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THE HISTORY, VEGETATION AND FLORA OF THE NORDHOUSE DUNES, MANISTEE NATIONAL FOREST, MASON COUNTY, MICHIGAN

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Brian Theodore Hazlett

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John H. Beaman
Major professor

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THE HISTORY, VEGETATION AND FLORA OF THE NORDHOUSE DUNES, MANISTEE NATIONAL FOREST, MASON COUNTY, MICHIGAN

By

Brian Theodore Hazlett

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ABSTRACT

THE HISTORY, VEGETATION AND FLORA OF THE
NORDHOUSE DUNES, MANISTEE NATIONAL
FOREST, MASON COUNTY, MICHIGAN

By

Brian Theodore Hazlett

This study describes the flora and vegetation of Lower Michigan's only recommended RARE II wilderness, and represents the first botanical research of any of these RARE II areas since their review by the United States Forest Service. Summary descriptions of the various vegetation associations of the Nordhouse area with lists of species for each are included. A spectral analysis of the flora and a community ordination of selected vegetation associations are also part of this study. Abundance estimates and flowering data for the 350 species collected are recorded. Among these species, one (*Cirsium pitcheri*) is listed by the state of Michigan as threatened and three others (*Chimaphila maculata, Cypripedium arietinum* and *Rotala ramosior*) are listed as rare. Comments are made concerning the biological significance of this Lake Michigan dune system including recommendations concerning the future management and use of the Nordhouse region.

In memoriam
WILLIAM T. GILLIS
Botanist, teacher, friend

ACKNOWLEDGEMENTS

I would like to acknowledge the assistance of several individuals and organizations who helped make this study possible. First, I would like to thank my parents, Mr. and Mrs. Theodore M. Hazlett, for their financial support and constant encouragement during my undergraduate and graduate programs. I am grateful to the United States Forest Service, especially District Ranger Russell M. Garrigus, for generously supplying a seasonal campsite at Lake Michigan Recreation Area and for freely providing access to Forest Service records. I should also thank the directors of the Hanes Fund for providing a grant which covered incidental expenses during this study. I appreciate the suggestions and help of my graduate committee, Drs. Raymond H. Hollensen, Peter G. Murphy and its chairman, John H. Beaman, during the field work and final preparation of this thesis. Dr. Susan Kephart has also been very helpful during Dr. Beaman's leave of absence. I have enjoyed the encouragement of my colleagues in the Beal-Darlington Herbarium and the fellowship of my friends at Hilltop. My special thanks and praise, however, must go to Marcia Blackson for diligently typing this manuscript.

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INTRODUCTION

The flora of Lake Michigan's sand dunes has been the subject of numerous botanical investigations since the early papers of Bailey (1880) and Hill (1893, 1896). The first comprehensive study of the dune vegetation from the south end of Lake Michigan to North Fox Island was written by H. C. Cowles (1899). This paper, however, is best known for its presentation of a primary plant succession model to explain the zonation of plant associations along these dunes. Several subsequent investigators have described the flora and vegetation of Lake Michigan sand dunes in Indiana (Olson, 1958; Peattie, 1930; Harman, 1970), Wisconsin (Brunchen, 1910; Gates, 1912; Van Denack, 1961), and Michigan (Witford, 1901; Waterman, 1917, 1922, 1927; Fuller, 1918; Thompson, 1967; Harman, 1970; Wells et al., 1975). The dunes along the east shore of Lake Michigan are more extensive than those along the west shore due to the prevailing westerly winds. Consequently more studies have been completed along the east shore. Geographically, the centers of concentration for these studies have been the southeast end of Lake Michigan and in the Sleeping Bear Dune National Lakeshore regions. The vegetation of the sand dunes between these centers has only been

described by summaries of small areas (Hill, 1900; Coulter, 1906; Thompson, 1972; Furlow, 1971). Brief reports on a few sites along the east coast of Lake Michigan have been included in natural area descriptions compiled by Crispin (1980) and the Michigan Natural Areas Council (1979). A detailed study is needed to contribute floristic information now lacking for this little known belt of sand dunes.

The Nordhouse Dunes are an excellent site for a study of the dune flora of Lake Michigan's eastern shoreline because they are undeveloped and large enough to cover the range of representative dune habitats, including wooded dunes, found in this region of Michigan. The documentation of the occurrences of the vascular plant species of Nordhouse should aid in filling gaps in knowledge of shoreline plant distributions. Few floristic studies have been conducted in this part of the state. The earliest (Daniels, 1904) was written for the Manistee area. Mustard's survey (1979), located 20 kilometers east of Lake Michigan, extended slightly into Mason County, but was principally concentrated in Oceana County.

Over 90 percent of the study area is within the Grant-Hamlin-Pere Marquette Series I Area designated under the Michigan Sand Dune Protection and Management Act. Sand mining in Series I areas is closely monitored by the Michigan Department of Natural Resources (DNR). Sand mining is not a management alternative for the

Nordhouse area, but a study here could provide data to facilitate the evaluation of the degree of human disturbance in similar dune areas.

The Nordhouse Dunes area has recently gained statewide attention after the review and subsequent wilderness recommendation by the U. S. Forest Service during its Roadless Area Review and Evaluation (RARE II) program. One objective of this study has been to assist the Forest Service in its survey of the Nordhouse area by providing additional information on the natural history of this potential wilderness. A botanical inventory, especially the documentation of rare and threatened species, would help to make the evaluation of the area as wilderness less subjective. A vegetation map with descriptions of each vegetation association should be an asset to the Forest Service since earlier work on the vegetation had been limited to timber surveys. The botanical inventory of the Nordhouse area also provides baseline data by which future changes in this potential wilderness may be observed. Information on the presence of rare and threatened plants may assist in determinations of the biological significance of the Nordhouse Dunes and should help certain areas which may need special protection to maintain these populations.

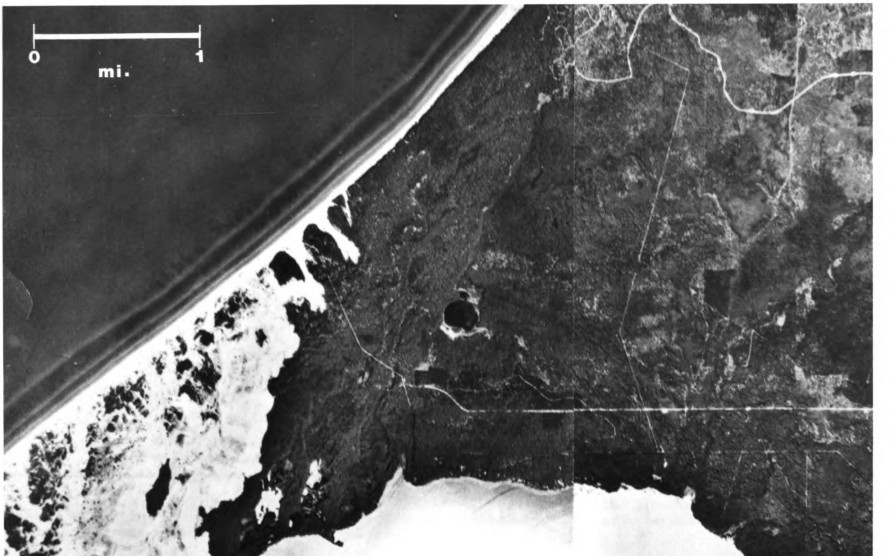
General Description

Area Studied

The Nordhouse Dunes study area is located in Grant Twp., T 20 N, R 18 W, Mason Co., Michigan (Figures 1 and 2). The total area occupies 1422 hectares (5.5 square miles) with five kilometers of Lake Michigan shoreline. Approximately 1181 hectares of the study area were reviewed and recommended as wilderness under RARE II. The reviewed area included: all of secs. 26 and 27; sec. 25 south of Forest Road (FR) 5629 and west of FR 5356; sec. 36 north of Nurnburg Rd. and west of FR 5356; sec. 35 north of Nurnburg Rd; sec. 34 west of the two-track extension of Nurnburg Rd. Sixteen hectares of the roadless area in sec. 34 originally reviewed by the Forest Service were privately owned. In addition to the RARE II area, field studies for this thesis included 225 hectares of additional private holdings known during the Forest Service wilderness review as the Sensibar property (secs. 32 and 33) and 16 hectares of additional Forest Service land. About 2 hectares of this Forest Service land are found in sec. 28 and 14 hectares are found between the two-tract extension of Nurnburg Rd. and the old powerline clearing in sec. 34 SE¼.

In late 1979 the Nature Conservancy purchased the Sensibar property including the 16 private hectares in sec. 34. The Conservancy, prompted by the unspoiled character of the dunes, their key location and the

Figure 1. Aerial photograph of the study area, 1972 (ASCS-USDA).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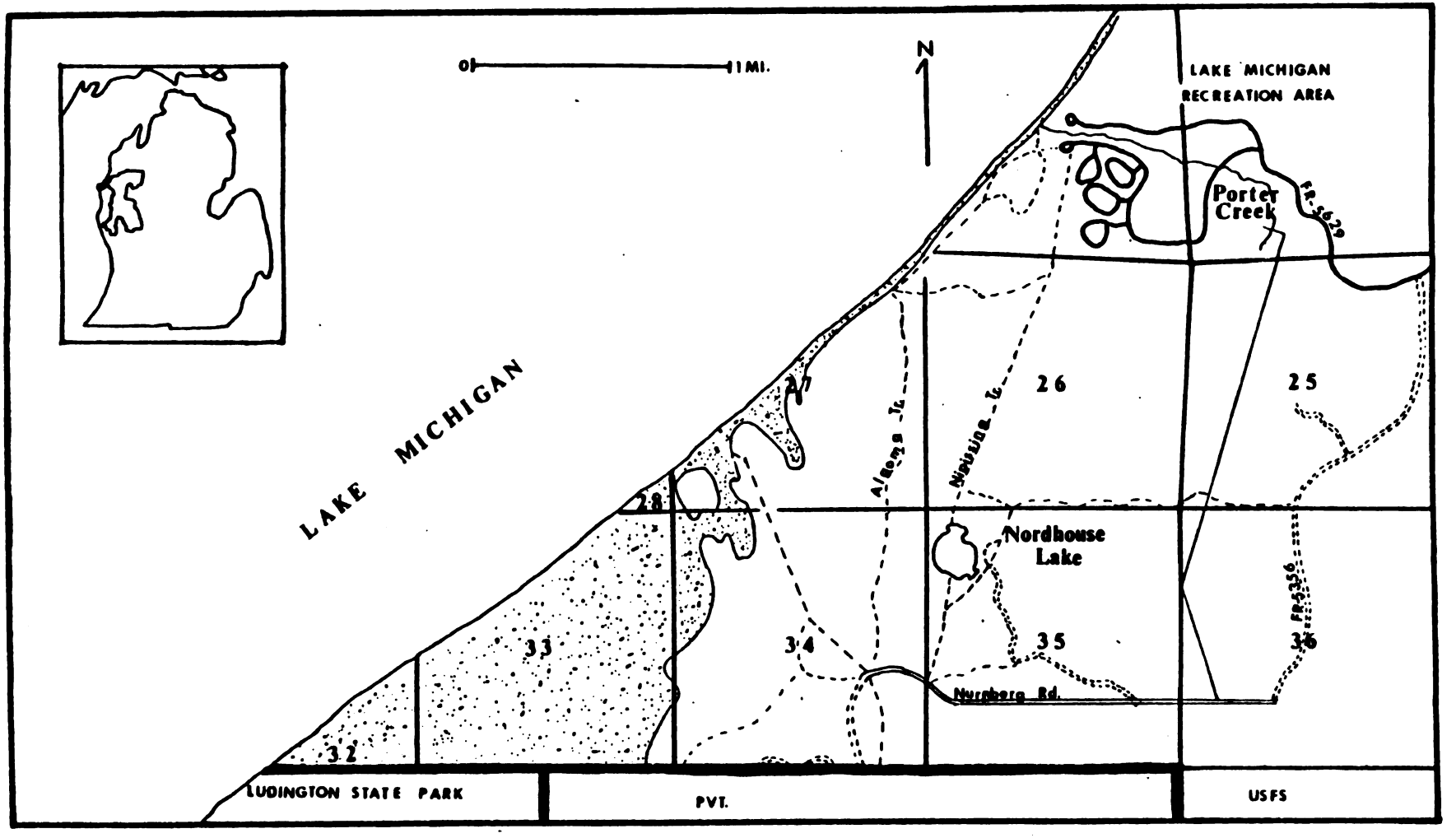

Figure 2. Map of roads, trails and physical features of the Nordhouse Dunes study area. Stippling shows open sand. Inset shows location of the area within Manistee National Forest and the state of Michigan.

occurrence of threatened species, purchased this land for $777,000 with money from its Land Preservation Fund. Later this land was transferred to the Forest Service when federal funds became available. This land will be included with the original area reviewed under RARE II and will be managed as wilderness. With the Forest Service aquisition of the Sensibar property, more than 20 kilometers of contiguous Lake Michigan shoreline came under public ownership through both state and federal agencies.

Climate

Michigan Weather Service stations are located in both Ludington and Manistee. Since the Nordhouse area lies approximately 16 kilometers between these cities, the weather data from both stations have been included here. Except where otherwise noted, all temperature and precipitation data are based on the period 1940-1969 (data from the Michigan Weather Service, E. Lansing). The climate of this part of Michigan varies between semi-marine and continental as regional weather patterns change. The prevailing winds, averaging 17 kph from the west, induce cooler spring and early summer temperatures than would normally be expected at this latitude (44° 5' N). Conversely, the winters are milder. Easterly or northeasterly winds may be accompanied by clearing skies with the associated colder nighttime temperatures more common

inland. The buffering effect of Lake Michigan is reflected in the number of days having extreme temperatures. Both the average annual number of days less than -18°C (0°F) and also those greater than 38°C (90°F) are less than five. Other weather records are listed in Table 1.

