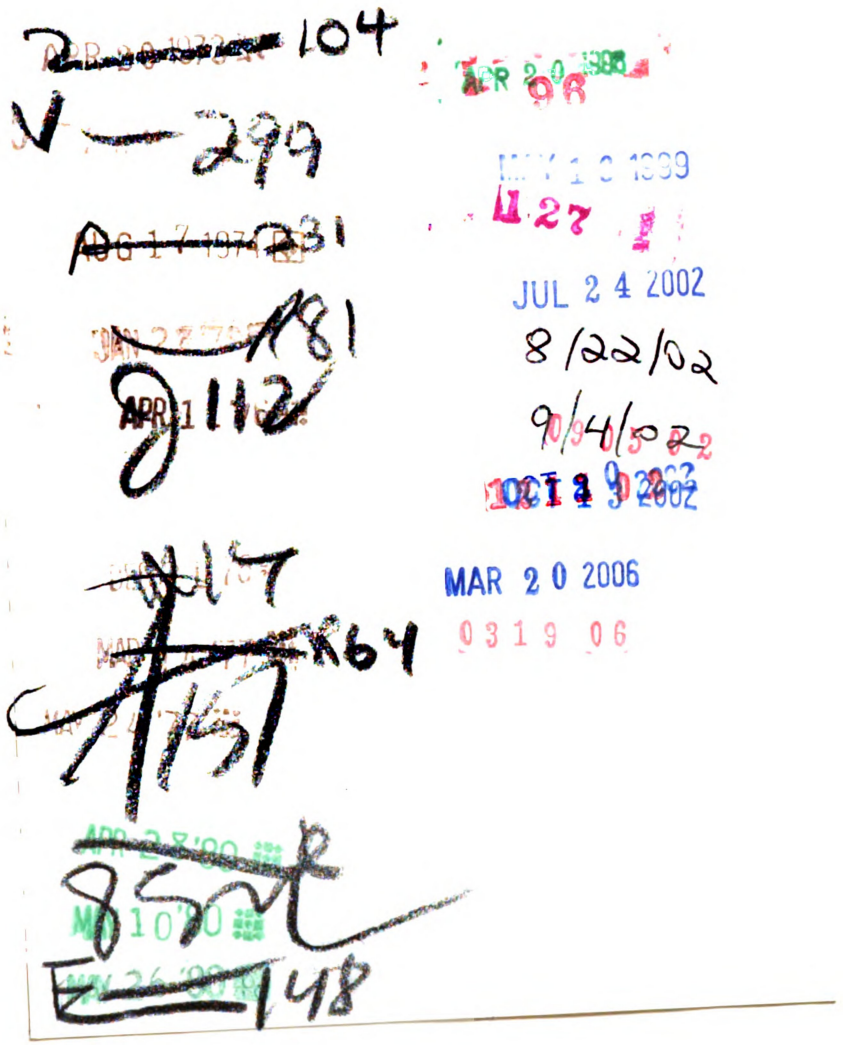
AN ECOLOGICAL, FLORISTIC, AND PHYTOGEOGRAPHIC ANALYSIS OF A SOUTHERN MICHIGAN BOG

Thesis for the Degree of M. S.
MICHIGAN STATE UNIVERSITY
GARRETT EUGENE CROW
1968


104
V—299
112
MAR 20 2006
0319 06
148

ABSTRACT

AN ECOLOGICAL, FLORISTIC, AND PHYTOGEOGRAPHIC ANALYSIS OF A SOUTHERN MICHIGAN BOG

by Garrett Eugene Crow

Pennfield Bog, Calhoun County, Michigan, lies in one of the many depressions of the Kalamazoo morainal system. Field work was carried out from April to October, 1967. The bog consists of seven major plant zones: a Nuphar-Eleocharis zone, a Decodon zone, a Carex-Vaccinium macrocarpon zone, a Cassandra zone, a Cassandra-Thelypteris zone, a Larix zone, and an outermost Acer rubrum zone. Frequency, cover and importance values have been tabulated for each vegetational zone.

A total of 144 species of vascular plants was collected and these species are discussed in terms of their occurrence within the bog, perennation, general habitat, and North American distribution. The North American ranges have been determined from the literature. Five basic patterns are represented by the bog species: 1) widespread species; 2) eastern United States species; 3) Northeast-Coastal Plain species; 4) northeastern North American species; and

5) northern species. Postglacial migration from Pleistocene refugia may account for the present flora. The bog flora appears to have been derived from four important sources: 36% of the species have southern affinities, 42% have eastern affinities, 10% represent a Cordilleran element and 2% are of Alaskan affinity.

AN ECOLOGICAL, FLORISTIC, AND PHYTOGEOGRAPHIC ANALYSIS OF A SOUTHERN MICHIGAN BOG

By

Garrett Eugene Crow

A THESIS

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

MASTER OF SCIENCE

Department of Botany and Plant Pathology

1968

ACKNOWLEDGMENTS

I wish to express my sincere appreciation to my major professor, Dr. John H. Beaman, for his guidance and encouragement during this study. I also appreciate the helpful suggestions concerning the thesis provided by Drs. William B. Drew and Stephen N. Stephenson and those on phytogeography by Dr. Hugh H. Iltis. Mr. Norton G. Miller made determinations of several bryophytes and Mr. Loren Perry flew me over the bog.

I am also greatly indebted to Miss Bertha A. Daubendiek and the Eastern Michigan Nature Association for permitting and encouraging this study of the Pennfield Bog Plant Preserve and for the generous grant which made the field studies possible.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

INTRODUCTION

The term "bog" refers to a soil-vegetation complex made up of specialized herbs, subshrubs, shrubs, and trees growing on a wet, acid peat soil.

Gates (1942, p. 214) defines a bog as:

> An area of vegetation, developing in undrained or poorly drained situations, which by the development of a mat invading open water, forms a cover over a body of water. It consists of a series of successional stages or associations beginning with mat-forming sedges and passing through shrub (mostly ericad) and Sphagnum stages to an expected culmination in the development of a characteristic coniferous tree association.

Rigg (1916) says that a Sphagnum bog is "that stage in the physiographic succession of an area during which its surface is entirely devoid of hard soil and is composed entirely of living sphagnum moss under which is a fiberous brown peat composed mainly or entirely of partially decayed sphagnum."

A bog generally has a high water table, but usually there is little standing water other than the associated bog lake. The upper peat and bog waters are typically strongly acid.

Bogs occur in depressions and lowlands. Many form in kettle holes in glacial moraines and in low spots in uplands. Bog

conditions may develop in quiet bays of large lakes or stream channels. They are characteristic of cold regions with long winters and high rainfall. The shallow, little differentiated podzols of these regions often support a coniferous forest. Dansereau (1957, p. 87) cites these regions as ". . . the zone of bogs, par excellence, with their typical moss, sedge, and ericad flora: the tendency to peat accumulation is in evidence everywhere that drainage is impeded." The term "bog" is often loosely applied to any peat-covered land of cold, northern regions. However, bogs become scattered and less numerous as the major vegetational units of North America transcend from the northern conifer forest, toward the glacial boundary through the hemlock--white pine--northern hardwood tension zone, to that of the eastern deciduous forest.

The southern limit of Wisconsin glaciation (Flint, 1957) is shown in Map 21.

Transeau (1905) noted that peat deposits of considerable extent occur occasionally south of the margin of the Wisconsin ice sheet. Many of these are believed to be associated with earlier glacial advances of the Pleistocene.

Bog formations associated with former localized glaciation are also known in the mountains of the eastern and western United States.

Other situations in which there is considerable peat accumulation are associated with coastal plain phenomena of eustatic movement, irregular depositions of alluvial materials in deltas, and reef building causing extension of the land. In North America the greatest development of the southern bog condition is in eastern Virginia, and North Carolina, Florida and the Mississippi floodplain. The vegetation in these habitats is noted for its density and luxuriance and this combined with stagnant water allows peat formation in spite of high temperatures (Transeau, 1905).

Although these southern peat deposits are sometimes referred to as "bogs," they have a very different appearance from those to the north. In comparing the vascular plants of two sphagnus wetlands in New Jersey, Montgomery and Fairbrothers (1963) noted that the northern bog, located within the glacial boundary, had a floating mat encroaching upon open water and the peat was deep. The southern bog, on the other hand, located on the unglaciated coastal plain at the southern tip of New Jersey, had no floating mat and the peat deposit was shallow. The northern bog reflected a dominance of woody species in contrast to a chiefly herbaceous flora in the southern bog. The northern bog had a constant water level and continuous Sphagnum distribution, whereas the southern bog was characterized by fluctuating seasonal water levels and a scattered Sphagnum distribution.

Although northern and southern bogs differ in their origin, they have a strong physiological similarity. Factors such as acidity, peaty soils, high water table, and the presence of a number of species with otherwise northern distributions suggest the possibility of southern bogs having served as refugia during Pleistocene times.

Description of Pennfield Bog

The bog which is the subject of this study is located in Calhoun County, Michigan, $1\frac{3}{4}$ miles north of Pennfield and 7 miles northeast of Battle Creek. Pennfield Bog, as it will be referred to here, is associated with two adjacent lakes, Goose Lake and Little Goose Lake, each of which ~~are~~ is 4 acres in area. During years of high water table the lakes are connected by a narrow channel of water filled with Nuphar luteum and Nymphaea tuberosa. They appear as two distinct lakes during years of low water table (as indicated by an aerial photograph made in 1961). The bog possesses all the features necessary to fulfill the bog definitions given by Rigg (1916) and Gates (1942).

Little Goose Lake, now owned and set aside as a plant preserve by the Eastern Michigan Nature Association, has had the greatest amount of bog development, being completely surrounded by a floating mat. This mat is most extensive to the northwest, the direction of prevailing winds.

Goose Lake has a floating mat on the northwest side, but although the lake shore is completely organic, there is virtually no floating mat on the southeast side of the lake. The only outlet of the bog is at the east corner of Goose Lake. It probably is functional only during periods of high water table. The shallow outlet runs a short distance into Deep Lake, a 7-acre lake also with a completely organic shore (Humphrys, et al., 1965).

Pennfield Bog, in one of the numerous depressions of the Kalamazoo end moraine of Wisconsin age, is at an elevation of 860 feet above sea level. The glacial till of the morainal system is generally sandy and is underlain by a bedrock of sandstone (Leverett and Taylor, 1915). The glacial ice flow in the locality was that of the Saginaw ice lobe progressing from a northeast to a southwesterly direction (Flint, et al., 1959).

The morainal ridges surrounding the study areas support various vegetation types. The northernmost ridge supports an oak woods and a small reforestation of red pine; the northwest side is pasture; the southwestern and southern border is an old orchard returning to an oak woods; the northeast ridge is a black oak-red maple woods.

Climate

The climate of the region of Pennfield Bog is modified considerably by Lake Michigan. When there is little or no wind the

climate is continental, but when there are strong winds from the Lake the weather becomes semimarine. Winter winds are warmed in transit across Lake Michigan and summer winds are cooled, thus creating a more moderate climate than that on the western side of the Lake. Spring temperatures tend to be depressed while fall temperatures are elevated (Eichmeier, no date).

Weather data for the Battle Creek area show the highest temperature recorded was 104° F in July 1936 and the lowest was -24° in February 1899. Days with 90° temperatures occur on an average of 20 per summer and the mean temperature of January, the coldest month, is 11.4°. The Climatological Survey (Eichmeier, no date) for the period 1926-1955 at the nearest weather station at Battle Creek shows the mean daily maximum temperature to be 58.6° for the year, while the mean daily minimum temperature is 38.8°. The warmest month is July with a mean temperature of 85.1°. The average dates of the last freezing temperature of spring and the first freezing temperature of fall are May 8th and October 9th, respectively. In the fall of 1967 signs of frost were in evidence at Pennfield Bog about 20 days earlier than the average date recorded at the nearest station.

Precipitation averages 46% greater for the months May-October than for the rest of the year. May and June are the peak

months with heaviest amounts of rainfall due to thundershower activity. Average precipitation ranges from a high of 4.04 inches in May to 1.73 inches in February with the annual mean at 33.43 inches.

Snowfall averages 39.8 inches during Battle Creek winters. The first snowfall usually occurs in November and the last in April, with an average of 57 days with snow on the ground.

Sunshine is only 30% of the possible total during January, while in the June-August period sunshine reaches about 70% of the possible amount.

Relative humidity averages of the summer season range from 78% in early morning to 50% in early afternoon while winter averages are 85%-75%.

Water and Soil

The open lake waters of Pennfield Bog are neutral in pH (6.9) and are rich in planktonic organisms. The water is stagnant and abounds with colloids. The shore is 100% organic and the substrate of the entire bog is made up of peat. The waters of the bog mat are acid (see Table 1).

Transeau (1906) considered putrefaction to be the chief process of reduction by which disintegration is carried on by

anaerobic organisms and is favored by low temperatures, presence of acids, and low oxygen availability due to high water table. Products of putrefaction are of little use as nutrient materials for higher plants and nitrogen remains unavailable to plants.

Table 1. -- Average pH values in Pennfield Bog

Zone	pH value
Open water	6.9
Nuphar-Eleocharis	
Surface water	7.15
Submerged mat	6.25
Decodon	
Surface water	6.93
Submerged mat	6.5
Carex-Vaccinium macrocarpon	6.03
Depressions	6.8
Sphagnum hummocks	4.7
Cassandra	4.76
Larix	
Vaccinium corymbosum understory	4.5
Deep Sphagnum mat	4.18
Larix-Salix subzone	6.07
Acer rubrum	4.81
Openings at outer edge	6.42

Putrefaction seems to be the dominant process of decay throughout most of the bog during much of the year, as low pH, high water table, and cool temperature retard aerobic decay.

Methods

Field studies were made at Pennfield Bog from mid-April to mid-October, 1967. The bog was visited once each week during spring and fall and two collection and study trips a week were made during the summer months. Voucher specimens for all species reported from the bog are deposited in the Michigan State University Herbarium. Collections were also made of representative species in the major vegetation types surrounding the bog.

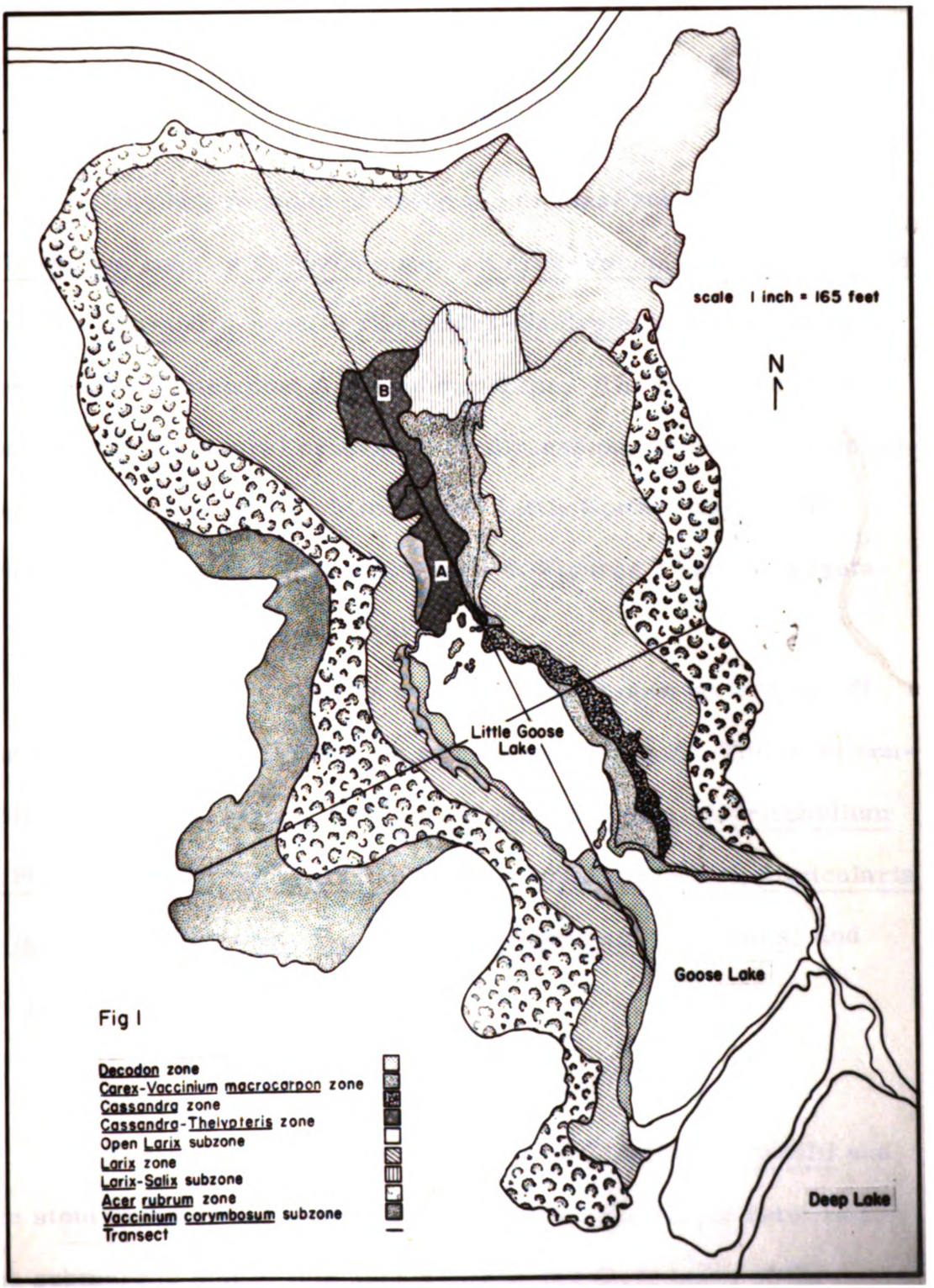
Quantitative data were collected during August to support recognition of the several vegetational societies. Two transects were run in the bog. The long axis ran at 16° west of magnetic north and was 660 meters in length. The shorter, perpendicular axis was 480.5 meters long. Because of the structural nature of the habitat two kinds of sampling procedures were employed. The herb and subshrub societies were sampled by $\frac{1}{2}$ m^2 quadrats. In the tree communities $\frac{1}{2}$ m^2 quadrats were used to examine the ground cover, while point intercepts were used to survey canopy and understory shrub and tree species. One hundred quadrats were distributed along each transect (as determined by a table of random numbers). Point intercepts recorded in the Larix and Acer rubrum zones were at the same locations as the quadrats.

In each quadrat the species and their approximate percent cover were recorded. Species with little significant cover were recorded as having 1% cover. Frequency, cover, and importance values were then tabulated for each vegetational zone. Determination of importance values follows the method of Beaman and Andresen (1966) which is a summation of percent total frequency and percent total cover data, thus giving a summation constant of 200.

A Beckman Pocket pH meter (model 180) was used to obtain pH values of surface soil and water in the major plant communities. The total of 53 readings was taken on August 31.

The vegetation map of Pennfield Bog was adapted from an aerial photograph (BDF-5AA-102 by USDA Agricultural Stabilization and Conservation Service) enlarged with a Saltzman' s projector (Figure 1).

Fig. 1. -- Vegetation map of Pennfield Bog showing vegetation zones and subzones and transect locations


scale 1 inch = 165 feet
N
B
A
Little Goose Lake
Goose Lake
Deep Lake
Fig I
Decadon zone
Carex-Vaccinium macrocarpon zone
Cassandra zone
Cassandra-Thelypteris zone
Open Larix subzone
Larix zone
Larix-Salix subzone
Acer rubrum zone
Vaccinium corymbosum subzone
Transect

VEGETATION

The bog consists of seven major plant zones: a Nuphar-Eleocharis zone, a Decodon zone, a Carex-Vaccinium macrocarpon zone, a Cassandra zone, a Cassandra-Thelypteris zone, a Larix zone, and an outermost Acer rubrum zone. The bog community, undergoing the natural processes of succession, is slowly encroaching upon the open water of Goose and Little Goose Lakes. The general aspect of the bog can be seen in Figures 2 and 3. Vegetational zones are shown in Figure 1.

A number of species occur in nearby open water just off the bog mat and are floating or submerged aquatics. The most conspicuous species include Ceratophyllum demersum, Myriophyllum verticillatum, Nymphaea tuberosa, Brasenia schreberi, Utricularia vulgaris, U. purpurea, Potamogeton illinoensis, P. natans, and P. gramineus.

The Nuphar-Eleocharis Zone

The rhizomes and fibrous roots of Eleocharis smallii and the stout rhizomes of Nuphar luteum provide the major network for the submerged mat of this zone which is the forerunner of the

Figure 2. -- Oblique aerial view of Little Goose Lake encircled by bog mat

Figure 3. -- Decodon mat encroaching upon Little Goose Lake (view looking northwest)

Figure 2

Figure 3

quaking bog mat. Frequency, cover, and importance values of the species in this zone are given in Table 2.

Table 2. -- Frequency, cover, and importance values of 21 species encountered in quadrats in the Nuphar-Eleocharis zone

Species	% Frequency	% Cover	Importance Value
Nuphar luteum	73.68	40.05	47.26
Eleocharis smallii	89.47	28.58	40.73
Potamogeton gramineus	63.15	11.79	21.79
Nymphaea tuberosa	42.10	16.32	21.55
Pontederia cordata	47.36	3.84	12.18
Utricularia vulgaris	36.84	6.31	12.24
Brasenia schreberi	21.05	2.16	5.79
Potentilla palustris	21.05	2.16	5.79
Potamogeton illinoensis	21.05	1.05	5.26
Carex lasiocarpa	10.52	2.37	3.95
Sparganium minum	15.78	0.79	3.64
Sparganium chlorocarpum	15.78	0.68	3.55
Lemna minor	15.78	0.16	3.12
Decodon verticillatus	5.26	2.37	2.95
Dulichium arundinaceum	10.52	0.26	2.20
Sagittaria latifolia	10.52	0.16	2.12
Cassandra calyculata	5.26	0.53	1.43
Triadenum virginicum	5.26	0.21	1.16
Lemna trisulca	5.26	0.05	1.03
Sium suave	5.26	0.05	1.03
Utricularia purpurea	5.26	0.05	1.03

The dominant species, Eleocharis smallii and Nuphar luteum, are perennial, rhizomatous aquatics. Other important species which contribute to the structure of the substrate include Pontederia cordata, Nymphaea tuberosa, Potentilla palustris, and

Carex lasiocarpa. A number of floating and submerged aquatic species are also present, but have little importance in terms of construction of the bog mat.

The Decodon Zone

Another pioneer zone is the Decodon mat which has developed on the west shores of Little Goose Lake and Goose Lake. Like the Nuphar-Eleocharis zone, the Decodon zone is characterized by a submerged mat. The surface water of the zone is nearly neutral while the submerged mat is slightly acid. The mat is a quaking structure and will occasionally break under the weight of a person. Frequency, cover, and importance values of the species in this zone are given in Table 3. Decodon verticillatus is the dominant species, comprising 23.58% of the total cover. Other important species include Cassandra calyculata, Typha latifolia, Nuphar luteum, Eleocharis smallii, and Thelypteris palustris, all of which are rhizomatous except C. calyculata, which is shrubby.

The majority of plants are emergent aquatics. They give a hummock-like aspect to the mat where the dense growth, especially that of Decodon verticillatus, with its thickened, spongy stem base, collects some litter and provides a microhabitat for bryophytes and such angiosperms as Drosera rotundifolia, Campanula aparinoides, Lycopus uniflorus, and Viola nephrophyllus.

Table 3. -- Frequency, cover, and importance values of 25 species encountered in quadrats in the Decodon zone

Species	% Frequency	% Cover	Importance Value
Decodon verticillatus	88.88	25.00	37.37
Cassandra calyculata	33.33	12.22	16.69
Brasenia schreberi	22.22	13.89	16.54
Typha latifolia	33.33	11.67	16.17
Nuphar luteum	22.22	11.11	13.92
Eleocharis smallii	44.44	6.11	12.65
Thelypteris palustris	44.44	5.67	12.23
Lycopus uniflorus	55.55	0.56	9.14
Osmunda regalis	11.11	6.67	8.01
Utricularia vulgaris	33.33	1.56	6.64
Spiraea tomentosa	22.22	3.11	6.37
Potentilla palustris	22.22	2.56	5.85
Sium suave	33.33	0.33	5.48
Triadenum virginicum	22.22	2.00	5.32
Sagittaria latifolia	22.22	1.56	4.91
Carex comosa	22.22	0.22	3.64
Sparganium minum	22.22	0.22	3.64
Salix petiolaris	11.11	0.56	2.24
Dulichium arundinaceum	11.11	0.22	1.92
Pontederia cordata	11.11	0.22	1.92
Campanula aparinoides	11.11	0.11	1.82
Drosera rotundifolia	11.11	0.11	1.82
Epilobium strictum	11.11	0.11	1.82
Vaccinium macrocarpon	11.11	0.11	1.82
Viola nephrophyllus	11.11	0.11	1.82

Growth of the mat is enhanced by the ability of Decodon verticillatus to root freely at the tips when the arching branches touch the water.

