ECOLOGICAL AND FLORISTIC SURVEY OF P. J. HOFFMASTER STATE PARK, OTTAWA AND MUSKEGON COUNTIES, MICHIGAN

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ECOLOGICAL AND FLORISTIC SURVEY OF P. J. HOFFMASTER STATE PARK, OTTAWA AND MUSKEGON COUNTIES, MIGHIGAN

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INTRODUCTION

Although this represents the eighth in a series of ecological and floristic studies we have carried out on Michigan's sand dunes it is our first study in a state park. Since the readership of this report may therefore be expanded to include other branches of state government we have re-stated selected portions from earlier studies; namely, the methods and materials section as well as a general bibliography on Michigan's sand dunes. The P. J. Hoffmaster State Park with its 417 hectares (1,043 acres) is the largest study area we have examined in this our fifth year of research on Michigan's sand dunes. The Park was named in honor of the former director of the Department of Conservation who served in that capacity from 1934 to 1951.

All field work for this report took place during the months of April through September, 1983. Visits to the site throughout the growing season provided ample opportunity to sample the vegetation in each of the seasonal aspects. Based upon comparisons with our earlier studies in western lower Michigan we believe that the 1983 spring growing season was two weeks later in arriving than might otherwise obtain. During our early June visit we noted spring flora which is normally past flowering stage by that date.

Although our primary focus was upon areas that have experienced little or no recent disturbance by man we did include parking lots and campgrounds within the general purview of our study. Such areas can often be the sites of initial invasion by weedy or other foreign floristic elements brought in through various means by visitors. In the same regard we paid some attention to the small amount of frontage within the Park

boundary on Little Black Lake although we presume this area is little used by the majority of Park visitors.

In our earlier studies (Wells and Thompson, 1979a, 1979b, 1980, 1981a, 1981b, 1981c, and 1982) we have focused upon dunes sites in western Michigan from Sturgeon Bay in Emmet County southward to those in Berrien County. This report concerns an area located somewhat in the middle between the two geographical extremes. Since this "mid-point" area is a dedicated park it will presumably persist for such comparative purposes for decades to come.

The primary purpose of this study was not to compare one area with another but to characterize plant habitat types and to correlate this information with the various types of dune morphology. Our work is carried out under the provisions of Act 222, the Sand Dune Protection and Management Act of 1972.

DESCRIPTION OF STUDY SITE

The location of the study site is shown on the map (Fig. 1) along Lake Michigan's eastern shore. Most of its 417 hectares (1,043 acres) are situated in Muskegon County but the southern portion (Fig. 2) is in Ottawa County. Also depicted in Fig. 2 are the location of the E. Genevieve Gillette Nature Center and campground accomodating more than 300 camping units as well as other visitor convenience facilities. The 16 km (10 mi) of trails pass through principal natural features of one of the state's premier sand dunes areas.

Within the Gillette Nature Center building is a three-dimensional relief map of the area (Fig. 3). The 4 km (2.5 mi) of Lake Michigan shoreline stretch in front of eight extensive dune blowouts. We have numbered these blowouts consecutively from south to north--on Fig. 3, left to right. Thus, the Gillette Nature Center is between blowouts four and five and the large parking lot between blowouts six and seven. This is the largest assemblage of blowouts we have seen in any study site and with their size and height, up to 250 meters (820 ft.) in blowout number eight, they consititute a geological feature of considerable significance. Eastward of the range of dunes that include the blowouts the altitudinal variation is less extreme and along the eastern border and at the north end of the park the land shows little variation in altitude. Little effort seems to have been warranted in calling the public's attention to that small eastern portion of the Park bordering Little Black Lake.

Except for the shoreline, blowouts and areas devoted to public accomodation the Park is essentially forested, albeit sometimes the result of reforestation efforts as in the southern sector. Large trees occur in a number of localities but there is no extensive area we would characterize as having "virgin" timber. Recent timber harvesting was not in evidence.

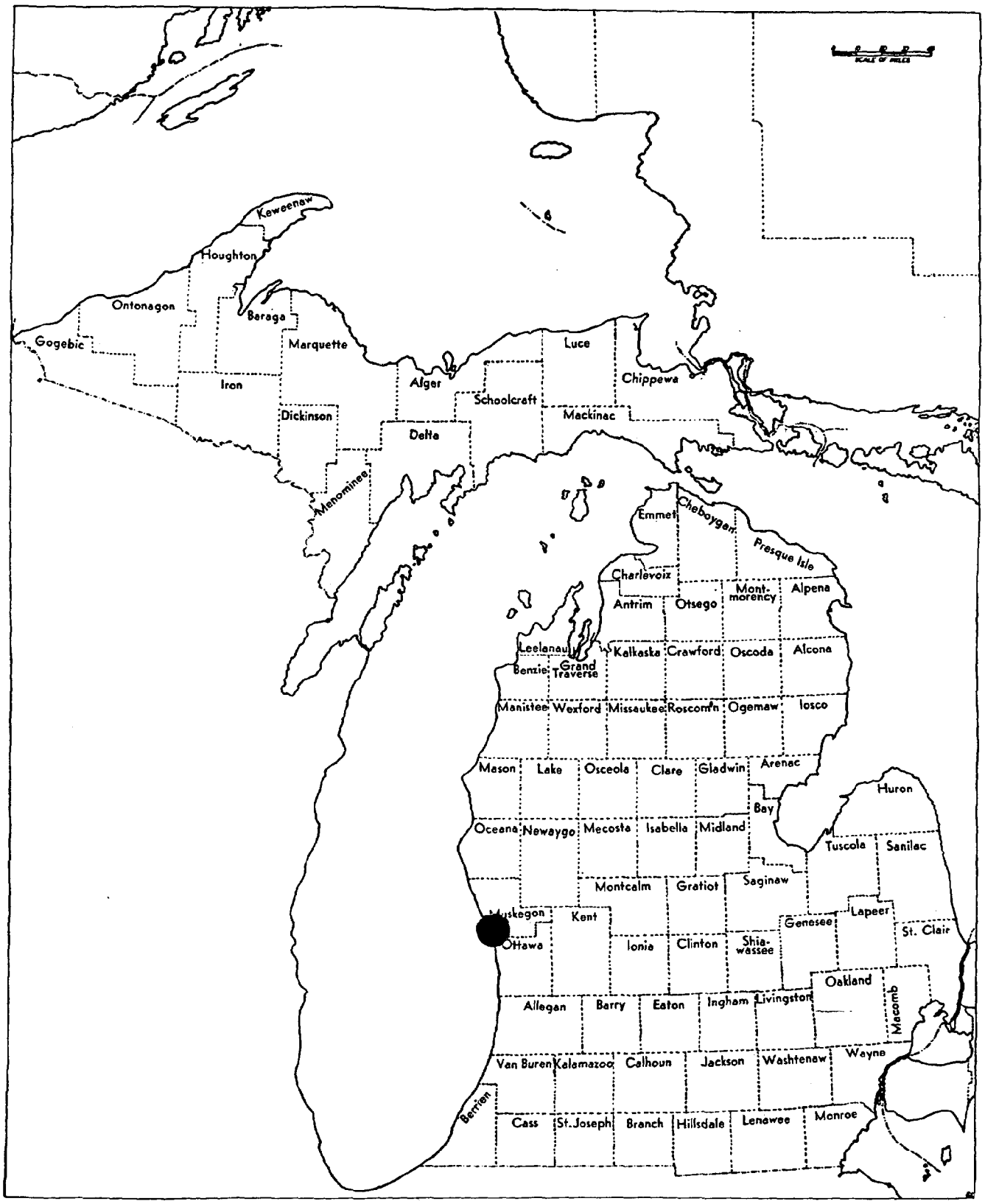


Fig. 1. Map showing location of P. J. Hoffmaster State Park in Muskegon and Ottawa Counties, Michigan.

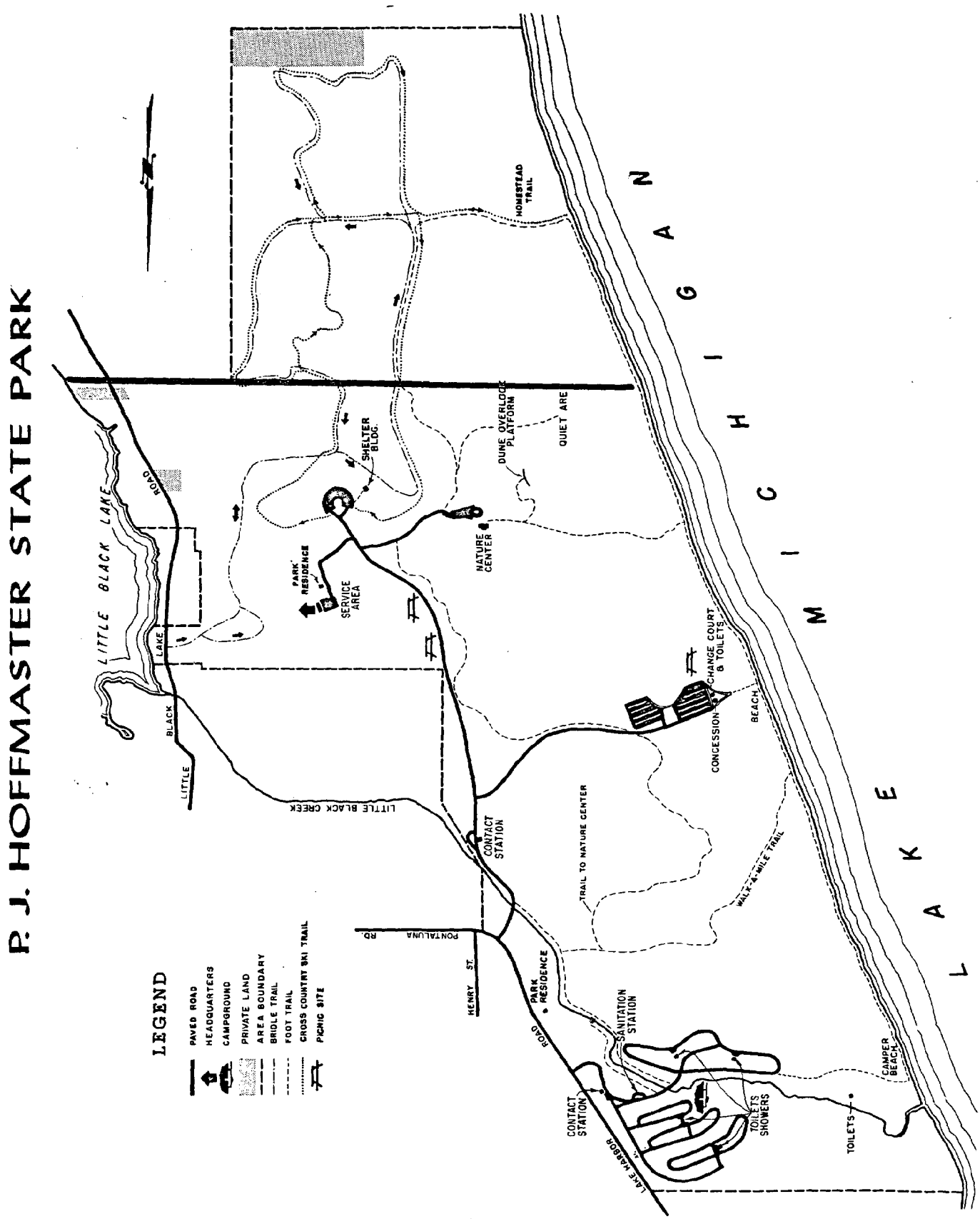


Fig. 2. Visitor facilities map showing location of Ottawa County portion of the Park above red line and Muskegon County portion below the line.

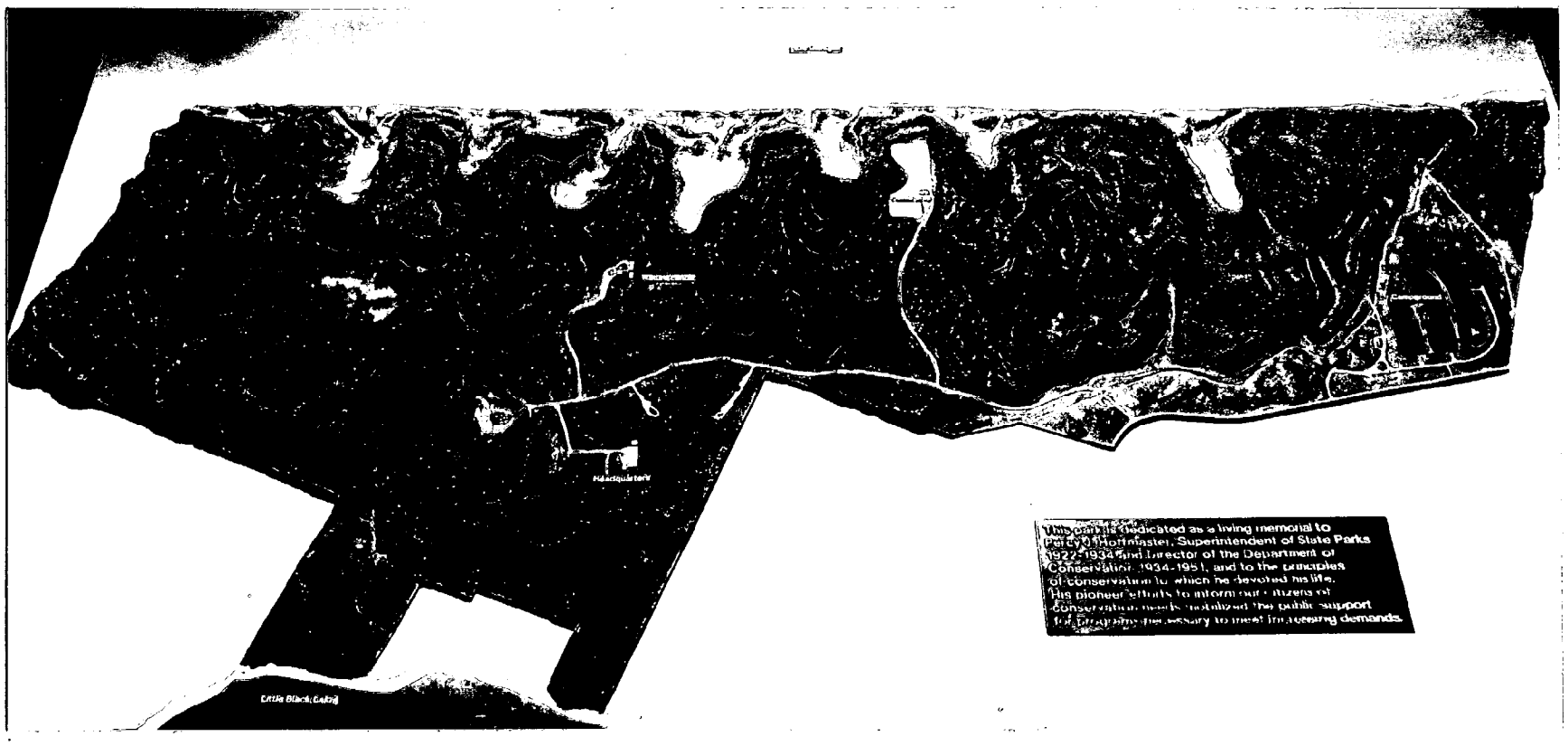


Fig. 3. Photograph of model of relief map in Gillette Nature Center, Hoffmaster State Park. Note eight dune blowouts along the western, Lake Michigan, shoreline and the small amount of frontage on Little Black Lake along the eastern Park boundary. The Nature Center is strategically situated in the central portion of the Park and the campground is at the extreme north portion.