Soils and Geology

The latest soil survey for Mason Co. (Wonser et al., 1939) maps the soils of the Nordhouse area as five types of sand and three organic soils. Dune sand, a well drained soil, is non-forested and subject to deformation by wind. Bridgeman fine sand is also well drained, but stabilized due to forest cover. A progression from younger to older soils in these series can be observed along a transect from Lake Michigan across the Algoma and Nipissing ridges to Nordhouse Lake (Watson, 1976). Rubicon sand, another well drained sand, has developed on glacial outwash plains. Saugatuck sand, typically imperfectly drained, occupies old sandy lake-bed plains. Drainage is inhibited by a clay pan 15-46 cm thick around 15-76 cm below the surface. Newton loamy sand, the most poorly drained soil in the Nordhouse area, was formed under a high water table on sandy lake beds. Water associated with this soil type either stands on or remains near the surface much of the year (Wonser et al., 1939).

TABLE 1.--Selected Weather Records for Ludington and Manistee, Michigan (Michigan Weather Service)

Record	Ludington	Manistee
record high t	36° (97°F)	38° (100°F)
record low t	-29° (-21°F)	-34° (-29°F)
annual precipitation (ave.)	79.5 cm	78.8 cm
wettest month (ave.)	Sept. 8.6 cm	Sept. 9.1 cm
driest month (ave.)	March 4.4 cm	Feb. 4.1 cm
annual snow fall (ave.)	182.9 cm	207.5 cm
record high snowfall (season)	326.6 cm (1958-59)	340.9 cm (1958-59)
record low snowfall (season)	100.1 cm (1943-44)	96.0 cm (1960-61)
free freeze period (growing season)	167 days	153 days

The organic soils, Lupton muck, Rifle peat and Greenwood peat, are found in wet and boggy places. These soils have developed where old lake beds became filled with decayed vegetation. The locations of soils within the Nordhouse area are mapped in Figure 3.

The bedrock consists of Ellsworth Shale. The uppermost unit of this shale is a sandy carbonate rock which correlates with Berea-Bedford sandstone. The boundary between the Mississippian and Devonian systems probably occurs within the lower part of the upper part of the Ellsworth (Kelly, 1968). The bedrock is covered with at least 152 meters of glacial drift and sand (Fry, 1913), so any bedrock effects on the surface topography and vegetation is minimal. Around 12,500 B.P. the Port Huron lobe of the Wisconsinan glacier covered this area. The margin of this lobe retreated to the Manistee moraine, 14 kilometers north, and the water of Lake Chicago (Glenwood stage) covered the study area (Farrand and Eschman, 1974). The clay pan underlying the study area is a remnant of this lake.

During the subsequent deglaciation of Michigan, the water levels in the Lake Michigan basin fluctuated greatly due to the advance and retreat of the ice margin, changing outlets of the lakes, erosion of lake outlets resulting in falling water levels, and isostatic rebound (Wayne and Zumberge, 1965). The order and chronology of these lake stages has been described in detail elsewhere

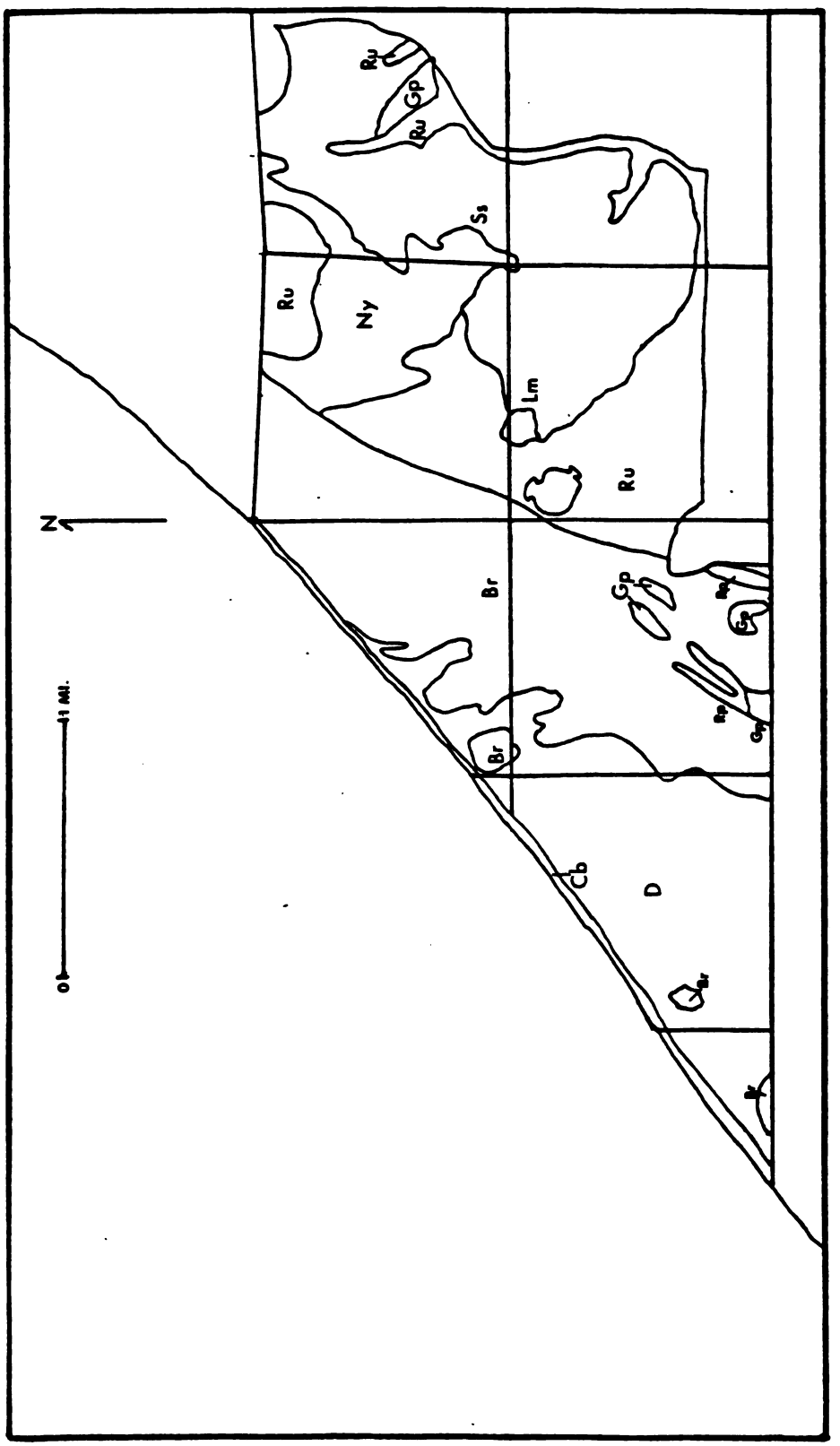

Figure 3. Soil map of the Nordhouse Dunes study area; adapted from Wonser et al. (1939); Br, Bridgeman fine sand; Cb, coastal beach; D, dune sand; Ny, Newton loamy sand; Ru, Rubicon sand; Ss, Saugatuck sand; Gp, Greenwood peat; Lm, Lupton muck; Rp, Rifle peat.

(Hough, 1958; Wayne and Zumberge, 1965; Dorr and Eschman, 1970; Farrand and Eschman, 1974), so a discussion concerning the lake levels in the Nordhouse area can begin with the Algonquin stage (10,000 B.P.). At this time the ice margin had retreated from the Straits of Mackinac. The level of this lake had an elevation of 605 ft. At Nordhouse the area now occupied by the marginal sand apron (Figure 4) was then a series of open dune ridges and dune pools. The water level in the Lake Michigan Basin dropped to an elevation of 235 ft. (Wayne and Zumberge, 1965) as lower eastern outlets were opened by retreating ice and erosion. This lake, Lake Chippewa (9,5000 B.P.), was 350 ft. below the present elevation of Lake Michigan (580 ft.). Lake Nipissing (605 ft.) was formed as isostatic rebound from 4,000 - 9,500 B.P. raised the North Bay outlet of Lake Chippewa. Subsequent down-cutting of the Port Huron outlet brought the levels of Lakes Huron and Michigan to their present elevation (580 ft.) via the Algoma stage (595 ft.) which occurred around 2,000 - 3,000 B.P.

Stream valleys which had been graded to the Chippewa level were drowned by the rising Nipissing waters and occasionally were cut off from the main lake by the construction of bay-mouth bars and spits (Wayne and Zumberge, 1965). Hamlin Lake, just south of the study area, was formed as receding lake levels exposed Big Point sable (Dorr and Eschman, 1970). The center of

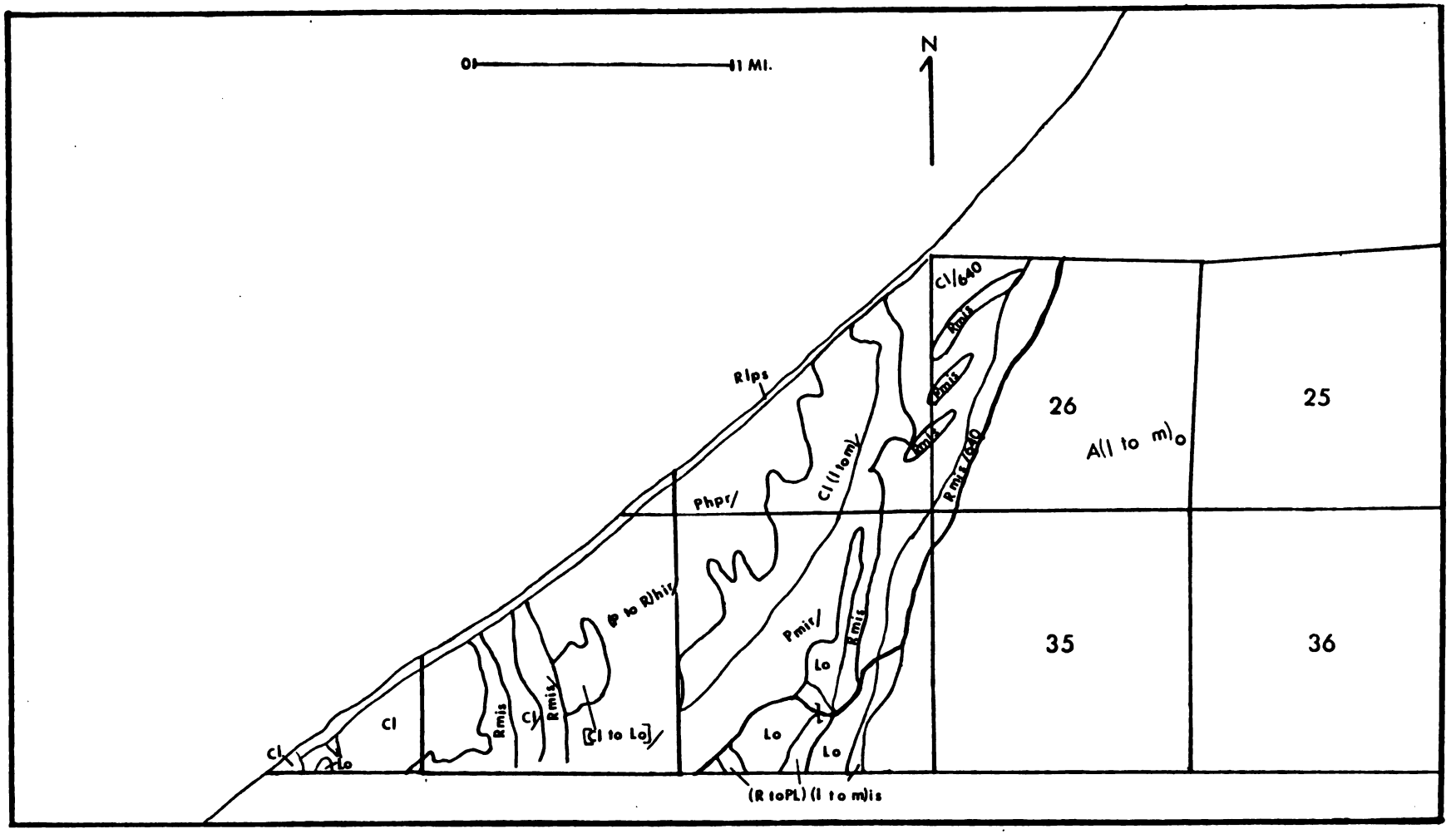

Figure 4. Michigan Department of Natural Resources dune morphology classification of the Nordhouse Dunes area. First letter (dune form): P, parabolic dune; R, linear dune ridge; C, complex dune field; L, interdune lowland; A, marginal sand apron. Second letter (relative relief): l, low (0-7m.); m, moderate (7-26m.); h, high (26+ m.). Third letter (orientation): p, parallel; i, irregular. Fourth letter (arrangement of dune form to substratum formation): Xxxx, non-elevated; Xxxx/#, perched with elevation of underlying non-dune formation: Xxxx/, overriding; o, glacial outwash.

active dune movement shifted away from the Nordhouse area as this point emerged.