The Carex-Vaccinium macrocarpon Zone

The establishment of the floating mat requires a dense community of sedges around the lake margin. The rhizomes of the sedges grow out into the water behind the Nuphar-Eleocharis zone, forming an interlacing of roots and rhizomes, buoyed up by the water. As the mat encroaches upon the open water it loses contact with the bottom.

The sedge mat is dominated by three clonal species, Carex lasiocarpa, Vaccinium macrocarpon, and Thelypteris palustris. The frequency, cover, and importance values of species in this zone are given in Table 4. The table indicates that Vaccinium macrocarpon is the most important species of the zone, but if an importance value could be determined from a summation of relative frequency, cover, and extensiveness of root system, Carex lasiocarpa would certainly be primary in importance, with Vaccinium macrocarpon the secondary species. The importance value of Cassandra calyculata is valid where the zone is relatively narrow, but at the north end of the bog where the development of the sedge mat is extensive, the species occurs almost exclusively where the sedge mat borders on the Cassandra zone.

The mat surface consists of small rises and pocket-like depressions. In early spring the mat is covered with water to a

Table 4. -- Frequency, cover, and importance values of 32 species encountered in quadrates and at point intercepts in the Carex-Vaccinium macrocarpon zone

Species	% Frequency	% Cover	Importance Value
Quadrats			
Vaccinium macrocarpon	88.88	47.22	43.64
Carex lasiocarpa	94.44	32.83	34.44
Thelypteris palustris	55.55	13.17	16.04
Cassandra calyculata	55.55	10.22	14.01
Triadenum virginicum	55.55	4.28	9.93
Potentilla palustris	38.88	3.94	8.83
Andromeda glaucophylla	22.22	4.44	5.84
Nuphar luteum	16.66	5.00	5.52
Sium suave	38.88	0.61	5.30
Typha latifolia	22.22	3.61	5.18
Lycopus uniflorus	33.33	1.22	5.02
Salix pedicellaris	27.77	1.39	4.44
Sagittaria latifolia	27.77	0.78	4.02
Sarracenia purpurea	22.22	1.11	3.55
Sphagnum spp.	11.11	2.83	3.33
Eleocharis smallii	11.11	2.50	3.10
Potamogeton gramineus	16.66	1.06	2.81
Onoclea sensibilis	16.66	0.39	2.35
Utricularia intermedia	16.66	0.39	2.35
Hypericum boreale	11.11	1.39	2.34
Carex comosa	11.11	1.22	2.22
Campanula aparinoides	16.66	0.17	2.20
Boehmeria cylindrica	11.11	1.11	2.15
Toxicodendron vernix	5.55	1.67	1.83
Spiraea tomentosa	11.11	0.72	1.81
Bidens coronata	11.11	0.55	1.76
Scutellaria galericulata	11.11	0.28	1.58
Drosera rotundifolia	11.11	0.11	1.46
Carex aquatilis	5.55	0.56	1.07
Drosera intermedia	5.55	0.28	0.88
Dulichium arundinaceum	5.55	0.06	0.73
Point intercepts			
Larix laricina	11.11		

depth of approximately 30 cm. By mid-summer the water subsides, leaving only shallow pools in the depressions. Sphagnum, when it is present, occurs on the rises and the pH is an average 4.7 in these places. The pH is nearly neutral in the depressions, averaging 6.8, and the entire zone has an average pH of 6.03. During late summer the aerobic decay process is enhanced by higher temperatures, near-neutral pH, and lowered water table. Some decay is apparent in the wet depressions. Only two species, Utricularia intermedia and Drosera intermedia, were observed to inhabit these depressions. They were also noted to be restricted to this microhabitat.

The greatest diversity of species apparently occurs in this zone, but most have very low importance values.

The Cassandra Zone

The Cassandra zone succeeding the Carex-Vaccinium macrocarpon zone is characterized by a dense growth of this low shrub, with Sphagnum forming a cushion about the stems and branches. The substrate of the zone is very acid, having an average pH value of 4.7.

The portion of the zone on the east side of Little Goose Lake is representative of what might be considered a "typical" Cassandra zone. The zone is dominated by C. calyculata with a deep cushion of Sphagnum which grows up around the base of the

shrubs. The number of species present is small. Table 5 gives the frequency, cover, and importance values of the zone.

Table 5. -- Frequency, cover, and importance values of 6 species encountered in quadrats in the Cassandra zone on the east side of Little Goose Lake

Species	% Frequency	% Cover	Importance Value
Sphagnum spp.	100.00	87.50	77.31
Cassandra calyculata	100.00	71.25	67.60
Vaccinium macrocarpon	75.00	5.25	21.88
Drosera rotundifolia	75.00	0.75	19.19
Typha latifolia	25.00	1.25	6.99
Sarracenia purpurea	25.00	1.25	6.99

The Cassandra-Thelypteris Zone

In the northern part of the bog the Cassandra dominated zone takes on a quite different appearance. Although C. calyculata is the most important species in this very wet zone, Thelypteris palustris and Typha latifolia nearly equal it in importance; thus the zone is referred to as the Cassandra-Thelypteris zone. The zone has become a tension zone, being bordered on the south by the Nuphar-Eleocharis zone, on the west and north by the Larix zone, on the northeast by the Larix-Salix subzone, and on the east by the Carex-Vaccinium macrocarpon zone. Because of the very wet nature of the zone, Sphagnum has a much lower importance value in

this portion of the zone, making up only 12.83% of the total cover. This part of the bog is very diverse in number of species.

Table 6 gives the frequency, cover, and importance values of the zone. There are two distinct areas of subdivision. The column heading "Subzone A" refers to the area to the immediate north of Little Goose Lake (see Figure 1). Cassandra calyculata, Thelypteris palustris and Typha latifolia are still the dominant species, but Sphagnum is more prevalent in this area and makes up 24.08% of the total cover, second only to C. calyculata.

The area further north along the transect is very wet and scattered clumps of Larix are numerous. The data for this area in Table 6 is headed "Subzone B." In this transitional area the dominant species are again Cassandra calyculata, Thelypteris palustris, and Typha latifolia. Sphagnum, however, is much less important, making up only 4.56% of the total cover. The clumps of Larix provide a niche for some species that would not otherwise be present in the zone, such as Menyanthes trifoliata, Calla palustris, Cypripedium acaule, Maianthemum canadense, Carex aquatilis, and Rosa palustris.

Data for both areas are totaled in a third column in Table 6. Although the frequency of Larix is nearly the same in both areas, the trees in subzone A are often single in occurrence while the trees

Table 6. -- Frequency, cover, and importance values of 32 species encountered in quadrats and at point intercepts in the Cassandra-Thelypteris subzone A and subzone B

Species	% Frequency		
	Subzone A	Subzone B	Total A + B
Quadrats			
Cassandra calyculata	66.66	75.00	72.09
Thelypteris palustris	80.00	75.00	76.74
Typha latifolia	66.66	67.85	67.44
Sphagnum spp.	60.00	25.00	37.20
Carex lasiocarpa	26.66	53.57	44.18
Potentilla palustris	26.66	32.14	30.23
Lycopus uniflorus	26.66	32.14	30.23
Cornus stolonifera	0.00	14.28	16.27
Potamogeton gramineus	20.00	14.28	16.27
Salix petiolaris	0.00	21.42	13.95
Triadenum virginicum	26.66	7.14	13.95
Scirpus cyperinus	0.00	3.57	2.32
Eupatorium purpureum	26.66	3.57	11.62
Bidens coronata	0.00	21.42	13.95
Toxicodendron vernix	13.33	3.57	6.97
Calla palustris	0.00	10.71	6.97
Spiraea alba	6.66	3.57	4.65
Vaccinium macrocarpon	0.00	7.14	4.65
Spiraea tomentosa	13.33	0.00	4.65
Scutellaria galericulata	6.66	7.14	6.97
Campanula aparinoides	13.33	3.57	6.97
Onoclea sensibilis	13.33	0.00	4.65
Sium suave	13.33	3.57	6.97
Salix pedicellaris	6.66	3.57	4.65
Carex aquatilis	0.00	3.57	2.32
Acer rubrum	6.66	0.00	2.32
Viola nephrophylla	6.66	0.00	2.32
Cypripedium acaule	0.00	3.57	2.32
Maianthemum canadense	0.00	3.57	2.32
Muhlenbergia racemosa	6.66	0.00	2.32
Drosera rotundifolia	6.66	0.00	2.32
Rosa palustris	0.00	3.57	0.36
Point intercepts			
Larix laricina	20.00	17.85	18.60
Toxicodendron vernix	26.66	14.28	18.60
Ilex verticillata	0.00	3.57	2.32

Table 6. -- Continued

% Cover			Importance Value		
Subzone A	Subzone B	Total A + B	Subzone A	Subzone B	Total A + B
45.00	38.10	40.51	42.83	49.63	47.08
20.87	20.57	20.67	29.06	33.65	31.79
23.06	14.28	17.53	28.04	26.50	27.42
35.73	5.00	15.72	35.33	9.48	20.06
4.07	8.18	6.74	7.73	18.09	14.09
3.67	4.96	4.74	7.46	10.90	9.73
1.20	0.50	1.14	5.79	6.83	6.80
0.00	4.46	2.90	0.00	6.89	5.52
1.13	0.43	0.67	4.51	3.22	3.70
0.00	1.36	0.88	0.00	3.67	3.42
1.20	0.07	0.47	5.79	2.72	3.09
0.00	0.54	0.35	0.00	1.19	2.93
2.00	0.18	0.81	6.33	0.86	2.91
0.00	0.36	0.23	0.00	4.57	2.89
2.20	1.43	1.58	3.97	2.00	2.63
0.00	1.60	1.05	0.00	3.67	2.20
1.00	1.43	1.28	1.91	2.00	1.94
0.00	1.89	1.23	0.00	3.13	1.90
3.00	0.00	1.05	4.51	0.00	1.75
0.13	0.32	0.26	1.32	1.70	1.56
0.27	0.07	0.14	2.67	0.76	1.46
1.80	0.00	0.63	3.70	0.00	1.41
0.13	0.04	0.07	2.57	0.73	1.40
0.27	0.11	0.16	1.42	0.80	1.03
0.00	0.89	0.58	0.00	1.51	0.92
0.67	0.00	0.23	1.69	0.00	0.64
0.53	0.00	0.19	1.59	0.00	0.60
0.00	0.25	0.16	0.00	0.92	0.58
0.00	0.25	0.16	0.00	0.92	0.58
0.33	0.00	0.12	1.46	0.00	0.54
0.07	0.00	0.02	1.28	0.00	0.46
0.00	2.32	0.23	0.00	2.81	0.25

mostly occur in clumps in subzone B. Fifty percent of the species in the zone are not duplicated in the two areas, and those of subzone B have affinities with the Larix zone and the Larix-Salix subzone.

The Larix Zone

Larix forms a very extensive zone encircling the bog and dominates the stage of succession replacing the Cassandra zone. The zone can be divided into three subzones: the open Larix subzone, the Larix-Salix subzone, and the closed Larix bog forest.

The younger stages of the zone are characterized by an open bog forest. This has a general appearance somewhat suggestive of savanna vegetation, with the frequency of Larix laricina being 23.52% and Toxicodendron vernix occurring with a frequency of 17.64%. There is a deep, luxuriant mat of Sphagnum magellanicum (det. by N. G. Miller) carpeting the zone.

In Table 7, frequency, cover, and importance values are tabulated for the open portion of the Larix zone. The mat is acid, having an average pH value of 4.18. The most acid reading, pH 3.7, was taken on this Sphagnum mat.

The Larix-Salix subzone occurs in the northern part of the bog. Since neither transect passed through this area, no quantitative data were recorded. The subzone is, however, easily recognized.

Table 7. -- Frequency, cover, and importance values of 24 species encountered in quadrats and at point intercepts on the deep Sphagnum mat associated with the Open Larix subzone of the west side

Species	% Frequency	% Cover	Importance Value
Quadrats			
Sphagnum magellanicum	88.23	80.59	69.12
Thelypteris palustris	47.05	17.18	20.45
Vaccinium macrocarpon	58.82	8.65	17.40
Cassandra calyculata	47.05	9.52	14.11
Andromeda glaucophylla	29.41	8.53	11.37
Menyanthes trifoliata	23.52	4.76	9.25
Carex lasiocarpa	29.41	4.88	9.05
Osmunda regalis	11.76	6.76	6.68
Typha latifolia	17.64	3.57	6.37
Eriophorum virginicum	17.64	3.06	5.51
Carex interior	11.76	4.41	5.18
Pogonia ophioglossoides	17.64	0.29	3.75
Potentilla palustris	11.76	0.94	2.97
Vaccinium corymbosum	11.76	0.94	2.97
Acer rubrum	11.76	0.53	2.71
Campanula aparinoides	11.76	0.12	2.45
Sagittaria latifolia	5.88	0.47	1.48
Sarracenia purpurea	5.88	0.47	1.48
Salix petiolaris	5.88	0.24	1.34
Potamogeton gramineus	5.88	0.12	1.26
Triadenum virginicum	5.88	0.12	1.26
Lycopus uniflorus	5.88	0.06	1.22
Scutellaria galericulata	5.88	0.06	1.22
Trientalis borealis	5.88	0.06	1.22
Point intercepts			
Larix laricina	23.52		
Toxicodendron vernix	17.64		

Larix laricina is the most conspicuous tree species and Salix bebbiana the most abundant shrub. The area is very wet and takes on the aspect of a young swamp forest with tall shrubs and small trees with hummocks formed at the base. The average pH is 6.07. A number of the species present are common in swampy habitats. These include Cornus stolonifera, Betula pumila, Rosa palustris, Ribes americanum, R. hirtellum, Salix serissima, Bidens coronata, B. cernua, and Scirpus americanum.

A number of years ago a path was constructed by dragging logs through the Larix-Salix subzone to provide easy access for cranberry pickers. The path now consists of very loosely consolidated peat and is under water most of the summer. By the end of the summer, when the water table is much lower, the path takes on a consistency of a very wet muck. A few plants were recorded from along this path and nowhere else in the bog. Among these are Ranunculus scleratus, Rumex orbiculatus, Scirpus americana, and Boehmeria cylindrica (shade form).

The mature Larix zone is a closed bog forest where Larix laricina has a frequency of 72.22%. It has a very dense understory with Vaccinium corymbosum being the dominant shrub. The frequency, cover, and importance values for the ground cover are given in Table 8. As the table indicates, there is very little ground

Table 8. -- Frequency, cover, and importance values of 28 species encountered in quadrats and at point intercepts in the Larix zone

Species	% Frequency	% Cover	Importance Value
Quadrats			
Sphagnum spp.	72.22	39.67	81.58
Cassandra calyculata	16.66	7.36	16.16
Vaccinium corymbosum	27.77	4.91	16.04
Osmunda regalis	5.55	5.28	9.57
Acer rubrum	27.77	0.44	9.42
Carex interior	16.66	2.50	8.90
Maianthemum canadense	19.44	0.44	6.79
Trientalis borealis	16.66	0.50	6.00
Carex trisperma	16.66	0.17	5.51
Sarracenia purpurea	11.11	3.51	4.82
Ilex verticillata	8.33	0.83	3.85
Cypripedium acaule	11.11	0.22	3.83
Lycopus uniflorus	8.33	0.36	3.16
Thelypteris palustris	8.33	0.28	3.04
Rubus hispidus	8.33	0.08	2.74
Rosa palustris	2.77	1.11	2.51
Salix pedicillaris	2.77	1.11	2.51
Quercus velutina	5.55	0.17	2.00
Vaccinium macrocarpon	5.55	0.17	2.00
Carex aquatilis	2.77	0.56	1.69
Typha latifolia	2.77	0.14	1.07
Menyanthes trifoliata	2.77	0.06	0.95
Viola affinis	2.77	0.06	0.95
Woodwardia virginica	2.77	0.06	0.95
Drosera rotundifolia	2.77	0.03	0.91
Habenaria ciliaris	2.77	0.03	0.91
Monotropa uniflora	2.77	0.03	0.91
Rhynchospora alba	2.77	0.03	0.91
Point intercepts			
Vaccinium corymbosum	86.11		
Larix laricina	72.22		
Nemopanthus mucronata	13.88		
Acer rubrum	8.33		
Ilex verticillata	8.33		
Quercus velutina	5.55		
Toxicodendron vernix	5.55		
Nyssa sylvatica	2.77		
Salix petiolaris	2.77		
Ulmus rubra	2.77		

cover. Sphagnum is by far the most frequent plant, but has a cover value of 39.67%. The remaining species provide very little cover. Most of the species listed in Table 8 occur near the margin of the zone.

The zone is acid with an average pH value of 4.5.

The Acer rubrum Zone

The climax stage of the bog forest encircles the Larix zone and is dominated by Acer rubrum, which has a frequency of 65.78%. Other tree species are infrequent, as indicated by the low incidence of point intercepts (Table 9). The frequencies of Nyssa sylvatica and Pinus strobus are inflated. Nyssa sylvatica was located in only two stations, both of which occurred on the transect line. Only two tall trees and two saplings of Pinus strobus were noted in the bog.

The understory is dominated by Ilex verticillata and Vaccinium corymbosum. Together the two species have a frequency of 73.68%. Nemopanthus mucronata is also frequent in the zone and should, perhaps, have a higher percent frequency than is indicated in Table 9. Toxicodendron vernix occurs in this zone also, but tends to frequent places where the shade is light.

The Acer rubrum zone has a much denser ground cover than the Larix zone. Frequency, cover, and importance values are

Table 9. -- Frequency, cover, and importance values of 23 species encountered in quadrats and at point intercepts in the Acer rubrum zone

Species	% Frequency	% Cover	Importance Value
Quadrats			
Sphagnum spp.	42.10	13.95	53.07
Maianthemum canadense	85.71	5.60	40.84
Ilex verticillata	85.71	3.87	35.72
Osmunda cinnamomea	15.78	5.24	19.97
Trientalis borealis	28.94	1.50	12.62
Lycopus uniflorus	26.31	0.47	8.84
Rubus hispidus	18.42	0.58	6.92
Vaccinium corymbosum	7.89	0.92	4.94
Acer rubrum	5.26	0.71	3.59
Thelypteris palustris	7.89	0.18	2.76
Carex trisperma	7.89	0.08	2.46
Galium trifidum	5.26	1.49	1.63
Woodwardia virginica	2.63	0.18	1.27
Cypripedium acaule	2.63	0.13	1.12
Rosa palustris	2.63	0.13	1.12
Toxicodendron vernix	2.63	0.13	1.12
Quercus velutina	2.63	0.05	0.88
Mitchella repens	2.63	0.03	0.82
Point intercepts			
Acer rubrum	65.78		
Ilex verticillata	39.47		
Vaccinium corymbosum	34.21		
Nemopanthus mucronata	7.89		
Nyssa sylvatica	5.26		
Pinus strobus	5.26		
Aronia melanocarpa	2.63		
Betula lutea	2.63		
Quercus velutina	2.63		
Toxicodendron vernix	2.63		

presented in Table 9. The predominate species of Sphagnum is S. fimbriatum (det. by N. G. Miller), which forms clumps rather than a deep, continuous cushion as does S. magellanicum in the Larix zone. Maianthemum canadense is the most frequent herb and Ilex verticillata is the most frequent woody seedling. Osmunda cinnamomea is also an important species of the zone and is abundant in very wet places.

Along the outer margin of the bog there are numerous openings in the Acer rubrum zone. The species present in these openings tend to be typical of swampy sites. These include such species as Viburnum lentago, Cornus stolonifera, Corylus americana, Echinocystis lobata, Vitis vulpina, Leersia oryzoides, Glyceria striata, Aster umbellatus, Urtica dioica, Bidens cernua, B. coronata, Impatiens biflora, and Alisma plantago-aquatica. The pH of these openings averages 6.42 while the pH of the Acer rubrum zone averages 4.81.

On the west side of Little Goose Lake there is a large Vaccinium corymbosum subzone associated with the Acer rubrum zone. Vaccinium corymbosum, with a 100% frequency value, forms a very dense thicket. Aronia melanocarpa is also frequent, occurring at one-third of the point intercepts. Acer rubrum occurs with a frequency of 22.72% and the trees are mostly very large and quite

scattered. They cast very little shade on the area. There are very few ground-cover species and these provide very little cover. Sphagnum attains its highest importance value here since it has high frequency and cover values and since few other species contribute to the ground cover. It is interesting to note that no Acer rubrum seedlings were encountered in the quadrats. Frequency, cover, and importance values are given in Table 10.

Table 10. -- Frequency, cover, and importance values of 10 species encountered in quadrats and at point intercepts in the Vaccinium corymbosum subzone associated with the Acer rubrum zone on the west side

Species	% Frequency	% Cover	Importance Value
Quadrats			
Sphagnum spp.	77.27	52.73	116.51
Rubus hispidus	31.81	14.89	19.38
Maianthemum canadense	36.36	1.45	19.22
Vaccinium corymbosum	18.18	4.77	15.77
Trientalis borealis	22.72	0.32	11.11
Osmunda cinnamomea	18.63	2.82	10.67
Aronia melanocarpa	13.63	0.59	7.27
Point intercepts			
Vaccinium corymbosum	100.00		
Aronia melanocarpa	36.36		
Acer rubrum	22.72		
Toxicodendron vernix	9.09		
Amelanchier arborea	4.54		

ENUMERATION OF SPECIES

A total of 144 species of vascular plants was collected in Pennfield Bog, including nine aquatic plants of the associated bog lake. The species are discussed in terms of their occurrence within the bog, perennation, general habitat, and North American distribution. The order in which the plants are discussed follows Gleason and Cronquist (1963) for pteridophytes and gymnosperms and the system of Takhtajan (1966) for angiosperms.

Osmundaceae

Osmunda cinnamomea L.

Frequent in very wet places in the Acer rubrum zone. Forming large clumps with Sphagnum often the only other ground cover present. Crow 146 (fertile June 26), 235, 368.

The species is represented in eastern Asia by subsp. asiatica (Fern.) Hultén, and in subtropical and tropical America by var. imbricata Fern. The typical plant is North American (Hultén, 1964).

Perennial from stout rhizome. Swamps, low woods, and streambanks. Newfoundland to Minnesota south to the Gulf States (Fernald, 1950; Hultén, 1964).

Osmunda regalis var. spectabilis (Willd.) A. Gray

Frequent in the very wet Carex-Vaccinium macrocarpon zone. Occasional in very wet places in light shade of the Acer rubrum zone at the outer margin of the bog. Crow 144 (fertile June 22), 242.

This North American variety differs from the typical in its smaller size, and in the absence of black hairs on the rachis of the fertile portion of the blade (Hultén, 1957).

Perennial from rhizome. Swamps and moist places, usually acid soil. Eastern half of the United States and Mexico, the West Indies, Panama, Brazil and Uruguay. Also in central and southern Africa, Madagascar, Japan, China, and Burma (Hultén, 1958).

Equisetaceae

Equisetum fluviatile L.

Always in wet, shady places in the Carex-Salix subzone and wet depressions in the Larix zone. Crow 51, 199.

Shallow water, wet shores and swales. Circumpolar; Labrador and Newfoundland to Alaska, south to Virginia; west to Nebraska, Wyoming and Oregon (Hultén, 1964).

Polypodiaceae

Onoclea sensibilis L.

Frequent in openings and light shade at outer edge of the Acer rubrum zone and occasional immature plants in the Carex-Vaccinium macrocarpon zone at north end of bog. Crow 386 (fertile August 12), 488.

Perennial from rhizomes. Low open ground, alluvial thickets and low woods. Newfoundland to southern Labrador Peninsula to Manitoba, south to Florida, Louisiana and Texas (Fernald, 1950).

Thelypteris palustris var. pubescens (Laws.) Fern.

Very important mat building species. A dominant of the Carex-Vaccinium macrocarpon zone and of the Cassandra-Thelypteris zone. Frequent on the Decodon submerged mat. Occasionally in shade of the Acer rubrum zone, but having little or no cover value. Crow 339 (fertile August 2).

Fernald regards the species as having two varieties in North America, var. pubescens (Laws.) Fern., the northern variation, and var. haleana Fern., the southern element. Hultén has transferred the former taxon to subspecific level (subsp. pubescens [Laws.] Hultén).

Perennial fern of marshes and bog margins. Nearly cosmopolitan; in North America, eastern half of the United States and southern Canada (Hultén, 1964).