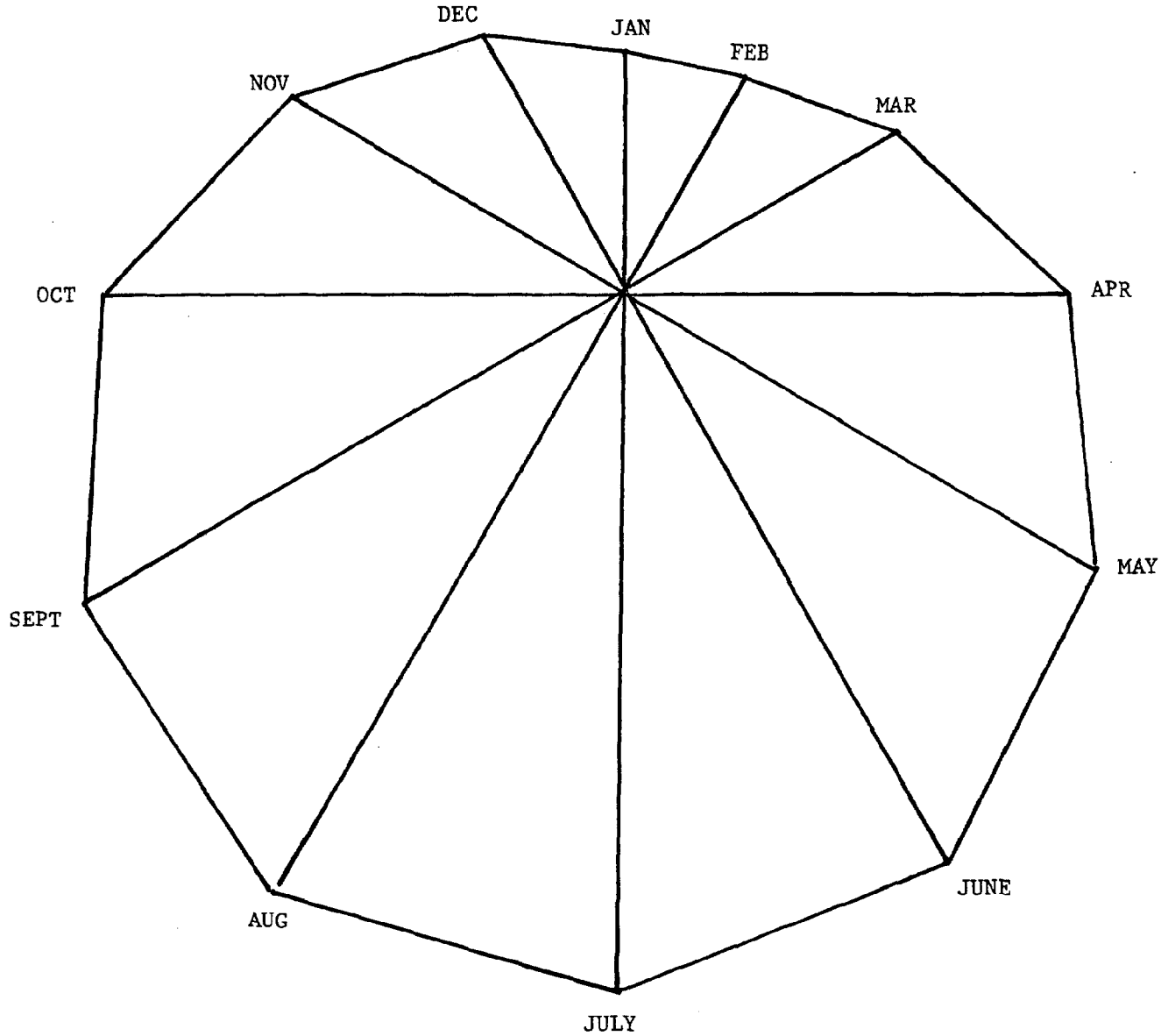
The average frost-free period for the Muskegon area is 160 to 170 days. Lake Michigan has a moderating effect on climate resulting in a somewhat later arrival of spring than occurs at similar latitudes farther inland and correspondingly later appearance of fall temperatures. The monthly mean temperatures for the period 1940-1971 have been compiled by the U. S. Dept. of Commerce (1971) and are graphically depicted in Fig. 4. The "bulge" in the graph for the months July through October is due to the influence of the now warmer water of the tremendous thermal mass of Lake Michigan--which effect we alluded to above.

Mean annual precipitation is 79.3 cm (31.22 in) and its mean monthly distribution is indicated in Fig. 5. Precipitation is relatively equally distributed throughout the year with February having the least with 4.50 cm (1.77 in) and September the wettest month with a mean of 8.28 cm (3.26 in). According to the U. S. Dept of Commerce (1971) snowfall averages around 218 cm (86 in) annually.

Relative humidity averages about 73%. Annual mean humidity measurements taken at 01:00 hrs. is 78%; at 07:00 hrs., 81%; at 13:00 hrs., 64%; and at 19:00 hrs., 67% (U. S. Dept. of Commerce, 1971). These figures represent a length of record of 11 years. The lowest monthly mean humidity reading is for May at 13:00 hrs.--52% and the highest mean recordings were at 07:00 hrs. for August and September with 86%. High monthly humidity means for this region increase the precipitation effectiveness. This factor together with the moderating effects of Lake Michigan and the evenness of precipitation throughout the year create a very desirable climatic regime for farming--a fact of which all fruit crop growers take full advantage.

Mean wind speed is 17.38 km/hr (10.8 mi/hr) and the prevailing direction is SSW, (U. S. Dept. of Commerce, 1971). Monthly means vary from

Fig. 4. Mean monthly temperature profile, °C (°F), for Muskegon, Michigan for period 1940 - 1971. *

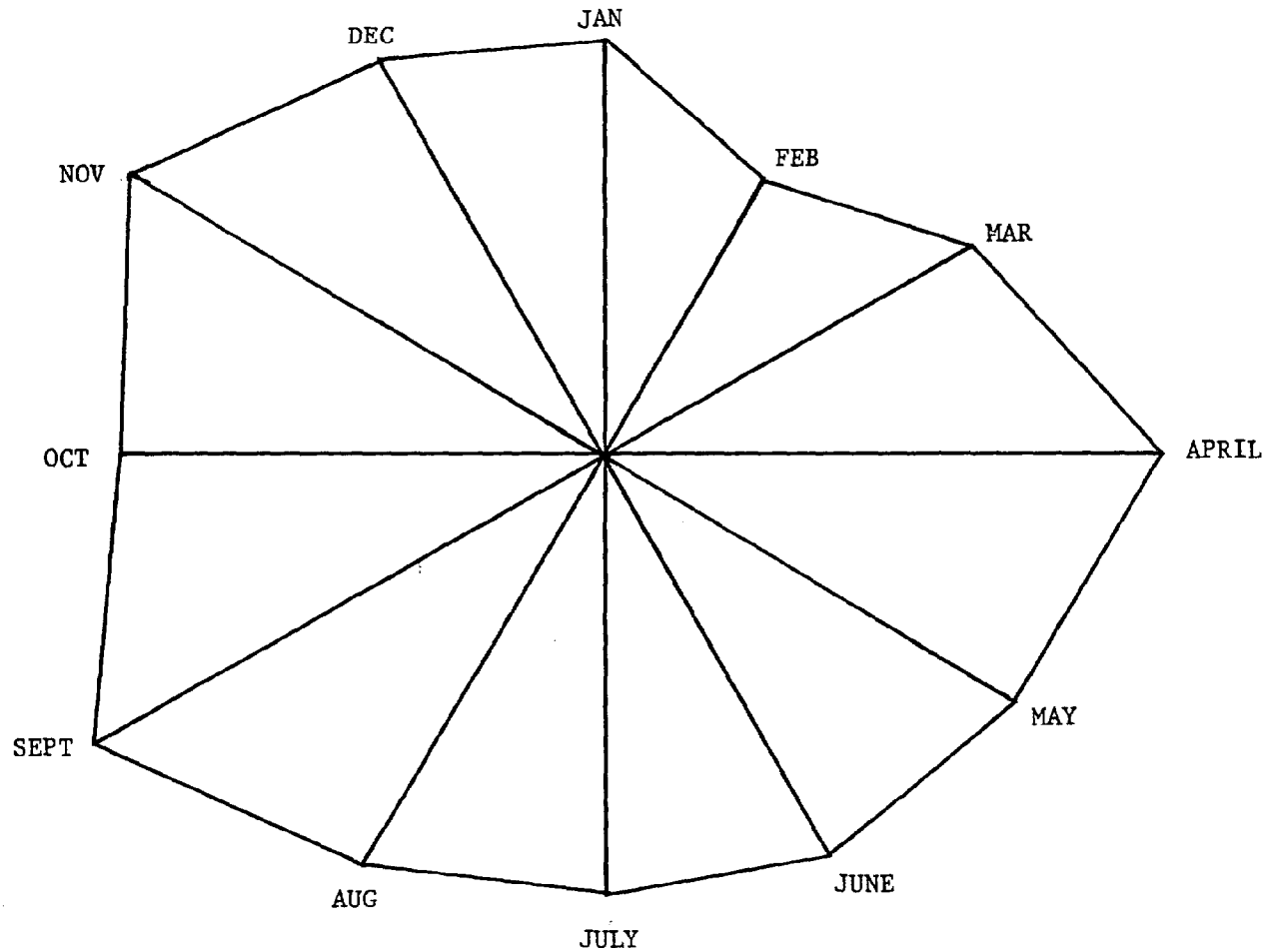


Jan.	-4.5	(23.9)	July	21.1	(70.0)
Feb.	-4.1	(24.6)	Aug.	20.4	(68.8)
March	0.0	(32.0)	Sept.	16.4	(61.6)
April	7.4	(45.3)	Oct.	11.0	(51.8)
May	13.0	(55.4)	Nov.	3.9	(39.1)
June	18.7	(65.7)	Dec.	-1.8	(28.7)

Annual mean 8.4 (47.2)

* Data compiled by U. S. Dept. Commerce, NOAA and Michigan Weather Service, 1971.

Fig. 5. Mean monthly precipitation profile, cm (in), for Muskegon Michigan for Period 1940 - 1971.*



Jan.	5.69	(2.24)	July	6.20	(2.44)
Feb.	4.50	(1.77)	Aug.	6.63	(2.61)
March	6.05	(2.38)	Sept.	8.28	(3.26)
April	7.90	(3.11)	Oct.	6.68	(2.63)
May	6.81	(2.68)	Nov.	7.65	(3.01)
June	6.58	(2.59)	Dec.	6.35	(2.50)

Mean annual total 79.30 (31.22)

Monthly mean 6.60 (2.60)

* Data compiled by U. S. Dept. Commerce, NOAA and Michigan Weather Service, 1971.

a low of 13.52 km/hr (8.4 mi/hr) in July and August to a high of 19.95 km/hr (12.4 mi/hr) for January.

The predominant soil type in the study site is Bridgman fine sand (Wheeting and Matthews, 1929). Along the western border of Little Black Lake the predominant soil type is Saugatuck sand but near the Muskegon-Ottawa County line along the same lake border Houghton muck is found.

Bridgman fine sand is typically overlain with litter beneath which is a grayish fine or medium sand some 10-15 cm (4-6 in) in depth. The subsoil is pale yellow in the upper portion and less so with increasing depth. Fertility is low and acidity is moderate to high. Saugatuck sand has a surface zone of 15-30 cm (6-12 in) of gray loamy sand which is underlain by a lighter gray sand extending to depths of 30-60 cm (12-24 in). Beneath the latter horizon is a coffee brown or dull yellow sand 45-106 cm (18-42 in) in depth that is cemented to varying degrees of hardness (Wheeting and Matthews, 1929). Muck consists of plant parts in varying degrees of decomposition. Organic matter varies from 15% to 95% and were it not for the muck's high water concentration it would be transformed into humus. Muck accumulations tend to be shallow--often not exceeding 1 m (3 ft) in depth and their pH tends toward neutrality (Wheeting and Matthews, 1929).