Glacial drift is the origin of dune sand. Wave action separates the sand from the drift and washes it up on the shore. Today sand is exposed to onshore winds during those years when Lake Michigan is low. In the past, the receding of glacial lakes exposed large amounts of sand to the prevailing westerly wind. Fossil beaches of previous lake stages were excellent sites for the deposition of this wind-blown sand. Two large linear dune ridges (DNR classification, Figure 4) run along what may have been ancient lake beaches. The ridge bordering the dune apron is believed to be a Nipissing formation (Watson, 1976). Evenson et al. (1973) suggests that this ridge may have formed on the beach of Lake Calumet (11,500 B.P.). The linear ridge west of the Nipissing ridge may be an Algoma formation (Watson, 1976). Today wind-blown sand builds dunes as the sand is deposited after it encounters an obstacle such as vegetation or wood. An embronic dune forms and becomes an obstacle to the wind-blown sand itself. These dunes may continue to grow as more wind-blown sand is deposited and may even move until stabilized by vegetation.

The foredune is a low relief dune which runs along the lake shore. Sometimes a breach may be made in the foredune by wave action or human disturbance. Sand can then be blown through this opening forming a parabolic

dune which invades the area behind the foredune. A common name for this parabolic dune is a blowout. Blowouts can extend inland up to 1600 meters and reach heights up to 76 meters (Kelly, 1971). The largest blowout in the Nordhouse region extends slightly less than 800 meters inland and reaches only 43 meters high. Blowouts are a common feature in sec. 27.

The DNR has classified the study area east of the Nipissing ridge as a marginal sand apron with numerous scattered intertwining low-relief ridges possibly of eolian origin. The DNR describes the dunes in sec. 33 as "confused and chaotic with some low relief ridges" and the dunes of sec. 32 as having "numerous irregularly arranged low to moderate relief ridges which are separated by lower areas typically of lacustrine sands."

Vegetation History

Post-Pleistocene Forests

The vegetation history of the Nordhouse region since glaciation can be inferred from studies of other sites in Michigan. It must be noted, however, that the Nordhouse area may have distinctive differences due to the climatic influence of Lake Michigan. A pollen analysis of the local bogs might illuminate this history further. The spruce forest, the first to occupy this region after the margin of the glacier retreated, gave way to a conifer-hardwood forest characterized by pine (*Pinus*

banksiana and *P. resinosa*) around 10,000 B.P. as the climate warmed (Bernabo and Webb, 1977). *Pinus strobus* was evident in the pollen record about 1,000 years later. A predominantly deciduous forest characterized by oak began to replace the conifer-hardwood forest in southern Michigan, reaching its northernmost limit around 7,000 B.P. The Nordhouse region is now on the northern edge of the conifer-hardwood deciduous forest ecotone. Beech and hemlock elements were not apparent in the presettlement forest of this region until somewhat later, around 6,000 and 7,000 B.P., respectively (Davis, 1976; Bernabo and Webb, 1977).

Presettlement Forest

Various authors have different interpretations of the nature of the presettlement forest of the Nordhouse Dunes study area. Perejda (1946) mapped the entire area as pine plains consisting of jack, norway, and white pines. Veach (1959) proposed three forest types for the area. First, southern region oaks with a great diversity of other species (both deciduous and coniferous) occupied the Nipissing and Algoma ridges. A wet northern-coniferous-deciduous forest occupied the area that is now covered by bogs in secs. 27 and 36. A transition pine and oak forest occupied the area between the forest types. Küchler (1964) proposed a potential vegetation of Great Lakes pine forest for the Nordhouse region.

The best primary source to determine the presettlement forest is the field notes from the General Land Office Survey (GLOS) of 1839 available at the Lands Division of the Department of Natural Resources, Lansing. A general description of the presettlement forests in other areas of Michigan (Kenoyer, 1930, 1934, 1940, 1943) has been written by using the land and forest descriptions for each surveyed section line. During the survey two witness trees were blazed at each section corner. The species, diameter and distance from the corner for these trees were recorded. Many authors (Bourdo, 1956; Hushen et al., 1966; Kapp, 1978; Mustard, 1979) have used witness tree data to quantitatively describe the composition of presettlement forests. Such an analysis is not feasible for the Nordhouse Dunes since the area is too small to provide an adequate number of witness trees. In addition, two surveyors, John Brink and John Mullett, were responsible for different sections of the study area. Each surveyor might have had different biases regarding the species and size of the witness trees selected making an accurate quantitative analysis of the presettlement forest difficult.

A qualitative view of the presettlement forest is supplied by the land descriptions written for each section line. The description from east to west along the south section line of secs. 34, 35 and 36 reads, "land rolling, third rate, hemlock, pine, beech, maple, and sugar." The description from east to west along the south section

line of secs. 25, 26, 27 and 28 reads, "land level, tamarack and cedar swamp; land rolling second rate except for swamp and sand hills, white and yellow pine, hemlock, beech and oak." The description from east to west along the north section line of secs. 25, 26 and 27 reads, "land mostly swamp, tamarack, cedar, oak and hemlock; land rolling second rate and thinly timbered with yellow and white pine and oak." A list for Manistee National Forest (Griffin, no date) correlating common names used by the surveyors with scientific names translates yellow pine as *Pinus resinosa;* cedar as *Thuja occidentalis;* maple as *Acer rubrum;* and sugar as *Acer saccharum.* The GLOS notes, therefore, indicate three major forest types: a mixed pine forest with oak understory on much of the forested dune ridges; a mixed hardwood-conifer forest on the moist upland sites of the marginal sand apron east of these ridges; and a wet *Larix-Thuja* forest in the lowland areas of the marginal sand apron.

The location of physical features such as lakes, streams, blowdowns and swamps were also recorded in the surveyors notes. Of special interest concerning the Nordhouse Dunes is the record of the location of the sand/ forest boundaries in sec. 33, because the rate of sand movement since the survey can be determined by comparing these boundaries with the present boundaries.

The GLOS notes record the "summit of sand hills" at 18.5[1] west of the corner of secs. 33 and 34. Beyond this point is "loose drifting sand, no trees...land mostly drifting sand." Going north from the corner of secs. 33 and 34 "46.00 to drifting sand C.S.W." is recorded. A comparison of these distances (about 272 m and 925 m, respectively) with recent aerial photographs suggests that the average rate of sand movement since 1838 is around 60 cm/yr.

The extent of the presettlement forest before the survey might have been almost 800 meters into sec. 33. Conifer cemeteries, exumed remnants of buried forests, are present on the dunes in this area, and three large dunes in sec. 33 appear to be the remains of the wooded clay bank behind the foredune in sec. 27. Perhaps the bank extended into sec. 33 and was later dissected by invading blowouts. This bank probably was formed by wave action after the Algoma stage since the Algoma ridge intersects the foredune in sec. 27 NE¼. If a forest occupied almost half of sec. 33, it would not have done so until 2000 B.P. at the earliest. This would allow time for the recession of Lake Algoma to the present level of Lake Michigan and for the development of a conifer forest on the open sand.

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[1]Measured in chains. One chain equals 20.12 meters.

Human History

Indian Culture

The north shore of Hamlin Lake has been described as the summer site of Huron Indians (Fitting, 1967, 1975). Janet G. Brashler, Forest Service archeologist, relates (personal communication) that,

> the age of some of these (prehistoric Indian village and campsite areas) is uncertain, but it is clear that Indian people were living along the shore of Lake Michigan and Hamlin Lake at least as far back as 2500 B.C., and almost certainly several thousand years earlier. Some of the village and/or campsites were located on post-Pleistocene beach ridges and possibly on the backsides of related dunes. As yet we know relatively little about the people who lived in the campsites as far as how many, what they ate, and where they went on their seasonal rounds. We believe they were basically hunter-gatherers, and we presume they were people who travelled within a territory depending on the seasonal availability of wild plant and animal food. Until a site or sites in the area is (are) excavated, we will be unable to say precisely what their subsistence and settlement practices were.
>
> We know that Indian people continued to live in the area through the first millenium A.D. and into the historic period in the 17th and 18th centuries. After 1000 A.D. it is possible that some agriculture was practiced in the area, but again we have no direct evidence of the presence of cultigens. During the early historic period Ottawas, Chippewas, and possibly Algonkian speaking peoples lived and travelled in the general area of the Nordhouse Dunes.

European Settlement

A man named Porter built the first sawmill in Grant Twp. five kilometers north at Old Freesoil in 1845. This mill later burned, but was rebuilt by Freeman and Hopkins (Anon., 1882). R. G. Peters, "king of the

lumbermen", owned much of the study area in the late 1800's. The timber on this property was probably cut during his ownership. Hochkiss (1898) described him as follows:

> the more prominent among the lumbermen in all sections of the northwest have been noted for their energy and push, and none more fully show these admirable qualities who for the past half-century have operated in the forests of Michigan from the time when stately forests began to be musical with the ring of the woodsman's axe, to the day when the mills of many sections began to cease operations because of the decadence of supply. No more pushing or enterprizing lumberman can be named among the thousands of operators of whom this can be said, than Richard G. Peters of Manistee... As a purchaser of pine lands while a close buyer, Mr. Peters has shown his faith in their value by his ever readiness to purchase from government or from private lands any desirable sections in which he could see a profit fully realizing that opportunities for desirable interest in this line was rapidly vanishing. As a result, he became the owner of perhaps the largest quantity of pine stumpage that was held by any individual in the state of Michigan.

A narrow gauge logging railroad may have once followed the Nipissing trail. This railroad is indicated by ditches which line both sides of the trail, which can best be observed in the Lake Michigan Recreation Area campground.

According to Forest Service compartment records for the Nordhouse area, the earliest years of stand origin date from the late 1800's (Figure 5). These stands lie along the Algoma and Nipissing ridges and a short distance into sec. 26. The oldest year of stand origin, 1878, is recorded for the deciduous vegetation "island" surrounded by sand in sec. 27 SW¼. Stumps which would suggest logging have not been found here although stumps have been found on

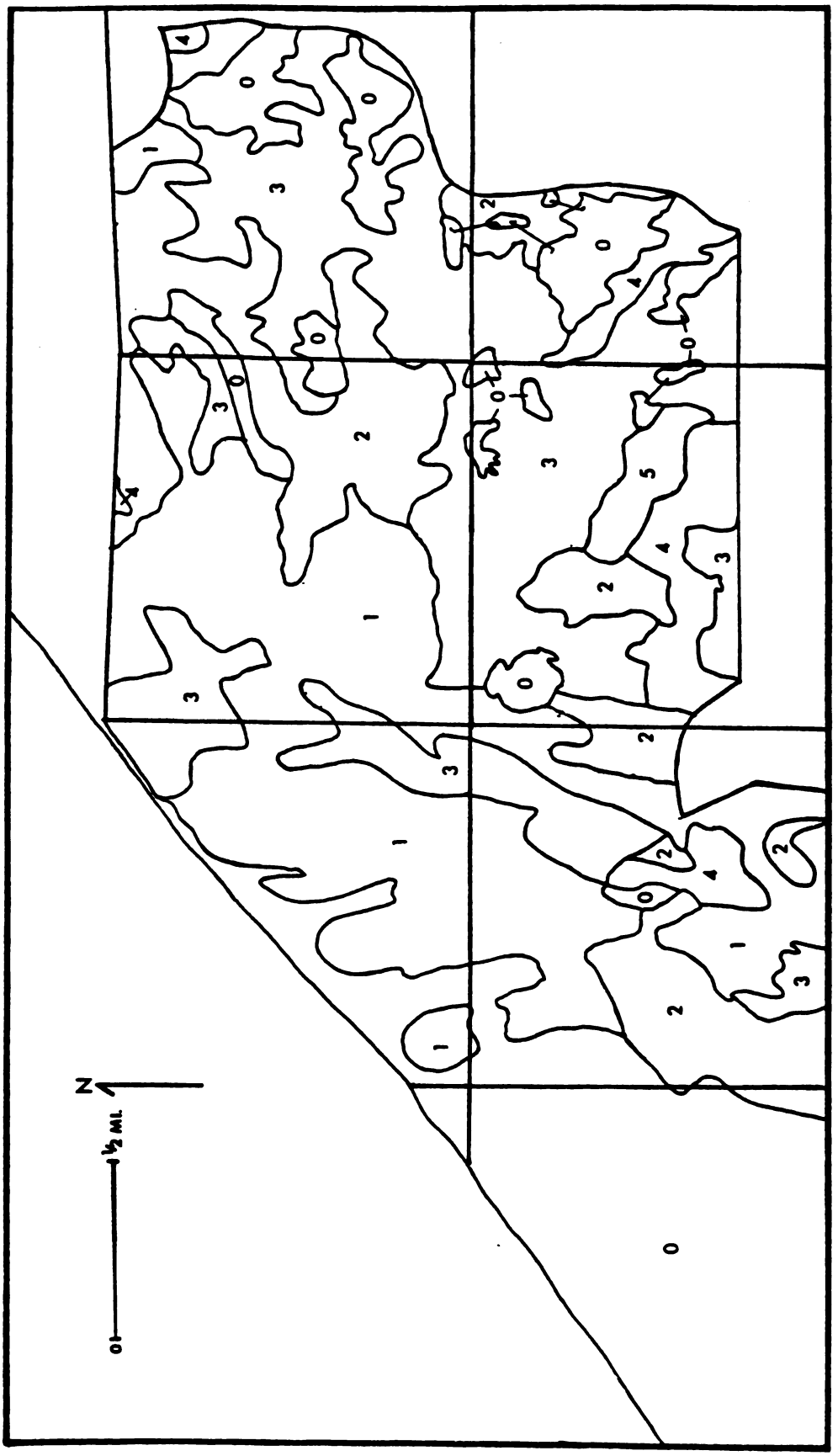


Figure 5. U. S. Forest Service records for year of stand origin: 1, pre-1900; 2, 1900-1919; 3, 1920-1939; 4, 1940-1959; 5, 1960-1979; 0, no date.

the islands of deciduous trees in sec. 33. The most recent lumbering, a 13 hectare clearcut, was done in 1977 just north of the red pine plantation in sec. 35.