Woodwardia virginica (L.) Smith

In deep Sphagnum and light shade of open Larix subzone. Clonal. Crow 271 (fertile July 11), 315.

Perennial from rhizomes. Acid bogs, swamps and wooded bottoms. Florida to Texas, north to Nova Scotia, southwestern New Brunswick, central Maine, southwestern Quebec, southern Ontario, Ohio and southern Michigan; Bermuda (Fernald, 1950).

Pinaceae

Larix laricina (DuRoi) K. Koch.

One of the most important species of the bog. Forming an extensive zone behind the Carex-Vaccinium macrocarpon and Cassandra zones. With a dense understory of Vaccinium corymbosum and little ground cover where trees are most dense, but

Sphagnum abundant in less dense portion of the zone at the north end. Crow 35 (pollinating April 22), 236.

Tree. Restricted to cool swamps or Sphagnum bogs in southern portion of range, reaching greatest development farther north on moist beaches and better drained uplands. Labrador to Alaska, south to northern New Jersey, northern Pennsylvania, northern Ohio, northern Illinois to Minnesota, and in northern West Virginia (Harlow and Harrar, 1958; Little, 1965).

Pinus strobus L.

Two very large trees (approximately 20 m. tall) in the transition between the Larix zone and the Acer rubrum zone. Seedlings in the Larix zone, rare. Crow 91.

Tree of many habitats from dry rock ridges to wet Sphagnum bogs. Best development on moist sandy loams. Newfoundland to Manitoba, south to Delaware, south along the Appalachians to Georgia, Kentucky, and Iowa (Gleason and Cronquist, 1963; Little, 1965).

Nymphaeaceae

Brasenia schreberi Gmel.

Forerunner of bog mat. Abundant in open water at edge of floating mat. Crow 184 (flowering June 30), 527, 559.

Perennial from creeping rootstock. Ponds and slow streams. Florida to Texas, north to Prince Edward Island, southern Quebec, southern Ontario and Minnesota, and southern British Columbia to Oregon. Also in tropical America, Asia, Africa, and Australia (Fernald, 1950).

Nuphar luteum subsp. macrophyllum (Small) Beal

Important forerunner of the floating bog mat. Abundant in intermittent pools in the Carex-Vaccinium macrocarpon mat at the north end of Little Goose Lake. Crow 140 (flowering June 22), 528.

E. O. Beal (1956) recognizes the genus Nuphar in North America as having one polymorphic species, Nuphar luteum, with 8 subspecies having the following distributions: subsp. pumilum in northeastern North America; subsp. variegatum in northern United States and Canada; subsp. sagittifolium in Virginia and the Carolinas; subsp. orbiculatum on the coastal plain in Georgia and northern Florida; subsp. ulvaceum in the Blackwater River of western Florida; subsp. ozarkanum in the Ozark region of Missouri and Arkansas; subsp. polysepalum in northwestern North America and subsp. macrophyllum throughout eastern United States.

Subspecies macrophyllum (previously treated as N. advena): perennial from thick, heavy rhizomes. Tidal waters, pond-margins,

swamps, and sluggish streams. Florida to Texas and northeastern Mexico, north to coast of New England, central New York, southern Michigan and southern Wisconsin (Beal, 1956).

Nymphaea tuberosa Paine

Important forerunner of floating bog mat. In Nuphar-Eleocharis zone and in deeper water off the bog mat. Crow 138 (flowering June 22).

Perennial, from thick rhizomes. Quiet waters of pond margins and slow streams. Southwestern Quebec to northern Ontario, Minnesota, and Nebraska, south to Maryland, Ohio, Indiana, Illinois and Arkansas (Fernald, 1950).

Ceratophyllaceae

Ceratophyllum demersum L.

Free floating in open water just off edge of bog mat. Abundant. Crow 428.

Perennial herb of quiet waters. Widespread from southern Canada to South America and widely distributed in the Old World. (Gleason and Cronquist, 1963).

Ranunculaceae

Coptis trifolia var. groenlandica (Oeder) Fass.

Frequent in shade of damp Acer rubrum zone. In Sphagnum or partially decayed leaves. Crow 157 (flowering June 26), 510.

Perennial herb from slender rhizomes. Damp mossy woods and bogs. Greenland to Alaska and eastern Asia, south to New Jersey, North Carolina, northern Indiana, Iowa and Idaho (Gleason and Cronquist, 1963).

Ranunculus sceleratus L.

In very wet, mucky peat of path through the Larix-Salix subzone. Light shade. Noted once. Crow 562.

Annual or short lived perennial herb of marshes, ditchbanks, and swampy meadows. Circumboreal; Newfoundland to Alaska, south to Nova Scotia, through New England and to Florida, Louisiana, Arkansas, New Mexico and California (Fernald, 1950).

Sarraceniaceae

Sarracenia purpurea L.

Most abundant on the east side of the bog in the wet Carex-Vaccinium macrocarpon zone. Also abundant in the Cassandra zone in depressions between Sphagnum hummocks. Frequent in deep

Sphagnum in the open Larix zone. Crow 64, 131 (flowering June 10), 366.

Wherry (1933) recognized two subspecies, but Bell (1949) and McDaniel (1966) agree that no subspecific or varietal division is desirable.

Perennial herb from rhizome. Sphagnum bogs and peaty barrens. Chiefly in the Northeast and Coastal Plain from Labrador to Lake Athabaska, south to the Wisconsin glacial boundary, and extending into northeastern Maryland and Delaware. Again in extreme southern Virginia, common on the Gulf Coastal Plain from western Florida to Mississippi (McDaniel, 1966).

Ulmaceae

Ulmus rubra Mühl.

Occasional. In the Acer rubrum zone, the Larix zone, and in the open at the edge of the Larix zone behind the Cassandra zone. All locations very wet. Crow 198, 217.

Tree. Rich, low grounds, and low, rocky woods and hillsides (Blakeslee and Jarvis, 1931). Throughout the eastern United States from Quebec and Maine to North Dakota, south to the northern border of Florida and eastern Texas. Absent from the southeast Atlantic Coastal Plain and the Gulf Coastal Plain (Little, 1965).

Urticaceae

Boehmeria cylindrica (L.) Sw.

Abundant in open on very wet margin of Carex-Vaccinium macrocarpon zone. Frequent in wet peat of the Acer rubrum zone and the Larix-Salix subzone. Sun form with leaves more scabrous and pubescent beneath and short petioled. Shade form with slightly scabrous leaves. Crow 205, 287 (flowering July 14), 346.

Perennial herb of moist or wet soil. Quebec and Ontario to Minnesota, south to Florida and New Mexico (Gleason and Cronquist, 1963).

Urtica dioica var. procera (Mühl.) Wedd.

Infrequent. In open, swampy site at outer edge of bog. Crow 556 (flowering October 7).

Perennial herb. Weedy in thickets and roadsides. Moist, especially alluvial soil. Newfoundland to North Carolina, west to British Columbia and New Mexico (Gleason, 1952; Hultén, 1958).

Fagaceae

Quercus velutina Lam.

In the Larix and Acer rubrum zones. Rare within the bog. Dominant tree species on hillsides surrounding the bog. Crow 278.

Tree. Best growth on rich, well-drained soils, but oftener on poor, dry, sandy or heavy glacial clay hillsides. Eastern half of the United States, but absent from the southeastern Atlantic Coastal Plain and the Gulf Coastal Plain and the Blue Ridge and Ridge and Valley Provinces of West Virginia, Virginia, North Carolina and Tennessee (Harlow and Harrar, 1958).

Betulaceae

Betula lutea Michx. f.

Occasional near the outer margin of the bog in the Acer rubrum zone. Crow 77, 90 (flowering May 30).

Tree. Moist, cool locations on steep northerly slopes and at the edge of Sphagnum bogs. Newfoundland to Minnesota, Great Lakes region and New England, and south in mountains to eastern Tennessee and northern Georgia (Little, 1965).

Betula pumila var. glabra Regel

Infrequent. Noted only in the Larix-Salix subzone. Very wet substrate. Crow 75, 290.

Var. glabra occurs locally in Michigan and northern Indiana.

Shrub of bogs and wooded swamps. Newfoundland and Quebec to southern Ontario and Michigan, south to New Jersey,

Maryland, central Ohio and northern Indiana (Gleason and Cronquist, 1963).

Corylus americana Walt.

In understory of the Acer rubrum zone at outer edge of bog. Noted once. Crow 542.

Tall shrub of dry or moist woods and thickets. Maine to Saskatchewan, south to Georgia, Missouri and Oklahoma (Gleason and Cronquist, 1963).

Polygonaceae

Polygonum hydropiperoides Michx. var. hydropiperoides

In deep open water just off edge of the Decodon mat, rooted in false bottom. Occasionally prostrate with erect inflorescence on edge of submerged Decodon mat. Crow 313 (flowering July 22), 353, 383.

Perennial herb from rhizomes. Wet soil, beaches, marshes, and shallow water. Florida to Texas, north to Nova Scotia, New Brunswick, southern Quebec, southern Ontario, Michigan, Wisconsin, Minnesota and Nebraska (Fernald, 1950).

Polygonum sagittatum L.

In wet openings at outer edge of the Acer rubrum zone. Infrequent. Crow 514 (flowering August 31).

Annual of marshes and wet meadows. Newfoundland and Quebec to Saskatchewan, south to Georgia and Texas (Gleason and Cronquist, 1963).

Rumex orbiculatus Gray

Occasional in very wet, loosely consolidated peat along path through Larix-Salix subzone. In light shade. Crow 196, 519 (flowering September 11).

Perennial herb of wet meadows, swamps and shores. Newfoundland to North Dakota, south to Nova Scotia, New England, New Jersey, Pennsylvania, Ohio, Indiana, Illinois, Iowa, and Nebraska (Fernald, 1950).

Hypericaceae

Hypericum boreale (Britt.) Bickn.

Very wet places near edge of water in Carex-Vaccinium macrocarpon zone. Crow 308, 357 (flowering August 4), 504.

Perennial herb of damp peat, sand, and shallow water. Newfoundland to Ontario and Minnesota, south to Nova Scotia, New

England, Long Island, southeastern and western Virginia, Ohio, Indiana, Illinois, and eastern Iowa (Fernald, 1950).

Triadenum virginicum (L.) Raf.

Abundant near water's edge on very wet Carex-Vaccinium macrocarpon mat and on floating island dominated by Decodon verticillata. Occasionally in Larix-Salix subzone. Crow 307, 390, 406 (flowering August 16).

Perennial herb of bogs, marshes and wet shores. Nova Scotia to Florida and Mississippi, mostly near the coast or inland at low altitudes across New York to southern Ontario, Ohio and the southern end of Lake Michigan (Gleason and Cronquist, 1963).

Violaceae

Viola affinis LeConte

In wet, decaying leaves at outer margin of Acer rubrum zone at north end of bog. Crow 85 (flowering May 27).

This species is a member of a complex of five violets which are now treated at the species level. Russell (1965) feels that eventually these plants might be better considered as subspecies. Viola affinis is the northeastern element, V. missouriensis is in the midwest, V. langloisii in the southern midwest, and V. floridana represents the complex in the southeast. Viola affinis intergrades with

V. missouriensis in Indiana and Illinois and V. affinis is indistinguishable from V. floridana in southern North Carolina and South Carolina (Russell, 1965).

Perennial herb from rhizome. Deciduous woodlands. Vermont to Wisconsin, south to Georgia and Alabama (Gleason and Cronquist, 1963; Russell, 1965).

Viola nephrophylla Greene

Abundant in Sphagnum hummocks of Cassandra zone, frequent in Carex-Vaccinium macrocarpon zone, and occasional in Decodon zone. Producing only cleistogamous flowers. Crow 322 (cleistogens July 30), 394, 524.

Perennial herb from rhizomes. Gravelly shores, slopes, bogs and open low grounds. Newfoundland to British Columbia, south to northern and western New England, northern New York, southern Ontario, Michigan, Wisconsin, northern Iowa, North Dakota, New Mexico, Arizona and southern California (Fernald, 1950; Russell, 1965).

Curcurbitaceae

Echinocystis lobata (Michx.) T. & G.

Climbing vine rooted in muck at swampy outer edge of bog at north end. Occasional. Crow 418 (flowering and fruiting August 22).

Annual. High-climbing herbaceous vine. Moist ground and thickets, and rich soil along streams. New Brunswick to Saskatchewan, south to Florida and Texas (Fernald, 1950).

Salicaceae

Populus tremuloides Michx.

Infrequent. In the open on the edge of the Carex-Vaccinium macrocarpon zone, and in the Larix zone where growth is not dense. Crow 79, 285.

Tree. Along water courses and sites where forest cover is sparse. Widely distributed throughout North America, from Labrador west to Alaska, southward along the Rocky Mountains into Sonora, Mexico; in eastern North America south to the glacial boundary (Little, 1965).

Salix bebbiana Sarg.

Most abundant willow of Larix-Salix subzone. Always in very wet peat. Crow 52 (flowering May 6), 291.

Shrub of moist or wet places. Newfoundland to Alaska, south to New Jersey, South Dakota, and New Mexico (Gleason and Cronquist, 1963; Raup, 1947).

Salix candida Flügge

In open, on Carex-Vaccinium macrocarpon mat at border of Larix zone at northeast end of bog. Frequent at this location. Crow 38, 39, 40 (flowering April 22), 86.

Shrub of cold bogs and thickets. Labrador to British Columbia, south to Newfoundland, northern and western New England, northern New Jersey, Pennsylvania, northern Ohio, northern Indiana, northern Illinois, northern Iowa, South Dakota and Colorado (Fernald, 1950).

Salix pedicellaris var. hypoglauca Fern.

On wet Carex-Vaccinium macrocarpon mat at north end of Little Goose Lake and on submerged mat dominated by Typha latifolia on northern shore of Goose Lake. Infrequent. Crow 41 (flowering April 22), 55, 59, 154, 216.

Shrub of Sphagnum bogs and swamps. Newfoundland to Mackenzie District and British Columbia, south to New York, northern Iowa and Washington (Gleason and Cronquist, 1963).

Salix petiolaris Sm.

Always in very wet sites. In open on Carex-Vaccinium macrocarpon mat near border of Larix zone at north end,

Larix-Salix zone, and occasional in Decodon zone. Crow 37 (flowering April 22), 370.

Shrub of moist meadows, streambanks, and lake shores. New Brunswick to New Jersey, west to Alberta, northern Nebraska and Colorado, sporadic in Virginia and Oklahoma (Gleason and Cronquist, 1963).

Salix serissima (Bailey) Fern.

On very wet sites on the Carex-Vaccinium macrocarpon mat at edge of Larix-Salix subzone and along path through Larix-Salix subzone. Crow 87, 89 (flowering May 30).

Shrub of swamps and bogs. Newfoundland to Alberta, south to northern New York, northern Indiana, central Minnesota and Colorado (Gleason and Cronquist, 1963).

Ericaceae

Andromeda glaucophylla Link.

Always in very wet places. Colonies of plants scattered in Carex-Vaccinium macrocarpon zone and on deep Sphagnum mat. Crow 54 (flowering May 6), 63, 189, 239.

Low shrub of bogs. Newfoundland and Labrador to Saskatchewan, south to New Jersey, West Virginia, northern Indiana, and Minnesota (Gleason and Cronquist, 1963).

Cassandra calyculata (L.) D. Don

An important shrub species in the bog. Forming a Cassandra zone on the east side of Little Goose Lake, characterized by a cushion of Sphagnum growing up around the shrub bases. Dominant of the very dense, wet Cassandra-Thelypteris zone north of Little Goose Lake. Frequent, but not dominant, on submerged Decodon mat of west side of bog. Noted once in shade of Larix-Salix subzone. Crow 42 (flowering April 22), 188, 240, 295.

Although the name Chamaedaphne Moench is deeply entrenched in the literature, the earliest legitimate name is Cassandra D. Don (Wood, 1961).

Shrub of bogs and peaty soils. Nearly circumboreal; Labrador to Alaska, south to New Jersey, local on the Coastal Plain to South Carolina, New York, Pennsylvania, northern Ohio, northern Indiana, northern Illinois, Minnesota, Alberta and British Columbia (Wood, 1961).

Gaultheria procumbens L.

Prostrate on moist, partially decayed leaves of Acer rubrum zone on west side of Little Goose Lake where ground cover is sparse. Infrequent. Crow 376.

Subshrub. Dry or moist woods in acid soul. Newfoundland to Manitoba, south to Virginia, Kentucky, Minnesota and in the mountains to Georgia (Gleason and Cronquist, 1963).

Vaccinium corymbosum L.

Very abundant, forming dense understory of the mature Larix zone and frequent in the Acer rubrum zone, with little herbaceous ground cover beneath the dense growth. Crow 69 (flowering May 13), 74, 92, 153, 363.

Shrub. Usually in swamps or boggy areas, or along lake and stream margins. Nova Scotia to Michigan, south to New Jersey, Pennsylvania, Ohio and Indiana (Gleason and Cronquist, 1963).

Vaccinium macrocarpon Ait.

A dominant of the Carex-Vaccinium macrocarpon zone. Also abundant in deep Sphagnum of the open Larix subzone, and less dense in the Cassandra zone. Crow 36, 134 (flowering June 22), 238. Plants flowering only in open sunlight.

Subshrub of open bogs, swamps, and wet shores. Newfoundland to Minnesota, south to Nova Scotia, New England, Long Island, North Carolina, West Virginia, Ohio, Indiana, Illinois, and (rarely) Arkansas (Fernald, 1950).

Monotropaceae

Monotropa uniflora L.

Only in Larix zone. In deep Sphagnum on west and north sides of bog and in moist peat beneath Vaccinium corymbosum where herbage is sparse. Infrequent. Crow 186 (flowering July 3), 323, 512.

Perennial herb of rich woods. Newfoundland to Washington, south to Florida, California and Central America; east Asia (Gleason and Cronquist, 1963).

Primulaceae

Lysimachia thyrsiflora L.

Frequent on outer edge of submerged mat dominated by Decodon verticillatus. Crow 101 (flowering June 10).

Perennial herb of river bottomlands, swamps, marshes, pond margins, and bogs. Circumboreal; eastern Quebec to the Aleutian Islands, Alaska, southward to Pennsylvania, Missouri, and northern California (Ray, 1956).

Trientalis borealis Raf.

Abundant in Sphagnum in the Larix zone and among partially decayed leaves of the Acer rubrum zone. Crow 76 (flowering May 27), 232, 245.

Perennial herb of woodlands and peaty slopes. Labrador to Saskatchewan, south to Newfoundland, Nova Scotia, New England, Virginia, West Virginia, Ohio, Indiana, Illinois and Minnesota (Fernald, 1950).

Rosaceae

Amelanchier arborea (Michx. f.) Fern.

Small tree, occasional in understory of open Acer rubrum zone in moist peat. Crow 33 (flowering April 22), 374.

Tree of dry woods and open ground and on wooded hillsides. Maine to Minnesota, southward to Louisiana, and northern Florida (Jones, 1946).

Aronia melanocarpa (Michx.) Ell.

At the edge of the Larix zone on west side of bog in light shade and frequent in the Vaccinium corymbosum subzone associated with the Acer rubrum zone on the west side of the bog. Crow 82 (flowering May 27), 362.

Shrub of acid soil of bogs, dunes, dense woods, and rocks. Newfoundland to Minnesota, south to South Carolina, northern Georgia, and Tennessee (Gleason and Cronquist, 1963).

Potentilla palustra (L.) Scop.

Frequent in very wet places. Most abundant on submerged Decodon mat. Frequent in wet Cassandra zone of north end of bog. Occasional in deep Sphagnum of open Larix subzone.

Perennial herb from rhizomes. Marshes, bogs, and margins of streams. Circumboreal: Greenland and Labrador to Alaska, south to Newfoundland, Nova Scotia, New England, northern New Jersey, Pennsylvania, central Ohio, northern Indiana, northern Illinois, northern Iowa, Wyoming and California (Fernald, 1950).

Prunus virginiana L.

Low shrub in light shade of the Acer rubrum zone near outer margin at north end of bog. Noted only once. Crow 88 (flowering May 30).

Shrub or small tree of varying habitats from rocky hills and dunes to borders of swamps. Newfoundland to Manitoba, south to Virginia and Arkansas (Gleason and Cronquist, 1963).

Rosa palustris Marsh.

In light shade at margin of Larix zone and submerged Decodon mat at north end. Also in light shade of Acer rubrum zone and Larix-Salix subzone. Always in very wet sites. Infrequent. Crow 73, 297 (flowering July 14).

Climbing shrub of swamps, marshes, wet thickets and shores. Florida to Arkansas, north to Nova Scotia, New Brunswick, southern Quebec, Algoma District of Ontario, Michigan, Wisconsin, Minnesota (Fernald, 1950).

Rubus hispidus var. obovalis (Michx.) Fern.

Always in shade of Larix zone and Acer rubrum zone. Usually growing in Sphagnum. Frequent. Crow 167 (flowering June 26), 208, 277, 364, 417.

Trailing subshrub of moist or dry open soil, ditches, swales and open woods, most often in damp habitats. Quebec and Nova Scotia to Wisconsin, south to North Carolina and isolated stations in eastern Oklahoma (Braun, 1937).

Rubus pubescens Raf.

Only one station noted. In Sphagnum hummock around base of Larix in Larix-Salix zone. Crow 83 (flowering May 27).

Perennial herb from rhizome. Low and boggy land and swamps, or firmer soils farther north. Labrador to Yukon and British Columbia, south to New Jersey, West Virginia, Indiana, Wisconsin, Iowa, Colorado, and Washington (Bailey, 1941).

Spiraea alba DuRoi

Frequent in open sunlight and light shade. In deep Sphagnum of the open Larix subzone, and in the Larix-Salix subzone, Cassandra-Thelypteris zone, the Carex-Vaccinium macrocarpon zone and in the Acer rubrum zone at the outer edge of the bog. Crow 283, 289 (flowering July 14), 344, 361, 489.

According to Kugel (1958) Spiraea alba forms a complex with Spiraea latifolia which ranges from Alberta to Newfoundland, south to North Dakota and Iowa, Ohio, Pennsylvania, and south in the mountains to North Carolina. Map 14 gives the distribution of those plants of the complex which have been considered by Kugel as "good" S. alba.

Shrub of wet meadows, swamps, and shores. Western Quebec to Alberta, south to Virginia, North Carolina, Indiana, northern Missouri and South Dakota (Kugel, 1958; Gleason and Cronquist, 1963).

Spiraea tomentosa L.

Abundant. Usually in wet open places. Frequent on submerged Decodon mat, in Carex-Vaccinium macrocarpon zone and in Cassandra-Thelypteris zone. Occasional in deep Sphagnum and light shade of Larix zone at north end. Crow 283, 326 (flowering August 2), 532.

Shrub of swamps and wet meadows. Northeastern United States from Nova Scotia and New Brunswick to Quebec and Minnesota, south to North Carolina, Tennessee and Arkansas (Braun, 1937).

Saxifragaceae

Ribes americanum Mill.

In wet peat and light shade of Larix-Salix subzone. One station noted. Crow 200, 549.

Shrub of rich thickets and slopes. Western New Brunswick to Alberta, south to New England, Delaware, western Virginia, Ohio, Indiana, Illinois, Missouri, Nebraska, and New Mexico (Fernald, 1950).

Ribes hirtellum Michx.

In light shade of Larix-Salix subzone. Substrate very wet. One station noted. Crow 541.

Shrub of rocky or swampy woods and clearings. Southern Labrador to eastern Manitoba, south to Newfoundland, Nova Scotia, New England, Pennsylvania, West Virginia, northern Ohio, northern Indiana, northern Illinois and Minnesota (Fernald, 1950).

Droseraceae

Drosera intermedia Hayne

Restricted to the Carex-Vaccinium macrocarpon zone on the east side of Little Goose Lake; occurring only in wet, shallow depressions with some indication of organic decay. Almost always the only species in this microhabitat, but occasionally occurring with Utricularia intermedia. Crow 266, 318 (flowering July 26), 355.

A perennial herb of bogs. Frequent in the northeastern states and Atlantic Coastal Plain. From Newfoundland to Florida along the Coastal Plain and Piedmont and along the Gulf Coastal Plain, and west from Newfoundland through the Great Lakes states to Minnesota. An amphi-Atlantic plant, occurring frequently in Europe (Wynne, 1944; Hultén, 1958).

Drosera rotundifolia L.

Very abundant. In deep Sphagnum near the lake margin. Often on Sphagnum hummocks at the base of Cassandra calyculata. Also in hummock-like accumulations of Sphagnum at the bases of tall herbs and shrubs of the submerged mat dominated by Decodon verticillatus. Crow 319 (flowering July 26), 354.