METHODS AND PROCEDURES

Our seven earlier reports to the Michigan Department of Natural Resources (Wells and Thompson 1979a, 1979b, 1980, 1981a, 1981b, 1981c, and 1982) are based upon the same methods and procedures employed in this study.

The nine quadrats in this study measured 20 meters on a side and compass lines were used to establish coordinates for boundaries on north-south and east-west lines. Each quadrat was then subdivided into four 10 x 10 meter units to enhance detail of coverage.

Each vascular plant species was categorized as to its placement in the community structure as a member of the canopy, shrub, or ground cover. By employing a combination of scales used by Braun-Blanquet (1932) and Benninghoff (1966) we arrived at the following cover-abundance scale for ground cover species:

5 = cover more than 3/4 of area (75%)

4 = cover 1/2 to 3/4 of area (50-75%)

3 = cover 1/4 to 1/2 of area (25-50%)

2 = cover 1/20 to 1/4 of area (5-25%)

1 = numerous but less than 1/20 (5%)

+ = few with small cover

r = solitary with small cover

For understory analysis the following scale was employed. It was an attempt to estimate the total number of stems with a tally for each species.

4 = over 100 individuals

3 = 11-100 individuals

2 = 2-10 individuals

1 = one stem only

- - + stem off plot, overhangs into area

All tree species with stems at least 8 cm diameter at breast height (DBH = 1.3 m, = 4½ ft.) were identified and their diameters recorded separately. For these measurements a steel diameter tape was used. From DBH measurements basal area values were obtained and herein used as a measure of relative abundance of a given species within that quadrat. Analyses of basal area values by species and quadrat appear in Table 1.

Trips were made to the study site during the growing seasons of 1983. All of our voucher collections of vascular plants were prepared and are on permanent deposit at Cranbrook Institute of Science's Billington Herbarium. Plant identifications follow the taxonomy of Gleason (1952) and Voss (1972). The checklists included as part of this report, i.e. the appendices, represent all species we found in the study area during the course of our investigation.

Quadrats of the Hoffmaster State Park bear the prefix "H" denoting the eighth set of plots studied by these workers. Thus, quadrat H-5 would indicate the fifth quadrat analyzed in a chronological sequence among the eighth set of dune studies.

ANALYSIS OF PLANT COMMUNITIES

An aerial view of Hoffmaster State Park points up several of its principal characteristics--the geomorphic features consisting of eight blowouts which are the best set of parabolic blowouts we have seen along Lake Michigan's eastern shore, and the unbroken stretch of shoreline some 4 km (2.5 mi) in length. A third dominant feature is forest-covered land. Although these forested lands have been subjected to selective cutting some decades past they will, in time, with the present ownership and management strategy evolve into even more magnificant examples of mature dunes vegetation. Some signs of this are already apparent.

Our observations concerning plant communities of the Park fall into two categories, those pertaining to the communities we examined in greater detail in localities scattered throughout the Park (Fig. 6) and general comments concerning other areas of the Park also included in this section of our report. In our initial reconnaissance of the study area we walked over dunes, on and off many of the trails in order that we might obtain a general impression of what we were to see in greater detail later. The nine quadrat study sites represent samples of plant communities which may be much greater in extent of coverage that our 20 m^2 quadrat or the quadrat's vegetation type may be very restricted in area. Our quadrat studies, then, indicate examples of plant habitat types present at this time and which may be present to a greater or lesser degree in the future. In addition to the locality map to quadrat sites (Fig. 6) we have included a photograph for each of the nine quadrats to aid in our description as well as to provide some opportunity for comparison in the future. For several reasons permanent stakes denoting quadrat boundaries were deemed inadvisable.

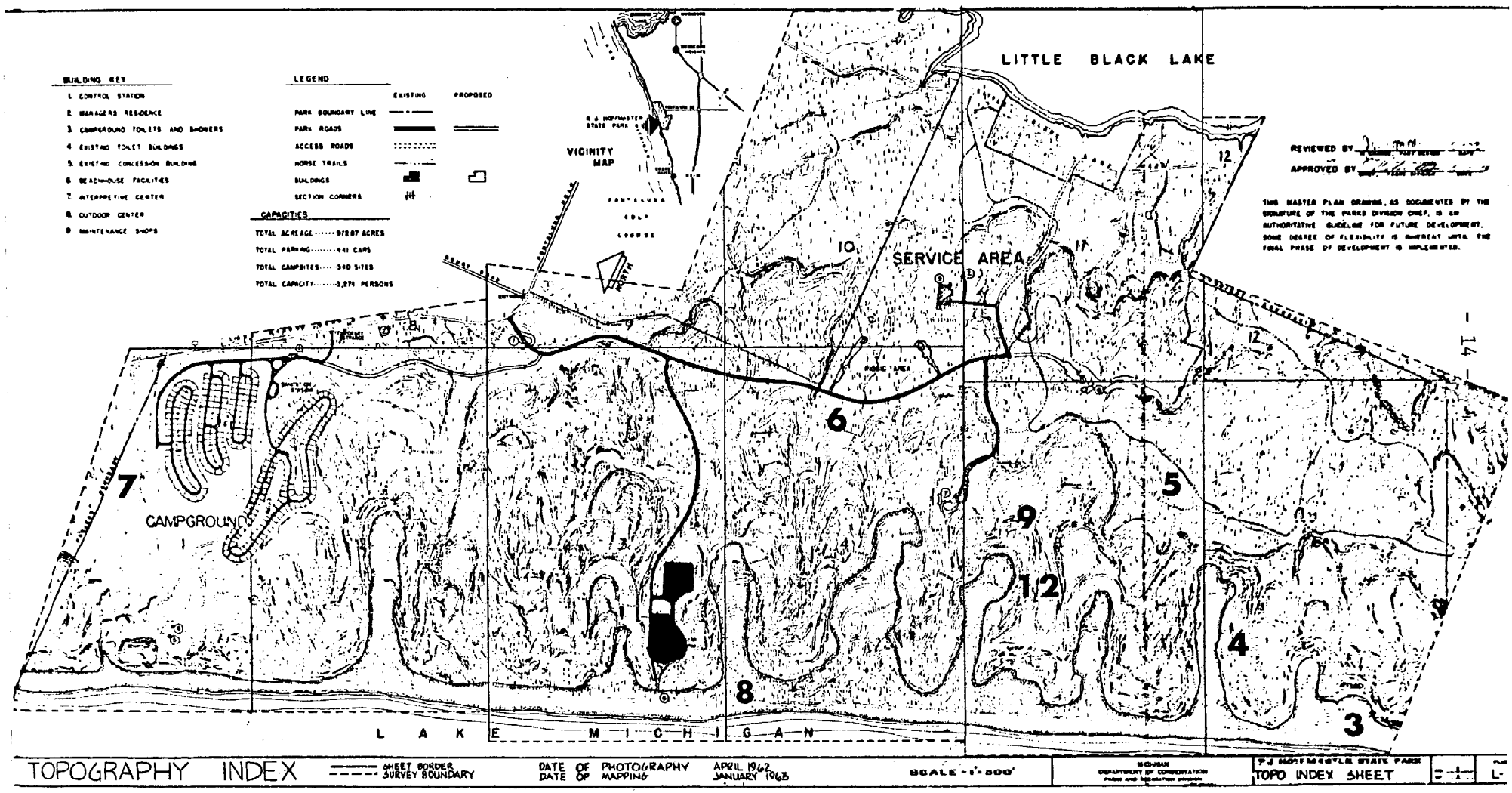


Fig. 6. Map of P. J. Hoffmaster State Park showing localities of nine study quadrats.

Open Dunes Vegetation

The vegetation of open dunes areas at any given point in time suffers one of two typical fates. It is succeeded by forest cover or else is destroyed by shifting sand only to be replaced by the same species or by other species collectively presenting the same treeless aspect on dune slopes and ridges. The principal examples of open dunes vegetation at Hoffmaster Park are the eight extensive blowouts which extend inland from Lake Michigan as indicated on the map (Fig. 6). We have chosen to number the eight blowouts sequentially beginning at the south end of the Park with no. 1, a photograph of which is shown below (Fig. 7). It is at the eastern end of some of these blowouts that we find the Park's highest elevations--up to 250 m (820 ft). Since the average elevation of Lake Michigan is 177 m (580 ft) (Dorr & Eschmann, 1970) the sand accumulations in these blowouts may be as high as 73 m (240 ft) above the level of Lake Michigan.

In the southern section of blowout no. 1 we carried out a quadrat analysis in the location indicated by the numeral "3" on the map (Fig. 6). A view of this quadrat site appears below (Fig. 8). The vegetation in this blowout typifies much of the open dune vegetation east of the foredunes along Lake Michigan. Quadrat H-3 was situated only about 100 m (300 ft.) inland from Lake Michigan yet was completely devoid of marram grass (*Ammophila breviligulata* Fern.). Although tree species were represented in the quadrat including cottonwood (*Populus deltoides* Marsh.), red oak (*Quercus borealis* Michaux f.) and dune willow (*Salix glaucophylloides* Fern.) all were in early growth stages. Other woody plants included sand cherry (*Prunus pumila* L.) and river-bank grape (*Vitis riparia* Michaux).

Fig. 7. View from Lake Michigan of blowout no. 1 at south end of Park. Note common juniper in right foreground. Photographed April 29, 1983.

Fig. 8. South-facing view of quadrat H-3 near blowout no. 1. Although near Lake Michigan this quadrat lacked marram grass. Photographed June 8, 1983.

Cover plants in greatest abundance were sand reed-grass (Calamovilfa longifolia (Hooker) Scribner), little bluestem (Andropogon scoparius Michaux) along with some horse mint (Monarda punctata L.), sand cress (Arabis lyrata L.), hoary puccoon (Lithospermum carolinense (Walter) MacM.) and beach wormwood (Artemisia caudata Michaux). Minor constituents also present were common milkweed (Asclepias syriaca L.), evening primrose (Oenothera biennis L.) and dune goldenrod (Solidago spathulata DC.). Of special note was Pitcher's thistle (Cirsium pitcheri (Torrey) T. & G.) which is on the list of rare and threatened species in Michigan (Wagner et al, 1977) as well as for the United States (Ayensu & DeFilipps, 1978).

It appears that the presence of shifting sand favors the occurrence of marram grass over other dune grass species which lack the ability to continue sufficient vertical growth along with the accumulations of sand. It therefore becomes common to encounter marram grass on the windward side of foredunes as depicted in quadrat H-8 (Fig. 9). In areas where the blowing of sand occurs to a somewhat less degree, such as in quadrat H-3 (Fig. 8), other grass species and forbs are competitively favored over marram grass.

In quadrat H-8 the only woody species found were small specimens of sand cherry, cottonwood, and heart-leaved willow (Salix cordata Michaux). The ground cover was almost totally that of marram grass with a few plants of dune goldenrod and beach wormwood. It is in this type of shoreline plant community that one can see dramatic effects of erosion due to high wind and wave action. In some instances there may result a vertical drop-off of 1-2 m (3-6 ft.), or even more, along Lake Michigan's shore. The slope of quadrat H-8 was 13° in a westerly direction although much steeper slopes are not uncommon.

Farther north near the entrance to blowout no. 8 we noted seedlings of bugseed (Corispermum hyssopifolium L.) along the foredune. Just inland

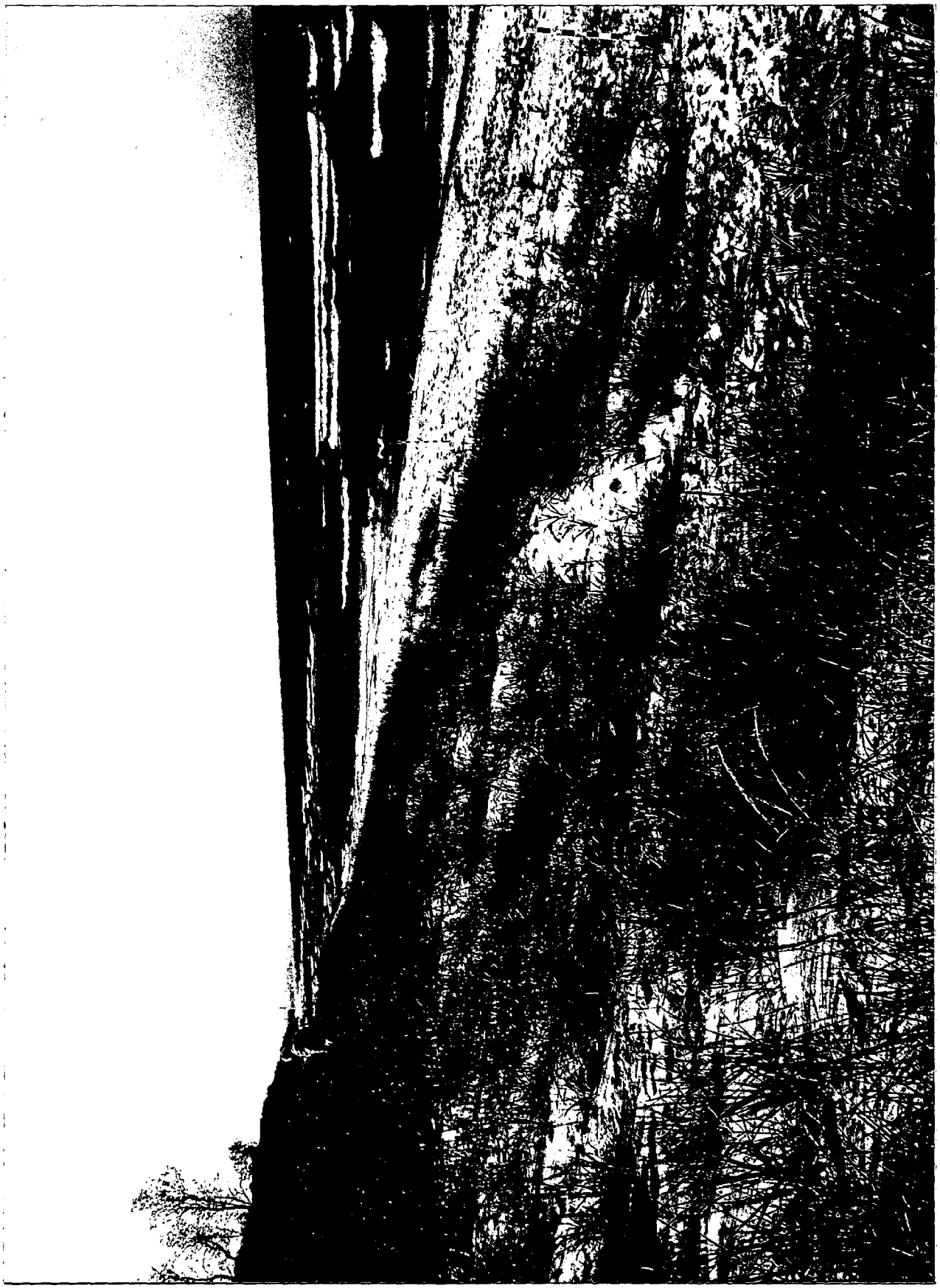


Fig. 9. South-facing view of quadrat H-8 near blowout no. 6. The dominant species on this 13° west-facing slope was marram grass. Photographed June 9, 1983.

over the first foredune and south of the entrance to blowout no. 8 along a ridge was a stand of about a dozen wafer-ash (Ptelea trifoliata L.) plants which included some of the largest we have seen.