Few fire records exist for the Nordhouse area. Charred stumps throughout the area suggest that post-lumbering fires were most severe in the upland areas. According to District Ranger Russel M. Garrigus (personal communication) the most recent fire occurred around 20 years ago in the bog-swamp of sec. 34 SW¼.

Administration

Much of the land within the recommended RARE II wilderness was acquired by the U.S. Forest Service during the 1930's and 40's. A large portion known as the Porter-Mulder tract was purchased in the early 1960's. Plans for a recreation area were drawn after this purchase. These included a visitor center, swimming pool, enormous campground facilities and elaborate trail system. Later these plans were scaled down to the present campground and picnic area. During the late 1960's and early 1970's the open dunes at Nordhouse became a popular attraction for Off Road Vehicle (ORV) operators who used the Nordhouse Lake area as a campground. It has been estimated that during peak periods an average of 50 ORVs were on the dunes and an average of 200 vehicles could be found at Nordhouse Lake and the end of Nordhouse Rd. at one time (United States Department of Agriculture, 1976). In 1973, the

Forest Service closed the dunes to ORVs in order to conduct a study to determine the extent of any deleterious effects of ORV use on the dunes. The study (United States Department of Agriculture, 1976) concluded that the dunes should remain closed to motorized vehicles to stop the excessive use of the land around Nordhouse Lake, to retard the deterioration of the dune formations, to prevent erosion of trails, to end any damage to private property and to eliminate the danger of ORV related accidents. Barriers were erected and notices of the restricted area were posted around its perimeter.

The Nordhouse Dunes and 13 other Michigan areas were evaluated for wilderness suitability under RARE II in 1977. The Forest Service recommended that eight areas totalling 22,863 hectares be designated as wilderness. Those in the Upper Peninsula include Sylvania, Sturgeon River and Little Silver Addition in Ottawa National Forest and Carp River and Horseshoe Bay in Hiawatha National Forest. Hiawatha National Forest also administers two islands, Government Is. and Round Is., in northern Lake Huron. The Nordhouse Dunes, Manistee National Forest, is Lower Michigan's only proposed wilderness under RARE II.

The management of the Nordhouse Dunes Wilderness would not differ significantly from the area's management before the RARE II process. Wilderness management would halt any timber harvesting or stand improvement and areas

restricted from motor vehicles would be expanded from the dune formations closed in 1973 to include the entire proposed wilderness. Hunting and dispersed camping will still be permitted. Congressional approval is needed before a wilderness designation is official, but until that time the Forest Service will manage the area as if it had such a designation.

METHODS

Field work for this thesis began during the 1979 growing season. In early May the first trip was made to document the vascular plant flora of the Nordhouse area. Two weekend collecting trips were made until June 28. From that time until August 27 I established summer residence at Lake Michigan Recreation Area campground and continued an intensive collecting program. The last collecting trip of 1979 was made on the third weekend of September and a few additional specimens were collected in mid-June 1980. Voucher specimens have been deposited in the Beal-Darlington Herbarium, Michigan State University (MSC) and in the University of Michigan Herbarium (MICH) in cooperation with the Michigan Flora Project. In rare cases when only one specimen of a species was collected, that specimen was deposited at MSC.

Data on the species composition of the various vegetation associations were gathered using the relevé method of Braun-Blanquet as described by Mueller-Dombois and Ellenberg (1974). This method fit the varied pattern of the Nordhouse vegetation, and the final vegetation map could be directly compared to previous timber mapping by the Forest Service. A floristic comparison among the

various vegetation associations was also assisted by using the relevé method because detailed species lists for each association were made. Aerial photographs of the Nordhouse area were used extensively in determining the boundaries of the vegetation associations and locating sites where releves could be run. This method, however, was not used to analyze the open sand, bogs, alder thickets and ponds. Descriptions of these areas instead were based on specimen collections made in these areas and from field observations.

Before any ecological analysis was begun a preliminary vegetation map was drawn after consulting the Forest Service compartment records describing the timber of the area (on file at the USFS District Ranger Station, Manistee) and 1" = 600' scale black and white sectional enlargements of ASCS 1:40,000 scale aerial photography. Boundaries between the vegetation associations were drawn after ground observations confirmed that each association had an identifiable shade and texture in these photographs. A total of 35 releves, most with a minimal area ranging from 200-400 square meters, was used to gather data from which descriptions of the associations could be written. After several stands were relevéd, some unrelevéd stands which were determined by field observations and aerial photographs as being similar to relevéd stands could also be mapped.

The procedure for the relevé method was followed from its description in Mueller-Dombois and Ellenberg (1974). Each relevé was begun with the establishment of a plot in the center of a stand. The center would presumably have the least influence from adjacent stands and thereby would best represent the entire stand. In this study the initial plot of a relevé was 100 square meters (10 m x 10 m). The area of this plot was successively doubled in a nested fashion until the minimal area needed to adequately include a representative sample of the stand vegetation was reached. The minimal area was determined by the leveling off of the species/area curve which was drawn by plotting the number of species found in the quadrat over quadrat area. The slope of this line was steep at first, but soon approached zero as area was increased. When the species/area curve leveled off, or when no new species were encountered as quadrat area was increased, the minimal area had been reached making additional increases in quadrat area unnecessary. The reliability of using the leveling off of a species/area curve to determine the minimal area of a relevé was checked and confirmed by comparing minimal areas derived in this way to minimal areas defined as the place where on the species/area curve where an increase in area by 10 percent yielded an increase of species of 5 percent (Mueller-Dombois and Ellenberg, 1974). After the minimal area was reached, each species in a relevé was listed as being either a tree,

sapling, shrub, or herb. A qualitative value of the cover of each species in the relevé could then be assigned after the relevé had been traversed several times while making the plant list. The cover of herbs, shrubs and saplings (dbh 5 cm) was estimated in the field by visually comparing the cover of each species to the size of the relevé. The cover of trees (dbh 5 cm), however, was determined by measuring the basal area of each tree in the relevé. The rank of each species in a relevé was determined using the Braun-Blanquet cover-abundance scale (Mueller-Dombois and Ellenberg, 1974):

5, any number of individuals with a combined cover greater than 75 percent.
4, any number of individuals with a combined cover of 50-75 percent.
3, any number of individuals with a combined cover of 25-50 percent.
2, any number of individuals with a combined cover of 5-25 percent.
1, few individuals with a combined cover from 1-5 percent.
+, few individuals with cover less than 1 percent.
r, species occurring only once.

The analysis of the relevé data began by compiling the data from all relevés into a "raw table." The constancy, the percent of relevés in which a given species was found, was determined for each species from this table. A second table listing only those species in each relevé with intermediate constancy (10-60%) was made (Mueller-Dombois and Ellenberg, 1974). A tabular comparison of the relevés in this table was used to spot differentiating species. Differentiating species are those species used to segregate

one vegetation association from another. Whenever possible species with intermediate constancy are used as differentiating species. In this study, however, the large rating (either 4 or 5) of *Acer rubrum* (73% constancy) was used as one factor in differentiating both the wet lowland hardwood and moist deciduous associations from the others. Similarly, the large rating (4-5) of *Pteridium aquilinum* (65% constancy) was used as a factor differentiating the oak and aspen associations from the rest. Later other differentiating species were used to separate both the wet lowland and moist deciduous associations and the oak and aspen associations from each other. A final table, grouping the releves of the same association together, was made and the preliminary vegetation map was modified in accordance to this final grouping.

A community ordination was constructed to compare the flora of the open dunes, jack pine stands, oak woods, moist deciduous woods, wet lowland hardwoods, cedar swamp, red pine forest, and bogs based on the species present in each association to illustrate the similarity among the associations. Community similarity coefficients (C) were calculated using the formula (Cox, 1976):

$$C = \frac{2w}{a + b}$$

Where: w = the sum of the lower of the two quantitative values of species shared by the two communities.
a = the sum of all species for the first community.
b = the sum of all species for the second community.

Community dissimilarity coefficients were calculated by subtracting C from .85 and these values were used to plot the relative positions of the vegetation associations in a two-dimensional ordination of each association following Cox (1976).

Life-forms (Raunkier, 1936) for each species were determined following McDonald (1937) or from a published description of that species. The life-form spectrum of the Nordhouse Dunes was determined using all species both native and introduced occurring in the area and was compared with spectra from other regions in Michigan.

RESULTS AND DISCUSSION

Present Vegetation

Species with the highest constancy are listed in Table 2 and the distribution of the present vegetation in the Nordhouse study area are depicted in Figure 6. This classification of the Nordhouse vegetation differs little from the Forest Service classification of the area. In the Forest Service classification only the tree species were used to determine the composition of a given stand. The Forest Service procedure is compatible with its management of most forests for a future timber yield. The relevé method draws from a wider data base because shrubs and herbs are included in characterizing the vegetation associations. Perhaps the greatest difference between the results of the relevé method and those of the Forest Service would be in the application of an "oak" association. Some areas designated as moist deciduous woods are shown as oak in Forest Service compartment records. The parameters which I have assigned to the oak association are: a) greater than 50 percent cover of *Quercus* spp. based on basal area; b) minimum cover of 50 percent of *Pteridium aquilinum* and/or *Vaccinium angustifolium*. If the cover of

Vaccinium and *Pteridium* is lower than 50 percent and trees such as *Acer rubrum, Betula papyrifera* and *Fagus grandifolia* were also present, I classified the area as moist deciduous woods even though *Quercus* might have had the greatest cover at that site. A system limited only to trees might have the area classified as an oak association. Other differences between the results of the classification used here and that of the Forest Service are minor.

TABLE 2.--Constancy Values (%) of the Most Common Species Encountered During Relevé Analysis of Wooded Areas

Species	%	Species	%
Acer rubrum	73	*Pinus strobus*	32
Gaultheria procumbens	65	*Fagus grandifolia*	30
Pteridium aquilinum	65	*Gaylussacia baccata*	27
Betula papyrifera	57	*Viburnum acerifolium*	24
Maianthemum canadense	54	*Cornus canadensis*	22
Mitchella repens	49	*Dryopteris spinulosa*	22
Trientalis borealis	49	*Epigaea repens*	22
Vaccinium angustifolium	49	*Tsuga canadensis*	22
Populus grandidentata	46	*Quercus alba*	19
Quercus borealis	46	*Viola* sp.	19

Since no two relevés were the same with respect to the species listed or to the cover-abundance rating for

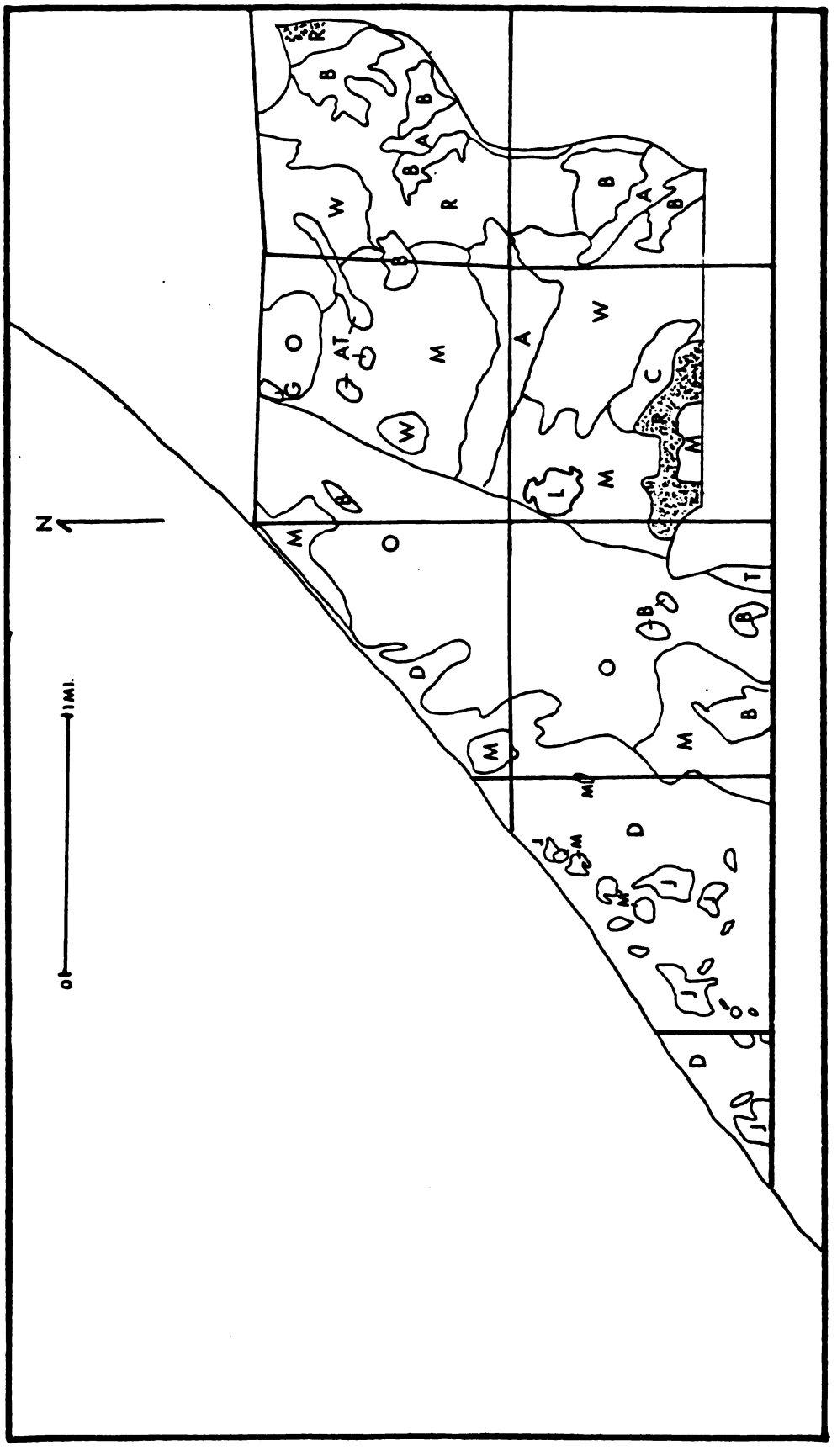


Figure 6. Vegetation map of the Nordhouse Dunes study area; A, aspen; AT, alder thickets, marshes and ponds; B, bog; C, clear-out; D, open dunes; G, meadow; J, jack pine; L, Nordhouse Lake; M, moist deciduous woods; O, oak woods; R, red pine; T, cedar swamp; W, wet lowland hardwoods; stippling, planted conifers.

each species (Mueller-Dombois and Ellenberg, 1974), I determined the parameters for a given vegetation association based on a composite description as determined from the releves of that association. These parameters and a list of characteristic species were included with the description of each association. The average rating according to the cover-abundance scale (5, 4, 3, 2, 1, +, r) described earlier from each species is also included in this list. Additional species which occurred outside plot boundaries, and certain seasonal species, although not included in the analysis were collected and listed in the appropriate tables.

