1								1	
Eragrostis pectinacea										1	
Koeleria cristata	1					2	1	3			
Panicum depauperatum						1					
Carex pensylvanica	4	5	5	5	5				1	5	
Cyperus filiculmis						1		1	1		
Ambrosia psilostachya	1	1	1	1	1	1	1	1	2	1	
Artemisia caudata						1	1		1		
Euphorbia corollata	1	1	1	1	1	1		1	1		
Helianthus occidentalis						2	3				
Hypericum perforatum										1	
Liatris aspera			1	1	1	1	1	1	1	1	
Monarda punctata							1				
Polygala polygama						1		1			
Polygonella articulata							1				
Rubus sp.	2	1				1	1	1			

Area 26, Plot I

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi	4	3		4	2	2			3	3	
A. scoparius		1			2	1		4	3	2	
Aristida purpurascens		1	1							1	
Danthonia spicata			1		1	1					
Eragrostis pectinacea											x
Koeleria cristata					1	1		1			
Panicum pseudopubescens										1	
Sorghastrum nutans	1	1		1				1	1		
Carex pensylvanica	2	2	5	2	2	4	5	1	2	1	
Cyperus filiculmis			1								
Ambrosia psilostachya	1	1	1	1	1	1		1		1	
Aster azureus								1	1		
Coreopsis lanceolata											x
Crataegus sp.	1							1			
Euphorbia corollata	1										
Hypericum perforatum			1								
Liatris aspera		1			1					1	
Penstemon hirsutus									1		
Polygala polygama		1		1	1			1			
Polygonella articulata											x
Rosa carolina								1			
Rumex acetosella		1								1	
Solidago nemoralis			1	1	1	1		1	1	1	
Viola pedata									1		

Area 31, Plot I

	Quadrats: 1	2	3	4	5	6	7	8	9	10	Plot
Andropogon gerardi	2	2	1	1	2	4	3	4	3	4	
A. scoparius	1	1	2	1				1	1	1	
Koeleria cristata		1	1				1		1	1	
Carex pensylvanica	1	2	1	1	1	1	1	1	1	1	
Ambrosia psilostachya	1	1	1	1	1		1	1	1	1	
Arenaria stricta			1		1						
Artemisia caudata		1		1						1	
Euphorbia corollata			1								
Geum triflorum	1	1	2	3	1	2	1	1	1	2	
Liatris cylindracea	1										
Linum sulcatum											x
Lupinus perennis											x
Polygala polygama			1					1			
Rosa carolina		1		1	1		1				
Silene antirrhina		1									

C. List of Species Found in the Prairies of Newaygo County

The following is a list of the species of plants collected within the prairie areas of Newaygo County by the writer. The nomenclature of the grasses follows Hitchcock[2], and of the other plants it is according to Fernald[3].

Agrostis hiemalis (Walt.) B. S. P.
A. scabra Willd.
Andropogon gerardi Vitman
A. scoparius Michx. var. septentrionalis Fern. & Grisc.
Aristida purpurascens Poir.
Bromus secalinus L.
Danthonia spicata (L.) Beauv.
Eragrostis pectinacea (Michx.) Nees.
Festuca ovina L.
Koeleria cristata (L.) Pers.
Leptoloma cognatum (Schult.) Chase.
Panicum capillare L.
P. depauperatum Muhl.
P. pseudopubescens Nash.
P. scribnerianum Nash.
P. virgatum L.
Poa compressa L.
P. pratensis L.
Setaria italica (L.) Beauv.
S. viridis (L.) Beauv.
Sorghastrum nutans (L.) Nash.
Spartina pectinata Link.
Sporobolus cryptandrus (Torr.) A. Gray.
Stipa spartea Trin.

Bulbostylis capillaris (L.) C. B. Clarke.
Carex pensylvanica Lam.
Cyperus filiculmis Vahl.
Juncus greenei Oakes & Tuckerm.

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[2]Hitchcock, A. S. 1950. Manual of the Grasses of the United States. 2d edition. U. S. D. A. Washington. Misc. Pub. No. 200.

[3]Fernald, M. L. 1950. Gray's Manual of Botany. 8th edition. American Book Co. New York.

Equisetum sp.
Polytrichum piliferum
Selaginella rupestris

Ambrosia artemisiifolia L. var. elatior (L.) Descourtils.
A. psilostachya DC var. coronopifolia (T. & G.) Farw.
Anemone cylindrica Gray.
Apocynum cannabinum L.
Arenaria stricta Michx.
Artemisia caudata Michx. var. calvens Lunell.
Asclepias tuberosa L.
A. verticillata L.
A. viridiflora Raf. var. lanceolata (Ives) Torr.
Aster azureus Lindl.
A. ericoides L.
A. ptarmicoides (Nees) T. & G.
A. sericeus Vent.
Blephilia ciliata (L.) Benth.
Comptonia peregrina (L.) Coult.
Convolvulus spithamaeus L.
Coreopsis lanceolata L.
Crataegus sp.
Desmodium paniculatum (L.) DC.
Erigeron canadensis L.
E. strigosus var. strigosus Muhl.
Euphorbia corollata L.
Euphorbia cyparissias L.
Fragaria virginiana Duchesne
Gerardia flava L.
G. pedicularia var. ambigens Fern
Geum triflorum Pursh.
Gnaphalium macounii Greene.
G. obtusifolium L.
Helianthemum canadense (L.) Michx.
Helianthus hirsutus Raf.
Helianthus occidentalis Riddell.
Hieracium aurantiacum L.
Hieracium longipilum Torr.
Houstonia longifolia Gaertn.
Hypericum perforatum L.
Krigia virginica (L.) Willd.
Kuhnia eupatorioides L. var. corymbulosa T. & G.
Lactuca canadensis L. var. longifolia (Michx.) Farw.
Lespedeza capitata Michx.
Liatris cylindracea Michx.
Liatris aspera Michx. var. intermedia (Lunell) Gaiser.
Linaria canadensis (L.) Dumont.
Linum sulcatum Riddell.
Lithospermum croceum Fern.
Lupinus perennis L.

Melilotus alba Desr.
Mollugo verticillata L.
Monarda punctata L. var. villicaulis Pennell
Opuntia humifusa Raf.
Oenothera rhombipetala Nutt.
Oenothera sp.
Penstemon hirsutus (L.) Willd.
Physalis heterophylla Nees. var. ambigua (Gray) Rydb.
P. virginiana Mill.
Plantago aristata Michx.
Polygala polygama Walt. var. obtusata Chodat.
Polygonella articulata (L.) Meisn.
Polygonum tenue Michx.
Potentilla arguta Pursh.
Prunus pumila L.
Prunus serotina Ehrh.
Prunus virginiana L.
Quercus alba L.
Q. velutina Lam.
Robinia pseudo-acacia L.
Rosa carolina L.
Rubus spp.
Rudbeckia serotina Nutt.
Rumex acetosella L.
Silene antirrhina L.
Saponaria officinalis L.
Solidago graminifolia var. graminifolia (L.) Salisb.
S. juncea Ait.
S. missouriensis Nutt.
S. nemoralis Ait.
S. speciosa Nutt.
Specularia perfoliata (L.) A. DC.
Spiraea alba DuRoi
Spiranthes gracilis (Bigel.) Beck.
Stachys hyssopifolia Michx.
Tephrosia virginiana (L.) Pers. var. holosericea (Nutt.) T.& G.
Verbena bracteata Lag. & Rodr.
V. stricta Vent.
Vicia villosa Roth.
Viola pedata L. var lineariloba DC.

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APR 1 1965

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