Forested Dunes Vegetation

A total of six quadrats were set up to assist in the identification and characterization of principal kinds of forest communities in the study area. Quadrats H-1 and H-2 consisted of a "matched pair", i.e. south- and north-facing, respectively, on opposite sides of a common valley.

The relative dominance of a given tree species is indicated by the total basal area for stems of that species taken at 1.4 m (4½ ft.). This value, expressed as percent coverage, along with total number of trees and total basal area for each quadrat are listed in Table 1. The south-facing quadrat, H-1 was dominated by red oak (69.5%) and beech (21.6%). Minor amounts of basswood and white ash were also present.

The principal understory constituents on this 32° slope were maple-leaved viburnum (Viburnum acerifolium L.), white ash (Fraxinus americana L.), sugar maple (Acer saccharum Marsh), witch hazel (Hamamelis virginiana L.), black cherry (Prunus serotina Ehrh.) along with lesser amounts of such species as beech (Fagus grandifolia Ehrh.), prickly gooseberry (Ribes cynosbati L.), choke cherry (Prunus virginiana L.), hop-hornbeam (Ostrya virginiana (Miller) K. Koch) and black maple (Acer nigrum Michaux f.). Also present among understory species was river-bank grape which is shown below (Fig. 10). However, one of the largest specimens of river-bank grape we have seen was located near quadrat H-2 and this specimen had a DBH of 12 cm (4.7 in.). A photograph of this plant is shown in Fig. 11.

The most conspicuous species among ground cover in H-1 included large white trillium (Trillium grandiflorum Michaux Salisb.), sweet cicely

Fig. 10. South-facing view in center of quadrat H-1 showing entanglement of grape vines (Vitis riparia). Photographed June 7, 1983.

Fig. 11 . Large grape vine (Vitis riparia) with a DBH of 12 cm (4.7 in.) located near quadrat H-2. Photographed June 7, 1983 showing author Paul Thompson.

(Osmorhiza claytoni (Michaux) Clarke), marginal shield-fern (Dryopteris marginalis (L.) Gray), false Solomon's-seal (Smilacina racemosa (L.) Desf.) and numerous plants but less than 5% cover for each of the following: Canada Mayflower (Maianthemum canadense Desf.), hairy Solomon's-seal (Polygonatum pubescens (Willd.) Pursh), blue-stemmed goldenrod (Solidago caesia L.), bellwort (Uvularia grandiflora Sm.), and long-spurred violet (Viola rostrata Pursh). Some of the remaining 21 herbaceous species noted were less conspicuous such as columbine (Aquilegia canadensis L.), white lettuce (Prenanthes alba L.), bishop's-cap (Mitella diphylla L.), poke milkweed (Asclepias exaltata L.), rattlesnake fern (Botrychium virginianum (L.) Sw.), large-leaved aster (Aster macrophyllus L.), wild sarsaparilla (Aralia nudicaulis L.), and common greenbrier (Smilax rotundifolia L.).

Quadrat H-2 is the north-facing slope counterpart of H-1 and their relative locations are indicated on the map (Fig. 6). Quadrats on both slopes had a 32° slope and both were dominated by red oak and beech. However, the total basal area in H-2 was about twice that in H-1 (Table 1). Among the differences we noted between the two quadrats was the greater dominance of beech in the north-facing slope as well as the presence of hemlock (Tsuga canadensis (L.) Carr.) and fly honeysuckle (Lonicera canadensis Marsh) in the shrub zone. Sugar maples of tree size were present in H-2 with a relative dominance factor of 7%. Only saplings of this species were noted on the south-facing slope. As this forest matures we can expect sugar maple and hemlock to become increasingly important on the north-facing slope. Marginal shield-fern was predictably more common on the north-facing slope quadrat than on the south facing quadrat.

A suggestion of the ground cover is offered in the photograph of quadrat H-2 (Fig. 12). Of interest among ground cover species were such

Fig. 12. View of quadrat H-2, a 32° north-facing slope showing a 54.7 cm (21.5 in) DBH red oak. Photographed June 7, 1983.

species as starflower (Trientalis borealis Raf.), bishop's-cap, fringed polygala (Polygala paucifolia Willd.), partridge-berry (Mitchella repens L.), indian cucumber-root (Medeola virginiana L.), wood betony (Pedicularis canadensis L.), blunt-lobed hepatica (Hepatica americana (DC.) Ker), wild sarsaparilla, white baneberry (Actaea alba (L.) Miller), spinulose shield-fern (Dryopteris austriaca (Jacq.) Woynar), several species of sedges (Carex spp.) and Canada mayflower. This partial listing of ground cover species indicates a very rich spring flora near the Gillette Nature Center building. The greater richness of the flora of the north-facing slope is suggested by the much greater coverage value of tree stem basal area (Table 1)--almost 15,000 cm^2 (2,400 in^2) compared to 8,300 cm^2 (1,328 in^2) for the south-facing slope.

All of Hoffmaster Park seems to have been cut over leaving no virgin stands of timber. During our preliminary reconnaissance of the study site we noted a considerable number of young hemlock trees scattered throughout the area. These young hemlocks were most conspicuous in spring prior to canopy closure as suggested in the photograph below (Fig. 13). Given sufficient time they can be expected to regain the stature the species once held as constituents of the canopy layer. Along north-facing slopes such as that shown in Fig. 13 is a prime exposure on which to expect their best development. This development can be attributed to effects of reduced insolation resulting in greater moisture effectiveness which favors hemlock over many broad-leaved tree species. Optimal growing conditions can result in pure stands of mature hemlock such as we have seen in other sand dune localities.

A search was made for a stand of mature hemlock in which to carry out a quadrat analysis. The scarcity of mature hemlock in this site which contains so many young trees of the same species attests to the successional

Fig. 13. Early spring aspect showing hemlock succession in a deciduous forest. This north-facing slope is located near the south end of the Park. Photographed April 29, 1983.

stages in this maturing forest. One of the best stands of mature hemlock was found just east of quadrats H-1 and H-2. Its location is indicated on the map (Fig. 6) and is designated by the numeral "9".

In quadrat H-9 a total of six species were noted as having attained tree size. These six are listed in Table 1 and show hemlock to be dominant with approximately 37% of the basal area recorded therein. About equal dominance is suggested (15-18%) for each of beech, black cherry and sugar maple. Smaller amounts of red oak and basswood were present. Woody plants in the understory included seedlings of yellow birch (Betula alleghaniensis Britton), hazel (Corylus americana Walter), white ash, sugar maple, witch hazel, beech, basswood (Tilia americana L.), red oak and prickly gooseberry. Of these understory species the most abundant were white ash, sugar maple, witch hazel and hazel. The development of the understory layer in this forested quadrat was quite sparse resulting in an open, park-like aspect (Fig. 14) such as one typically finds in hemlock stands elsewhere.

Although 15 species were found in the ground cover layer, their abundance is sparse. Wild sarsaparilla is the most common species followed by Canada mayflower, large white trillium, sweet cicely, hairy Solomon's-seal, and marginal shield-fern. Our 20 m^2 quadrat included most of this hemlock stand. As a result of the edge effect which here included increased light, the checklist of species although limited might have been even somewhat less if taken from the central portion of a larger hemlock stand. Several centuries are required for conditions, including soil development, leading up to the establishment of a mature hemlock stand having begun with open dunes sand.

Fig. 14 . North-facing view of hemlock stand, quadrat H-9. Large tree in foreground had a DBH of 45.0 cm (17.7 in). Photographed June 9, 1983.

A quadrat (H-4) was laid out in a broad, slightly undulating, forested ravine. Its location between blowouts no's. one and two, shown on the map (Fig. 6), is along the north edge of an east-west trail. Our data on tree measurements (Table 1) show 14 trees in the quadrat with a total basal area of 22,423 cm^2 (3,588 in^2). This unusually high value (one of the highest we have recorded) is due principally to the few very large beech, red oak, and black cherry each of which comprised about 30% of the basal area. Basswood and sugar maple contributed the remainder to the quadrat's forest composition with two trees for each species. The DBH of the largest red oak, shown in Fig. 15, was 89.3 cm (35.2 in) while that of the largest beech, also shown in Fig. 15, was 82.7 cm (32.6 in). The two largest black cherry trees each measured slightly more than 52 cm (20.5 in).

An understory layer was dominated by such species as maple-leaved viburnum, beech sugar maple and black cherry. Somewhat less abundant were red-berried elder (Sambucus pubens Michaux), prickly gooseberry, white ash, hazel, hop-hornbeam, witch hazel, blackberry (Rubus alleghaniensis Porter), red oak and basswood.

This floristically diverse site included 21 species in the ground cover. Among the more important finds were squirrel corn (Dicentra canadensis (Goldie) Walp.), long-spurred violet, jack-in-the pulpit (Arisaema triphyllum (L.) Schott), Canada mayflower, early bedstraw (Galium aparine L.), beech-drops (Epifagus virginiana (L.) Bart.), smooth yellow violet (Viola eriocarpa Schw.), bellwort, sweet cicely, marginal shield-fern, indian cucumber root, and wild sarsaparilla.

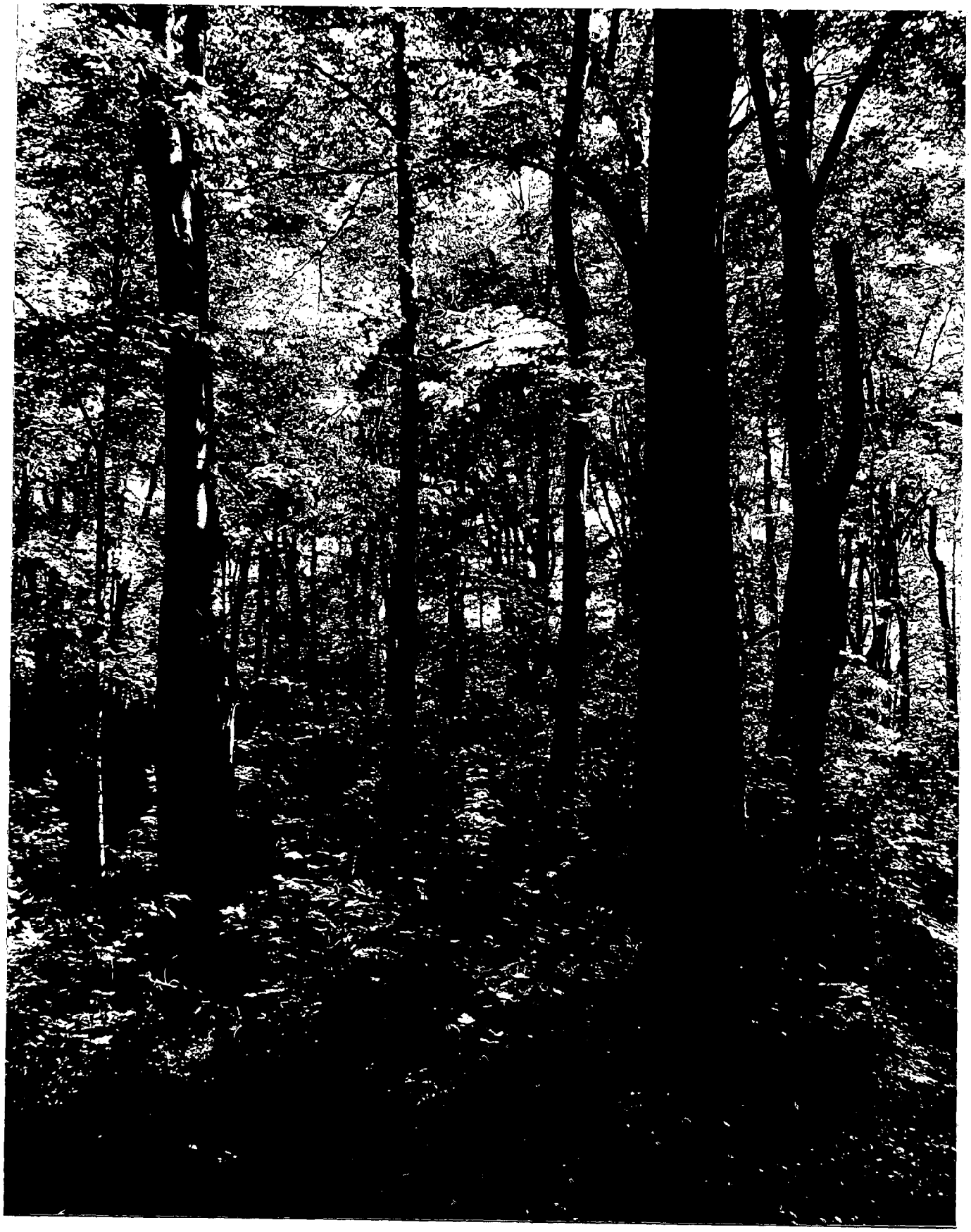


Fig. 15 . East-facing view of quadrat H-4 showing beech at left and red oak at right whose DBH measured 89.3 cm (35.2 in). Photographed June 8, 1983.