Open Dunes (D)

The open dunes occur in secs. 27, 28, 32, and 33 and are composed of a beach, foredune, blowouts, and dune ridges. Jack pine stands and dune pools interrupt the open sand in secs. 32 and 33. The highest dunes, sec. 33 E½, rise about 50 meters above Lake Michigan. Hardwood forests border the open dunes on the south and east. One place additional to the blowout where the dunes seem to be invading these forests is in sec. 33 E½. Here sand is creeping into the forest and the tops of dead trees can be observed near the crest of the lee slope. The rate of movement must have slowed since oak and maple seedlings have become established on this slope. At present the

main direction of sand movement on the open dunes is north rather than east. One such active dune in sec. 27 W½ was once a stabilized dune ridge, but ORV use removed enough vegetation to renew sand movement.

Grasses are the dominant cover of the open dunes. *Ammophila breviligulata* is common in disturbed areas such as dune crests and on the edges of moving dunes and blowouts. *Calamovilfa longifolia* and *Andropogon scoparius* are common on the stable lee sides of dune ridges and on the foredune. Woody species are most common along the foredune. These include *Juniperus communis, Hypericum kalmianum, Salix cordata, S. interior, Prunus pumila,* and *Cornus stolonifera. Populus balsamifera* is common along the foredune while *Populus deltoides* may be found on stabilized dunes farther from the lake shore. Species common on the open dunes are listed in Table 3.

Dune Pools and Pannes

Although no streams flow into Lake Michigan from the study area, local wet areas occur on the dunes in secs. 32 and 33. Dune pools are areas of standing water with an average depth of 7-13 cm. These pools probably form due to the closeness of the water table which is influenced by Lake Michigan and the underlying clay pan. The vegetation of dune pools is usually confined to the outside edge. A few of these species include *Lobelia kalmii, Potentilla anserina,* and *Senecio pauperculis. Triglochin maritimum,*

TABLE 3.--Characteristic Species on the Beach Foredune, Blowouts and Open Dunes (D).

Ammophila breviligulata	**Juniperus communis*
Andropogon scoparius	*#Koeleria macrantha*
#Arabis lyrata	*Lathyrus maritimus*
Arctostaphylos uva-ursi	**Lilium philadelphicum*
Artemisia caudata	*Lithospermum caroliniense*
**Asclepias syriaca*	*Monarda punctata*
**Cakile edentula*	**Oenothera biennis*
Calamovilfa longifolia	*#Polygonella articulata*
**Campanula rotundifolia*	*Populus balsamifera*
Cirsium pitcheri	*Prunus pumila*
**Cornus stolonifera*	**Pteridium aquilinum*
#Cyperus schweinitzii	**Rosa blanda*
Elymus canadensis	**Salix cordata*
**Equisetum arvense*	**S. interior*
**E. hyemale*	**Smilacina stellata*
Euphorbia polygonifolia	**Solidago spathulata*
#Hudsonia tomentosa	**Toxicodendron rydbergii*
**Hypericum kalmianum*	**Zigadenus glaucus*

*Foredune and beach species only.

#Blowout and open dune species only.

Cyperus americanus and *Juncus balticus* are the only emergents. Dune pools that are filled by moving sand yet remain moist are dune pannes. Grasses and sedges are frequent and *Salix glaucophylloides* and *S. interior* are common woody species. These sites have the potential to become and probably have succeeded to jack pine stands. Species common in dune pools and pannes are listed in Table 4.

TABLE 4.--Species of Dune Pools and Pannes

Agrostis hyemalis	*Rudbeckia hirta*
Aster tradescanti	*Salix glaucophylloides*
Carex flava	*S. interior*
Eleocharis elliptica	*Senecio pauperculis*
Equisetum arvense	*Solidago graminifolia*
E. hyemale	
Eupatorium perfoliatum	Aquatic Species
Lobelia kalmii	*Cyperus americanus*
Panicum virgatum	*Triglochin maritimum*
Potentilla anserina	*Juncus balticus*

Jack Pine Stands (J)

This vegetation type is hard to describe since the boundaries of these stands are not well defined and moisture conditions are not constant from stand to stand. Jack pine stands develop on dune pannes and around dune

pools. *Pinus banksiana* cover is almost 100 percent although a few small *Thuja occidentalis* and *Betula papyrifera* trees may be found here. These stands have the potential to develop into deciduous forest stands, but probably will be limited in their succession by moving dunes as regional wind patterns change. One place where a jack pine stand may have succeeded to a deciduous stand is the vegetation island of sec. 27. The soil age suggests that the forest of this island arose on the dunes rather than being cut off from the mainland by a blowout (Watson, 1976). A list of species found in these jack pine stands can be found in Table 5. A few species found only in these stands include *Goodyera oblongifolia, Chimaphila maculata, C. umbellata,* and *Cypripedium arietinum.*

Oak Woods (O)

The forest occupying much of the Nipissing and Algoma ridges is dominated by three *Quercus* species. The combined cover of *Q. alba, Q. borealis* and *Q. velutina* is usually over 50 percent throughout this forest type, but the distribution of these species is not random. *Quercus alba* is most common in the low interdunal sites; *Q. velutina,* in contrast, is most common along the crests of the dune ridges. The distribution of *Q. borealis* is generally constant throughout the oak association and is even found in the moist deciduous woods. Trees with secondary cover values include *Pinus strobus, P. banksiana,*

TABLE 5.--Characteristic Species of Jack Pine Stands (J).

Species Encountered in Releveé Plots	Additional Species
Pinus banksiana (5)	*Antennaria plantaginifolia*
Arctostaphylos uva-ursi (2)	*Betula papyrifera*
Linnaea borealis (2)	**Chimaphila umbellata*
Anaphalis margaritacea (1)	*Corallorhiza maculata*
Salix discolor (1)	**Goodyera oblongifolia*
Shepherdia canadensis (1)	*G. repens*
**Chimaphila maculata* (+)	*Moneses uniflora*
**Cypripedium arietinum* (+)	*Smilacina stellata*
Juniperus communis (+)	*Spiranthes cernua*
Linnaea borealis (+)	*Thuja occidentalis*
Pyrola elliptica (+)	
Toxicodendron rydbergii (+)	
Vaccinium macrocarpon (+)	
Vitis riparia (+)	
Fragaria virginiana (r)	
**Linum virginianum* (r)	
Melampyrum lineare (r)	
Viburnum acerifolium (r)	

*Species only found in this association.

Cover-Abundance values (p. 30) based on two releveés.

P. resinosa, Sassafras albidum, Hamamelis virginiana, Populus grandidentata, Acer rubrum and *Betula papyrifera*. *Betula papyrifera* and *Acer rubrum* are most common where the oak woods border the open sand. In some sites inclusions of aspen (*Populus grandidentata*) and pine (*Pinus strobus* and *P. banksiana*) occur. The 5-25 percent cover of young *Pinus strobus* trees throughout the oak woods suggests that this association may be succeeding to a white pine forest similar to the one in this area during presettlement times. The canopy of this forest is open and allows an extensive development of undergrowth. The cover of *Gaylussacia baccata* and *Pteridium aquilinum* is usually at least 50 percent. Species found in the oak woods are listed in Table 6. Some species found only in this stand include *Diervilla lonicera* and *Taenidia integerrima*.

Moist Deciduous Woods (M)

A mixed deciduous forest occupies the moist sites of the Algoma and Nipissing ridges and the upland sites of the marginal dune apron. Generally *Acer rubrum* has a cover value between 50-75 percent in which other trees of widely varying cover such as *Fagus grandifolia, Quercus rubra, Betula papyrifera, Populus grandidentata,* and *Tsuga canadensis* have a part. *Acer saccharum* is not common in the moist deciduous woods and is only found in a small but rich upland area in sec. 26 SE½. Other

TABLE 6.--Characteristic Species of the Oak Woods (O).

Species Encountered in Releveé Plots	Additional Species
Quercus alba (4)	*Carex pensylvanica*
Q. borealis (4)	*Conopholis americana*
Q. velutina (4)	*Deschampsia flexuosa*
Gaylussacia baccata (3)	**Diervilla lonicera*
Pteridium aquilinum (3)	*Houstonia canadensis*
Gaultheria procumbens (2)	*Pedicularis canadensis*
Pinus strobus (2)	**Potentilla norvegica*
Vaccinium angustifolium (2)	**Taenidia interrima*
Acer rubrum (1)	
Pinus banksiana (1)	
P. resinosa (1)	
Populus grandidentata (1)	
Sassafras albidum (1)	
Vaccinium myrtilloides (1)	
Epigaea repens (+)	
Hamamelis virginiana (+)	
Maianthemum canadense (+)	
Melampyrum lineare (+)	
Trientalis borealis (+)	
Cyripedium acaule (r)	
Mitchella repens (r)	

*Species only found in this association.

Cover-abundance values (p. 30) based on six relevés.

species limited to this upland area include *Lycopodium lucidulum, Erythronium americanum, Hepatica americana* and *Osmorhiza claytoni*. The entire moist deciduous woods is characterized by dense shade which prevents an extensive development of a shrub layer, but the herbaceous cover is rich in species such as *Cornus canadensis, Epigaea repens, Epifagus virginiana, Gaultheria procumbens, Mitchella repens, Oryzopsis asperifolia* and *Trientalis borealis*. Species found in this association are listed in Table 7. *Goodyera pubescens* and *Botrychium matricariaefolium* are a few species which are found only in this association.

A diverse flora occurs where the moist deciduous woods occupies the clay bank behind the foredune in sec. 27 and the remnants of this bank occupied by deciduous islands in secs. 27 and 33. Perhaps the floristic richness of these sites is due to increased soil moisture from the underlying clay pan and the edge effect created by the closeness of the forest to the foredune and open sand. Species found in these areas are listed in Table 8.

Wet Lowland Hardwoods (W)

The wet lowland hardwoods is most extensive on the marginal sand apron east of the Nipissing ridge. The occurrence of wet sites which favor this forest is in part due to the underlying clay pan which is very close to the surface in these areas. In the spring these woods are

TABLE 7.--Characteristic Species of the Moist Deciduous Woods (M).

Species Encountered in Releveé Plots	Additional Species
Acer rubrum (3)	*Betula alleghaniensis*
Betula papyrifera (2)	*Circaea alpina*
Fagus grandifolia (2)	*Corallorhiza maculata*
Pteridium aquilinum (2)	*Epifagus virginiana*
Quercus borealis (2)	**Erythronium americanum*
Gaultheria procumbens (1)	**Hepatica americana*
Mitchella repens (1)	**Lycopodium clavatum*
Trientalis borealis (1)	**L. complanatum*
Aralia nudicaulis (+)	*L. lucidulum*
Maianthemum canadense (+)	*L. obscurum*
Tsuga canadensis (+)	*Monotropa hypopithys*
Vaccinium angustifolium (+)	*Osmunda cinnamomea*
Athyrium filix-femina (r)	*Pilea pumila*
Conopholis americana (r)	*Viola cucullata*
Cornus canadensis (r)	
Dryopteris spinulosa (r)	
Epigaea repens (r)	
Galium triflorum (r)	
Monotropa uniflora (r)	
Oryzopsis asperifolia (r)	
Pinus resinosa (r)	
P. strobus (r)	
Populus grandidentata (r)	
Prunus serotina (r)	
Viburnum acerifolium (r)	

*Species only found in this association.

Cover-abundance values (p. 30) based on sixteen releveés.

TABLE 8.--Species of the Moist Deciduous Woods Found on the Clay Bank Behind the Foredune in Sec. 27 and on Deciduous Vegetation Islands Sec. 27 and 33.