Perennial plant of bogs and swamps. Circumboreal; south to northern Georgia, Illinois, Wisconsin, Montana, and California (Wynne, 1944).

Fabaceae

Apios americana Medic.

Abundant in light shade of the Larix zone on west shore of Goose Lake. In deep Sphagnum, often intwining Larix laricina and Woodwardia virginiana. Crow 365.

Perennial, herbaceous climbing vine of rich thickets. New Brunswick to Minnesota and Colorado, south to Nova Scotia, New England, Long Island, Florida, Louisiana and Texas (Fernald, 1950).

Lythraceae

Decodon verticillatus (L.) Ell. var. verticillatus

Dominating submerged mat along west side of Goose and Little Goose Lakes. Shaded by trees of the Larix zone. Dense growth allows accumulation of debris and Sphagnum above the spongy, thickened stem bases forming a hummock-like microhabitat. Vegetatively reproducing by rooting at tips of arching branches. Crow 314 (flowering July 22), 328.

Perennial herb of swamps and shallow pools. Florida to Louisiana, north to central Maine, southern New Hampshire, Massachusetts, New York, southern Ontario, and southern Illinois (Livingston and Shreve, 1921; Fernald, 1950).

Onagraceae

Epilobium strictum Muhl.

Near edge of water in Carex-Vaccinium macrocarpon zone on east side of Little Goose Lake, and in light shade of the Acer rubrum zone at outer edge of the bog. Infrequent. Crow 338 (flowering August 2), 358, 480.

Perennial herb with slender rhizomes. Bogs, swamps, mossy thickets, and meadows. Gaspé Peninsula, Quebec, to Minnesota, south to Nova Scotia, New England, northern Virginia, northern Ohio, central Indiana, and northern Illinois (Fernald, 1950).

Haloragaceae

Myriophyllum verticillatum L.

Free floating in open water just off bog mat. Abundant. Crow 56, 183, 230 (flowering July 7), 352, 561.

Perennial aquatic, wintering by turions. Herbaceous. In quiet waters. Circumboreal; south to Massachusetts, New York, Indiana, Illinois and Utah (Gleason and Cronquist, 1963).

Anacardiaceae

Toxicodendron vernix (L.) Ktze.

Very abundant throughout the bog. Usually in light shade or in the open. Frequent in Sphagnum. Always in wet soil. Crow 132 (flowering June 22), 515.

Shrub of swamps and bogs. Eastern United States from Maine to Minnesota, south to Maryland, Ohio and Indiana and along the coastal plain from Delaware to Florida and Texas (McNair, 1925; Barkley, 1937).

Aceraceae

Acer rubrum L.

Dominant of a zone at the outer margin of the bog, replacing Larix laricina in the successional process. Occasional individuals in the open on the Carex-Vaccinium macrocarpon mat. Crow 157, 263.

Tree. Swampy sites, but often in drier locations. Eastern half of the United States and southeastern Canada (Harlow and Harrar, 1958).

Balsaminaceae

Impatiens biflora Walt.

Only at outer edge of bog in openings of the Acer rubrum zone. Numerous colonies. Crow 387 (flowering August 12), 399.

Annual herb of moist woods, brooksides, and springy places. Newfoundland and Quebec to Saskatchewan, south to South Carolina, Alabama and Oklahoma (Gleason and Cronquist, 1963).

Cornaceae

Cornus stolonifera Michx.

Frequent in light shade of Larix-Salix subzone and wet places at outer margin of Acer rubrum zone. Crow 72 (flowering May 27), 192, 288, 345.

Shrub of shores, thickets, streambanks and moist woods. Newfoundland to Alaska, south to Pennsylvania, Indiana, Illinois, and northern Mexico (Rickett, 1944; Gleason and Cronquist, 1964).

Nyssaceae

Nyssa sylvatica Marsh.

Numerous small trees in the Acer rubrum zone at outer margin of bog at north end. One station in the Acer rubrum zone on the east side, a tree of ca. 14 meters and a few saplings

observed. One station on west side in the Larix zone, a tree of ca. 13 meters. Crow 360, 427, 492.

Tree. Low acid woods, swamps and shores. Eastern half of the United States with isolated localities in Mexico (Eyde, 1963; van Balgooy, 1966).

Araliaceae

Aralia nudicaulis L.

Frequent in wet peat and light shade at outer edge of Acer rubrum zone at north end of bog. Crow 483.

Perennial herb from stout rhizome. Moist or dry woods. Newfoundland and southern Labrador peninsula to British Columbia, south to District of Columbia, Indiana, Nebraska, and Colorado, and in the mountains to Georgia (Gleason and Cronquist, 1963).

Apiaceae

Hydrocotyle umbellata L.

At lake edge where mat is slightly submerged (1-5 cm). Also on two floating islands just off the bog mat. Colonies infrequent. Crow 191, 350 (flowering August 2), 395, 507.

Perennial herb with stems creeping and rooting at nodes. Pond shores, ditches and low grounds. On the coastal plain from

Florida to Texas and Mexico, north to Massachusetts and western Nova Scotia, New York, northeastern Ohio and southern Michigan, coast of southern California and tropical America (Fernald, 1950).

Sium suave Walt.

Frequent in open sunlight in Decodon zone, Carex-Vaccinium macrocarpon zone, Cassandra-Thelypteris subzone B, and occasional in light shade at the outer edge of the Acer rubrum zone. Crow 382, 497 (flowering August 28), 502.

Perennial herb of sunny wet meadows, swamps, and muddy banks. Newfoundland to British Columbia, south to Nova Scotia, New England, Florida, Ohio, Indiana, Illinois, Missouri, eastern Kansas, Colorado, Utah, Nevada and California (Fernald, 1950).

Aquifoliaceae

Ilex verticillata (L.) Gray var. verticillata

Frequent in understory of Acer rubrum zone. Occasional at outer edge of Larix zone. Crow 169.

Four varients are recognized in North America: var. verticillata, var. cyclophylla Robins, var. padifolia (Willd.) T. & G., and var. fastigiata (Bickn.) Fern.

Var. verticillata: shrub of swamps, pond-margins, and damp thickets. Newfoundland to Minnesota, south to Nova Scotia,

New England, Long Island, Georgia, Tennessee and Illinois (Fernald, 1950).

Nemopanthus mucronata (L.) Trel.

In understory of Acer rubrum zone and transiton from Larix zone to Acer rubrum zone. Frequent. Crow 60 (flowering May 13), 170, 276, 335.

Shrub of swamps, bogs, and wet woods. Newfoundland to Minnesota, south to Nova Scotia, New England, upland Virginia, West Virginia, Ohio, Indiana, and northern Illinois (Fernald, 1950).

Vitaceae

Parthenocissus quinquefolia (L.) Planch.

Creeping vine in wet peat at outer edge of bog in Acer rubrum zone. Crow 494.

Perennial woody vine of moist soil of woods and rocky banks. Florida to Texas and Mexico, north to southeastern Maine, southern New Hampshire, Vermont, southwestern Quebec, New York, Indiana, Illinois, and Minnesota. Spread from cultivation elsewhere (Fernald, 1950).

Vitis vulpina L.

Climbing vine in Acer rubrum zone at open of outer edge of the bog. Crow 498.

Woody vine of river-banks, bottomlands, and rich thickets. Florida to Texas, north to southeastern New York, Pennsylvania, West Virginia, Ohio, Indiana, Illinois, Missouri, and eastern Kansas (Fernald, 1950).

Asclepiadaceae

Asclepias incarnata L. subsp. incarnata

Always in open, very wet areas. Frequent on submerged mat dominated by Decodon verticillatus, and near shallow pools of the Carex-Vaccinium macrocarpon zone. Also on a Cassandra island just off the bog mat. Crow 203 (flowering July 7), 523.

Two subspecies are recognized by Woodson. Subspecies incarnata has nearly the range of the whole species, but is rare in the Atlantic coastal states, while subsp. pulchra occurs chiefly on the Atlantic Coastal Plain and Piedmont south to South Carolina, with single stations in Texas, Georgia, Florida and Ohio.

Perennial herb from rhizome. Watersides and wet soils. Chiefly northeastern United States, south to Florida and westward to New Mexico and Utah (Woodson, 1954).

Menyanthaceae

Menyanthes trifoliata L.

Always in very wet depressions. On deep Sphagnum mat of open Larix subzone; in water-filled depressions between hummocks where growth of tamaracks is not dense; and along animal trails of Carex-Vaccinium macrocarpon zone and Larix-Salix subzone. Crow 71 (flowering June 26), 163.

Perennial herb of Sphagnum bogs and wet coniferous forests. Labrador to Alaska, south to Newfoundland, Nova Scotia, New England, Delaware, Maryland, western Virginia, West Virginia, central Ohio, Indiana, Illinois, Missouri, Nebraska, and Wyoming (Fernald, 1950).

Rubiaceae

Cephalanthus occidentalis L. var. occidentalis

Always in the open on slightly submerged mats dominated by Decodon verticillatus. Occasional. Crow 296, 333 (flowering August 2), 416.

Shrub of swamps, pond margins, and stream margins. Chiefly of eastern half of the United States and adjacent Canada; var. occidentalis: from New Brunswick and Quebec to Minnesota, south

to Mexico and the West Indies (Livingston and Shreve, 1921; Gleason and Cronquist, 1963).

Galium trifidum L. var. trifidum

Most abundant in the open on wet Carex-Vaccinium macrocarpon mat on east side of Little Goose Lake. Occasional in light shade of Larix zone margin, Larix-Salix subzone, and at the outer edge of Acer rubrum zone. Crow 231 (flowering July 7), 242b, 284, 415.

Perennial herb of swamps and wet shores. Southern Labrador and Newfoundland to Alaska, south to Nova Scotia, New England, New York, Ohio, Michigan, Northern Illinois, Minnesota, Nebraska, Colorado and California (Fernald, 1950).

Mitchella repens L.

Prostrate on moist substrate of peat and partially decayed leaves in the Acer rubrum zone. On west side of bog. Ground cover sparse. Infrequent. Crow 375.

Perennial subshrub of dry or moist knolls in woods. Florida to Texas, north to southwestern Newfoundland, southern Quebec, Ontario, and Minnesota (Fernald, 1950).

Caprifoliaceae

Sambucus canadensis L.

Large shrub in the Acer rubrum zone near outer margin of bog. Noted once. Crow 234 (flowering July 11).

Shrub of moist woods, fields, and roadsides. Cape Breton Island, Nova Scotia, to Manitoba, south to New England, Georgia, Louisiana, and Oklahoma (Fernald, 1950).

Viburnum lentago L.

Tall shrubs in wet peat in openings at outer edge of Acer rubrum zone at north end of the bog. Crow 492.

Shrub or small tree of borders of woods, stream banks and roadsides. Western Quebec to Manitoba, south to New England, New Jersey, Pennsylvania, upland to Georgia, Ohio, Indiana, Illinois, northeastern Missouri, South Dakota, and Colorado (Fernald, 1950).

Solanaceae

Solanum dulcamara L.

Occasional in very wet openings at outer edge of bog. Once noted in Cassandra-Thelypteris subzone B. Crow 180 (flowering June 30).

Perennial vine from rhizomes. Thickets, clearings and in open woods, often in moist soil. Native of Eurasia and naturalized throughout northeastern United States (Gleason and Cronquist, 1963).

Scrophulariaceae

Agalinis purpurea (L.) Pennell

Always in open at water's edge on Cassandra hummocks. Crow 392 (flowering August 12), 486.

The generic name Gerardia in recent manuals is misapplied. Gerardia tuberosa L. is the type specimen of a member of the Acanthaceae. Gerardia purpurea L. is a member of the Schropulariaceae. The next oldest generic name is Chytra, but Agalinis Raf. has been conserved (Lanjouw, et al., 1966, p. 336).

Annual of damp open ground, shores, bogs, depressions and sand dunes and locally on dry or barren soil. Massachusetts to Florida, Minnesota, Nebraska and Texas (Pennell, 1935).

Lentibulariaceae

Utricularia gibba L.

Always in very shallow water. Three stations: on slightly submerged portion at edge of floating island dominated by Decodon verticillata; on slightly submerged portion of a sedge island at south

end of Little Goose Lake; and in very shallow water between Goose and Little Goose Lakes. Crow 397 (flowering August 12), 506.

Perennial, wintering by turions. Shallow pools, spring heads, quaking bogs. Florida to Texas and Mexico, north to Nova Scotia, New England, southern Quebec, New York, southern Ontario, Michigan, Wisconsin, Minnesota, Oklahoma, and California (Fernald, 1950; Rossbach, 1939).

Utricularia intermedia Hayne

Restricted to Carex-Vaccinium macrocarpon zone. Only in wet shallow depressions where there is some organic decay and the pH is near neutral (6.4-7.0). Almost always the only species in this microhabitat, but occasionally with Drosera intermedia. Crow 139 (flowering June 22) 268b.

Perennial herb, wintering by turions. Creeping at bottoms of shallow pools, on shores, and in quagmires. Greenland and Newfoundland to Alaska, south to Nova Scotia, New England, Long Island, northern Delaware, Pennsylvania, Ohio, northern Indiana, northern Illinois, northern Iowa, and farther west only at higher altitudes to the Pacific States; Eurasia (Fernald, 1950; Rossbach, 1939).

Utricularia purpurea Walt.

Abundant. Free floating in open water just off bog mat in Goose and Little Goose Lakes. Crow 233 (flowering July 11), 269, 525.

Perennial, wintering by turions. Ponds and sluggish streams. Nova Scotia, New Brunswick, New England, southwest Quebec and New York, northern Indiana, and southern Michigan to Minnesota, south along the Atlantic and Gulf Coastal Plain to Florida, Mississippi, Louisiana; Cuba and British Honduras (Rossbach, 1939).

Utricularia vulgaris L.

Abundant. Free floating in open water around margins of Goose and Little Goose Lakes. Crow 57, 104 (flowering June 10), 247, 268a, 533.

Perennial aquatic, wintering by turions. Deep or shallow quiet waters. Circumboreal; southern Labrador and Newfoundland, south through New England and western New York, less frequent southward to southern Florida, west to Alaska and British Columbia, and in the South, west through Louisiana to Texas and locally to southern California (Rossbach, 1939).

Lamiaceae

Lycopus uniflorus Michx.

In all zones of the bog except the Nuphar-Eleocharis zone. Most frequent on the Decodon mat and in the Carex-Vaccinium macrocarpon zone. Very infrequent on deep Sphagnum mats and in the Larix zone. Almost always in open sunlight. Crow 341 (flowering August 2), 343, 359, 484, 520, 537.

Perennial herb of wet places. Newfoundland to British Columbia, south through New England to Maryland, upland to North Carolina, Ohio, Indiana, Illinois, Iowa, Nebraska, western Oklahome, Montana and Oregon (Fernald, 1950).

Scutellaria galericulata L.

Always in open wet places. Most frequent in the Carex-Vaccinium macrocarpon zone. Also on submerged mat of west and north sides and in the Cassandra-Thelypteris zone at north end. Common. Crow 133 (flowering June 22), 202, 281.

The name S. epilobiifolia Hamilton has been used to distinguish the American plant from its Eurasian homologue. Epling, however, does not consider the differences sufficient to warrant giving the American plant recognition as a separate species. He concludes that the species is fairly stable in North America, except

for a glabrous form collected in Washington and Oregon and occasionally in the eastern United States, and that it is more variable in Eurasia, thus suggesting eastern and western races. Yet there are no satisfactory grounds for segregating the American group (Epling, 1942).

Rhizomatous perennial herb. Gravelly, sandy or rocky shores, meadows, and swampy thickets. Transcontinental Canada and United States to Alaska and south to northern Arizona and northern New Mexico. Most common in the Great Lakes region and New England and lake and swamp regions of northern Canada. Largely absent from the plains states. Local in the northern Rocky Mountains (Epling, 1942).

Scutellaria lateriflora L.

On submerged Decodon mat near the Larix zone, in light shade. Also in light shade at outer edge of the Acer rubrum zone. Crow 391 (flowering August 2), 405, 482.

Perennial from slender rhizomes. Alluvial thickets, meadows, and swampy woods. Most abundant in the drainages of the Ohio and St. Lawrence rivers. Transcontinental through the United States, south to southern California and northern Georgia (Epling, 1942).

Campanulaceae

Campanula aparinoides Pursh var. aparinoides

Always in open. Frequent in Carex-Vaccinium macrocarpon zone. Occasionally in Decodon zone and Cassandra-Thelypteris zone. Crow 201 (flowering July 7), 280.

Perennial herb from filiform rhizomes. Wet, sunny meadows, swales, and wet shores. Maine to Saskatchewan, south to Georgia, Kentucky, Iowa, Nebraska and Colorado (Fernald, 1950).

Asteraceae

Aster junciformis Rydb.

Frequent in wet, sunny parts of the Carex-Vaccinium macrocarpon zone. Crow 517 (flowering September 11).

Perennial herb from slender rhizomes. Bogs, swamps, and shores. Anticosti Island and the Gaspé Peninsula, Quebec to northern Alaska, south to Prince Edward Island, New Brunswick, northern and western New England, northern New Jersey, northern Pennsylvania, Ohio, northern Indiana, Wisconsin, Iowa, Colorado, and Washington (Fernald, 1950).

Aster umbellatus Mill.

In swampy opening at outer edge of Acer rubrum zone. Occasional. Crow 410 (flowering August 22).

Perennial herb of moist, low places. Newfoundland to northern Georgia, west occasionally as far as Minnesota and Illinois (Gleason and Cronquist, 1963).

Bidens cernua L.

In wet, mucky peat and light shade of the Larix-Salix subzone and in sunny openings of outer edge of the Acer rubrum zone rooted in muck and decaying leaves. Frequent. Crow 513 (flowering August 31), 518, 555.

Annual of low wet places. New Brunswick to British Columbia, south to California and North Carolina; widespread in old world (Hultén, 1958; Gleason and Cronquist, 1963).

Bidens coronata (L.) Britt.

Always in the open. Large patches in openings of the Acer rubrum zone at outer edge of bog. Frequent and occurring as single plants throughout the Carex-Vaccinium macrocarpon zone and the Cassandra-Thelypteris subzone B. Crow 197, 423 (flowering August 24), 426, 493.

Annual herb of wet places. Massachusetts, southern Ontario, and northern Wisconsin, south to Virginia, Kentucky and Nebraska (Gleason and Cronquist, 1963).

Eupatorium perfoliatum L. var. perfoliatum

In the open on the Carex-Vaccinium macrocarpon mat and in openings of the Acer rubrum zone at the outer edge of bog. Frequent. Crow 389 (flowering August 12), 409.

Perennial herb of low woods and thickets, wet shores, swales and prairies. Quebec to southeastern Manitoba, south through New England to Florida, Alabama, Louisiana and Texas (Fernald, 1950).

Eupatorium purpureum L.

Frequent in openings of the Cassandra-Thelypteris subzone B and occasional in the Carex-Vaccinium macrocarpon zone. Crow 388 (flowering August 12).

Perennial herb of rich, dry to moist, chiefly calcarious woods. Southern New Hampshire to Minnesota and Nebraska, south to northern Florida, Tennessee, Arkansas and Oklahoma (Fernald, 1950).

Alismataceae

Alisma plantago-aquatica var. americanum Roem. & Schult.

Open areas or light shade. Usually in mucky peat at outer edge of the Acer rubrum zone. Occasionally in shade of the Larix-Salix subzone at north end of bog and on the sedge mat near water's edge of Goose Lake on southwest side. Crow 320 (flowering July 22), 400, 420.

Perennial of marshes, ponds and streams. Circumboreal; Nova Scotia to Alberta and Washington, south to California and New Mexico (Hultén, 1964).

Sagittaria latifolia Willd. var. latifolia

Frequent in very wet sites, usually in open sunlight. In deep Sphagnum on west side of Little Goose Lake, in wet depressions in the Carex-Vaccinium macrocarpon zone, and in mucky peat of the Larix-Salix subzone. Crow 136, 325 (flowering August 2), 347, 511.

Perennial herb from rhizomes. Swamps, ponds, and streams. Nova Scotia to Quebec to southern British Columbia, south to northern South America (Gleason and Cronquist, 1963).

Juncaginaceae

Triglochin maritima L.

In openings of the Carex-Vaccinium macrocarpon zone. Rare in the bog. Crow 340 (fruiting August 2), 557.

Perennial of brackish or fresh marshes and bogs. Circumboreal, south to New Jersey, Ohio, Iowa, Nebraska and Mexico (Hultén, 1964).

Potamogetonaceae

Potamogeton gramineus L.

Frequent in shallow intermittent pools (outliers of the Nuphar-Eleocharis zone) on the Carex-Vaccinium macrocarpon mat at the north end of the bog. Common in shallow, wet depressions on the mat where it appears terrestrial, the floating leaves lying flat on the wet muck as the pools begin to dry in mid-summer. Abundant in open water just off the bog mat in Goose Lake. Crow 218, 228, 349, 529 (fruiting September 11).

Perennial herb from rhizomes. Lakes, ponds, and streams. A variable species, common and widespread in both North America and Europe. Newfoundland south to northern New Jersey, west through the Great Lakes states and scattered throughout the western

states, north to the Northwest Territory and Alaska. Most common in New England and the Great Lakes states (Ogden, 1943).

Potamogeton illinoensis Morong

Always in the open water just off the mat edge. Abundant in the lake. Crow 182 (flowering June 30).

The several variants of the species are difficult to distinguish because ecological forms often simulate the normal habit of varieties.

Perennial from rhizomes. Quiet waters. Scattered throughout the United States with its greatest abundance in the region of the Great Lakes and eastward to New Hampshire (Hultén, 1958; Ogden, 1943).

Potamogeton natans L.

Restricted to the shallow water of the open lake near the margin of the mat. Very abundant. Crow 181 (flowering June 30), 185, 246.

Perennial herb from rhizomes. A common species of shallow lakes, intermittent pools, and sluggish streams from Newfoundland, south to Pennsylvania, west to California and north to southern Alaska; occurring chiefly in the northern states. Also in Eurasia (Ogden, 1943).

Liliaceae

Maianthemum canadense Desf.

Most abundant herb of the Acer rubrum zone. Growing in Sphagnum and in damp, decaying leaves.

Two varieties occur in the bog and occupy the same habitat. Although small colonies of the two variations occurred in close proximity, the two plants appear to remain distinct. Var. canadense Desf. is the glabrous plant; Crow 81 (flowering May 27), 207, 244b, 272; var. interius Fern. has leaves usually larger and pubescent, and begins flowering about two weeks after the former variety begins flowering; Crow 164 (July 7), 187, 206, 244a, 538.

Perennial herb from filiform rhizomes, occurring in moist woods. Var. canadense: Labrador and Newfoundland to Mackenzie, south to New Jersey, South Dakota, and in the mountains to North Carolina; var. interius: British Columbia to southern Alberta, east to Ontario, Ohio and northern and western New York (Fernald, 1950; Hultén, 1964). Note: ranges of var. canadense and var. interius are reversed on Hultén's map 175.

Pontederiaceae

Pontederia cordata L.

Very abundant in shallow water of the Nuphar-Eleocharis

zone and submerged Decodon mat. Crow 145 (flowering June 26), 168, 241, 407.

Perennial herb from rhizomes. Marshes and shallow water. Nova Scotia to Ontario and Minnesota, south to South Carolina and Texas (Gleason and Cronquist, 1963).

Iridaceae

Iris versicolor L.

Only in large swampy openings outside the Acer rubrum zone. In peaty soil. Crow 411.

Perennial herb from the thick creeping rhizomes. Marshes, swamps, meadows, and shores. Southern Labrador to Manitoba, south to Newfoundland, Nova Scotia, New England, western Virginia, western Pennsylvania, northern Ohio, Michigan, Wisconsin, and Minnesota (Fernald, 1950).

Orchidaceae

Cypripedium acaule Ait.

Always in shade of the Larix zone. Usually in Sphagnum. Abundant, but never in clumps. Crow 70 (flowering May 24), 273, 334.

Perennial from coarsely fibrous roots. Moist or dry pine woods, occasionally in dry, open upland woods, swamps, bogs and

sterile soils of densely shaded woods along streams. Newfoundland to Saskatchewan and northeastern Alberta, south through the Great Lakes states and New England and along the Appalachians to northern Georgia and Alabama (Correll, 1950; Case, 1964).

Habenaria ciliaris (L.) R. Br.

Very abundant in deep Sphagnum and in sun and light shade of the open Larix zone of the west and north sides of Little Goose Lake. Occasional at edge of the Larix zone on east side. Crow 312 (flowering July 20), 530.