Located east of the major dunes in a section of hardwood forest is an extensive flat area wherein we set up quadrat H-6 (Fig. 6). It closely resembled quadrat H-2 with its total basal area of 14,704 cm^2 (2,353 in^2) as shown in Table 1. Also as in H-2 it was dominated by red oak. However, in H-6 quadrat the relative dominance of sugar maple (28.5%) and beech (5.5%) were essentially the reciprocal of what we found in H-2. It is tempting to suggest that forests in both quadrat sites are moving toward a beech-maple climax and that the 32° north-facing slope of H-2 is proceeding in that direction at a somewhat more advanced stage.

In the understory layer we observed successional species such as sassafras (Sassafras albidum (Nutt.) Nees) and white pine (Pinus strobus L.). Neither of these were found in quadrat H-2. Understory dominants included such species as sugar maple, beech, maple-leaved viburnum, white ash and black cherry. Noteworthy but less abundant were fly honeysuckle, shadbush (Amelanchier arborea Michaux f.) and hazel. The aspect of this understory is suggested in Fig. 16.

The herbaceous species comprising the ground cover were not abundant but principal among them were wild sarsaparilla, false Solomon's-seal and hairy Solomon's-seal. Smaller amounts of the following were noted: sweet-scented bedstraw (Galium triflorum Michaux), lance-leaved wild licorice (Galium lanceolatum Torrey), partridge-berry, rice-grass (Oryzopsis asperifolia Michaux), large-leaved aster and white lettuce. Of special interest was a plant of spotted wintergreen (Chimaphila maculata (L.) Pursh) --a rare species in Michigan (Wagner et al., 1977).

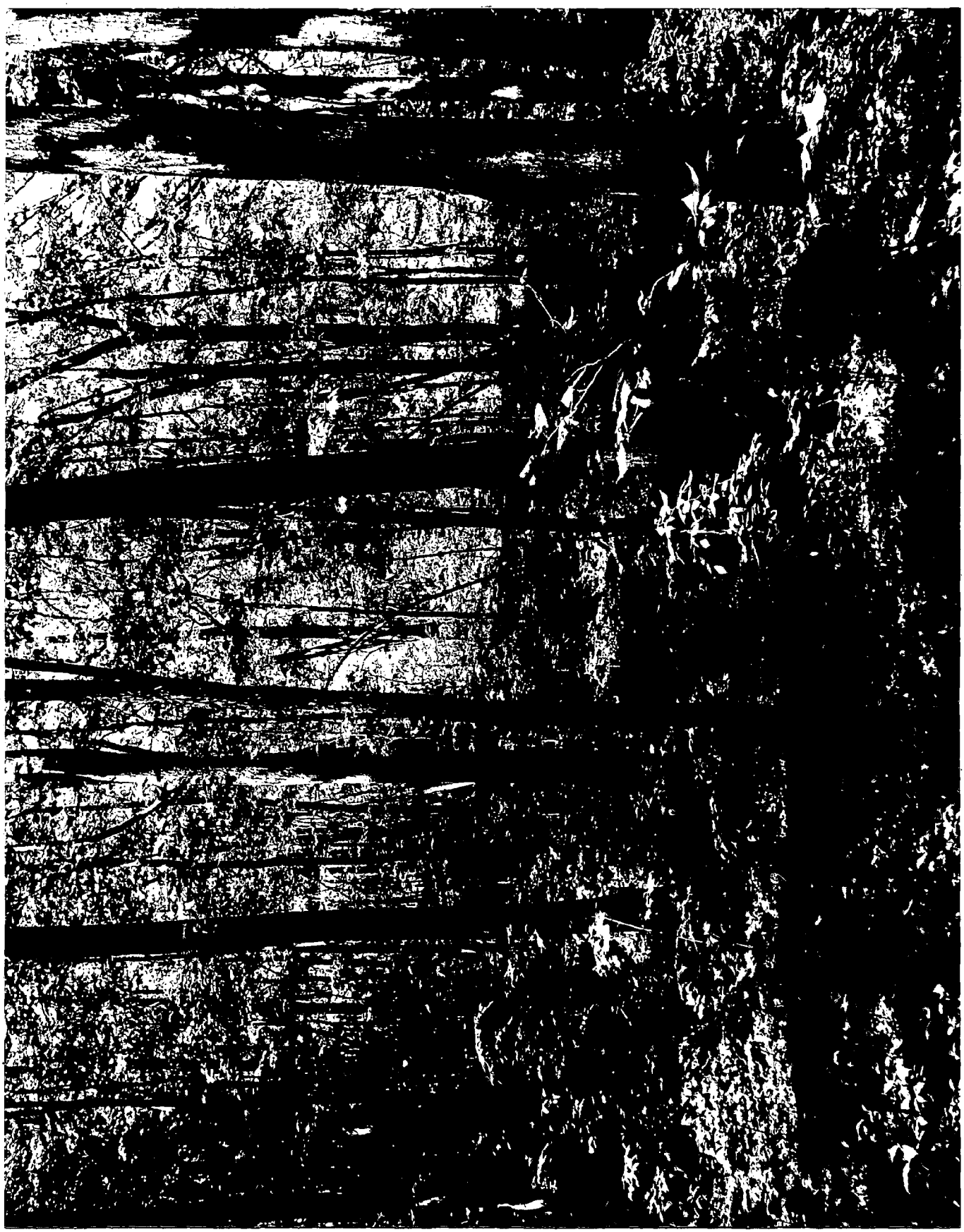


Fig. 16 . North-facing view of quadrat H-6 showing 3 trees in foreground, l. to r., hop hornbeam, DBH 11.7 cm (4.6 in), and two red oaks--26.8 cm (10.6 in), 41.0 cm (16.1 in). Photographed June 8, 1983.

In the northern sector of the Park is a large swampy area. A forest along the edge of this area has a number of northern hardwood characteristics quite unlike anything else we observed in the study site. A study quadrat (H-7) was made at this location (Fig. 6). These data show red maple to be a dominant species with its 44% basal area cover and a co-dominant, red oak with a 20% basal area factor. Of special interest is the 15% basal area supplied by yellow birch. Other species in the canopy layer include hemlock (4%), beech (9%), black cherry (6%), and sugar maple (3%). Some large trees in this quadrat are shown below (Fig. 17).

The total number of woody plant species recorded was 16. Among the species comprising the understory the most abundant were spice bush (Lindera benzoin (L.) Blume), sugar maple, black cherry, red maple, red oak, white ash, and maple-leaved viburnum. Other species in the understory included mountain ash (Sorbus americana Marsh), alternate-leaved dogwood (Cornus alternifolia L. F.), fly honeysuckle, hemlock, shadbush and red-berried elder.

The most conspicuous species in the ground cover which included 24 species were marsh fern (Thelypteris palustris Schott), cinnamon fern (Osmunda cinnamomea L.), wintergreen (Gaultheria procumbens L.) and Canada mayflower. Other common species included indian cucumber-root, partridge-berry, starflower, wild sarsaparilla, lady fern (Athyrium filix-femina (L.) Roth) and hairy Solomon's-seal. Among the more uncommonly found species in the Park were jack-in-the-pulpit, fringed polygala, dwarf ginseng (Panax trifolium L.) and stemless lady's-slipper (Cypripedium acaule Aiton).

Fig. 17. East-facing view of quadrat H-7 showing red maple, 76.0 cm (29.9 in), in the center foreground and yellow birch, 44.6 cm (17.6 in) at extreme left. At right of center are hemlock and black cherry. Photographed June 8, 1983.

In the south-central part of the study site near the county line (Fig. 2) we set up quadrat H-5 (Fig. 6). This area does not easily fit into the category of open sand dunes vegetation nor as forested dunes but is, to a degree, intermediate between the two. This area is typified by a sterile, sandy soil on which grow trees of scrubby growth form as indicated in the photograph (Fig. 18). In our quadrat only one tree, a small red oak, qualified for measurement (DBH 8.5 cm = 3.3 in.). Other woody plants in the shrub layer were small trees of red oak, choke cherry, white ash along with sand cherry and river-bank grape.

The most common species in the ground cover layer were sand reed-grass, Canada bluegrass (Poa compressa L.) and little bluestem. Other species with small coverage included dwarf dandelion (Krigia virginica L. (Willd.), dune goldenrod, sand cress, common milkweed, sheep-sorrel (Rumex acetosella L.), horse mint and blue toadflax (Linaria canadensis (L.) Dum.). The cryptogamic species, reindeer lichen (Cladonia spp.) and earthstar mushroom (Geastrum spp.) noted here are both indicators of sterile soils.

The total acreage occupied by vegetation such as in quadrat H-5 is not extensive but is unique owing to its aspect and floristic composition. Sitauted on flat, sterile, sandy soils it will likely persist in its present state longer than would be anticipated e.g. on a north-facing slope with the typically increased moisture effectiveness. The species now present which are typical of open dunes such as sand reed-grass and little bluestem will cease to exist as the mixed hardwood forest develops. In time coniferous species are expected to join the assemblage prior to the return of climax forest some centuries hence.

Fig. 18. Quadrat H-5 as viewed from the south. Note sparse vegetation and depauperate growth form of trees. Photographed June 8, 1983.

Located south of quadrat H-5 is a stand of Norway pines (Pinus resinosa Aiton). The aspect of this plantation, shown in Fig. 19, is one of uniform-aged trees (? 30 years) with little development in the understory or in ground cover. Seedling trees noted in the understory were sassafras, white ash, black cherry and sugar maple. No seedling pines were noted. Along the western perimeter of this stand we saw several plants of stemless lady's-slipper and the Michigan rare spotted wintergreen. Bracken fern was the most common herbaceous species with a smaller amount of Canada Mayflower.

As this stand of Norway pines matures we would anticipate that some thinning will occur normally. In time, this stand can be expected to give rise to a mixed deciduous forest which is now in the developmental sapling stage. At the present time this younger stage excludes essentially all coniferous species. Barring any catastrophe a small amount of white pine may ultimately occupy a position in the canopy layer.

Located somewhat eastward from this pine plantation near Little Black Lake are the remnants of a nursery. Herein are found a number of introduced cultivars of hydrangea and juniper along with a number of coniferous tree species. Adjacent to the rows of planted trees is a slight depression--presumably low due to removal of top soil. In this low area we found lance-leaved violet (Viola lanceolata L.) in considerable abundance along with bog clubmoss (Lycopodium inundatum L.), yellow-eyed grass (Xyris difformis Chapman), sundew (Drosera intermedia Hayne), rough goldenrod (Solidago rugosa Miller), ticklegrass (Agrostis hyemalis (Walter) BSP.), boneset (Eupatorium perfoliatum L.), marsh St. John's-wort (Triadenum fraseri (Spach) Gl.) and other St. John's-wort species (Hypericum spp.). A small pond near this site yielded American Bur-reed (Sparganium americanum Nutt.) and the pondweeds (Potamogeton gramineus L. and Potamogeton pectinatus L.).

Fig. 19. Norway pine plantation near south parking lot. Understory tree species include sassafras and white ash but no pine. Photographed June 8, 1983.

AQUATIC VEGETATION

For purposes of this study we have excluded submersed aquatic species that may occur near the shore of Lake Michigan. In recent years we have begun to notice occasional presence of some plant material along the beach following strong winds. At Hoffmaster Park this included green algae, presumably *Cladophora* sp., and some of the pondweeds (*Potamogeton* spp.).

Without further consideration to the small pond located near the abandoned nursery to which we earlier alluded we recognize two principal aquatic habitats; namely, the shore of Little Black Lake and the streams with their associated wetlands located in the northern sector of the study site.

Little Black Lake Shoreline

In the illustrations outlining Hoffmaster Park boundaries (Figs. 2, 3, and 6) it can be observed that Little Black Lake lies along portions of the Park's eastern boundary. During a late fall trip to the study site we were able to observe the sandy shoreline when the Lake level was some 0.3 m (1 ft.) lower than it had been earlier in the season. Rooted aquatics included such species as fragrant water lily (*Nymphaea odorata* Aiton), water-shield (*Brasenia shreberi* Gmel.), pickerelweed (*Pontederia cordata* L.) and pipewort (*Eriocaulon septangulare* With.). Species of pondweed were also present.