Acer rubrum	*Maianthemum canadense*
**Actaea alba*	*Moneses uniflora*
Aralia nudicaulis	**Ostrya virginiana*
**Aquilegia canadensis*	*Pinus resinosa*
Aster macrophyllum	*P. strobus*
Betula papyrifera	*Polygala paucifolia*
Botrychium virginianum	*Polygonatum biflorum*
Carex eburnea	*Polypodium virginianum*
C. laxiflora	*Pteridium aquilinum*
Circaea alpina	*Pyrola asarifolia*
Clintonia borealis	*P. segunda*
Cynoglossum boreale	*Quercus rubra*
Corallorhiza trifida	*Shepherdia canadensis*
Equisetum arvense	**Taxus canadensis*
E. hyemale	*Thuja occidentalis*
Fraxinus pennsylvanica	*Toxicodendron rydbergii*
Galium triflorum	*Trientalis borealis*
Linnaea borealis	*Tsuga canadensis*
Lonicera canadensis	*Viburnum acerifolium*
L. dioica	

*Species only found in this association.

flooded. A distinguishing character of this lowland forest is a cover of at least 75 percent for *Acer rubrum*. Other common forest trees include *Fraxinus pennsylvanica*, *Betula papyrifera* and *Populus grandidentata*. A second character defining this association is a cover of at least 25 percent for either *Osmunda cinnamomea* or *Onoclea sensiblis*. *Pteridium aquilinum* is rare. Table 9 lists species found in this association. Some species found only here include *Bartonia virginica, Cryptotaenia canadensis, Osmunda claytoniana, Sorbus americana* and *Thelypteris phegopteris*. *Sorbus americana* was most common as seedlings.

Cedar Swamp (T)

Although this stand may not be as rich and extensive as most cedar swamps, this term best describes the 14-hectare lowland conifer forest near Hamlin Lake. Moist conditions of this stand are maintained by a small stream which passes through its center. *Thuja occidentalis* has the highest cover with just over 50 percent while *Tsuga canadensis* is second with 30 percent. Trees with minor cover values are *Betula alleghaniensis, B. papyrifera, Acer rubrum* and *Prunus seratina*. The dense shade of the interior of this stand and heavy deer yarding in the winter prevent an extensive growth of a shrub layer. Common herbs in this stand are *Coptis trifolia, Botrychium virginianum, Circaea alpina, Gymnocarpium*

TABLE 9.--Characteristic Species of the Wet Lowland Hardwood Forest (W).

Species Encountered in Releved Plots	Additional Species
Acer rubrum (5)	*Acer spicatum*
Osmunda cinnamomea (3)	**Bartonia virginica*
Betula papyrifera (2)	*Botrychium simplex*
Onoclea sensibilis (2)	*Carex lupulina*
Dryopteris spinulosa (1)	*C. tuckermanii*
Fraxinus pennsylvanica (1)	*Cinna latifolia*
Populus grandidentata (1)	*Circaea alpina*
Arisaema triphyllum (r)	**Cryptotaenia canadensis*
Glyceria borealis (r)	*Dulichium arundinaceum*
Lycopus uniflorus (r)	*Galium triflorum*
Rubus hispidus (r)	*Habenaria clavellata*
**Sorbus americana* (r)	*Ilex verticillata*
Vaccinium myrilloides (r)	*Mimulus ringens*
	**Osmunda claytoniana*
	Pilea pumila
	Scutellaria lateriflora
	**Thelypteris palustris*
	**T. phegopteris*

*Species only found in this association.

Cover-abundance values (p. 30) based on six releves.

dryopters, Mitchella repens, Mitella nuda and *Trientalis borealis*. This stand was not part of the proposed RARE II wilderness, but it was included within this study to illustrate the diversity of vegetation on the Nordhouse area. While it will not have wilderness protection, the Forest Service should maintain this stand in its present condition. Orchid species including *Corallorhiza maculata, C. trifida, Goodyera repens* and *Listera cordata* are found here. On the basis of distribution records provided by Voss (1972), new county records for *Corallorhiza trifida, Goodyera repens* and *Listera cordata* are established by the discovery of these species. Species found in this stand are listed in Table 10.

Nordhouse Lake (L)

Nordhouse Lake covers about two hectares in sec. 35 NE¼. The lake is not more than two meters deep and rests on the underlying clay pan. In the spring it is filled by melting snow and rain. During the rest of the year the lake recedes through percolation and evaporation. Subsequently, the lake level is an accurate indicator of the soil moisture in the surrounding woods. During past droughts this lake has even dried up. The Nipissing ridge borders this lake on the west. If this ridge was formed on the fossil beach of Lake Calumet (Evenson, et al., 1973), perhaps Nordhouse Lake was once a lagoon at the mouth of a stream which entered into that ancient glacial lake.

TABLE 10.--Characteristic Species of the Cedar Swamp (T).

Species Encountered in Relevé Plots	Additional Species
Thuja occidentalis (4)	*Corallorhiza trifida*
Tsuga canadensis (3)	**Cystopteris bulbifera*
Acer rubrum (1)	**Listera cordata*
Botrychium virginianum (1)	*Pteridium aquilinum*
Circaea alpina (1)	*Thelypteris noveboracensis*
Coptis trifolia (1)	
Gymnocarpium dryopteris (1)	
Mitchella repens (1)	
Mitella nuda (1)	
Trientalis borealis (1)	
Vaccinium angustifolium (1)	
Arisaema triphyllum (+)	
Athyrium filix-femina (+)	
Betula alleghaniensis (+)	
B. papyrifera (+)	
Clintonia borealis (+)	
Corallorhiza maculata (+)	
Goodyera repens (+)	
Galium triflorum (+)	
Osmunda cinnamomea (+)	
Prunus serotina (+)	
Dryopteris spinulosa (r)	
Fraxinus pennsylvanica (r)	

*Species only found in this association.

Cover-abundance values (p. 30) based on one relevé.

The annual protracted lowering of Nordhouse Lake does not allow the typical pond emergents to develop. Instead plants such as *Eleocharis acicularis, E. smallii, Spartina pectinata, Mollugo verticillata,* and *Rotala ramosior* inhabit the mud flats around the lake. *Potamogeton spirillus* is the only submerged aquatic. *Stachys hyssopifolia,* at its northern-most limit in Michigan (Waterman, 1960), can be found in the grass along the lake margin. Peattie (1922) listed this species as a Coastal Plain disjunct, and suggested that such disjuncts first occupied the coastal lagoons along Lake Michigan after their arrival to this region. Now such disjuncts are generally confined to the edges of lakes and depressions similar to Nordhouse Lake. Species found in the vicinity of Nordhouse Lake are listed in Table 11.

The Meadow (G)

The meadow is located at the north end of Nipissing trail in sec. 26. As is the case with Nordhouse Lake, the Nipissing ridge borders the meadow's west side. Perhaps this area had also been a lagoon of an earlier lake, but its smaller size allowed it to succeed to a meadow. In the spring it may be filled with water up to 50 cm deep. By early July, however, the water has usually disappeared. The flora of the meadow is also similar to that around Nordhouse Lake. *Spartina pectinata* is the dominant species. Along the outer edge *Cornus stolonifera* and *Hypericum*

TABLE 11.--Species Found in and Around Nordhouse Lake (L).

Acer rubrum	*Pinus banksiana*
Agrostis hyemalis	*P. resinosa*
**Alisma plantago-aquatica*	*P. strobus*
**Anenome canadensis*	*Populus deltoides*
Aster tradescanti	*P. grandidentata*
Betula papyrifera	**Potamogeton spirillus*
**Cephalanthus occidentalis*	*Pteridium aquilinum*
**Eleocharis acicularis*	*Quercus alba*
**E. smallii*	*Q. borealis*
Fagus grandifolia	*Rosa acicularis*
Hypericum kalmianum	**Rotala ramosior*
Iris versicolor	*Rubus flagellaris*
Lobelia spicata	*Rumex acetosella*
Lysimachia lanceolata	*Sassafras albidum*
**Mentha arvensis*	*Spartina pectinata*
**Mollugo verticillata*	**Stachys hyssopifolia*

*Species only found in this association.

kalminanum are common shrubs. Species found in and around the meadow are listed in Table 12. One species found only here is *Spiraea latifolia*.

Ponds, Marshes and Alder Thickets (AT)

Local wet sites on the dune apron, usually having standing water throughout the summer, are the alder thickets, marshes and ponds. The greatest concentration of these areas is in sec. 26. Ponds are those sites with a large portion of their area remaining as open water. The marshes have less open water and instead are dominated by *Typha angustifolia*. The alder thickets have little open space at all and in most places have a thick *Alnus rugosa* cover of 100 percent. Perhaps this assortment of wet areas might be the remains of an early stream system which drained into Lake Nipissing or even Lake Calumet before this area was forested. A present day stream which flows into Lake Michigan and has its origins in the alder thickets of sec. 26 is Porter Creek (Figure 2). Species collected in these wet areas are listed in Table 13.

Bogs (B)

The bogs of the study area do not have a floating mat, but are shallow and overgrown with leatherleaf (*Chamaedaphne calyculata*). *Sphagnum* is common. A few small bogs are found in the oak woods, but the largest bogs of the study area are found in secs. 25 and 26. These bogs probably had their origin as dune pools and

TABLE 12.--Species Found in and Around the Meadow (G).

Acer rubrum	*Prunella vulgaris*
Centaurea maculosa	*Prunus pumila*
Cornus stolonifera	*P. serotina*
Erigeron strigosus	*Pteridium aquilinum*
Fragaria virginica	*Quercus alba*
Fraxinus pennsylvanica	*Q. borealis*
Helianthemum canadense	*Rubus flagellaris*
Houstonia candensis	*Rumex acetosella*
Lobelia spicata	*Salix petiolaris*
Lysimachia lanceolata	*Sassafras albidum*
Oenothera biennis	*Spartina pectinata*
O. perennis	**Spiraea latifolia*
Eleocharis elliptica	*Toxicodendron rydbergii*
Pinus banksiana	*Tragopogon dubius*
Polygala paucifolia	*Viola cucullata*
Populus grandidentata	*V. sagittata*
Potentilla simplex	

*Species found only in this association.

TABLE 13.--Species Found in Ponds, Marshes and Alder Thickets (AT).

Arisaema triphyllum	*Onoclea sensibilis*
Alnus rugosa	*Osmunda cinnamomea*
Bidens frondosa	*Pilea pumila*
Caltha palustris	*Polygonatum natans*
Carex crinita	**P. punctatum*
C. folliculata	**Potentilla palustris*
C. rostrata	*Rosa palustris*
Cicuta bulbifera	*Scirpus cyperinus*
Circaea alpina	*Thelypteris palustris*
Dryopteris spinulosa	*Triadenum virginianum*
Dulichium arundinaceum	*Typha angustifolia*
Ilex verticillata	*Viola cucullata*
Iris versicolor	*V. pallens*
Lycopus uniflorus	*Woodwardia virginica*
Lysimachia thyrsiflora	

*Species found only in this association.

swales. Presently they occupy shallow depressions which collect water during the winter and spring. Their interior is covered with dense stands of *Chamaedaphne calyculata* and *Vaccinium angustifolium*. An occasional *Larix laricina* and *Picea mariana* are scattered across the bogs, but are more common close to the bog margin. The extreme outer edges are densely surrounded by *Nemopanthus mucronatus*.

An exception to this general description is the bog-swamps in sec. 34 SW¼. These wetlands are an extension of Lost Lakes which lie just south of the study area in secs. 3 and 4 of Hamlin Twp. A zonation from open water to shrubs and trees can be observed here. *Nemopanthus mucronatus* and *Myrica gale* are common bordering the open water and along the surrounding upland forest. Conifers such as *Pinus strobus* and *Larix laricina* are common further from the open water. Grasses and sedges such as *Calamagrostis canadensis, Eriophorum virginicum* and *Scirpus atrovirens* are common in this zone. *Acer rubrum* dominates the next zone where a small wet lowland forest has developed. Species found in this bog which were not found in the bogs of the dune apron are *Myrica gale, Calla palustris* and *Iris versicolor*. Other species found in the study area bogs are listed in Table 14.

The bogs of the dune apron do not have a high number of species. This is due in part to the variability in water content during the year. These bogs can be

TABLE 14.--Characteristic Species of the Bogs (B).

**Andromeda glaucophylla*	*Osmunda cinnamomea*
Aronia prunifolia	**O. regalis*
#Caltha palustris	**Picea mariana*
Carex crinita	*Pinus resinosa*
C. folliculata	*Rubus hispidus*
C. intumescens	*Scirpus atrovirens*
C. oligosperma	*S. cyperinus*
Chamaedaphne calyculata	*Vaccinium angustifolium*
**Eriophorum virginicum*	*V. macrocarpon*
Gaylussacia baccata	*V. myrtilloides*
#Iris versicolor	*Viburnum cassinoides*
**Larix laricina*	*Woodwardia virginica*
**#Myrica gale*	

*Species only found in this association.

#Only found in bog-swamps of sec. 34.

very wet in the spring. At times water may even cover Forest Road 5356. By mid-July, however, the water disappears and in some places the *Sphagnum* begins to dry out. Species requiring moist conditions throughout the year cannot survive during the dry late summers. Those xeric species which may invade the bogs in late summer are eliminated in the wet springs. Additionally, during the winter and summer the moderating microclimate of deeper bogs is absent and so limits the flora to those species with wide temperature and moisture tolerances.

Aerial photographs of this area from 1938 show that the bogs of the dune apron were much larger and occupied much of the area now covered by *Pinus resinosa*. This trend is likely to continue in the future.