Perennial herb from buds forming on fleshy roots. In Sphagnum and sedge bogs, swamps, marshes, thickets on borders of streams and ponds, low flatwoods and wet pine barrens, wet meadows, and deep humus of forests. Rare and local in Ontario, Vermont, Massachusetts, Rhode Island, and Connecticut, becoming frequent through the Atlantic states to southern Florida, along the Gulf Coast to Texas and west through the central and Great Lakes states (Correll, 1950).

Habenaria clavellata (Michx.) Spreng.

Frequent in wet peat of the Acer rubrum zone at north margin of the bog. Always in shade. Crow 321 (flowering July 30), 478.

Perennial herb from buds formed on fleshy roots. In Sphagnum of tamarack-spruce bogs, balsam-cedar-spruce swamps, alder thickets or damp woods. Newfoundland, Nova Scotia, southern Quebec and Ontario to Minnesota, south through the Great Lakes states and New England, south along the coastal plain and in the mountains to northern Florida and Texas (Correll, 1950; Case, 1964).

Habenaria obtusata (Banks ex Pursh) Rich.

In deep Sphagnum and light shade at edge of the open Larix zone at north end. Infrequent. Crow 324 (flowers fading August 2).

Perennial from buds formed on fleshy roots. Cold wooded bogs and evergreen forests southward. More widespread northward in open heaths to birch-aspen forests. Alaska to Labrador and Newfoundland, south along the Appalachians to northern Georgia, the Great Lakes states, and in the mountains of Colorado and Utah (Correll, 1950; Case, 1964).

Isotria verticillata (Willd.) Raf.

In deep Sphagnum in shade of the Larix zone. Only three colonies noted. Crow 100 (flowering May 30).

Perennial herb from rootshoots. Sandy soils of moist, acid woods and deep Sphagnum beds of tamarack or spruce bogs. Throughout Eastern deciduous forests from southern part of the

Lake states and New England, south to Florida and Texas. Frequent in parts of the Atlantic Coastal Plain and Blue Ridge uplands. Local to rare elsewhere (Correll, 1950; Case, 1964).

Liparis Loeselii (L.) Rich.

Located twice in the bog, in the Carex-Vaccinium macrocarpon zone at the north end and in light shade at the edge of the Larix-Salix subzone. Both locations very wet. Crow 166 (flowering June 26), 348.

Perennial herb from corm. Damp or wet woods. In northeastern North America from Nova Scotia, Quebec, and Ontario to Minnesota and Manitoba, south through the Great Lakes states to the mountains of North Carolina and Alabama. Local in Saskatchewan, Washington and British Columbia. An amphi-Atlantic species which also occurs in Europe and northern Asia (Hultén, 1958).

Malaxis monophyllos var. brachypoda (Gray) F. Morris

In open sunlight in wet depressions on the Carex mat near water's edge. Infrequent. Crow 336 (flowering August 2).

Perennial from corm. Local or spotty in cold, wet soils, mainly neutral and usually shaded. Circumpolar. Newfoundland and Quebec, south through New England to New York and Pennsylvania, west through the Great Lakes region to Minnesota and

Manitoba, along the Pacific Coast of Alaska and British Columbia and California. Also in Europe, Asia, and Japan (Correll, 1950; Case, 1964; Hultén, 1964).

Pogonia ophioglossoides (L.) Ker.

Always in Sphagnum in open sunlight or light shade. Two large colonies in the Carex-Vaccinium macrocarpon zone on the east side of Little Goose Lake. A small population in the deep Sphagnum mat between Goose and Little Goose Lakes. Occasional scattered individuals on west side. Crow 141 (flowering June 22), 337.

Perennial from bulbs and root shoots. Sedge mats of Sphagnum bogs, meadows, swamps, low moist grassy pine barrens, cedar swamp edges and gravelly lake shores. Newfoundland through the Great Lakes region, New England, south along the Atlantic Coastal Plain and west along the Gulf Coastal Plain to central Texas (Correll, 1950; Case, 1964).

Juncaceae

Juncus brevicaudatus (Engelm.) Fern.

Emergent from shallow water on submerged Nuphar-Eleocharis mat. Frequent. Crow 384 (fruiting August 12), 503.

Perennial herb. Marshes, wet meadows and shores. Quebec and Nova Scotia to western Ontario and Minnesota, south to Massachusetts and New York and in the mountains to West Virginia (Gleason and Cronquist, 1963).

Juncus effusus var. solutus Fern.

Always in deep Sphagnum in the open or in light shade. Occasional. Crow 214 (flowering July 7), 330.

Gleason and Cronquist (1963) include var. Pylaei and var. decipens with var. solutus.

Perennial from rhizome. Bogs, peaty swamps and thickets, margins of pools, and wet open ground. A variable plant with a cosmopolitan distribution. Widespread in Europe and adjacent western Asia and less frequent on the Mediterranean coast, in the eastern Asiatic region, India, and south to Australia and New Zealand. Also in South America and several isolated oceanic islands.

The typical variety, widespread in Europe, also occurs in Newfoundland and on Prince Edward Island. Other eastern North American variations recognized by Fernald are var. compactus Lej. & Court, var. Pylaei (Laharpe) Fern. & Wieg., and var. decipens Buchen. The most common taxon in North America, var. var. solutus Fern., occurs widely in the eastern half of the United

States and adjacent Canada. In western North America var. pacificus Fern. & Wieg. is the predominant taxon (Hultén, 1958).

Cyperaceae

Carex aquatilis Wahl.

In open sun of the Carex-Vaccinium macrocarpon zone and light shade of the Larix-Salix subzone. Always in shallow water. Occasional. Crow 84, 194 (fruiting July 3), 286, 293.

Hultén (1964) indicates that there are three major races in this species. The high Arctic plant is subsp. stans (Drejer) Hultén and probably represents the race surviving glaciation to the north. The southern element is subsp. altior (Rydb.) Hultén and has probably survived in regions south of the ice advance. Subspecies aquatilis overlaps both the northern and southern races.

Perennial herb with horizontal stolons. Shallow pools, ponds and river margins and wet meadows. Circumboreal, south to New Jersey, Indiana, Iowa, and New Mexico (Hultén, 1964).

Carex canescens var. disjuncta Fern.

Occasional. In Carex-Vaccinium macrocarpon zone and on hummocks at base of trees in the Larix-Salix subzone. Crow 152 (fruiting June 26), 195.

Fernald distinguishes two varieties in North America; var. disjuncta Fern., with a long, loose inflorescence, occurs in eastern North America from Minnesota to Newfoundland, south to Indiana, Ohio, and Virginia; var. ~~subliacea~~ sublaevicea Laest., with short-ovoid to subglobose spikes, occurs almost throughout the range of the whole species in North America.

Perennial herb of swamps and bogs. Circumboreal; in the Great Lakes region to New England, southern Ontario and Quebec, south to Virginia, Ohio, Minnesota, along the Rocky Mountains to Arizona, and along the Pacific ranges to California (Hultén, 1964).

Carex chordorrhiza L. f.

Frequent on north shore of Goose Lake. Emergent from submerged Decodon mat. Crow 158 (fruiting June 26), 161.

Perennial herb of Sphagnum bogs. Circumboreal; south Baffin Island to Alaska, south to Newfoundland, eastern Quebec, central Maine, southwest Vermont, central New York, northern Indiana, northern Illinois, northern Iowa and Saskatchewan (Fernald, 1950; Hultén, 1964).

Carex comosa Boott

Always in shallow water; most frequent on the submerged mat dominated by Decodon verticillatus. Also on the east side with

Nuphar luteum and Nymphaea tuberosa and in shallow pools in the Carex-Vaccinium macrocarpon zone at the north end of Little Goose Lake. Crow 143, 274 (fruiting July 14), 327.

Perennial. Common in swamps and shallow water in the eastern half of the United States and in the Pacific Northwest (Hultén, 1958).

Carex interior Bailey

Frequent in the Larix zone. Especially abundant in Sphagnum in light shade of the Larix zone at north end of Little Goose Lake. Occasional in the Carex-Vaccinium macrocarpon zone. Crow 159, 221 (fruiting July 7), 369.

Perennial herb from rhizomes. Swamps, bogs, and peaty meadows, and on marshy banks of streams and lakes. Newfoundland to British Columbia, southwest to Pennsylvania, Indiana, Kansas, Chihuahua and California (Hermann, 1941).

Carex lasiocarpa var. americana Fern.

Important bog mat builder. A dominant of the Carex-Vaccinium macrocarpon zone, with Vaccinium macrocarpon and Thelypteris palustris. Sometimes in shallow water. Crow 142 (fruiting June 22), 223, 227.

The North American plants have been described by Fernald as var. americana. Hultén (1964) feels that this taxon would best be regarded as a subspecies (C. lasiocarpa subsp. americana [Fern.] Hultén).

Perennial of bogs, swamps, and marshes. Europe and northern Asia to Japan, eastern North America, the Pacific Northwest, and Alaska. Frequent from the Great Lakes states to New England and Newfoundland (Hultén, 1964).

Carex trisperma Dew.

Frequent, but with very little cover value. In Sphagnum in shade of the Larix and Acer rubrum zones. Crow 226 (fruiting July 7), 367.

Perennial herb of mossy woods, clearings, and bogs. Southern Labrador to Saskatchewan, south to Newfoundland, Nova Scotia, New England, northern New Jersey, Maryland, mountains to western North Carolina and eastern Tennessee, West Virginia, Ohio, Indiana, Illinois and Minnesota (Fernald, 1950).

Cyperus diandrus Torr.

At edge of water on small buoyant mat just beyond the submerged Decodon mat at north end of Little Goose Lake. Only one station located. Crow 398 (fruiting August 12), 508.

Annual of wet, sandy, gravelly, muddy, or peaty places. South Carolina to New Mexico, north to southwestern New Brunswick, central Maine, southwestern Quebec, southern Ontario, Wisconsin, Minnesota, and North Dakota (Fernald, 1950).

Cyperus engelmanni Steud.

On very wet edge of the Carex-Vaccinium macrocarpon mat on east side of Little Goose Lake and on wet hummock-like islands between Goose and Little Goose Lakes. Infrequent. Crow 393 (fruiting August 12), 505.

Annual of damp or wet soils. Massachusetts to southern Ontario, Minnesota and Nebraska, south to southeastern Virginia, Illinois, and Missouri (Fernald, 1950).

Dulichium arundinaceum (L.) Britt.

Very abundant in light shade of the Larix zone in deep Sphagnum mat, emergent from shallow water of submerged Nuphar-Eleocharis zone, and near water's edge of the Carex-Vaccinium macrocarpon zone. Crow 224 (flowering July 7), 381.

Perennial herb from rhizome. Swamps and marshes and margins of pools and streams. Newfoundland to British Columbia, south to Florida, Texas, and California (Livingston and Shreve, 1921; Fernald, 1950).

Eleocharis compressa Sull.

Frequent around margins of pools interspersed in Carex-Vaccinium macrocarpon zone at north end of bog. Crow 95 (fruiting May 30).

Perennial herb from rhizomes. Marshes and shores. Ontario to Saskatchewan, south to Georgia and Texas (Gleason and Cronquist, 1963).

Eleocharis intermedia (Muhl.) Schultes

At edge of water, forming small buoyant mat (1m × ½m) just beyond the submerged Decodon mat at north end of Little Goose Lake, and on floating muck islands in open water near edge of the Decodon mat. Infrequent. Crow 396 (fruiting August 12), 509.

Perennial herb of wet soils. Gaspé Co., Quebec to Minnesota, south to Pennsylvania, West Virginia, Tennessee and Iowa (Gleason and Cronquist, 1963).

Eleocharis smallii Britt.

A dominant species of the Nuphar-Eleocharis zone. Rhizomes often reaching deep water. Crow 147, 149, 209, 429.

Perennial herb of peaty or wet sandy swamps and shores. Southeastern Newfoundland to Ontario, south to Maryland,

Pennsylvania, western Virginia, West Virginia, southern Illinois, Iowa and Missouri (Svenson, 1939; Fernald, 1950).

Eriophorum gracile Koch

Mostly in shallow pools (outliers of the Nuphar-Eleocharis zone) on the Carex-Vaccinium macrocarpon mat and occasionally in very shallow water at the edge of the Carex-Vaccinium macrocarpon zone. Not abundant. Crow 93 (fruiting May 30), 151, 222.

According to Hultén (1964) racial conditions within this species are not clear. Eriophorum coreanum has been described by Palla from Korea and Hultén has transferred this plant to a subspecies of E. gracile. Fernald has described E. gracile var. caurinum from Oregon and California and the variety has also been reported from James Bay.

Perennial herb from rhizomes. Wet peat and inundated shores. Circumboreal; Newfoundland, through New England and the Great Lakes region to Minnesota and Iowa, James Bay to Alaska, south along the Pacific mountain ranges to California; Colorado (Hultén, 1964).

Eriophorum virginicum L.

Frequent in deep Sphagnum in light shade of the open Larix zone on west side of Little Goose Lake, and in the Cassandra zone

of east side of bog where growth of Cassandra is less dense. Crow 213, 329 (fruiting August 2), 331.

Perennial herb of bogs and peaty meadows. Southeast Labrador to Ontario, south to Newfoundland, Nova Scotia, New England, Long Island, Georgia, Tennessee, Wisconsin and Minnesota (Fernald, 1950).

Rhynchospora alba (L.) Vahl

Frequent in open sunlight of wet Carex-Vaccinium macrocarpon zone and in light shade of the open Larix zone growing in deep Sphagnum. Crow 331 (fruiting August 2), 535.

Perennial herb of bogs or wet peats and sands. Circumboreal; Newfoundland to Alaska, south to New England, Maryland, rarely eastern Virginia and western North Carolina, West Virginia, Ohio, northern Indiana and Illinois, Minnesota, Idaho and California; West Indies (Fernald, 1950; Hultén, 1958).

Scirpus cyperinus (L.) Kunth.

Occasional in deep Sphagnum in light shade of the open Larix subzone of west side and frequent in shallow water between Goose Lake and Little Goose Lake. Crow 332, 385 (fruiting August 12).

Perennial herb of bogs, marshes and wet meadows. Newfoundland to Saskatchewan, south to Florida and Louisiana (Gleason and Cronquist, 1963).

Poaceae

Agrostis stolonifera var. major (Gaud.) Farw.

Always in light shade of Larix zone. Usually in deep Sphagnum. Crow 150, 211, 279, 292.

A very variable plant. Native to Europe, cultivated and escaping into moist meadows, shores, coastal marshes, and other moist places throughout most of the United States and southern Canada and occasionally in Alaska and the Yukon. Widespread in Europe, Asia, and North Africa. Introduced in China and Japan. Occurring in the southern hemisphere in southern Chile, Juan Fernandez Islands, Falkland Islands, South Africa, Tristan de Cunha, South Australia and New Zealand (Hultén, 1964).

Glyceria canadensis (Michx.) Trin.

Always in deep Sphagnum, in light shade at edge of Larix zone. Most frequent on northwestern shore of Goose Lake. Crow 210 (flowering July 7), 419.

Perennial herb of bogs, meadows, damp thickets, and shores. Newfoundland to Lake Mistassini, Quebec, west to southern

Ontario and Minnesota, south to Virginia, mountains of Tennessee, Indiana, and northern Illinois (Fernald, 1950).

Glyceria striata (Lam.) Hitchc.

Occasional in openings at outer edge of Acer rubrum zone. Wet mucky peat. Crow 401 (fruiting August 16).

Perennial herb of open swamps and marshes. Newfoundland and Labrador to British Columbia, south to northern Florida, Texas, Arizona and northern California; naturalized in Europe (Hitchcock, 1950).

Leersia oryzoides (L.) Sw.

Occasional in light shade of openings at outer edge of the Acer rubrum zone in very wet peat. Crow 501 (fruiting August 28).

Perennial herb from rhizome. Marshes, river banks, and wet places. Quebec to British Columbia, south to northern Florida, Texas, Colorado, New Mexico, Arizona and southeastern California (Hitchcock, 1950; Hultén, 1958).

Muhlenbergia racemosa (Michx.) B.S.P.

In very wet places in the Carex-Vaccinium macrocarpon zone. Frequent. Crow 342 (flowering August 2), 414, 522.

Perennial herb from rhizomes. Meadows, bogs, and wet shores. Newfoundland to British Columbia, south to Maryland, Kentucky, Oklahoma, and Arizona (Hitchcock, 1950).

Araceae

Calla palustris L.

Usually in shade of the Larix zone in very wet places. Often in wet pockets between hummocks at bases of tamaracks. Occasionally in openings at outer edge of the Acer rubrum zone. Crow 137 (flowering June 22), 156, 237.

Perennial herb of bogs, swamps, and pond margins. Circumboreal; northeastern United States and transcontinental from Newfoundland to Alaska. Best known from the Great Lakes region and New England and southern Quebec; with large gaps in the European distribution (Hultén, 1964).

Lemnaceae

Lemna minor L.

In shallow pools on bog mat, most often in light shade. Never in open water of lake. Few stations present. Crow 356.

Temperate and tropical regions of the world, in Alaska nearly to the Arctic Circle (Hultén, 1964; Daubs, 1965).

Lemna trisulca L.

In a few shallow pools on the bog mat. Usually in shade of Larix laricina, mixed with Lemna minor and Potamogeton gramineus. Crow 228.

Ponds and springy places. Widespread in the Old and New Worlds (Hultén, 1964; Daubs, 1965).

Sparganiaceae

Sparganium chlorocarpum var. acaule (Beeby) Fern.

Emergent from shallow water of the Nuphar-Eleocharis zone. Abundant between Goose and Little Goose Lakes. Crow 229 (flowering July 7), 380.

Perennial herb from rhizomes. Muddy or peaty soil or shallow water. Newfoundland to Ontario and Minnesota, south to New England, northern New Jersey, West Virginia, Indiana and Iowa; local in North Carolina, Wyoming, Idaho, Alberta, Washington and California (Fernald, 1950; Beal, 1960).

Sparganium minium (Hartm.) Fries

Frequent in open water at edge of the Decodon mat at north end of Little Goose Lake. Leaves floating on water surface. Crow 351 (flowering August 2).

Perennial herb from rhizomes. Shallow water. Circumboreal; Newfoundland to Alaska, south to Nova Scotia, New England, northern New Jersey, northern Pennsylvania, Michigan, Wisconsin, Minnesota, Colorado, Utah and Oregon; widespread in Eurasia (Fernald, 1950; Hultén, 1964).

Typhaceae

Typha latifolia L.

Always in open, very wet places. Very abundant around the margin of Goose Lake and on the submerged mat between Goose and Little Goose Lakes on the west side. Scattered along the west side on submerged Decodon mat. Important plant of the Cassandra-Thelypteris zone. Crow 267 (flowering July 3).

Rhizomatous perennial. Most abundant in large lowland marshes. Also in ditches and small seepage areas, even on slopes and at high altitudes. The only species of Typha tolerating acidity. Circumpolar. Transcontinental through the United States, north to Alaska and south through Mexico to Guatemala. Also widespread in southern Manitoba and Saskatchewan; widespread in Eurasia (Hotchkiss and Dozier, 1949; Hultén, 1964).

PHYTOGEOGRAPHY

In order to assess the geographical affinities of a northern bog one must be greatly concerned with the effect of the Pleistocene on the flora of North America. Certainly there is no question that as the ice sheets advanced the vegetation standing in their paths was annihilated. There is much controversy, however, concerning the effect of the glaciers on the flora south of the glacial boundary.

One school of thought maintains that there was a major displacement of the boreal forest during Wisconsin glaciation, but "that Full-glacial tundra, boreal forest, and deciduous forest formations were not identical in species composition or even in vegetational structure with their present bioclimatic analogues" (Martin, 1958, p. 378). Whitehead (1965) feels that palynological evidence from Carolina Bay sediments demonstrates beyond doubt profound changes in both climate and vegetation in this region during late Pleistocene time.

On the other hand, some agree that the climate of the Pleistocene south of the glaciers did not differ greatly than that of the present. Braun maintains that ". . . the deciduous forest zone,

although narrowed, maintained itself on the Appalachian Plateaus in southern Ohio and Kentucky while glaciers extended southward in Ohio" (Braun, 1951, p. 145).

Wolfe (1951) raises two pertinent questions concerning some species of narrow ecological range which are present in microclimates near the glacial border. If a developing tundra caused these species to retreat to the southern Appalachians, ". . . how, with their narrow ecological amplitude and lack of continuous migration routes, did they get back near the glacial border?" And how did a plant like Sullivantia sullivantii (T. & G.) Britt., which is known only from limestone and sandstone cliff faces of southern Ohio, southern Indiana and northern Kentucky, return to its present range and ". . . not persist in some of the millions of grotto microclimates of the southern mountains" (Wolfe, 1951, p. 137)?

Iltis (1965, 1966) has observed that there is a large western floristic element in northeastern North America. In the East these western taxa are restricted to glaciated areas. He feels that this distribution pattern strongly suggests that during the Pleistocene the eastern deciduous forests were essentially closed communities and unchanged from those of today, except where subject to periglacial phenomena.

The following phytogeographic analysis takes the latter viewpoint.

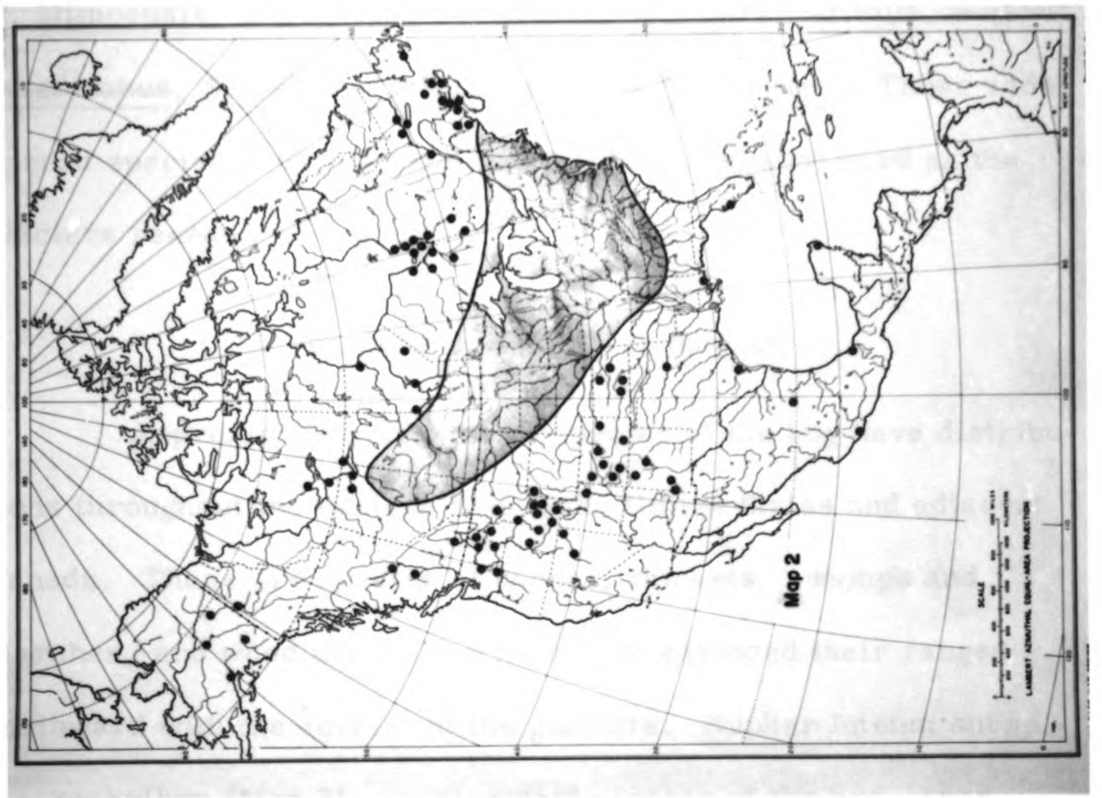
The North American ranges of all species in the bog have been determined as accurately as possible from the published literature. Five basic distribution patterns of the Pennfield Bog species are evident: 1) widespread species, occurring throughout much of the United States and adjacent Canada and often widespread in other parts of the world; 2) those occurring primarily in the eastern half of the United States and adjacent Canada; 3) those which occur in northeastern North America and also on the coastal plain; 4) those of northeastern North America, primarily north of the glacial boundary; and 5) northern, chiefly circumboreal species.