This sandy shoreline changes to a wetland quaking bog as one approaches the Ottawa-Muskegon County line. The aspect at this point is depicted in the photograph below (Fig. 20). Much of this area is covered by such sedges as *Carex lasiocarpa* Ehrh., *C. leptalea* Wahl., twig-rush (*Cladium mariscoides* (Muhl.) Torrey) and cotton-grass (*Eriophorum viridi-carinatum* (Engelm.) Fern.). Growing among the sedges are such entities as pitcher-plant

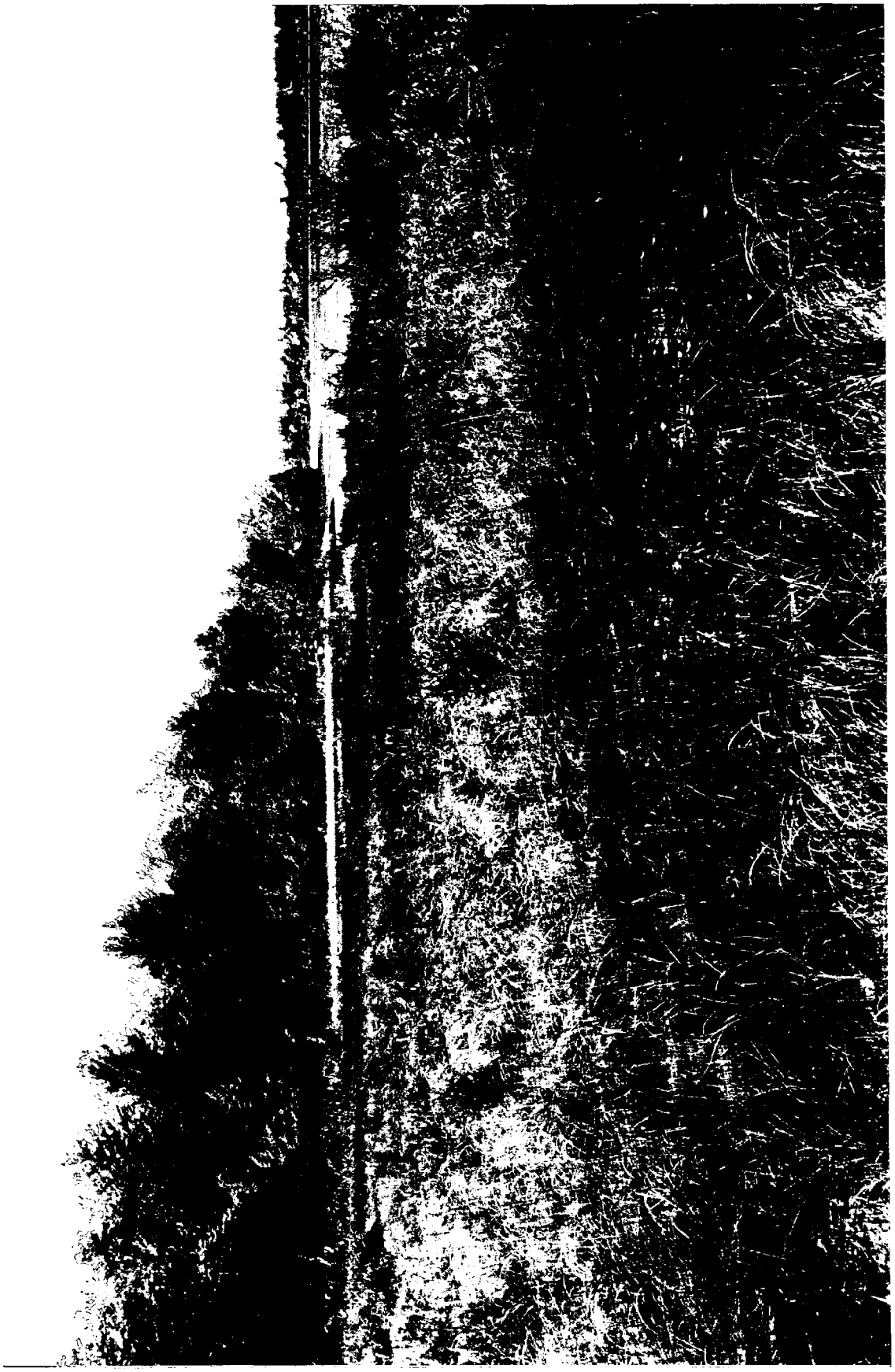


Fig. 20. North-facing view of bog area along west shore of Little Black Lake near the Muskegon-Ottawa County line. Photographed June 9, 1983.

(Sarracenia purpurea L.), marsh fern (Thelypteris palustris Schott), royal fern (Osmunda regalis L.) and threesquare (Scirpus americanus Pers.). Other plants growing in the sedge mat included marsh St. John's-wort, Michigan lily (Lilium michiganense Farw.), water willow (Decodon verticillatus (L.) Ell.), common cat-tail (Typha latifolia L.), marsh bellflower (Campanula aparinoides L.), marsh cinquefoil (Potentilla palustris (L.) Scop.), swamp rose (Rosa palustris Marsh) and marsh skullcap (Scutellaria galericulata L.). Among the slightly wetter areas one finds pickerelweed and arrow-arum (Peltandra virginica (L.) Schott & Endl.). The species along the border to the north include Michigan holly (Ilex verticillata (L.) Gray), speckled alder (Alnus rugosa (DuRoi) Sprengel), larch (Larix laricina (DuRoi) K. Koch) and black chokeberry (Aronia melanocarpa (Michaux) Ell.). Inland from this shrub border occurs red maple, tulip-tree (Liriodendron tulipifera L.) and red oak.

Stream and Associated Wetland

The broad valley at the junction of Little Black Creek and a second stream along the north boundary of the Park is depicted below (Fig. 21). Dominant species here include such sedges as water sedge (Carex aquatilis Wahl.), swollen sedge (Carex intumescens Rudge), fox sedge (Carex vulpinoidea Michaux) along with Carex lurida Wahl. Important grasses here include such species as blue-joint (Calamagrostis canadensis (Michaux) Beauv.), rattlesnake grass (Glyceria canadensis (Michaux) Trin.), reed canary grass (Phalaris arundinacea L.) and fowl manna grass (Glyceria striata (Lam.) Hitchc.). Broad-leaved herbaceous species include hedge bindweed (Convolvulus sepium L.), touch-me-not (Impatiens biflora Willd.), black bindweed (Polygonum convolvulus L.), Canada anemone (Anemone canadensis L.), stiff bedstraw (Galium tinctorium L.), hog-peanut (Amphicarpa

Fig. 21. Broad stream valley, probably glacially derived, in northwest sector of the Park. This west-facing view was photographed May 1, 1983.

bracteata (L.) Fern.), cursed crowfoot (Ranunculus scleratus L.) and yarrow (Achillea millefolium L.). Near the streambank one finds duckweed (Lemna minor L.), marsh fern , water plantain (Alisma plantago-aquatica L.) and water cress (Nasturtium officinale R. Br.).

Shrub species scattered within this wetland area include highbush cranberry (Viburnum opulus L.), common elder (Sambucus canadensis L.) and peach-leaved willow (Salix amygdaloides Andersson). Shrub species are found in greatest abundance around the perimeter of the wetland.

Among the more interesting finds in this wetland site are monkey-flower (Mimulus ringens L.), the sedge (Carex projecta Mack.)--a county record, and two other county records; namely, reed canary grass and helleborine (Epipactis helleborine (L.) Crantz).

As the stream flows westward it broadens considerably (Fig. 22). On the south border of the stream near Lake Michigan one finds a considerable stand of Canada yew (Taxus canadensis Marsh.) and the only population of common polypody (Polypodium vulgare L.) we found in the Park.

FLORISTICS

During the course of our study we found a total of 468 species of vascular plants representing 93 families and 278 genera. This total excludes a number of cultivars of horticultural species remaining in the abandoned nursery alluded to on p. 37. We believe that a floristics study of this site carried out over a period of several years might result in as many as 550 species for the "final" checklist.

A number of county records were noted among monocots, i.e. not listed in distribution maps (Voss, 1972). These records include: Muskegon Co.--Virginia wild rye (Elymus virginicus L.), hooded ladies'-tresses

Fig. 22. View of mouth of Little Black Creek at Lake Michigan. This photograph, of May 1, 1983, was taken near the site of common polypody fern.

(Spiranthes romanzoffiana Cham.), dropseed (Sporobolus cryptandrus (Torrey) Gray), the sedge (Carex projecta Mack.), helleborine (Epipactis helleborine (L.) Crantz), reed canary grass (Phalaris arundinacea L.), bracted orchid (Habenaria viridis (L.) R. Br.), the sedge (Carex tribuloides Wahl.), cotton-grass (Eriophorum viridi-carinatum (Engelm.) Fern.) and bluegrass (Poa saultensis Fern. & Wieg.).

The rarest plant we collected was Childing pink (Petrorhagia prolifera (L.) Ball & Heywood) which we found growing near the main Park entrance. This is the third known Michigan collection, not a county record, since its initial discovery in Michigan on August 8, 1976. Since it is an introduced species it is excluded from the state's list of rare, endangered and threatened species.

Among the species collected a total of 3 are on the list of rare and threatened species (Wagner, et al., 1977). The first of these is Pitcher's thistle (Cirsium pitcheri (Torrey) T. & G.) which is on the U. S. and Michigan lists of threatened species (Wagner, et al., 1977, and Ayensu & DeFilipps, 1978) is ginseng (Panax quinquefolium L.). Spotted wintergreen (Chimaphila maculata (L.) Pursh) is listed as "rare". The common polypody (Polypodium vulgare (L.) is of interest owing to its relative scarcity in the Lake Michigan dunes region. Two common species we expected to find but did not see were Jack pine (Pinus banksiana Lamb.) and wild bergamot (Monarda fistulosa L.).

SUMMARY AND CONCLUSIONS

P. J. Hoffmaster State Park with its 1,043 acres and six major blowouts as well as dunes rising to 250 m (820 ft.) elevation is a real jewel among conservation efforts along Lake Michigan's eastern shore. The vegetation with at least 468 species of vascular plants contains approximately

25% of the total for the state.

Forest maturation seems to be progressing satisfactorily and in time will lead to an interesting diversity of climax types including both coniferous and deciduous species. At present the forests are not as mature as selected portions of the Mt. Edward and Sturgeon Bay tracts. However, tree succession already underway gives a distinct impression as to what we might expect with the passage of several more decades. Hemlock will be a more important forest constituent--especially on north-facing slopes. The tract north of the campground site (quadrat H-7 locality) is reminiscent of more northern Michigan tracts and will likely remain essentially the same in floristic composition and dominant species.

A threat to the integrity of the Park should be addressed. Park officials are aware of the great amount of dune destruction occurring in the southern sectors of the Park--activity of off-road vehicles. Adequate funding must be found to protect in the southern portion of the Park that which is "interpreted" in the central portion of the Park--i.e. at the Gillette Nature Center.

If it became desirable to make available on a wider basis wetland habitats one might suggest trails (? boardwalks) along the bog area of Little Black Lake as well as into the sedge meadow just north of the campground. Both plant communities are likely viewed at present by the general public as "too threatening". (We did see a large massasauga rattlesnake along Little Black Lake's border near an abandoned shack.)

Park management as well as physical facilities must here be a model for other state parks. The wide variety of plant life will ever provide a stimulus and challenge to the park's interpretive naturalists. We find ourselves wondering what the aspect of the park is like during mid-winter? Perhaps this winter we shall find out.

Table 1. Tree basal area results from 20m x 20m plots.

Total number of trees, species basal area (cm^2) and (% coverage).

Plot no.	Slope	No. of Species	Total no. of Trees	Total Basal Area	basswood	beech	black cherry	hemlock	hop hornbeam	red maple	red oak	sugar maple	white ash	yellow birch
H-1	32°S	4	15	8,341	2 487 (5.8)	6 1805 (21.6)					6 5800 (69.5)		1 249 (2.9)	
H-2	32°N	3	16	14,778		7 5033 (34.0)					6 8719 (59.0)	3 1026 (6.9)		
H-4	flat	5	14	22,423	2 1387 (6.2)	4 6150 (27.4)	4 7415 (33.1)				2 7171 (32.0)	2 300 (1.3)		
H-5	flat	1	1	57							1 57 (100.0)			
H-6	flat	4	23	14,704		1 814 (5.5)			1 108 (0.7)		5 9587 (65.2)	16 4195 (28.5)		
H-7	flat	7	17	19,431		3 1684 (8.7)	1 1116 (5.7)	1 755 (3.9)		7 8596 (44.2)	2 3884 (20.0)	1 527 (2.7)		2 2869 (14.8)
H-9	9°S	6	17	15,332	1 611 (3.9)	4 2841 (18.5)	2 2574 (16.8)	7 5621 (36.7)			1 1439 (9.4)	2 2246 (14.6)		

PHYLOGENETIC CHECKLIST OF VASCULAR PLANTS

LYCOPODIACEAE - Clubmoss Family
- Lycopodium clavatum L. Running Clubmoss
- Lycopodium complanatum L. Ground Cedar
- Lycopodium inundatum L. Bog Clubmoss
- Lycopodium lucidulum Michaux Shining Clubmoss
- Lycopodium obscurum L. Ground Pine
- Lycopodium tristachyum Pursh Ground Cedar

EQUISETACEAE - Horsetail Family
- Equisetum arvense L. Field Horsetail
- Equisetum fluviatile L. Pipes
- Equisetum hyemale L. Scouring-rush

OPHIOGLOSSACEAE - Adder's-tongue Family
- Botrychium virginianum (L.) Sw. Rattlesnake Fern

OSMUNDACEAE - Royal Fern Family
- Osmunda cinnamomea L. Cinnamon Fern
- Osmunda regalis L. Royal Fern

POLYPODIACEAE - Polypody Family
- Athyrium filix-femina (L.) Roth Lady Fern
- Dryopteris austriaca (Jacq.) Woynar Spinulose Shield-fern
- Dryopteris marginalis (L.) Gray Marginal Shield-fern
- Onoclea sensibilis L. Sensitive Fern
- Polypodium vulgare L. Common Polypody
- Pteridium aquilinum (L.) Kuhn Bracken
- Thelypteris palustris Schott Marsh Fern