Red Pine Forest (R)

A forest dominated by red pine *(Pinus resinosa)* is closely associated with the bogs of the sand apron. In some places *Pinus resinosa* has a cover of 100 percent although some *Quercus* spp. and *Populus grandidentata* inclusions can be found on the drier ridges. I have also used this forest type to refer to the red pine plantations which date back to the 1940's. These plantations are much drier and barely support any herbaceous species. Common herbs in the natural red pine forests include *Cornus canadensis, Gaultheria procumbens* and *Pteridium aquilinum*. As succession

continues these forests will replace the bogs of the sand apron. Species common in the red pine forests are listed in Table 15.

Aspen Stands (A)

In these stands *Populus grandidentata* can be spaced openly with an assortment of other tree species such as *Quercus borealis, Pinus resinosa, P. strobus* and *Acer rubrum* as is found in the area north of Nordhouse Lake. In other areas dense stands develop allowing few other tree species like those stands in sec. 35 east of Nordhouse Lake. In the open stands *Pteridium aquilinum* is the dominant herb having from 75-100 percent cover. This cover value is much smaller, around 25 percent, in the closed aspen stands where *Populus grandidentata* has a cover of over 75 percent. These areas are successionally young and will be followed by either oak or moist hardwood forests depending on the local conditions. In some areas a mixture of *Acer rubrum* and *Betula papyrifera* suggests that a mixed hardwood forest may develop next. Oak forests would be more favored on drier sites. Species which are common to the aspen stands are listed in Table 16.

Open Disturbed Sites

Open disturbed sites are those areas which have recently experienced or are experiencing direct human influence. The three basic types of this influence are logging, powerline rights-of-way and roads.

TABLE 15.-- Species Found in the Red Pine Forest (R).

Species Encountered in Relevéd Plots	Additional Species
Pinus resinosa (5)	*Betula papyrifera*
Pteridium aquilinum (4)	*Dactylis glomerata*
Gaultheria procumbens (2)	*Epigaea repens*
Maianthemum canadense (2)	*Galium triflorum*
Trientalis borealis (2)	*Hamamelis virginiana*
Acer rubrum (1)	*Pinus banksiana*
Cornus canadensis (1)	*P. strobus*
Gaylussacia baccata (1)	*Quercus alba*
Populus grandidentata (1)	*Q. borealis*
Cypripedium acaule (+)	*Vaccinium angustifolium*
Quercus velutina (+)	*V. myrtilloides*
	Viburnum cassinoides

Cover-abundance values (p. 30) based on one relevé.

TABLE 16.--Species Found in the Aspen Stands (A).

Species Encountered in Releved Plots	Additional Species
Populus grandidentata (5)	*Amelanchier laevis*
Pteridium aquilinum (5)	*Betula papyrifera*
Gaultheria procumbens (3)	*Fagus grandifolia*
Deschampsia flexuosa (2)	*Pinus banksiana*
Gaylussacia baccata (2)	*P. strobus*
Poa compressa (2)	*P. resinosa*
Danthonia spicata (1)	*Quercus alba*
Epigaea repens (+)	*Q. borealis*
	Rumex acetosella
	Vaccinium angustifolium

Cover-abundance values (p. 30) based on two releves.

A 13 hectare clearcut made in 1977 is found just north of the red pine plantation in sec. 35. It cannot be observed in Figure 1 since it post-dates that photograph. Before timber harvest the Forest Service classified this area as aspen. *Populus grandidentata* saplings are very common in this clearcut at present indicating aspen regeneration. *Comptonia peregrina* is common near the margin of this clear-cut. Grasses such as *Agropyron repens, A. trachycaulum, Danthonia spicata, Phleum pratense* and *Poa compressa* along with *Pteridium aquilinum, Fragaria virginica* and *Epigaea repens* constitute the herbaceous cover.

Two powerline clearings cross the study area. The right-of-way which crosses secs. 27 and 34 once carried power to the lighthouse at Big Point Sable. This line was removed in the early 1970's, but the clearing remained a popular access route for ORVs to the dunes. The second clearing, cutting across secs. 36 and 25, was made to carry power to Lake Michigan Recreation Area. Both rights-of-way have exposed both wet and dry forest floors to sunlight. Usually the undisturbed dry sites are predominantly covered by *Pteridium aquilinum,* while the wet sites are dominated by several species of *Carex, Scirpus atrovirens* and *Osmunda cinnamomea.* One noteworthy site occurs where a part of the cedar swamp in sec. 34 SE¼ was cut. This opening has favored the growth of

Caltha palustris, Lobelia cardinalis and *Drosera rotundifolia.*

Roads delimit the boundaries of much of the study area. Local moisture conditions as well as the maintenance of Forest Road 5356, FR 5629 and Nurnburg Rd. have an effect on the species composition along these roads. Forest Road 5356 is an unimproved two-track occasionally used by four-wheel drive vehicles during the summer and fall. The species along the edge of this road vary little from the surrounding forests and bogs. Nurnburg Rd. is a medium duty gravel road which is cleared of snow in the winter. Its shoulders, however, are not maintained, and European species such as *Agropyron repens, Bromus inermis, Phleum pratense* and *Hypericum perfoliatum* are common. The only station for *Rhus copallinum* is found along Nurnburg Rd. as well. Forest Road 5629 is a medium duty paved road. It is closed in the winter, but its shoulders are mowed during the summer. Species such as *Barbarea vulgaris, Berteroa incana, Melilotus alba* and *Hieracium aurantiacum* are common along this roadside.

Community Ordination

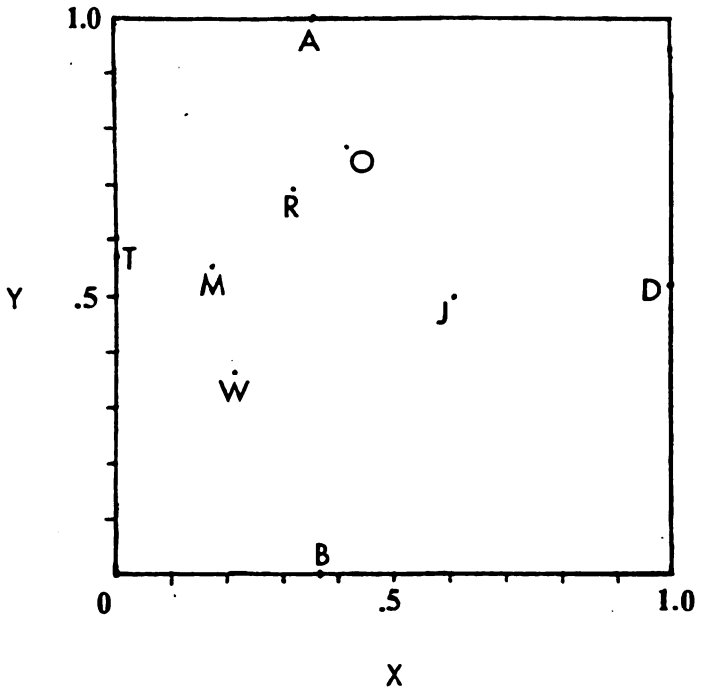
The floristic comparison among the vegetation associations in a two dimensional ordination constructed

from the dissimilarity values in Table 17 is illustrated in Figure 7. The associations most dissimilar to the others are the open dunes (D) and bogs (B). The dune association may have a large number of species, but the open dune habitat requires highly specialized species. The open dunes would be isolated from the other associations since few dune species would be found outside the open dunes. Likewise, only a few species from other associations would be found on the open dunes. The low species diversity of the bogs (B) might account for their dissimilarity to the other associations in Figure 7. While no quantitative measurements were taken, casual field observation suggests that Figure 7 may show increasing solar radiation at the soil surface on the *x* axis and decreasing soil moisture on the *y* axis.

TABLE 17.--Dissimilarity Coefficients for Vegetation Associations Compared by Two-dimensional Community Ordination.

M	-								
T	.47	-							
J	.76	.75	-						
B	.75	.79	.82	-					
O	.63	.79	.79	.81	-				
W	.60	.58	.80	.65	.77	-			
D	.81	.85	.52	.85	.80	.83	-		
A	.59	.62	.75	.85	.29	.73	.73	-	
R	.62	.71	.81	.80	.35	.75	.82	.45	-
	M	T	J	B	O	W	D	A	R

A, aspen stands; B, bogs; D, open dunes; J, jack pine stands; M, moist deciduous woods; O, oak woods; R, red pine forest; T, cedar swamp; W, wet lowland hardwoods.



A, aspen stands; B, bogs; D, open dunes; J, jack pine stands; M, moist deciduous woods; O, oak woods; R, red pine forest; T, cedar swamp; W, wet deciduous hardwoods.

Figure 7. Two-dimensional ordination of vegetation associations on the basis of *x* and *y* coordinates.

FLORISTIC COMPARISON WITH OTHER LAKE MICHIGAN DUNE AREAS

The flora of other dune areas around Lake Michigan in Wisconsin (Van Denack, 1961), Indiana (Peattie, 1930), and Leelanau Co., Michigan (Thompson, 1967) can be compared to the Nordhouse flora. A quantitative comparison among these areas, however, is not practical due to differences in the size of each area and the scope of each study. Thompson (1967) limits his study to only the common plants of a large portion of Leelanau Co. to which he refers as the "Sleeping Bear Region". Infrequent species which might also be found at Nordhouse would be excluded from this list. Van Denack's study (1961) of a low relief dune complex near Two Rivers, Wisconsin lists only those species encountered during ecological sampling. Rare species missed during sampling would not be listed, so an accurate floristic comparison with Nordhouse is not possible. Peattie's flora (1930) of Indiana dunes is most similar in its scope to the Nordhouse Dunes study. His total flora, however, consists of over 1,300 species, which is far too large for any significant quantitative comparison with the 350 species found at Nordhouse.

The habitats common to all Lake Michigan dunes are the beach, foredune and open sand. Several species from these habitats are common to each area mentioned above (Peattie, 1930; Van Denack, 1961; Thompson, 1967) and to Nordhouse. The common grasses and sand binders are *Ammophila breviligulata, Andropogon scoparious, Calamovilfa longifolia, Koeleria macrantha, Arctostaphylos uva-ursi, Cornus stolonifera, Lathyrus maritimus* and *Prunus pumila.* Other dune species include *Artemisia caudata, Cakile edentula, Campanula rotundifolia, Cirsium pitcheri, Juniperus communis, Shepherdia canadensis* and *Smilacina stellata.*

A possible climax forest for sand dunes is a rich *Acer saccharum* forest with herbs such as *Dryopteris marginalis, Allium tricoccum, Erythronium americanum, Trillium grandiflorum, Claytonia virginiana* and *Sanguinaria canadensis* (Fuller, 1934; Thompson, 1967). In the Nordhouse area, however, only a small upland site in sec. 26 SE¼ has a forest which partially resembles this climax. *Acer rubrum* characterizes the moist and lowland deciduous forests in the Nordhouse area. Climax vegetation, of course, is a function of local conditions. Perhaps the soils of the area are not rich enough to support an *Acer saccharum* forest and the growth of *Acer rubrum* was encouraged by the wet nature of the sand apron after logging. In contrast to the Nordhouse area, some perched dunes atop moraines at Sleeping Bear National

Lakeshore do support an *Acer saccharum* climax. Perhaps differences in geologic history accounts for this difference. The Nordhouse region is located on an old lake bed.

Another possible dune climax is an oak forest typical of dunes in Indiana as described by Cowles (1899) and Olson (1958). This forest is best represented in the Nordhouse area by the forest now occupying most of the Nipissing and Algoma dunes. Olson (1958) suggests that perhaps rapid podzolization is preventing the development of soils which would favor an *Acer saccharum* forest. In the Nordhouse area the oak forest appears to be succeeding to white pine. This trend would be more likely to continue at Nordhouse rather than in Indiana due to the importance of fire in maintaining the climax in Indiana (Harman, 1970) and a greater boreal influence at Nordhouse. On some local sites on the Algoma ridge, however, a forest association of *Acer rubrum, Fagus grandifolia* and *Betula papyrifera* has developed rather than an oak forest.

The model of sand dune succession and climax forests only describes a general pattern. The details of this pattern are a function of the local conditions of a given area. Although the Nordhouse Dunes region does not exhibit a "typical" dune climax, a succession from bare sand to forest has occurred and vegetation changes may still occur in the future. Whatever the case may be, four major areas, the open sand, wooded dune ridges and

the upland and lowland sites of the sand apron, will always be found in the Nordhouse region. Areas of open sand will continue to prevail due to shifting wind patterns and the wooded dune ridges will have a slightly different composition from the upland areas of the dune sand apron. The clay pan will continue to provide wet areas on which a forest distinct from the upland areas of the sand apron will develop.

LIFE-FORM SPECTRA

The life-spectrum of all species found in the Nordhouse Dunes study area is compared with other Michigan areas in Table 18. The percentages for each life-form are compatible with these studies, although the Nordhouse area exhibits an unusually high phanaerophyte percentage compared to the rest of Michigan. Thieret (1977) suggests that Michigan follows the general pattern of decreasing phanaerophyte values with increasing latitude. The large phanaerophyte percentage in Keweenaw Co. was explained as the result of a propensity for botanists to collect this life-form. There is no reason, however, to suspect that this bias should be restricted to Keweenaw Co. The use of the relevé method in the Nordhouse area would have minimized this bias because it forced the complete examination of sample plots for all species regardless of life-form.