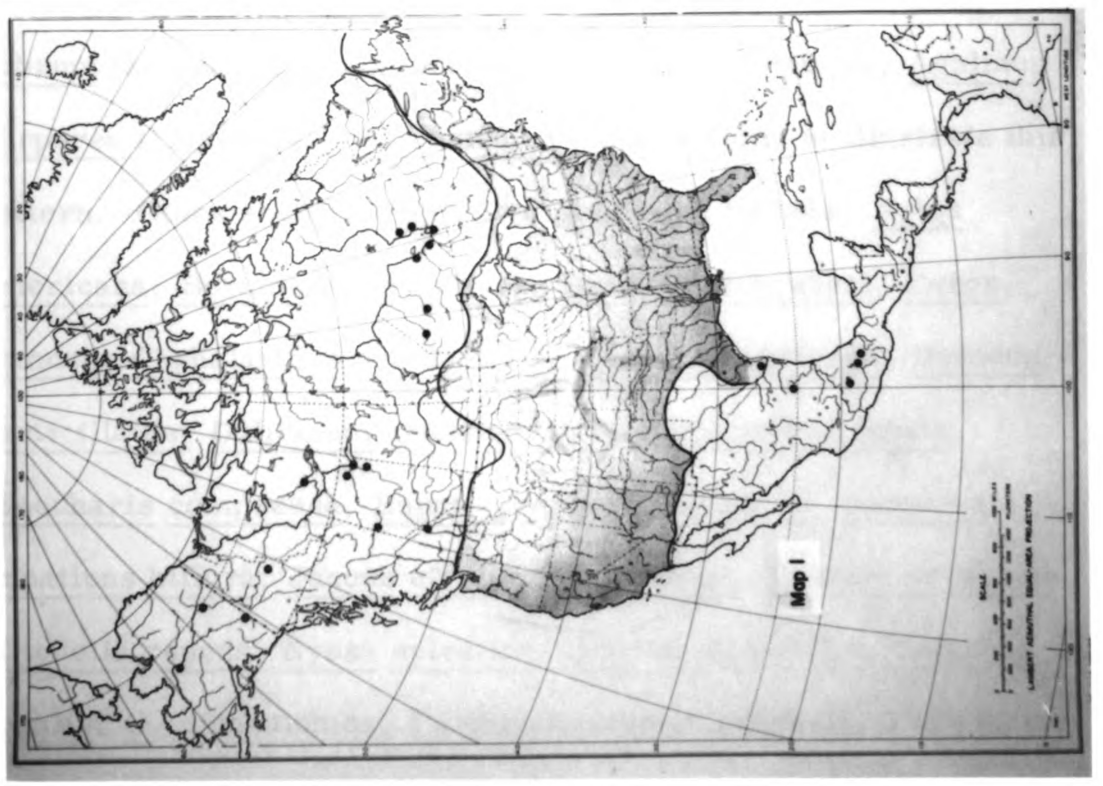
Widespread Species

About 10% of the species, of which Typha latifolia (Map 1) and Lemna minor (Map 2) are examples, occur widely throughout much of the United States. They are chiefly plants of swamps and meadows, quiet waters and shores. The majority of these plants occur in the pioneer zones and only Typha latifolia is an important constituent of the bog. Other species with this distribution include: Agrostis stolonifera, Ceratophyllum demersum, Glyceria striata, Lemna trisulca, Monotropa uniflora, Potamogeton gramineus,

Map 1. -- Distribution of Typha latifolia after Hotchkiss and Dozier, 1949

Map 2. -- Distribution of Lemna minor after Hultén, 1964


Map 2


Map 1

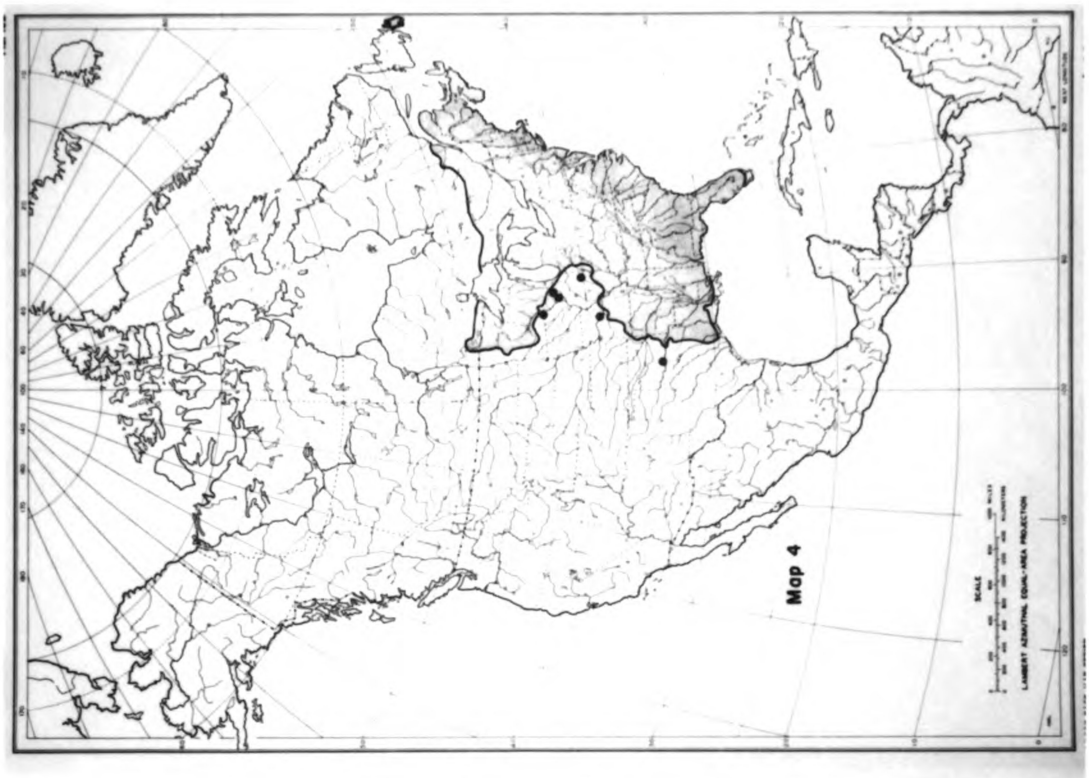
P. illinoensis, Ranunculus sceleratus, Sagittaria latifolia, ~~Scirpus americanus~~, Scutellaria lateriflora, and Sium suave. These widespread species probably extended their ranges northward as the glaciers receded.

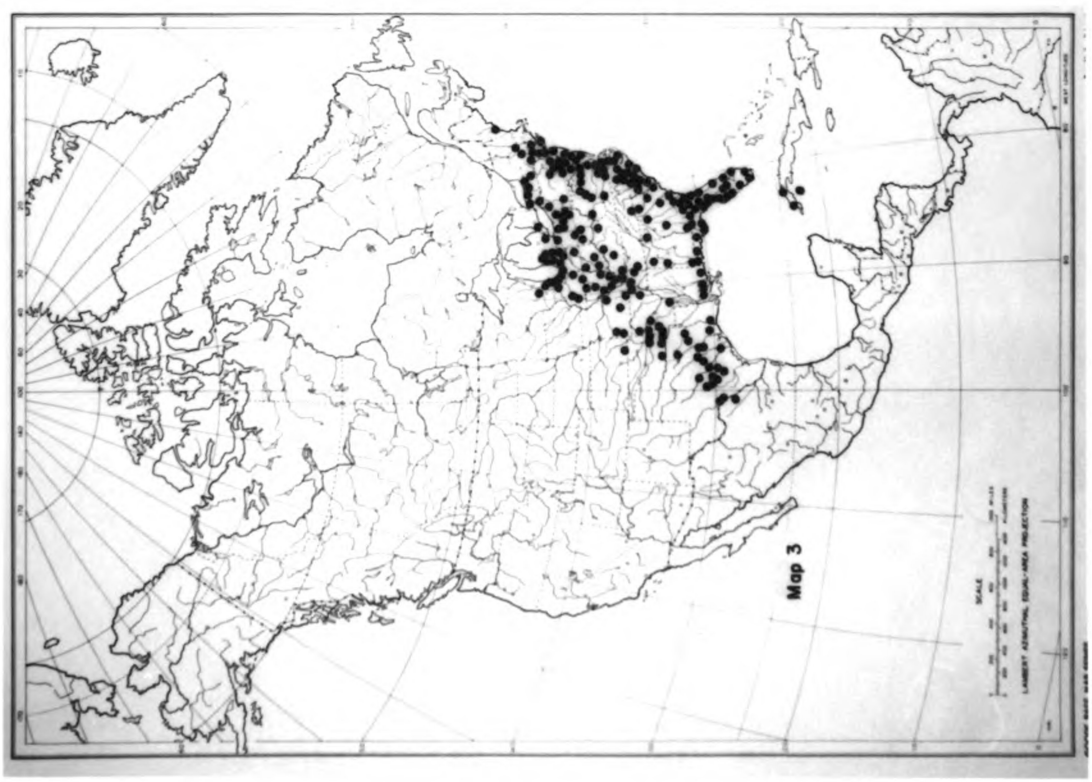
Eastern United States Species

Approximately 26% of the species of the bog have distributions throughout the eastern half of the United States and adjacent Canada. These are species of shores, thickets, swamps and marshes, and woodlands which have also extended their ranges northward with the retreat of the glaciers. Nuphar luteum subsp. macrophyllum (Map 3), an important pioneer of the bog, Acer rubrum (Map 4), the dominant of the climax community, Agalinus purpurea (Map 5), and Amelanchier arborea (Map 6) illustrate this pattern. Other species with this distribution include: Apios americana, Boehmeria cylindrica, Brasenia schreberi, Carex comosa, Cephalanthus occidentalis, Cyperus diandrøus, Decodon verticillatus, Dulichium arundinaceum, Echinocystis lobata, Eleocharis compressa, Eupatorium perfoliatum, E. purpurea, Impatiens biflora, Juncus effusus var. solutus, Leersia oryzoides, Mitchella repens, Nyssa sylvatica, Onoclea sensibilis, Osmunda regalis, O. cinnamomea, Parthenocissus quinquefolia, Polygonum hydropiperoides, P. sagittatum, Prunus virginiana, Quercus

Map 3. -- Distribution of Nuphar luteum subsp. macrophyllum after Beal, E. O., 1956

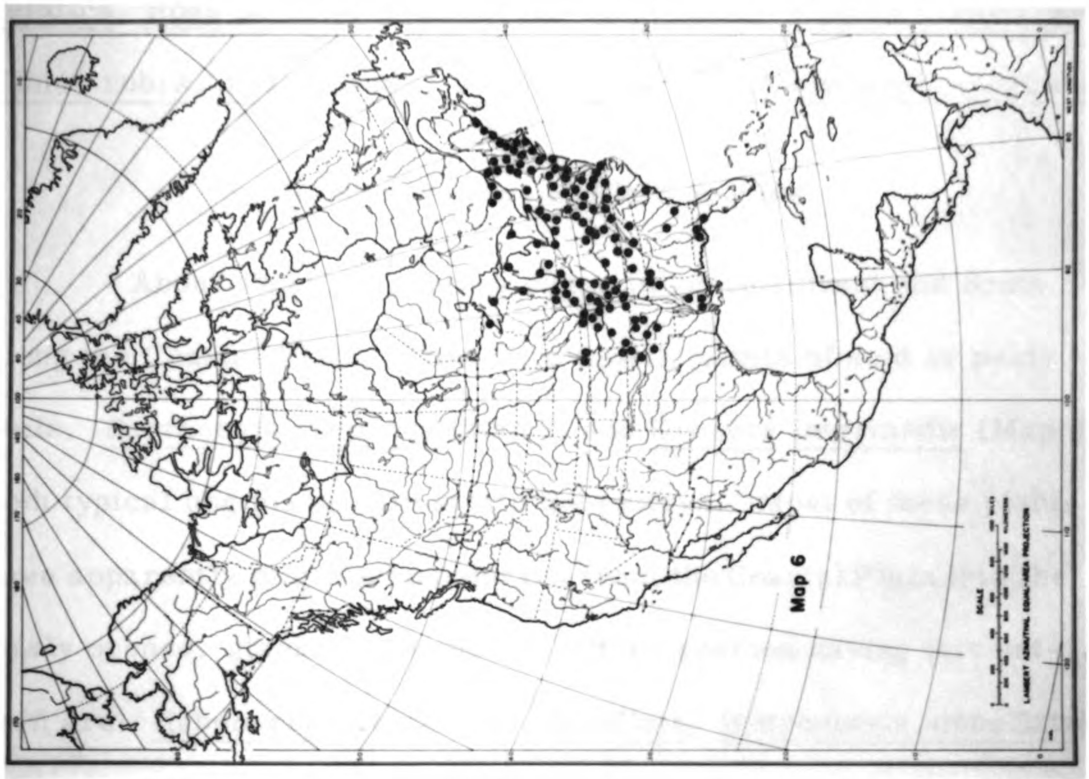
Map 4. -- Distribution of Acer rubrum after Little, 1965

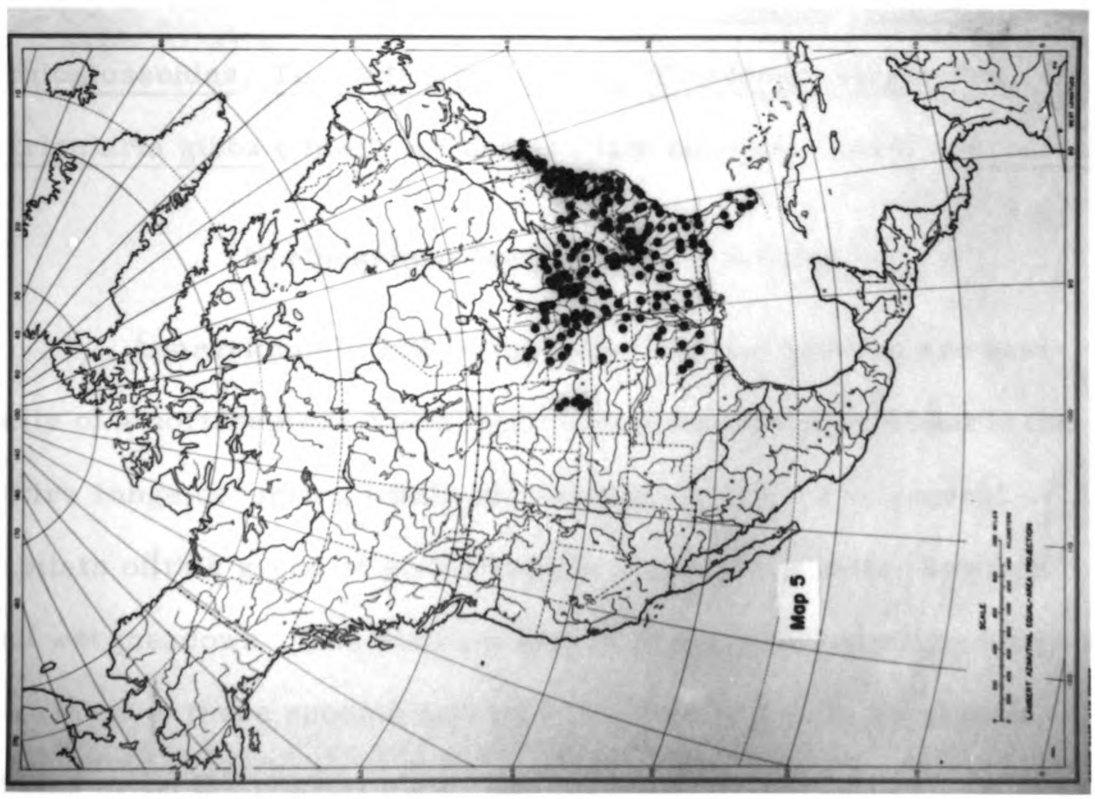

Map 4


Map 3

Map 5. -- Distribution of Agalinus purpurea after Pennell, 1935

Map 6. -- Distribution of Amelanchier arborea after Jones, 1946


Map 6


Map 5

velutina, Rosa palustris, Sambucus canadensis, Scirpus cyperinus, Ulmus rubra, Viola affinis, Vitis vulpina, and Woodwardia virginica.

Northeast-Coastal Plain Species

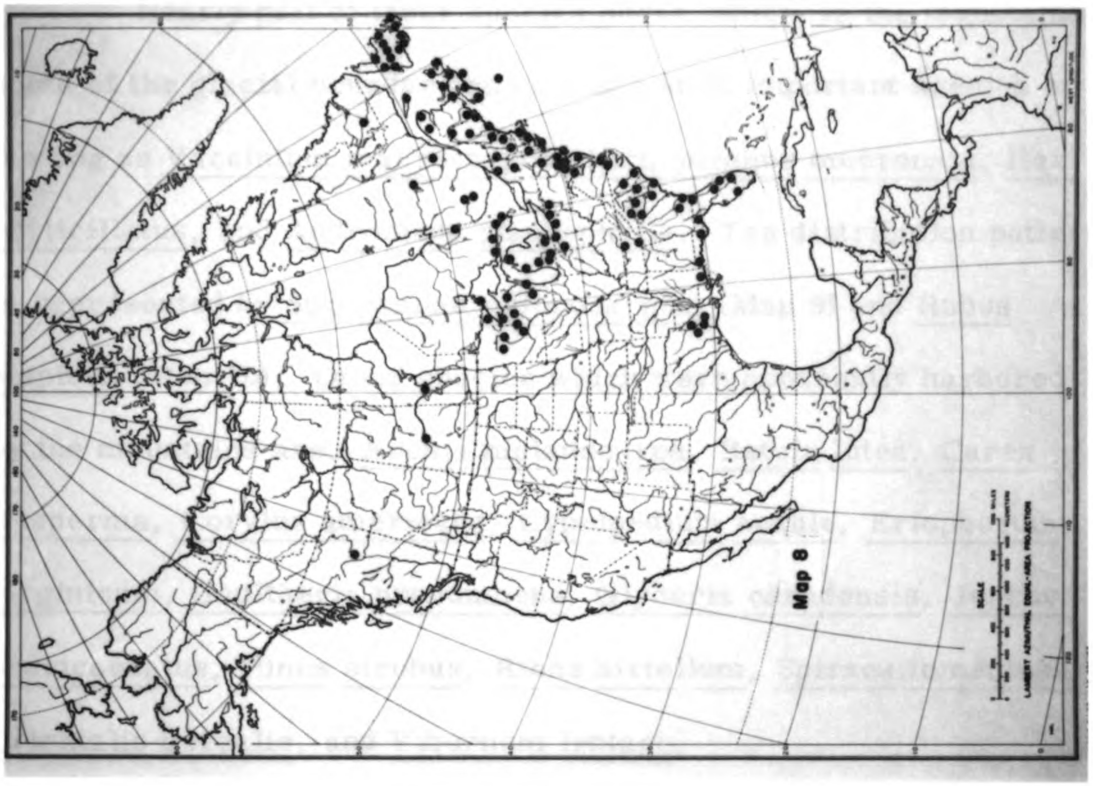
About 8% of the species occur in the Northeast and South along the Coastal Plain. These are mostly plants of acid or peaty soils. Sarracenia purpurea (Map 7) and Drosera intermedia (Map 8), both typical bog plants, illustrate the pattern. Most of these plants have apparently migrated northward from the Coastal Plain into the newly opened, glaciated northeast. Other species having this pattern are: Habenaria ciliaris, H. clavellata, Hydrocotyle umbellata (chiefly a Coastal Plain species), Isotria verticillata, Pogonia ophioglossoides, Toxicodendron vernix, Triadenum virginicum, Utricularia gibba (chiefly a Coastal Plain species), and U. purpurea.

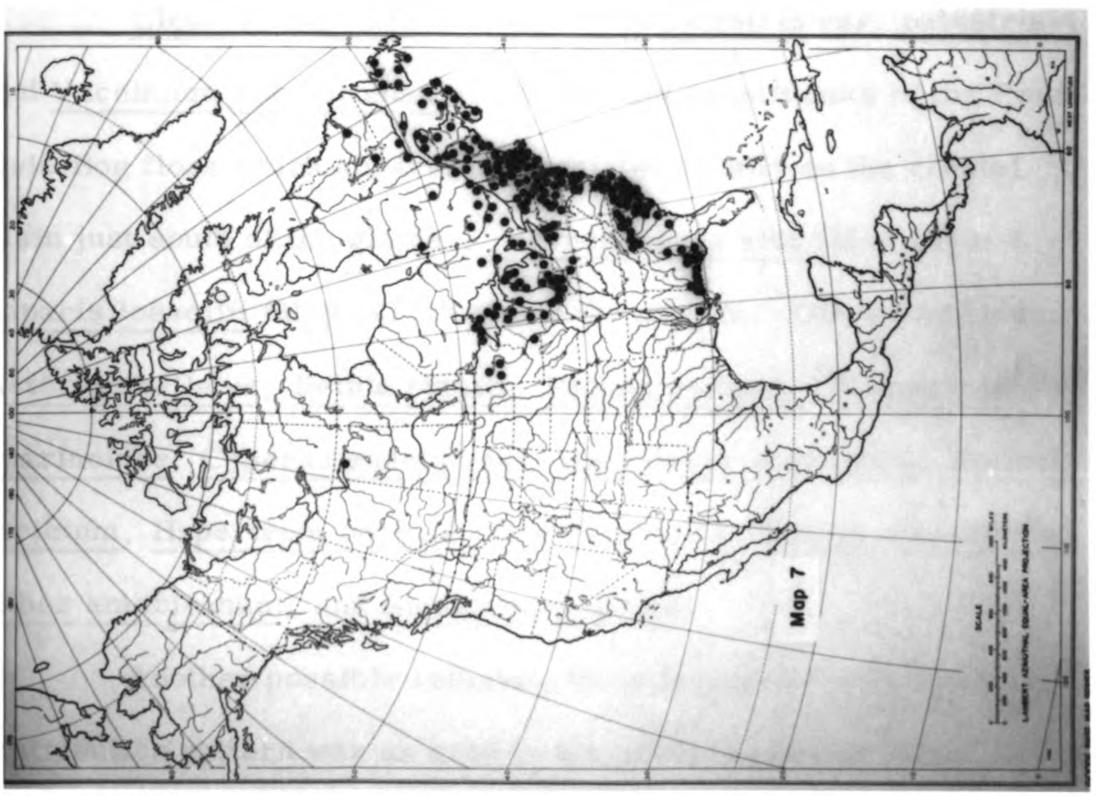
Northeastern North America Species

Approximately 28% of the Pennfield Bog species are basically of a northeastern North American distribution with nearly the entire range occurring within glaciated territory. The general habitats of this group of plants include bogs, peaty soils, swamps and wet meadows. The distributions of these plants strongly suggest that most of these species survived the Pleistocene in the Appalachians or on the coastal plain, not far from the ice front.

Map 7. -- Distribution of Sarracenia purpurea after McDaniel, 1966

Map 8. -- Distribution of Drosera intermedia after Wynne, 1944; Hultén, 1958


Map 8


Map 7

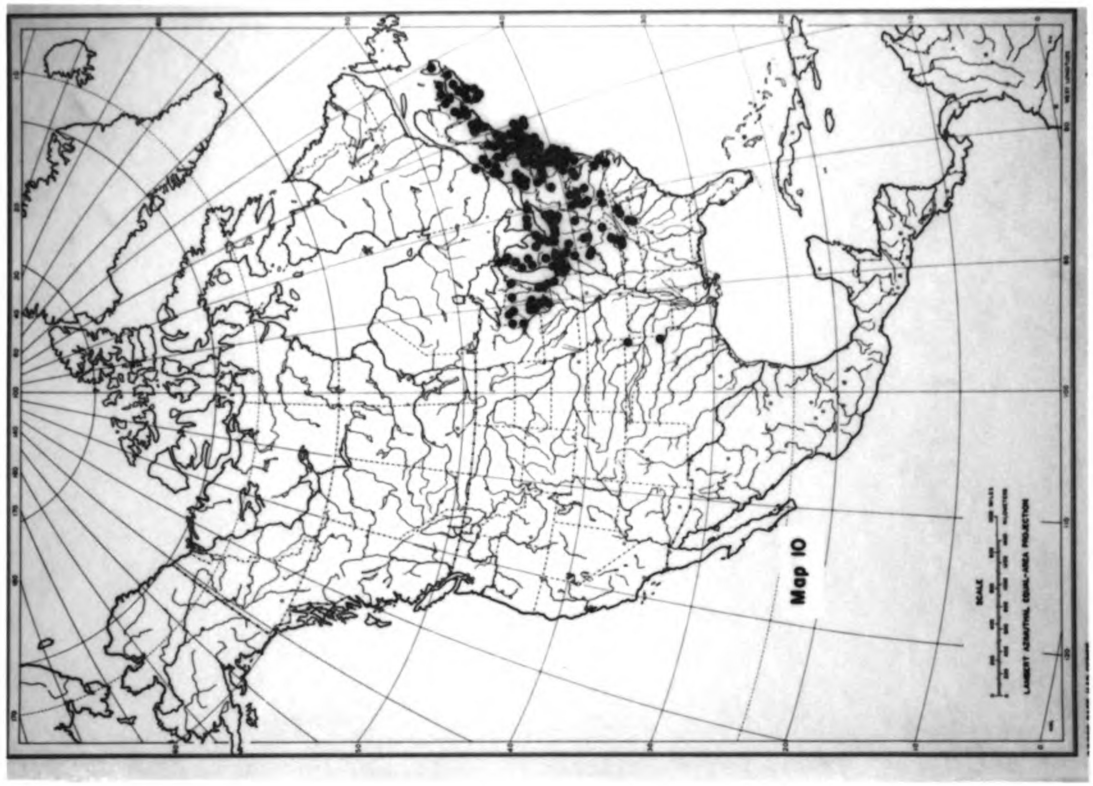
Nearly half of these species occur chiefly in the mountains south of the glacial boundary and include such important species of the bog as Vaccinium macrocarpon, Nemopanthus mucronata, Ilex verticillatus, and Andromeda glaucophylla. The distribution pattern is represented by Sparganium chlorocarpum (Map 9) and Rubus hispidus (Map 10). Other species which were apparently harbored by the mountains are: Aronia melanocarpa, Betula lutea, Carex trisperma, Corylus americana, Cypripedium acaule, Eriophorum virginicum, Gaultheria procumbens, Glyceria canadensis, Juncus brevicaudatus, Pinus strobus, Ribes hirtellum, Spiraea tomentosa, Trientalis borealis, and Viburnum lentago.