TAXACEAE - Yew Family
- Taxus canadensis Marsh. Canada Yew

PINACEAE - Pine Family
- Abies balsamea (L.) Miller Balsam Fir
- Larix decidua Miller Larch
- Larix laricina (DuRoi) K. Koch Larch
- Picea glauca (Moench) A. Voss White Spruce
- Picea pungens Engelm. Blue Spruce
- Pinus resinosa Aiton Red Pine, Norway Pine
- Pinus strobus L. White Pine
- Pinus sylvestris L. Scots Pine
- Pseudotsuga menziesii (Mirbel) Franco Douglas Fir
- Tsuga canadensis (L.) Carr. Hemlock

CUPRESSACEAE - Cypress Family
- Juniperus communis L. var. depressa Pursh Common Juniper
- Juniperus virginiana L. Red Cedar
- Thuja occidentalis L. Arbor Vitae, White Cedar

TYPHACEAE - Cat-tail Family
- Typha latifolia L. Common Cat-tail

SPARGANIACEAE - Bur-reed Family
Sparganium americanum Nutt. American Bur-reed

POTAMOGETONACEAE - Pondweed Family
Potamogeton gramineus L. Grass-leaved Pondweed
Potamogeton natans L. Common Pondweed
Potamogeton pectinatus L. Sago Pondweed
Potamogeton praelongus Wulfen White-stemmed Pondweed

ALISMATACEAE - Water-plantain Family
Alisma plantago-aquatica L. Water-plantain
Sagittaria latifolia Willd. Wapato

HYDROCHARITACEAE - Frog's-bit Family
Elodea canadensis Michaux Waterweed

GRAMINEAE - Grass Family
Agropyron repens (L.) Beauv. Quack Grass
Agrostis gigantea Roth Redtop
Agrostis hyemalis (Walter) BSP. Ticklegrass
Ammophila breviligulata Fern. Beach Grass
Andropogon scoparius Michaux Little Bluestem
Anthoxanthum odoratum L. Sweet Vernal Grass
Bromus inermis Leysser Smooth Brome
Bromus tectorum L. Downy Chess
Calamagrostis canadensis (Michaux) Beauv. Blue-joint
Calamovilfa longifolia (Hooker) Scribner Sand Reed-grass
Dactylis glomerata (L.) Orchard Grass
Danthonia spicata (L.) R. & S. Poverty Grass
Deschampsia flexuosa (L.) Trin. Hairgrass
Digitaria sanguinalis (L.) Scop. Crab Grass
Elymus canadensis L. Canada Wild-rye
Elymus virginicus L. Virginia Wild-rye
Eragrostis spectabilis (Pursh) Steudel Tumble Grass
Festuca obtusa Biehler Nodding Fescue
Festuca saximontana Rydb. Fescue Grass
Glyceria canadensis (Michaux) Trin. Rattlesnake Grass
Glyceria striata (Lam.) Hitchc. Fowl Manna Grass
Holcus lanatus L. Velvet Grass
Leersia oryzoides (L.) Sw. Cut Grass
Oryzopsis asperifolia Michaux Rice-grass
Panicum clandestinum L. Panic Grass
Panicum implicatum Britton Panic Grass
Panicum virgatum L. Switch Grass
Phalaris arundinacea L. Reed Canary Grass
Phleum pratense L. Timothy
Elymus canadensis L. Canada Wild-rye
Festuca obtusa Biehler Nodding Fescue
Festuca saximontana Rydb. Fescue Grass
Glyceria canadensis (Michaux) Trin. Rattlesnake Grass
Glyceria striata (Lam.) Hitchc. Fowl Manna Grass
Holcus lanatus L. Velvet Grass
Oryzopsis asperifolia Michaux Rice-grass
Panicum clandestinum L. Panic Grass
Panicum implicatum Britton Panic Grass

Phalaris arundinacea L. Reed Canary Grass
Phleum pratense L. Timothy
Poa alsodes Gray Grove Bluegrass
Poa compressa L. Canada Bluegrass
Poa saultensis Fern. & Wieg. Bluegrass
Setaria viridis (L.) Beauv. Green Foxtail
Sporobolus cryptandrus (Torrey) Gray Dropseed

CYPERACEAE - Sedge Family
Carex albursina Sheldon Sedge
Carex aquatilis Wahl. Water Sedge
Carex arctata Boott Drooping Wood Sedge
Carex argyrantha Tuckerman Sedge
Carex bromoides Willd. Sedge
Carex cephalophora Willd. Sedge
Carex communis Bailey Fibrous-rooted Sedge
Carex eburnea Boott Sedge
Carex hitchcockiana Dewey Sedge
Carex intumescens Rudge Swollen Sedge
Carex lasiocarpa Ehrh. Sedge
Carex leptalea Wahl. Sedge
Carex lurida Wahl. Sedge
Carex pedunculata Willd. Stalked Sedge
Carex pensylvanica Lam. Pennsylvania Sedge
Carex projecta Mack. Sedge
Carex rosea Schk. Stellate Sedge
Carex tribuloides Wahl. Sedge
Carex viridula Michaux Sedge
Carex vulpinoidea Michaux Fox Sedge
Cladium mariscoides (Muhl.) Torrey Twig-rush
Cyperus rivularis Kunth Nut-grass
Cyperus schweinitzii Torrey Nut-grass
Dulicium arundinaceum (L.) Britton Three-way Sedge
Eleocharis erythropoda Steudel Spike-rush
Eriophorum viridi-carinatum (Engelm.) Fern. Cotton-grass
Scirpus americanus Pers. Threesquare
Scripus atrovirens Willd. Dark-green Rush
Scirpus cyperinus (L.) Kunth Wool-grass
Scirpus validus Vahl Softstem Bulrush

ARACEAE - Arum Family
Arisaema triphyllum (L.) Schott Jack-in-the-pulpit
Peltandra virginica (L.) Schott & Endl. Arrow-arum

LEMNACEAE - Duckweed Family
Lemna minor L. Duckweed

XYRIDACEAE - Yellow-eyed-grass Family
Xyris difformis Chapman Yellow-eyed-grass

ERIOCAULACEAE - Pipewort Family
Eriocaulon septangulare With. Pipewort

PONTEDERIACEAE - Pickerel-weed Family
Pontederia cordata L. Pickerel-weed

JUNCACEAE - Rush Family
Juncus balticus Willd. Baltic Rush
Juncus dudleyi Wieg. Dudley's Rush
Juncus effusus L. Common Rush
Juncus nodosus L. Rush

LILIACEAE - Lily Family
Aletris farinosa L. Colic-root
Allium vineale L. Field Garlic
Asparagus officinalis L. Garden Asparagus
Lilium michiganense Farw. Michigan Lily
Maianthemum canadense Desf. Canada Mayflower
Medeola virginiana L. Indian Cucumber-root
Polygonatum pubescens (Willd.) Pursh Hairy Solomon's-seal
Smilacina racemosa (L.) Desf. False Solomon's-seal
Smilacina stellata (L.) Desf. Starry False Solomon's-seal
Smilax illinoensis Mangalay Carrion-flower
Smilax lasioneura Hooker Carrion-flower
Smilax rotundifolia L. Common Greenbrier
Smilax tamnoides L. Bristly Greenbrier
Trillium grandiflorum (Michaux) Salisb. Large White Trillium
Uvularia grandiflora Sm. Bellwort

DIOSCOREACEAE - Yam Family
Dioscorea villosa L. Wild Yam

IRIDACEAE - Iris Family
Iris virginica L. Southern Blue Flag

ORCHIDACEAE - Orchid Family
Corallorhiza trifida Chat. Early Coral-root
Cypripedium acaule Aiton Stemless Lady's-slipper
Epipactis helleborine (L.) Crantz Helleborine
Habenaria orbiculata (Pursh) Torrey Round-leaved Orchid
Habenaria viridis (L.) R. Br. Bracted Orchid
Spiranthes romanzoffiana Cham. Hooded Ladies'-tresses
Spiranthes cernua (L.) Rich. Nodding Ladies'-tresses

SALICACEAE - Willow Family
Populus balsamifera L. Balsam Poplar
Populus deltoides Marsh. Cottonwood
Populus grandidentata Michaux Large-toothed Aspen
Populus tremuloides Michaux Quaking Aspen
Salix amygdaloides Andersson Peach-leaved Willow
Salix cordata Michaux Heart-leaved Willow
Salix discolor Muhl. Pussy Willow
Salix glaucophylloides Fern. Dune Willow
Salix interior Rowlee Sandbar Willow
Salix nigra L. Black Willow
Salix rigida Muhl. Heart-leaved Willow

JUGLANDACEAE - Walnut Family
Juglans cinerea L. Butternut

BETULACEAE - Birch Family
Alnus rugosa (DuRoi) Sprengel Speckled Alder
Betula alleghaniensis Britton Yellow Birch
Betula papyrifera Marsh White Birch
Carpinus caroliniana Walter Blue Beech
Corylus americana Walter Hazel
Ostrya virginiana (Miller) K. Koch Hop-hornbeam

FAGACEAE - Beech Family
Fagus grandifolia Ehrh. Beech
Quercus alba. White Oak
Quercus borealis Michaux f. Northern Red Oak
Quercus velutina Lam. Black Oak

ULMACEAE - Elm Family
Ulmus americana L. American Elm

URTICACEAE - Nettle Family
Boehmeria cylindrica (L.) Sw. False Nettle
Laportea canadensis (L.) Gaud. Wood Nettle

POLYGONACEAE - Smartweed Family
Polygonum cilinode Michaux Bindweed
Polygonum convolvulus L. Black Bindweed
Polygonum hydropiperoides Michaux Mild Water Pepper
Polygonum persicaria L. Lady's-thumb
Polygonum punctatum Ell. Dotted Smartweed
Polygonum sagittatum L. Arrow-leaved Tear-thumb
Rumex acetosella L. Sheep-sorrel
Rumex crispus L. Sour Dock
Rumex obtusifolius L. Bitter Dock

CHENOPODIACEAE - Goosefoot Family
Chenopodium album L. Lamb's Quarters
Corispermum hyssopifolium L. Bugseed
Salsola kali L. Russian Thistle

AMARANTHACEAE - Amaranth Family
Amaranthus retroflexus L. Pigweed

PHYTOLACCACEAE - Pokeweed Family
Phytolacca americana L. Pokeweed

PORTULACACEAE - Purslane Family
Claytonia virginica L. Spring Beauty

CARYOPHYLLACEAE - Pink Family
Arenaria serpyllifolia L. Thyme-leaved Sandwort
Cerastium vulgatum L. Mouse-ear Chickweed
Dianthus armeria L. Deptford Pink
Lychnis alba Miller White Campion
Lychnis coronaria (L.) Desr. Mullein Pink
Petrorhagia prolifera (L.) Ball & Heywood Childing Pink
= Tunica prolifera (L.) Scop.

Saponaria officinalis L. Bouncing Bet
Scleranthus annuus L. Knawel
Silene cucubalus Wibel Bladder Campion
Stellaria graminea L. Common Stitchwort
Stellaria media (L.) Cyrill. Common Chickweed

NYMPHAEACEAE - Water Lily Family
Brasenia schreberi Gmel. Water-shield
Nuphar advena Aiton Yellow Water Lily
Nymphaea odorata Aiton Fragrant Water Lily

MAGNOLIACEAE - Magnolia Family
Liriodendron tulipifera L. Tulip-tree

RANUNCULACEAE - Buttercup Family
Actaea alba (L.) Miller White Baneberry
Anemone canadensis L. Canada Anemone
Aquilegia canadensis L. Columbine
Caltha palustris L. Marsh-marigold
Clematis virginiana L. Virgin's-bower
Coptis trifolia (L.) Salisb. Goldthread
Hepatica americana (DC.) Ker Blunt-lobed Hepatica
Ranunculus acris L. Tall Buttercup
Ranunculus scleratus L. Cursed Crowfoot
Thalictrum dasycarpum Fischer & Ave-Lall. Purple Meadow-rue

BERBERIDACEAE - Barberry Family
Berberis thunbergii DC. Japanese Barberry
Podophyllum peltatum L. Mayapple

LAURACEAE - Laurel Family
Lindera benzoin (L.) Blume Spice Bush
Sassafras albidum (Nutt.) Nees Sassafras

FUMARIACEAE - Fumitory Family
Dicentra canadensis (Goldie) Walp. Squirrel-corn
Dicentra cucullaria (L.) Bernh. Dutchman's Breeches

CRUCIFERAE - Mustard Family
Alliaria officinalis Andrz. Garlic-mustard
Alyssum alyssoides L. Alyssum
Arabis canadensis L. Sickle Pod
Arabis drummondi Gray Drummond's Rock Cress
Arabis lyrata L. Sand Cress
Barbarea vulgaris R. Br. Yellow Rocket
Berteroa incana (L.) DC. Hoary Alyssum
Cakile edentula (Bigelow) Hooker Sea-rocket
Capsella bursa-pastoris (L.) Medic. Shepherd's Purse
Cardamine bulbosa (Schreber) BSP. Bulbous Cress
Lepidium campestre (L.) R. Br. Field Cress
Lepidium virginicum L. Pepper Grass
Nasturtium officinale R. Br. Water Cress
Sisymbrium altissimum L. Tumbling Mustard

SARRACENIACEAE - Pitcher-plant Family
Sarracenia purpurea L. Pitcher-plant

DROSERACEAE - Sundew Family
Drosera intermedia Hayne Sundew
Drosera rotundifolia L. Round-leaved Sundew

SAXIFRAGACEAE - Saxifrage Family
Mitella diphylla L. Bishop's-cap
Ribes cynosbati L. Prickly Gooseberry