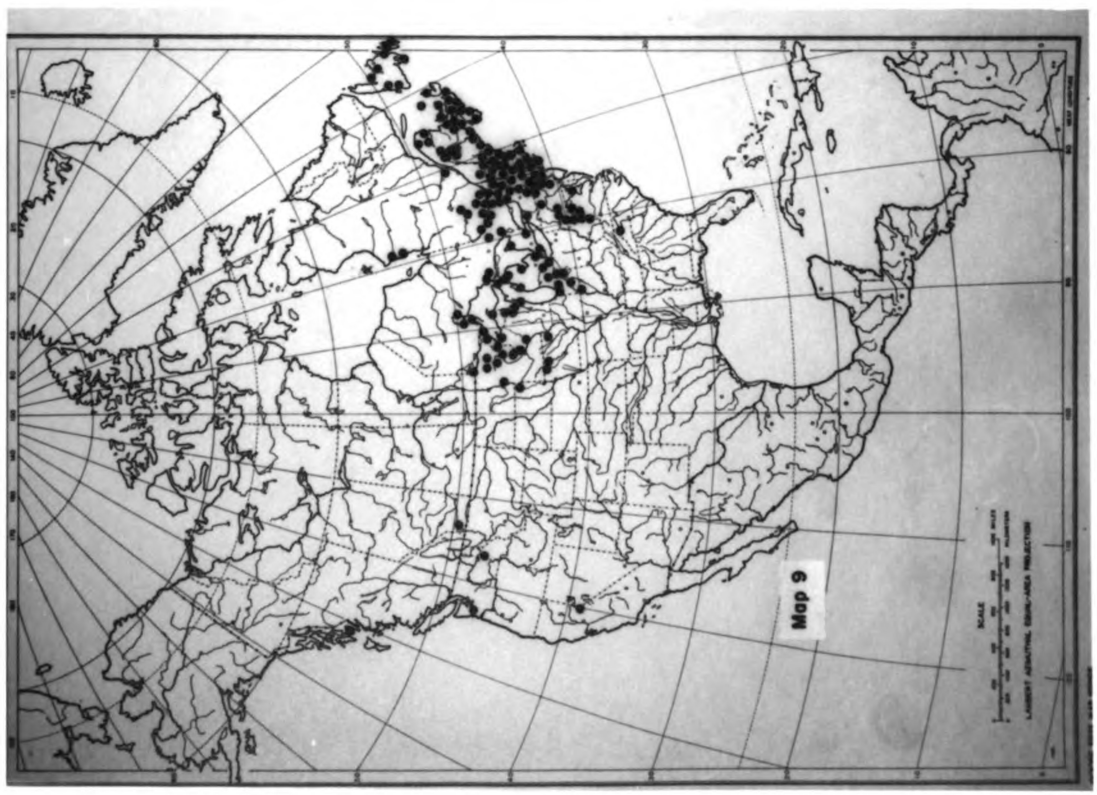
Eleocharis smallii, Thelypteris palustris var. palustris and Vaccinium corymbosum are important constituents of the Pennfield Bog flora which apparently persisted chiefly on the coastal plain just south of the glacier. Rhynchospora alba (Map 11) and Liparis loesellii (Map 12) illustrate the pattern. Others include: Aster umbellatus, Betula pumila, Bidens coronata, Campanula aparinoides, Cyperus engelmanni, Eleocharis intermedia, Epilobium strictum, Hypericum boreale, Iris versicolor, Nymphaea tuberosa, Ribes americanum, and Rumex orbiculatus.

Another possible refugium for a few plants with this basic distribution pattern was an area to the southwest of the Great Lakes.

Map 9. -- Distribution of Sparganium chlorocarpum after Beal, E. O., 1960

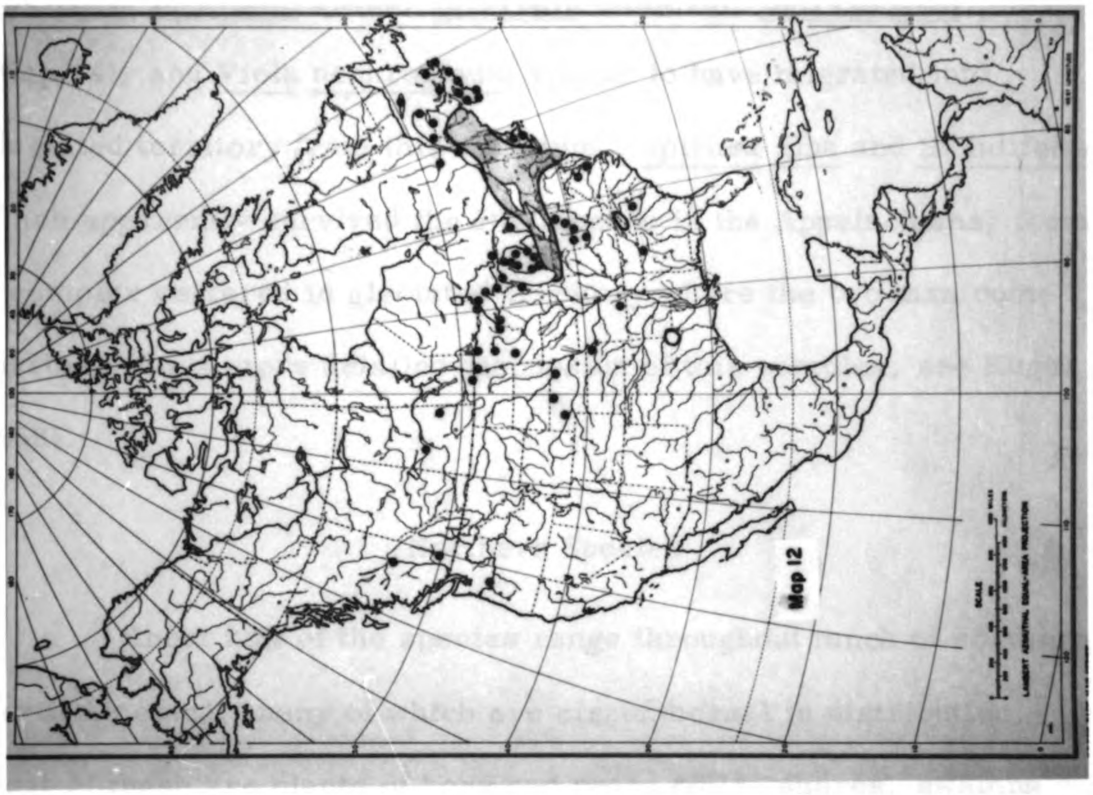
Map 10. -- Distribution of Rubus hispidus after Braun, 1937

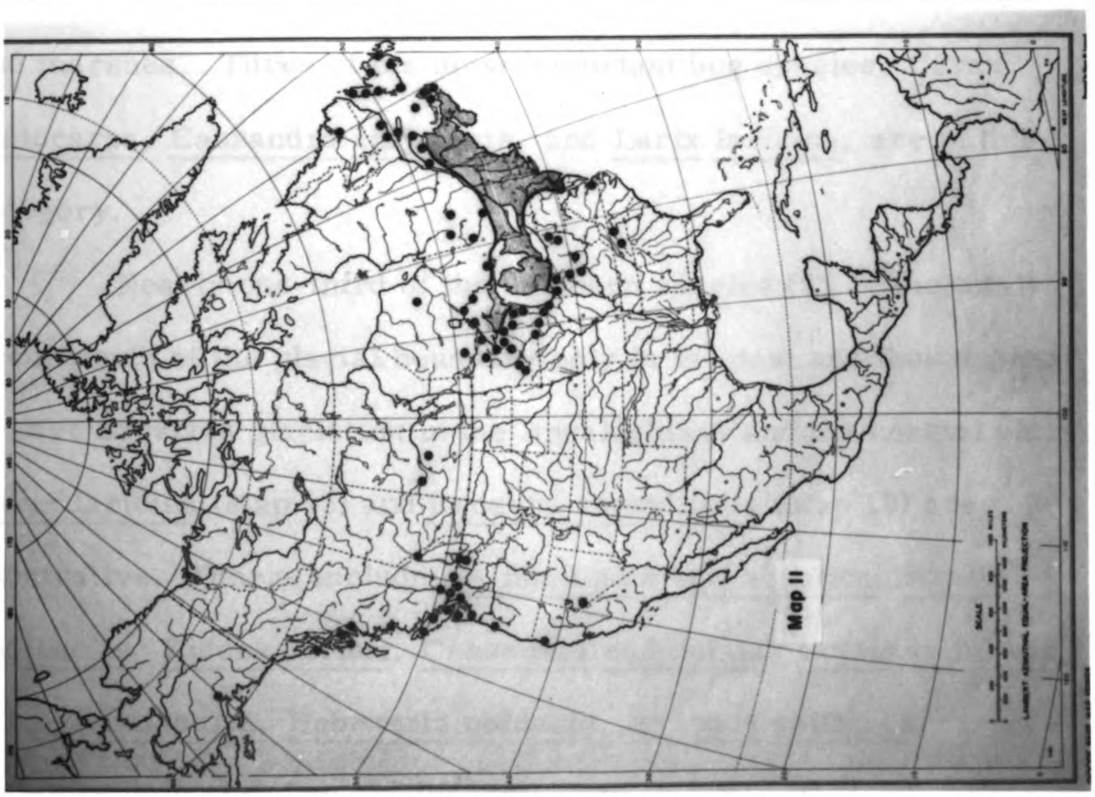

Map 10


Map 9

Map 11. -- Distribution of Rhynchospora alba after Hultén, 1958

Map 12. -- Distribution of Liparis loeselii after Hultén, 1958


Map 12


Map 11

Asclepias incarnata subsp. incarnata (Map 13), Spiraea alba (Map 14), and Viola nephrophylla appear to have migrated into glaciated territory from this refugium. Spiraea alba and S. latifolia, which apparently survived the Pleistocene in the Appalachians, form a complex centered in glaciated territory where the two taxa come together (for a more detailed discussion of this complex, see Kugel, 1958).

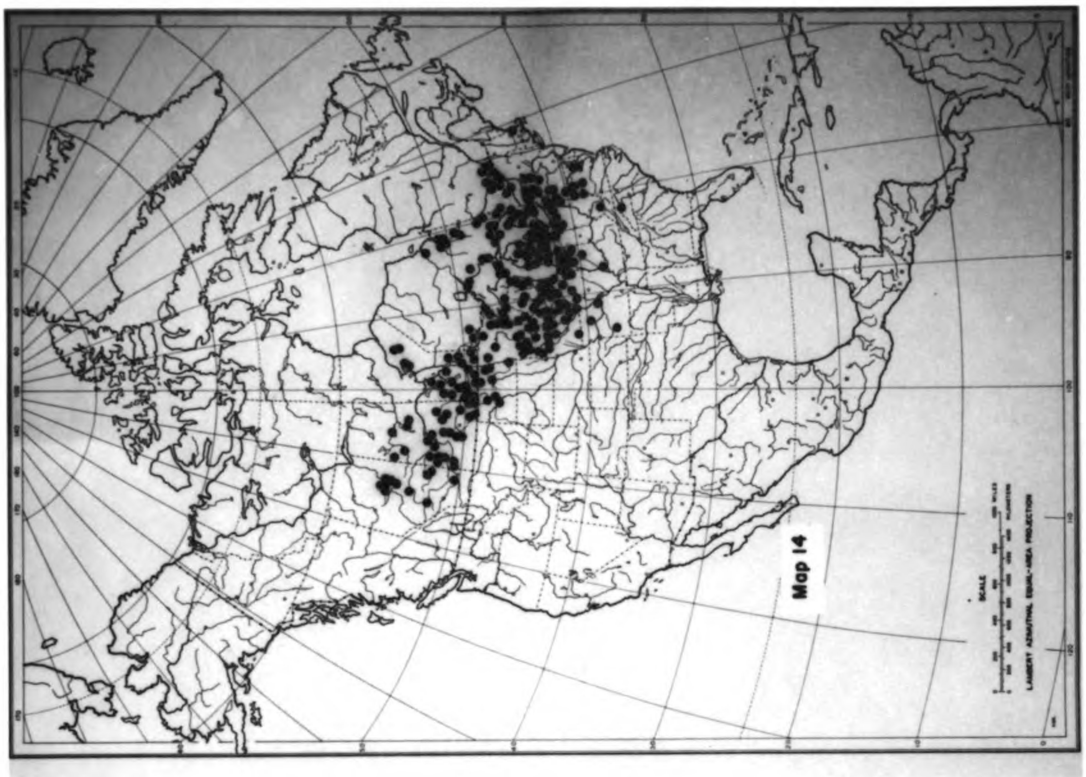
Northern Species

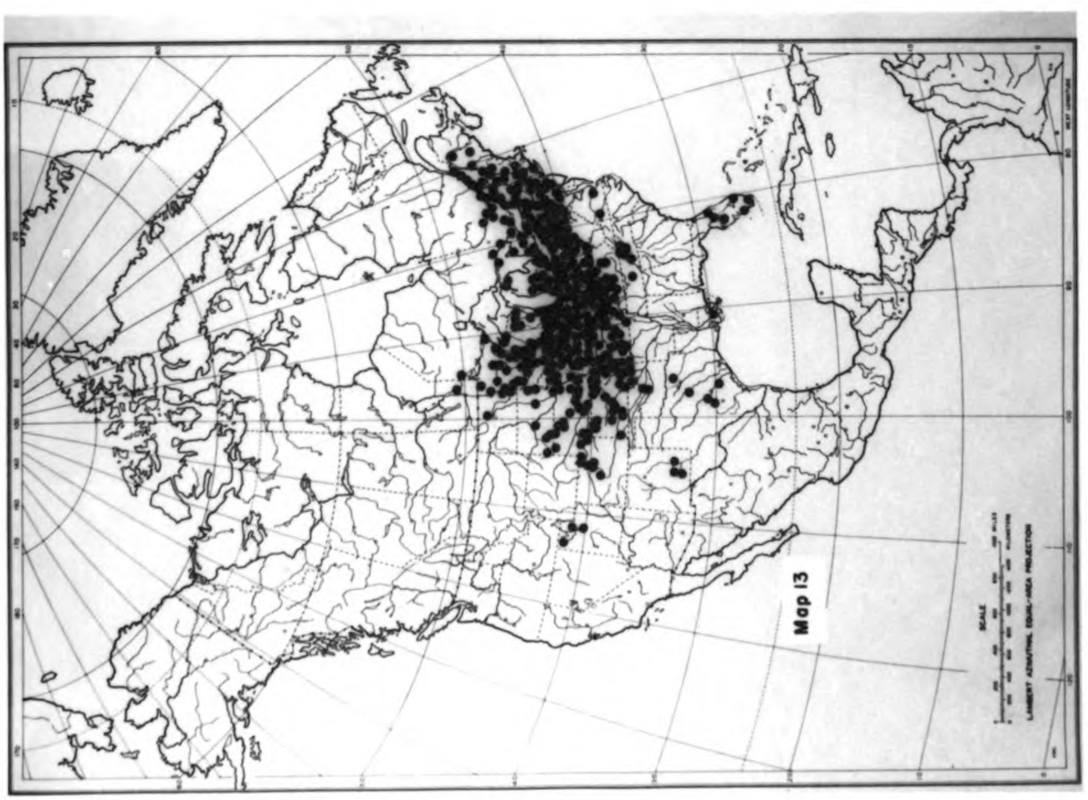
About 28% of the species range throughout much of northern North America, many of which are circumboreal in distribution. Most of these are plants of bogs and peaty soils, shores, swamps and marshes. Three of the most important bog species, Carex lasiocarpa, Cassandra calyculata, and Larix laricina, are in this category.

Nearly one-third of the northern species (9% of the total) occur south of the glacial boundary only in the east and thus appear to have survived glaciation in the Appalachians and the coastal plain. Larix laricina (Map 15) and Drosera rotundifolia (Map 16) are illustrative. Others include: Alisma plantago-aquatica, Aralia nudicaulis, Bidens cernua, Cassandra calyculata, Coptis trifoliata var. groenlandica, Habenaria obtusata, Lycopus uniflorus, Maianthemum canadense, Menyanthes trifoliata, and Rubus pubescens.

Map 13. -- Distribution of Asclepias incarnata subsp. incarnata after Woodson, 1954

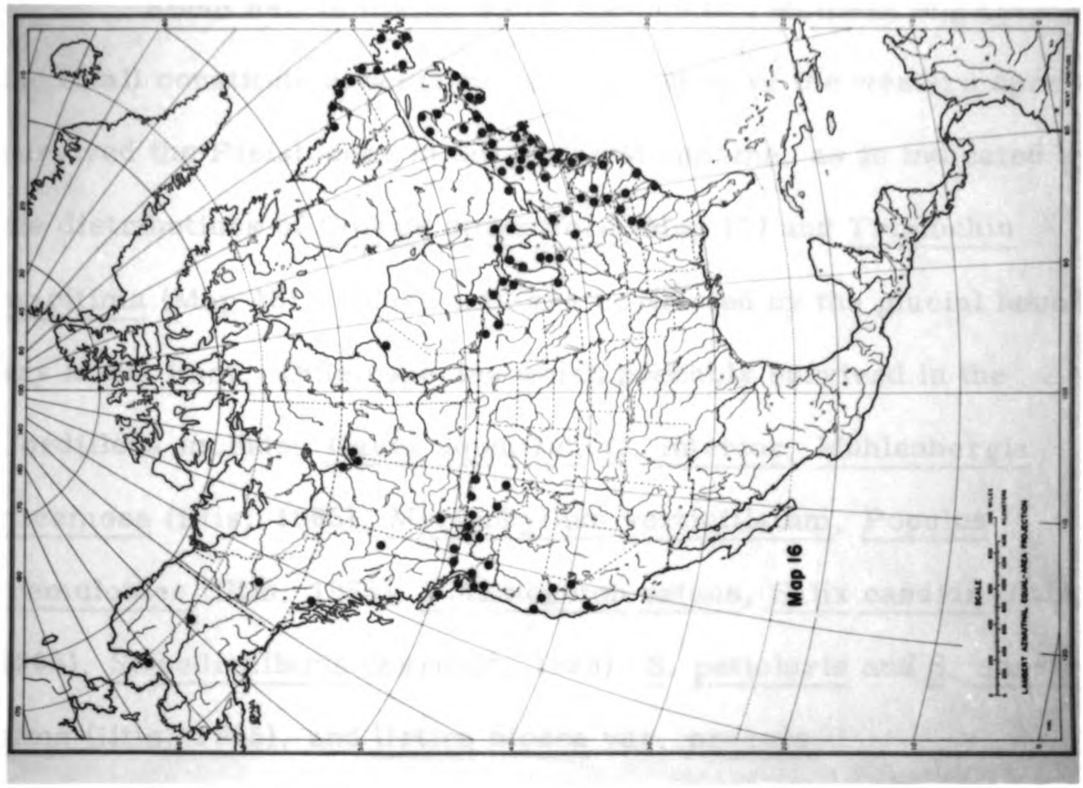
Map 14. -- Distribution of Spiraea alba after Kugel, 1958

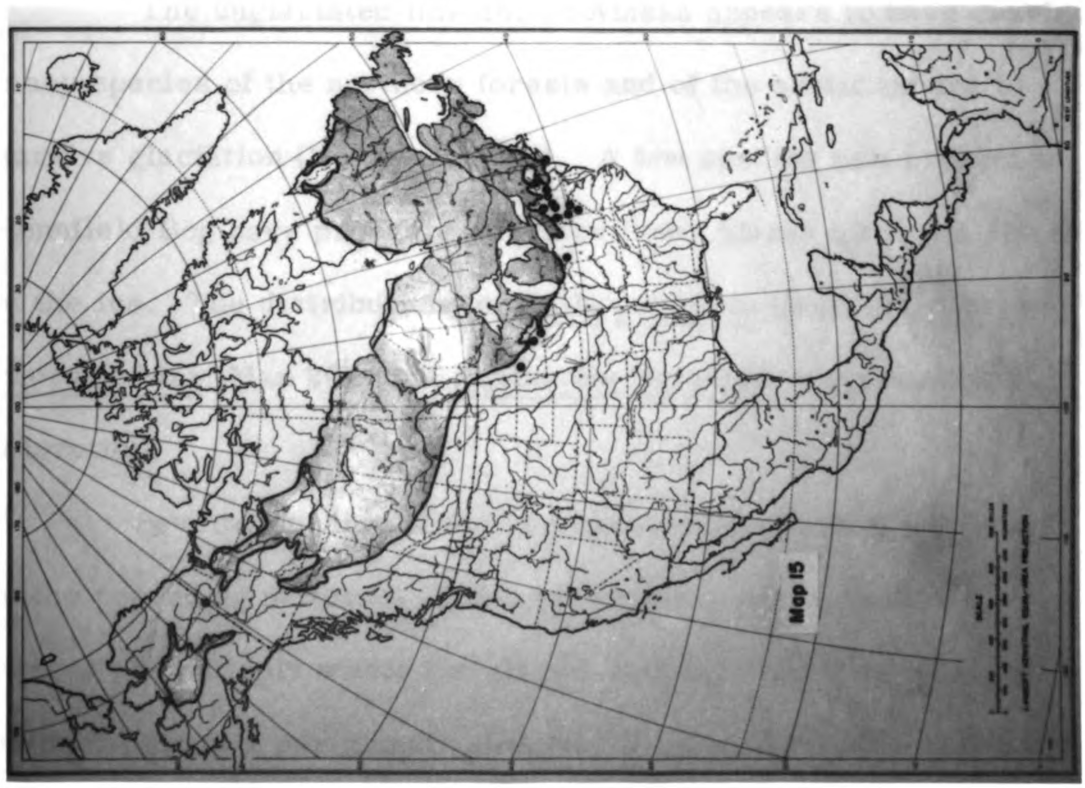

Map 14
SCALE
LAMBERT AZIMUTHAL EQUAL-AREA PROJECTION


Map 13
SCALE
LAMBERT AZIMUTHAL EQUAL-AREA PROJECTION

Map 15. -- Distribution of Larix laricina after Little, 1965

Map 16. -- Distribution of Drosera rotundifolia after Wynne, 1944


Map 16


Map 15

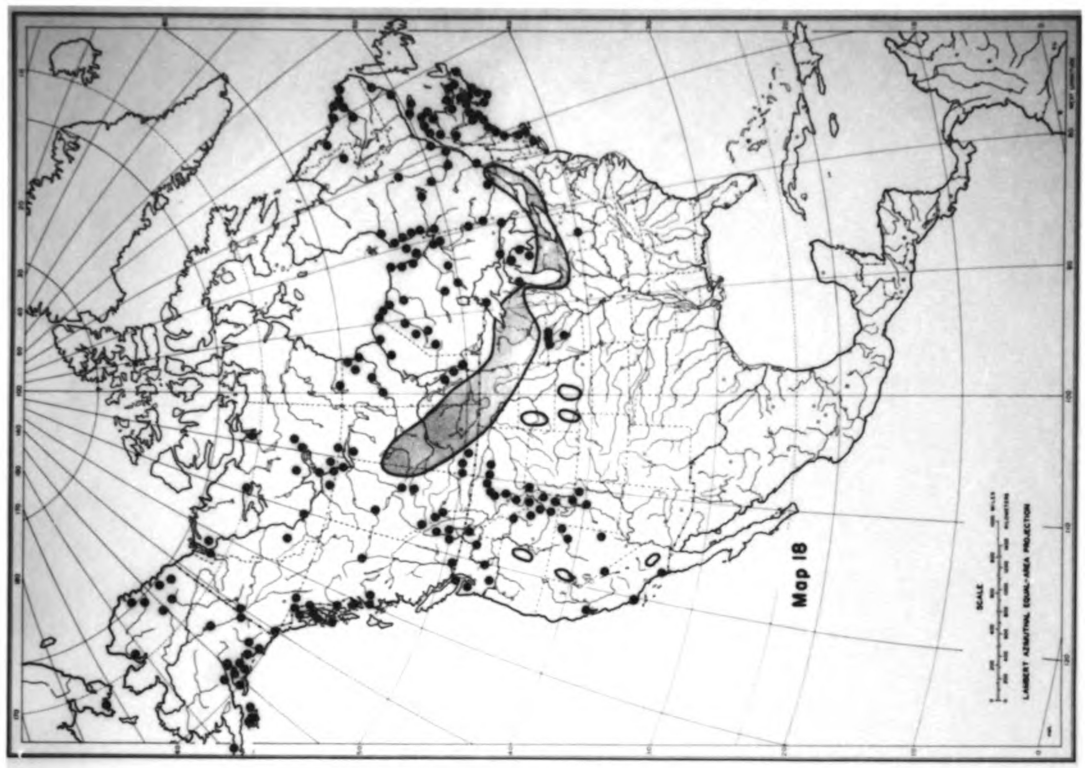
About half of the northern species of Pennfield Bog (14% of the total) constitute a western element. Most of the western species survived the Pleistocene in the Rocky Mountains, as is indicated by the distributions of Cornus stolonifera (Map 17) and Triglochin maritima (Map 18). These taxa are restricted by the glacial boundary in the East. Other species which probably survived in the Cordillera include: Carex aquatilis, C. interior, Muhlenbergia racemosa (Iltis, 1965), Myriophyllum verticillatum, Populus tremuloides (Iltis, 1965), Potamogeton natans, Salix candida (Iltis, 1965), S. pedicellaris (Fernald, 1925), S. petiolaris and S. serrissima (Iltis, 1965), and Urtica dioeca var. procera.