HAMAMELIDACEAE - Witch Hazel Family
Hamamelis virginiana L. Witch Hazel

ROSACEAE - Rose Family
Agrimonia gryposepala Wallr. Agrimony
Amelanchier arborea (Michaux f.) Fern. Shadbush
Aronia melanocarpa (Michaux) Ell. Black Chokeberry
Fragaria virginiana Duchesne Strawberry
Geum laciniatum Murray Rough Avens
Geum rivale L. Purple Avens
Potentilla anserina L. Silverweed
Potentilla argentea L. Silvery Cinquefoil
Potentilla arguta Pursh Tall Cinquefoil
Potentilla norvegica L. Rough Cinquefoil
Potentilla palustris (L.) Scop. Marsh Cinquefoil
Potentilla recta L. Sulfur Cinquefoil
Potentilla simplex Michaux Old-field Cinquefoil
Prunus pensylvanica L. f. Pin Cherry
Prunus pumila L. Sand Cherry
Prunus serotina Ehrh. Black Cherry
Prunus virginiana L. Choke Cherry
Rosa carolina L. Pasture Rose
Rosa palustris Marsh Swamp Rose
Rubus alleghaniensis Porter Common Blackberry
Rubus flagellaris L. Northern Dewberry
Rubus hispidus L. Dewberry
Rubus occidentalis L. Black Raspberry
Rubus pubescens Raf. Dwarf Raspberry
Rubus strigosus Michaux Red Raspberry
Sorbus americana Marsh American Mountain Ash
Spiraea alba DuRoi Meadow-sweet
Spiraea tomentosa L. Hardhack

FABACEAE - Bean Family
Amphicarpa bracteata (L.) Fern. Hog-peanut
Lathyrus maritimus L. Bigelow Beach-pea
Medicago lupulina L. Black Medick
Melilotus alba Desr. White Sweet Clover
Melilotus officinalis (L.) Desr. Yellow Sweet Clover
Robinia pseudoacacia L. Black Locust
Trifolium agrarium L. Hop-clover
Trifolium arvense L. Rabbit-foot Clover

Trifolium hybridum L. Alsike Clover
Trifolium pratense L. Red Clover
Trifolium repens L. White Clover
Vicia angustifolia Reichard Common Vetch
Vicia carolina Walter Carolina Vetch
Vicia villosa Roth Hairy Vetch

OXALIDACEAE - Wood Sorrel Family
Oxalis stricta L. Common Wood Sorrel

GERANIACEAE - Geranium Family
Erodium cicutarium (L.) L'Her Stork's-bill

LINACEAE - Flax Family
Linum striatum Walter Stiff Yellow Flax

RUTACEAE - Rue Family
Ptelea trifoliata L. Wafer-ash

POLYGALACEAE - Milkwort Family
Polygala paucifolia Willd. Fringed Polygala

EUPHORBIACEAE - Spurge Family
Euphorbia corollata L. Flowering Spurge
Euphorbia cyparissias L. Cypress Spurge
Euphorbia maculata L. Wartweed
Euphorbia polygonifolia L. Seaside Spurge

ANACARDIACEAE - Cashew Family
Rhus copallina L. Shining Sumac
Rhus radicans L. Poison Ivy
Rhus typhina L. Staghorn Sumac

AQUIFOLIACEAE 0 Holly Family
Ilex verticillata (L.) Gray Michigan Holly

CELASTRACEAE - Staff-tree Family
Celastrus scandens L. Bittersweet

ACERACEAE - Maple Family
Acer nigrum Michaux f. Black Maple
Acer rubrum L. Red Maple
Acer saccharum Marsh Sugar Maple

BALSAMINACEAE - Touch-me-not Family
Impatiens biflora Willd. Touch-me-not

RHAMNACEAE - Buckthorn Family
Ceanothus americanus L. New Jersey Tea

VITACEAE - Grape Family
Parthenocissus quinquefolia (L.) Planch Virginia Creeper
Vitis aestivalis Michaux Summer Grape
Vitis riparia Michaux River-bank Grape

TILIACEAE - Linden Family
Tilia americana L. Basswood, Linden

MALVACEAE - Mallow Family
Malva neglecta Wallr. Common Mallow

HYPERICACEAE - St. John's-wort Family
Hypericum boreale (Britton) Bicknell Northern St. John's-wort
Hypericum kalmianum L. Kalm's St. John's-wort
Hypericum majus (Gray) Britton St. John's-wort
Hypericum mutilum L. St. John's-wort
Hypericum perforatum L. Common St. John's-wort
Hypericum punctatum Lam. St. John's-wort
Triadenum fraseri (Spach) Gl. Marsh St. John's-wort

VIOLACEAE - Violet Family
Viola cucullata Aiton Blue Marsh Violet
Viola eriocarpa Schw. Smooth Yellow Violet
Viola lanceolata L. Lance-leaved Violet
Viola pallens (Banks) Brainerd Smooth White Violet
Viola pubescens Aiton Downy Yellow Violet
Viola rostrata Pursh Long-spurred Violet
Viola striata Aiton Cream Violet

ELEAGNACEAE - Oleaster Family
Shepherdia canadensis (L.) Nutt. Buffalo-berry

LYTHRACEAE - Loosestrife Family
Decodon verticillatus (L.) Ell. Water Willow

ONAGRACEAE - Evening-primrose Family
Circaea alpina L. Enchanter's Nightshade
Circaea quadrisulcata (Maxim.) Franch. & Sav. Enchanter's Nightshade
Epilobium hirsutum L. Hairy Willow-herb
Epilobium coloratum Biehler Cinnamon Willow-herb
Ludwigia palustris (L.) Ell. Marsh Purslane
Oenothera biennis L. Evening-primrose

ARALIACEAE - Genseng Family
Aralia hispida Vent. Bristly Sarsaparilla
Aralia nudicaulis L. Wild Sarsaparilla
Panax quinquefolium L. Ginseng
Panax trifolium L. Dwarf Ginseng

UMBELLIFERAE - Parsley Family
Cicuta bulbifera L. Bulblet Water Hemlock
Daucus carota L. Wild Carrot
Osmorhiza claytoni (Michaux) Clarke Sweet Cicely
Sanicula marilandica L. Black Snakeroot

CORNACEAE - Dogwood Family
Cornus alternifolia L. f. Alternate-leaved Dogwood
Cornus florida L. Flowering Dogwood
Cornus purpusi Koehne Silky Dogwood
Cornus racemosa Lam. Gray Dogwood
Cornus stolonifera Michaux Red Osier
Nyssa sylvatica Marsh Black Gum

ERICACEAE - Heath Family
Arctostaphylos uva-ursi (L.) Sprengel Bearberry
Chamaedaphne calyculata (L.) Moench. Leather-leaf
Chimaphila maculata (L.) Pursh Spotted Wintergreen
Chimaphila umbellata (L.) Bart. Prince's Pine, Pipsissewa
Epigaea repens L. Trailing Arbutus
Gaultheria procumbens L. Wintergreen
Monotropa uniflora L. Indian Pipe
Pyrola elliptica Nutt. Elliptic Shinleaf
Pyrola rotundifolia L. Round-leaved Shinleaf
Vaccinium angustifolium Aiton Low Blueberry
Vaccinium corymbosum L. High-bush Blueberry
Vaccinium myrtilloides Michaux Velvet-leaf Blueberry

PRIMULACEAE - Primrose Family
Lysimachia terrestris (L.) BSP. Swamp Candles
Trientalis borealis Raf. Starflower

OLEACEAE - Olive Family
Fraxinus americana L. White Ash
Fraxinus nigra Marsh. Black Ash

APOCYNACEAE - Dogbane Family
Vinca minor L. Periwinkle

ASCLEPIADACEAE - Milkweed Family
Asclepias exaltata L. Poke Milkweed
Asclepias incarnata L. Swamp Milkweed
Asclepias syriaca L. Common Milkweed

CONVOLVULACEAE - Morning-glory Family
Convolvulus sepium L. Hedge Bindweed

BORAGINACEAE - Borage Family
Lithospermum carolinense (Walter) MacM. Puccoon

VERBENACEAE - Vervain Family
Verbena hastata L. Blue Vervain

LABIATAE - Mint Family
Lamium purpureum L. Purple Dead-nettle
Leonurus cardiaca L. Motherwort
Lycopus americanus Muhl. Bugleweed
Lycopus virginicus L. Bugleweed
Mentha arvensis L. Wild Mint
Monarda punctata L. Horse Mint
Prunella vulgaris L. Self-heal
Satureja acinos (L.) Scheele Mother-of-thyme
Satureja vulgaris (L.) Fritsch Wild Basil
Scutellaria galericulata L. Marsh Skullcap
Stachys hispida Pursh Rough Hedge-nettle

SOLANACEAE - Nightshade Family
Physalis heterophylla Nees Clammy Ground-cherry
Solanum dulcamara L. Bittersweet Nightshade

SCROPHULARIACEAE - Figwort Family
Gerardia purpurea L. Purple False Foxglove
Gerardia tenuifolia Vahl. Slender False Foxglove
Linaria canadensis (L.) Dum. Blue Toadflax
Linaria vulgaris Hill Butter-and-eggs
Melampyrum lineare Desr. Cow-wheat
Mimulus ringens L. Monkey-flower
Pedicularis canadensis L. Wood Betony
Scrophularia marilandica L. Late Figwort
Verbascum blattaria L. Moth-mullein
Verbascum thapsus L. Common Mullein
Veronica arvensis L. Corn Speedwell

BIGNONIACEAE - Trumpet Creeper Family
Campsis radicans (L.) Seem. Trumpet Creeper

OROBANCHACEAE - Broomrape Family
Epifagus virginiana (L.) Bart. Beech-drops

LENTIBULARIACEAE - Bladderwort Family
Utricularia gibba L. Humped Bladderwort

PHRYMACEAE - Lopseed Family
Phryma leptostachya L. Lopseed

PLANTAGINACEAE - Plantain Family
Plantago lanceolata L. English Plantain
Plantago major L. Common Plantain

RUBIACEAE - Madder Family
Cephalanthus occidentalis L. Buttonbush
Galium aparine L. Early Bedstraw
Galium lanceolatum Torrey Lance-leaved Wild Licorice
Galium pilosum Aiton Hairy Bedstraw
Galium tinctorium L. Stiff Bedstraw
Galium triflorum Michaux Sweet-scented Bedstraw
Mitchella repens L. Partridge-berry

CAPRIFOLIACEAE - Honeysuckle Family
Diervilla lonicera Miller Bush Honeysuckle
Lonicera canadensis Marsh Fly Honeysuckle
Lonicera dioica L. Wild Honeysuckle
Lonicera morrowi Gray Honeysuckle
Sambucus canadensis L. Common Elder
Sambucus pubens Michaux Red-berried Elder
Viburnum acerifolium L. Maple-leaved Viburnum
Viburnum opulus L. Highbush Cranberry

CAMPANULACEAE - Harebell Family
Campanula aparinoides L. Marsh Bellflower
Campanula rotundifolia L. Harebell
Lobelia cardinalis L. Cardinal Flower
Lobelia inflata L. Indian Tobacco

COMPOSITAE - Composite Family
Achillea millefolium L. Yarrow
Ambrosia artemisiifolia L. Common Ragweed
Anthemis arvensis L. Dogfennel
Arctium minus (Hill) Bernh. Common Burdock
Artimisia absinthium L. Wormwood
Artemisia caudata Michaux Beach Wormwood
Aster laevis L. Smooth Blue Aster
Aster lateriflorus (L.) Britton Side-flowering Aster
Aster macrophyllus L. Large-leaved Aster
Aster pilosus Willd. Hairy Aster
Aster puniceus L. Swamp Aster
Aster simplex Willd. Panicled Aster
Aster umbellatus Miller Flat-top Aster
Bidens cernua L. Nodding Bur-marigold
Bidens coronata (L.) Britton Tickseed-sunflower
Bidens tripartita L. Beggar-ticks
Centaurea maculosa Lam. Star-thistle
Chrysanthemum leucanthemum L. Ox-eye Daisy
Cichorium intybus L. Chicory
Cirsium arvense (L.) Scop. Canada Thistle
Cirsium pitcheri (Torrey) T. & G. Pitcher's Thistle
Cirsium vulgare (Savi) Tenore Bull Thistle
Conyza canadensis Cron. Horseweed
Erigeron annuus (L.) Pers. Annual Fleabane
Erigeron strigosus Muhl. Daisy Fleabane
Eupatorium maculatum L. Joe-Pye Weed
Eupatorium perfoliatum L. Boneset
Gnaphalium obtusifolium L. Cudweed
Hieracium aurantiacum L. Tawny Hawkweed
Hieracium gronovii L. Hairy Hawkweed
Hieracium pratense Tausch Field Hawkweed
Hypochaeris radicata L. Cat's-ear
Krigia virginica (L.) Willd. Dwarf Dandelion
Lactuca canadensis L. Wild Lettuce
Prenanthes alba L. White Lettuce
Prenanthes altissima L. Tall White Lettuce
Rudbeckia hirta L. Black-eyed Susan
Senecio aureus L. Golden Ragwort
Solidago altissima L. Tall Goldenrod
Solidago caesia L. Blue-stemmed Goldenrod
Solidago canadensis L. Canada Goldenrod
Solidago graminifolia (L.) Salisb. Grass-leaved Goldenrod
Solidago juncea Aiton Early Goldenrod
Solidago nemoralis Aiton Gray Goldenrod
Solidago patula Muhl. Swamp Goldenrod
Solidago rugosa Miller Rough Goldenrod
Solidago spathulata DC. Dune Goldenrod
Solidago speciosa Nutt. Showy Goldenrod
Solidago tenuifolia Pursh Slender-leaved Goldenrod
Solidago uliginosa Nutt. Bog Goldenrod
Taraxacum officinale Weber Dandelion
Tragopogon dubius Scop. Goat's-beard

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