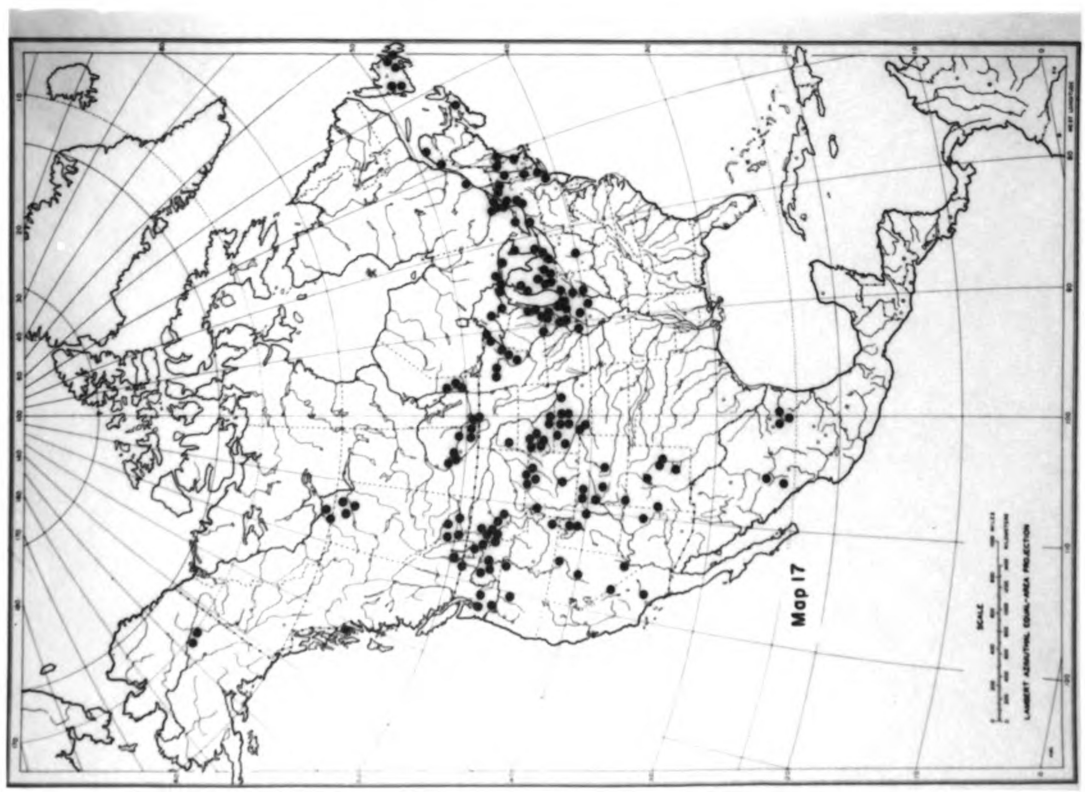
The unglaciated interior of Alaska appears to have enabled many species of the northern forests and of the arctic tundra to survive glaciation (Heusser, 1965). A few species now present in Pennfield Bog have probably migrated from Alaska after the retreat of the ice. The distributions of Calla palustris (Map 19), Carex chordorrhiza (Map 20), and Equisetum fluviatile suggest such a migration.

Several species of the bog cannot be accounted for by any of the preceding patterns. Some of these are aquatics whose present ranges are entirely within the glacial boundary and might be considered part of a periglacial element. It is also possible that some

Map 17. -- Distribution of Cornus stolonifera after Rickett, 1944

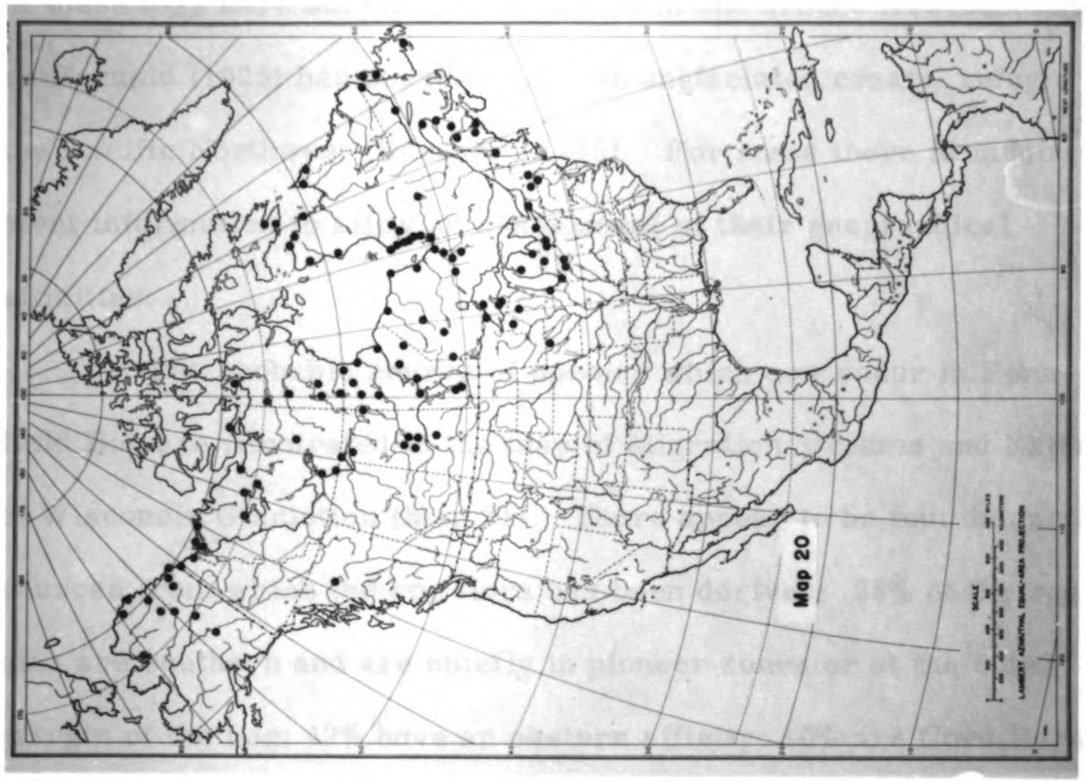
Map 18. -- Distribution of Triglochin maritima after Hultén, 1964

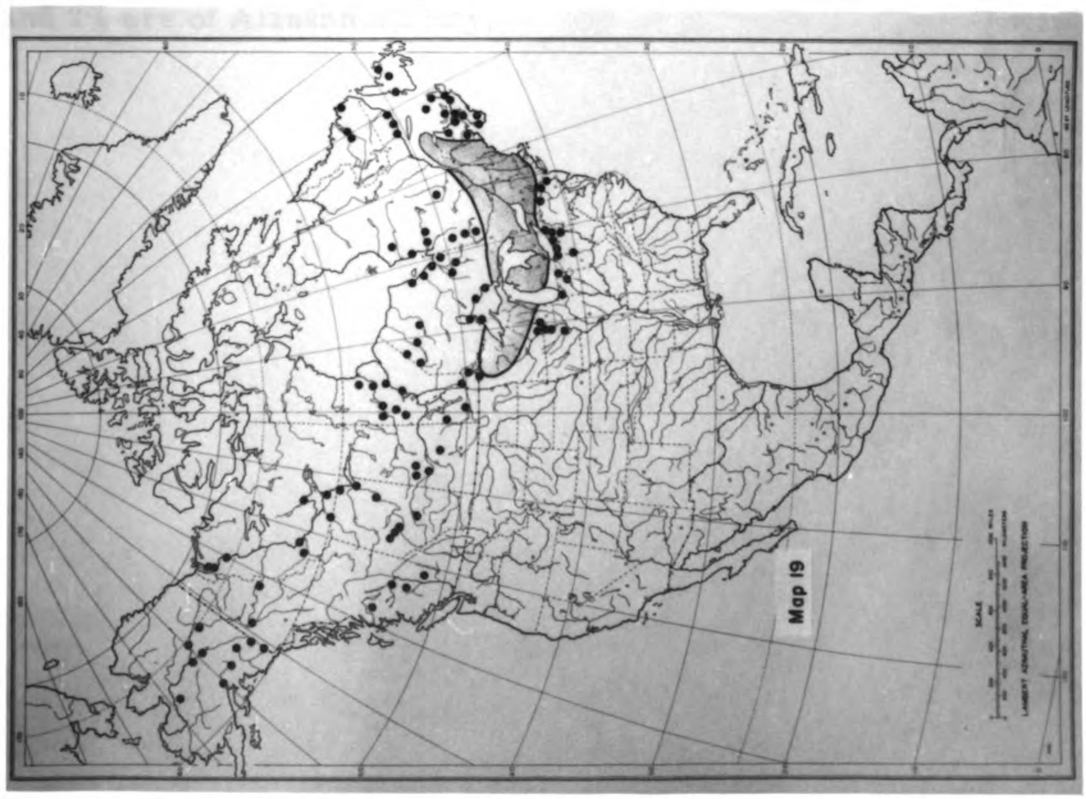

Map 18


Map 17

Map 19. -- Distribution of Calla palustris after Hultén, 1964

Map 20. -- Distribution of Carex chordorrhiza after Hultén, 1964

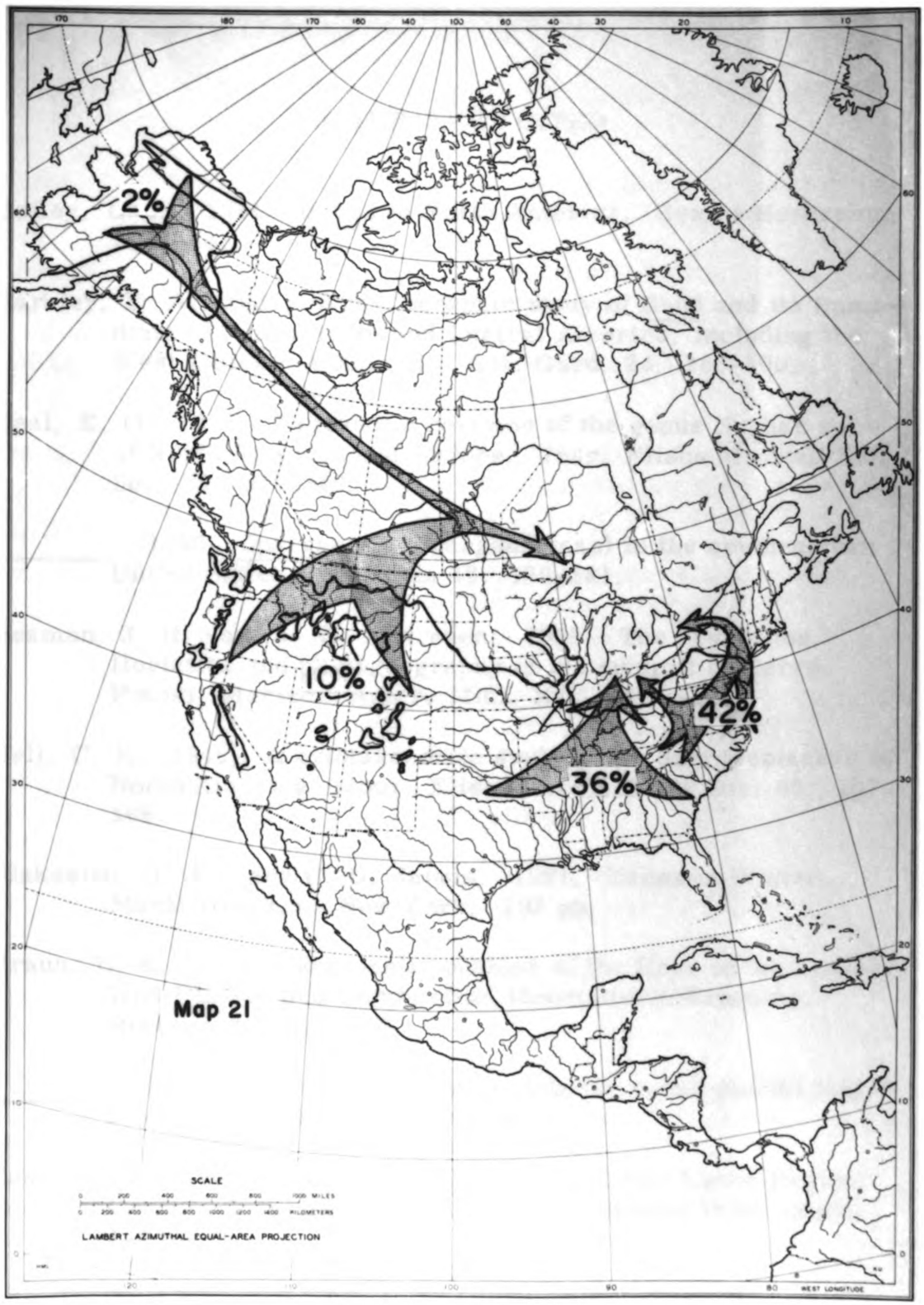

Map 20
SCALE
LAMBERT AZIMUTHAL EQUAL-AREA PROJECTION


Map 19
SCALE
LAMBERT AZIMUTHAL EQUAL-AREA PROJECTION

of these may have survived on nunataks in and around Newfoundland, as Fernald (1925) has suggested, or in unglaciated coastal refugia of the Pacific Northwest (Heusser, 1965). For some there is insufficient information to allow an assessment of their geographical affinities.

The probable source of species which now occur in Pennfield Bog are illustrated in the map of Migration Streams and Extent of Wisconsin Glaciation (Map 21). There appear to be four important sources from which the bog flora has been derived: 36% of the species are southern and are chiefly in pioneer zones or at the outer margin of the bog; 42% have an eastern affinity; 10% are Cordilleran; and 2% are of Alaskan affinity.

Map 21. -- Migration streams and extent of Wisconcin glaciation (glacial boundary after Flint, 1957, 1959)


2%
10%
42%
36%
Map 21
SCALE
LAMBERT AZIMUTHAL EQUAL-AREA PROJECTION
WEST LONGITUDE

LITERATURE CITED

Bailey, L. H. 1941. Rubus in North America. Gentes Herbarium 5: 1-64.

Barkley, F. A. 1937. A monographic study of Rhus and its immediate allies in North and Central America, including the West Indies. Annals Mo. Bot. Gard. 24: 265-500.

Beal, E. O. 1956. Taxonomic revision of the genus Nuphar sp. of North America and Europe. Jour. Elisha Mitchell Sci. Soc. 72: 317-346.

_____. 1960. Sparganium (Sparganiaceae) in the southeastern United States. Brittonia 12: 176-181.

Beaman, J. H., and J. W. Andresen. 1966. The vegetation, floristics and phytogeography of the summit of Cerro Potosi, Mexico. Amer. Midl. Nat. 75: 1-33.

Bell, C. R. 1949. A cytotaxonomic study of the Sarraceniaceae of North America. Jour. Elisha Mitchell Sci. Soc. 65: 137-166.

Blakeslee, A. F., and C. D. Jarvis. 1931. Trees in Winter. MacMillian Co. New York. 292 pp.

Braun, L. E. 1937. Some relationships of the flora of the Cumberland Plateau and Cumberland Mountains in Kentucky. Rhodora 39: 193-208.

_____. 1951. Plant distribution in relation to the glacial boundary. Ohio J. Sci. 51: 139-146.

Case, F. W. 1964. Orchids of the Western Great Lakes Region. Cranbrook Institute of Science. Bloomfield Hills, Mich. 147 pp.

Correll, D. S. 1950. Native Orchids of North America North of Mexico. Chronica Botanica Co. Waltham, Mass. 399 pp.

Dansereau, P. 1957. Biogeography. The Ronald Press. New York. 394 pp.

Daubs, E. H. 1965. A Monograph of Lemnaceae. Illinois Biological Monographs Vol. 34.

Eichmeier, A. H. Climatography of the United States. 1926-1955. Station 20-20 Battle Creek, Mich.

Epling, C. 1942. The American species of Scutellaria. Univ. of Calif. Publ. in Botany 20: 1-146.

Eyde, R. H. 1963. Morphological and Paleobotanical studies of the Nyssaceae, I. A survey of the modern species and their fruits. Jour. Arnold Arboretum 44: 1-59.

Fernald, M. L. 1925. Persistence of plants in unglaciated areas of boreal America. Memoirs Amer. Academy of Arts and Sci. Vol. 15, No. III.

_____. 1950. Gray's New Manual of Botany. 8th ed. American Book Co. New York.

Flint, R. F. 1957. Glacial and Pleistocene Geology. John Wiley and Sons, Inc. New York. 553 pp.

Flint et al. 1959. Glacial Map of the United States East of the Rocky Mountains. The Geological Society of America. New York.

Gates, F. C. 1942. The bogs of Northern Lower Michigan Ecological Monographs 12: 214-254.

Gleason, H. A. 1952. New Britton and Brown Illustrated Flora of the Northeastern United States and Adjacent Canada. 3 vols. Lancaster Press. Lancaster.

_____, and A. Cronquist. 1963. Manual of Vascular Plants of Northeastern United States and Adjacent Canada. D. Van Nostrand Co. Princeton.

Harlow, W. M., and E. S. Harrar. 1958. Textbook of Dendrology. 4th ed. McGraw-Hill Book Co. New York.

Hermann, F. J. 1941. The genus Carex in Michigan. Amer. Midl. Nat. 25: 1-72.

Heusser, C. J. 1965. A pleistocene phytogeographical sketch of the Pacific Northwest and Alaska. In Wright, H., and D. Frey (eds.). The Quaternary of the United States. Princeton University Press. Princeton.

Hitchcock, A. S. 1950. Manual of the Grasses of the United States. USDA Misc. Publ. No. 200. Government Printing Office. Washington, D. C.

Hotchkiss, N., and Dozier, H. 1949. Taxonomy and distribution of North American Cattails. Amer. Midl. Nat. 41: 237-254.

Hultén, E. 1958. The Amphi-Atlantic Plants and their Phytogeographical Connections. K. Sv. Vet. Akad. Handl. 7: 1. Almqvist and Wiksell. Uppsala.

_____. 1964. The Circumpolar Plants I. Vascular cryptogams, conifers, monocotyledons. K. Sv. Vet. Handl. 8: 5. Almqvist and Wiksell. Uppsala.

Humphrys, et al. 1965. Michigan Lakes and Ponds. Lake Inventory Bulletin No. 13. Agric. Exp. Station. Michigan State University. East Lansing.

Iltis, H. H. 1965. The genus Gentianopsis (Gentianaceae): transfers and phytogeographic comments. Sida 2: 129-154.

_____. 1966. The western element in the eastern North American flora and its phytogeographic implications. (abstract) Amer. Jour. Bot. 53: 634.

Jones, G. N. 1946. American Species of Amelanchier. Cont. Dept. Botany, Univ. of Illinois. Univ. of Illinois Press. Urbana. 126 pp.

Kugel, A. R. 1958. Variation in the Spiraea alba-latifolia complex. Unpublished Ph.D. dissertation. Univ. of Michigan.

Lanjouw, et al. 1966. International Code of Botanical Nomenclature. Regnum Vegetabile Vol. 46. Utrecht.

Leverett, F., and F. Taylor. 1915. The Pleistocene of Indiana and Michigan and the History of the Great Lakes. Monographs U. S. Geological Survey. Government Printing Office, Washington, D. C.

Little, E. L. 1965. In Fowells, H. A. Silvics of Forest Trees of the United States. Agric. Handb. No. 271. USDA. Government Printing Office. Washington, D. C.

Livingston, B., and F. Shreve. 1921. The Distribution of Vegetation in the United States, as Related to Climatic Conditions. Gibson Bros. Washington, D. C.

Martin, P. S. 1958. Pleistocene ecology and biogeography of North America. In Hubbs, C. S. (ed.) Zoography. Amer. Assoc. Adv. Sci. Publ. 51: 375-420.

McDaniel, S. 1966. A taxonomic revision of Sarracenia (Sarraceniaceae). Unpublished Ph.D. thesis. Univ. of Florida.

McNair, J. B. 1925. The geographical distribution of poison sumac (Rhus vernix L.) in North America. Amer. Jour. Bot. 12: 393-397.

Montgomery, J. D., and D. E. Fairbrothers. 1963. A floristic comparison of the vascular plants of two sphagnous wet lands in New Jersey. Bull. Torrey Bot. Club. 90: 87-99.

Ogden, E. C. 1943. The broad-leaved species of Potamogeton of North America north of Mexico. Rhodora 45: 57-105; 119-163; 171-214.

Pennell, F. W. 1935. The Scrophulariaceae of eastern temperate North America. Acad. Nat. Sci. Phil. Monographs. No. 1.

Raup, H. M. 1947. The botany of southwestern Mackenzie. Sargentia 6: 1-275.

Ray, J. D. 1956. The genus Lysimachia in the New World. Illinois Biological Monographs Vol. 24. Nos 3-4.

Rickett, H. W. 1944. Cornus stolonifera and Cornus occidentalis. Brittonia 5: 149-159.

Rossbach, G. B. 1939. Aquatic Utricularias. Rhodora 41: 113-128.

Russell, N. H. 1965. Violets (Viola) of central and eastern United States: an introductory survey. Sida 2: 1-113.

Svenson, H. K. 1939. Monographic studies in the genus Eleocharis. Rhodora 41: 43-77; 91-110.

Takhtajan, A. 1966. Sistema I Filogeniya Tsvetkovjkh Rasteniy. Science Press. Moscow-Leningrad.

Transeau, E. N. 1905. Bogs and bog flora of the Huron river valley. Bot. Gaz. 40: 351-448.

_____. 1906. Bogs and bog flora of the Huron river valley. Bot. Gaz. 41: 17-42.

Van Balgooy, M. (ed.). 1966. Pacific Plant Areas 2. Blumea Supplement V.

Wherry, E. T. 1933. The geographic relations of Sarracenia purpurea. Bartonia 15: 1-6.

Whitehead, D. R. 1965. Palynology and Pleistocene phytogeography of unglaciated eastern North America. In Wright, H., and D. Frey (eds.). The Quaternary of the United States. Princeton Univ. Press. Princeton.

Wolfe, J. N. 1951. The possible role of microclimate. Ohio J. Sci. 51: 134-138.

Wood, C. E. 1961. The genera of Ericaceae in the southeastern United States. Jour. Arnold Arboretum 42: 10-80.

Woodson, R. E. 1954. The North American species of Asclepias L. Mo. Bot. Gard. Ann. 41: 1-211.

Wynne, F. E. 1944. Drosera in eastern North America. Bull. Torrey Bot. Club 71: 166-174.