The transition zone conditions found in the Nordhouse area might be one reason for the high phanaerophyte values. This transition between the northern pine and southern deciduous forests is called the tension zone by Potzger (1948). His final criterion for defining this zone was the nature of the presettlement forest. If the

TABLE 18.--Life-form Spectrum for the Nordhouse Dunes Study Area, the Normal Spectrum and Spectra for Other Areas in Michigan

Region	Ph	Ch	H	Cr	Th
Normal* (Raunkier, 1934)	46.0	9.0	26.0	6.0	13.0
Michigan (Thieret, 1977)	14.2	2.2	51.6	22.1	9.2
Berrien Co. (Thieret, 1977)	15.1	1.9	50.4	21.3	11.2
Keweenaw Co. (Thieret, 1977)	17.5	2.7	49.3	25.5	4.8
Manistee National Forest (Mustard, 1979)	16.3	3.8	52.6	20.3	7.0
Nordhouse Dunes (this paper)	21.1	4.6	48.9	20.3	5.1

Ph (Phanaerophytes) - Perennial shoots or buds in air well over 25 cm.

Ch (Chamaephytes) - Perennial shoots or buds on ground surface to 25 cm above surface.

H (Hemicryptophytes) - Perennial shoots or buds close to the ground surface.

Cr (Cryptophytes) - Buds buried in the ground on a bulb or rhizome.

Th (Therophytes) - Annuals, survive unfavorable periods as seeds. Complete life cycle from seed to seed in one season.

*Based on 1000 randomly selected world species.

area was exclusively pine at the time of the GLOS survey, it was considered northern. Largely deciduous forests were treated as southern. The tension zone occurred where a mixed forest of deciduous and coniferous species existed in "tension" with each other. The GLOS records, as described earlier, does suggest that such a mixed presettlement forest occurred in the Nordhouse area.

Present botanical evidence also suggests that transition conditions occur at Nordhouse. Among the plants present which Ruthven (1912) listed as southern species are *Quercus velutina* and *Sassafras albidum*. Other species in the Nordhouse flora well north of their centers of distribution are *Nyssa sylvatica, Rhus copallinum* and *Cephalanthus occidentalis* (Little, 1977). Northern indicators in the Nordhouse flora listed by Ruthven (1912) include *Lycopodium complantum, Polypodium vulgare, Thelypteris phegopteris, Pinus banksiana, P. resinosa, Picea mariana, Tsuga canadensis, Taxus canadensis, Salix glaucophylloides, Comptonia peregrina, Deschamsia flexuosa* and *Clintonia borealis*. These lists of northern and southern indicators found at Nordhouse are rich in phanaerophytes, but may not be exhaustive. Several non-phanaerophyte species, even sedges, might also be listed as northern indicators, but may not have been included since these species are not as conspicuous or as widely known as those species that were listed.

RECOMMENDATIONS AND CONCLUSIONS

The Nordhouse Dunes should remain as one of Lower Michigan's largest undeveloped sand dune areas since it provides outstanding ecological, educational and recreational opportunities. A wilderness here, buffered by Ludington State Park and National Forest land, would not only protect threatened species such as *Cirsium pitcheri*, but would also permit the preservation of an assortment of vegetation associations. From such an area we can begin to study and understand its complexity and perhaps even measure the impact of human disturbance on other dune areas.

Preserving the intrinsic beauty of the Nordhouse area provides the rare opportunity for primitive recreation in an unspoiled environment. The natural character of the Nordhouse Dunes attracts hikers and cross-country skiers during the various seasons of the year. Occasional hunting and camping also occur. As the popularity of this area increases, the danger of its overuse and the subsequent deterioration of its quality will also increase. The pristine nature of the area which draws users should be protected, but much of this protection depends on the users themselves. The Forest Service should make every

effort to explain the fragile character of dune ecosystems in order to encourage intelligent non-motorized use of the area by the public.

Although overuse by hikers and campers will ruin any dune area, the recreational use by ORVs will surely destroy irreplaceable dune formations through erosion, compaction and destruction of the vegetation. Fortunately, the Nordhouse Dunes are showing a remarkable recovery since ORV use was banned seven years ago. Frequent pedestrian use of the area should insure that ORV use remains insignificant. Still some illegal motor vehicle activity occurs in the spring and fall when fewer people are present to report such activity. Unfortunately, in winter snowmobiles have easy access to the area. A wilderness, by definition, must be free of motorized vehicles. The best deterrent to ORV use in the Nordhouse area would be a strict enforcement of this policy by the Forest Service. Private land owners in the area could help by reporting any ORV activity to Forest Service officials.

The Nordhouse Dunes also have educational as well as recreational uses. Watson (1976) has suggested that the area can be used as an outdoor laboratory to demonstrate soil formation and illustrate post-glacial lake history. High school and college classes in geology, ecology and botany could observe the diversity of dune formations, habitats and plant species while on field trips

to the area. Knowledge and appreciation of the value of the Nordhouse area could be extended by studies on the birds, fungi, bryophytes and various other groups of organisms of the area.

Crispin (1980) has stressed the importance of preserving representative ecosystems as natural areas to save the diversity of Michigan's natural heritage for future generations. This thesis provides the first botanical inventory for any of Michigan's RARE II areas since they were reviewed by the Forest Service. Additional botanical studies of other RARE II areas, natural areas and wilderness areas in Michigan are needed.

CATALOGUE OF VASCULAR PLANTS

The catalogue of vascular plants of the Nordhouse Dunes study area consists of 75 families, 230 genera and 350 species. Thirty-nine species (11%) are introduced. This list adds 173 new species to the flora of Manistee National Forest which are not included in Mustard's list (1979) of 364 species. The dune habitat at Nordhouse is most responsible for these additional species. The systematic arrangement of this list follows Cronquist, et al. (1966) for the gymnosperms and lower vascular plants and Cronquist (1968) for angiosperms. Genera and species are arranged alphabetically within each family. Nomenclature generally follows Mickel (1979) for ferns and their allies, Voss (1972) for gymnosperms and monocots and Gleason and Cronquist (1963) for dicots. When known, flowering dates based on observations during the fieldwork for this thesis are placed in parentheses. Abundance estimates follow Voss (1972) as follows:

> Rare: occurring in small numbers wherever found and often absent in the expected habitats.
> Local: occurring in a very restricted habitat or region, but may be common when found.
> Occasional: Sporadic in occurrence throughout the region.
> Frequent: intermediate in abundance between occasional and common; likely to be found if one looks for it.
> Common: widespread and reasonably plentiful throughout its range in appropriate habitats,

where easily found.
Abundant: very common, likely to form dense stands.

All collection numbers are my own. One species, *Asclepias incarnata*, was not collected because sufficient material was not available to make specimens.

The four largest families are the Compositae with 21 genera, 33 species; the Gramineae with 19 genera, 29 species; the Cyperaceae with 6 genera, 32 species; and the Rosaceae with 10 genera, 23 species. Large genera include *Carex* (22), *Salix* (7), *Potentilla* (6), *Solidago* (6), *Aster* (5), and *Viola* (5).

Sixty-one species of gymnosperms and monocots not recorded for Mason County (Voss, 1972) were collected. Some of these new records must reflect the limited botanical collections previously made in the county since common grasses such as *Agropyron repens* and *Phleum pratense* had been overlooked by previous collectors and only seven of the 32 species of Cyperaceae collected during this study had been previously collected in Mason County. An important range extension is noted for the western disjunct *Goodyera oblongifolia*. Previously, its southern extent had been recorded as Manistee County (Voss, 1972). This study also fills some gaps in the distributions of *Pinus resinosa, Elymus canadensis, Carex crinita, C. trisperma* and *Cyperus schweinitzii*.

Cirsium pitcheri (Pitcher's thistle), a Great Lakes endemic which grows only on sand dunes, is listed as

threatened in Michigan (Wagner et al., 1977). The local abundance of *C. pitcheri* on the slightly stablized dunes is especially encouraging since much of this area had received intensive ORV impact. Three rare Michigan species (Wagner et al., 1977) occurring in the study are *Chimaphila maculata* (Spotted wintergreen), *Cypripedium arietinum* (Ram'shead lady-slipper) and *Rotala ramosior* (Tooth cup). *Chimaphila* and *Cypripedium* are found in the jack pine stands. *Rotala* grows on the mudflats around Nordhouse Lake.

A complete flora of the Nordhouse Dunes has its beginnings with this paper. Future collectors may find several species which might have been overlooked during this study or species which have yet to migrate into the area. *Comandra umbellata, Asclepias tuberosa* and *Orobanche fasciculata* have been found just north of the study area, but have yet to be included in this checklist.

Lycopodiophyta
Lycopodiales

LYCOPODIACEAE

Lycopodium clavatum L. Frequent in moist deciduous woods. 946.

Lycopodium complanatum L. Frequent in moist deciduous woods. 945.

Lycopodium lucidulum L. Local under sugar maples in moist deciduous woods of sec. 26. 978.

Lycopodium obscurum L. Frequent in moist deciduous woods and aspen stands. 919.

Equisetophyta
Equisetales

EQUISETACEAE

Equisetum arvense L. Common in moist jack pine stands and between foredune and wooded slope. 859, 908.

Equisetum hyemale L. Common in moist jack pine stands and between the foredune and wooded slope. 858, 909.

Equisetum sylvaticum L. Frequent in moist to wet shaded areas. 370, 837.

Polypodiophyta
Ophioglossales

OPHIOGLOSSACEAE

Botrychium matricariaefolium (Döll) A. Braun. Rare, only found in moist deciduous woods. 849.

Botrychium simplex E. Hitchc. Local in wet lowland hardwoods. 589.

Botrychium virginianum (L.) Sw. Frequent in moist deciduous woods, cedar swamp and on wooded bank behind foredune. 584, 815, 824.

Filicales

OSMUNDACEAE

Osmunda cinnamomea L. Common in both moist and wet woods and bog edges. 439, 478, 582.

Osmunda claytoniana L. Rare, only found in wet lowland hardwoods. 775.

Osmunda regalis L. Frequent along bog edges. 479, 797.

POLYPODIACEAE

Adiantum pedatum L. Rare. One small population found in moist deciduous forest south of meadow. 933.

Athyrium filix-femina (L.) Roth. Frequent in moist to wet woods and open sites. 805.

Cystopteris bulbifera (L.) Bernh. Local in south end of cedar swamp. 992.

Dryopteris intermedia (Muhl. ex Willd.) A. Gray. Frequent in moist deciduous woods and on hummocks in wet sites. 982.

Dryopteris spinulosa (O.F. Muell.) Watt. Frequent in moist deciduous woods and on hummocks in wet sites. 703, 768.

Gymnocarpium dryopteris (L.) Newm. Occasional in wet sites in moist deciduous woods and cedar swamp. 422, 771, 880.

Matteuccia struthiopteris (L.) Todaro. Occasional in wet woods east of Nordhouse Lake. 867.

Onoclea sensibilis L. Common in shady moist and wet sites. 947.

Polypodium virginianum L. Rare. One small patch found on wooded slope behind foredune. 921.

Pteridium aquilinum(L.) Kuhn. Abundant herbaceous cover in oak woods, roadsides and open sites. 443, 590, 776.

Thelypteris palustris Schott. Common on edges of ponds and wet areas. 803, 823.

Thelypteris phegopteris (L.) Slosson. Local on hummocks in wet woods east of Nordhouse Lake. 881.

Thelypteris noveboracensis (L.) Nieuwl. Frequent in moist deciduous woods. 822, 903.

Woodwardia virginica (L.) J. E. Smith. Common on bog and pond edges. 932.

Pinophyta
Coniferales

PINACEAE

Larix laricina (DuRoi) K. Koch. Frequent in bogs. 799.

Picea mariana (Mill.) BSP. Occasional in bogs. 955.

Pinus banksiana Lamb. Abundant on low relief dunes and old dune ridges. 793.

Pinus resinosa Ait. Abundant in plantations and around bogs of the marginal sand apron. 940.

Pinus strobus L. Common as understory in oak woods and frequent in red pine forests. 918.

Tsuga canadensis (L.) Carr. Frequent in moist deciduous woods and cedar swamp. 716.

CUPRESSACEAE

Juniperus communis L. Common at the border of forests with blowouts and open sand. 632.

Thuja occidentalis L. Common in moist sites such as cedar swamps, some jack pine stands and in the trough between the foredune and wooded slope. 795.

TAXACEAE

Taxus canadensis Marsh. Rare. Only small clumps protected by logs in the deciduous forest islands on the dunes of sec. 33. 760.

Magnoliophyta
Magnoliopsida
Magnoliidae
Magnoliales

LAURACEAE

Sassafras albidum (Nutt.) Nees. Frequent throughout oak woods and around edges of the meadow and Nordhouse Lake. 920, 996.

Ranunculales

RANUNCULACEAE

Actaea alba (L.) Mill. (late May-early June) Occasional in moist deciduous vegetation islands on the dunes near Lake Michigan. 395, 968.

Anemone canadensis L. (early June-early Sept.) Local in moist shaded sites around Nordhouse Lake. 617, 622, 695.

Aquilegia canadensis L. (late May-late June) Local on wooded bank behind foredune. 399.

Caltha palustris L. (mid May-early June) Occasional in standing water of alder thickets and small streams. 301, 338.

Coptis trifolia (L.) Salisb. (early-late May) Local in cedar swamp. 320, 375.

Hepatica americana (DC.) Ker. Local in rich deciduous woods of sec. 26. 588.

Ranunculus recurvatus Poir. (early-late June) Local on edge of vernal pond at end of Algoma trail, sec. 27 NE. 342, 994.

BERBERIDACEAE

Berberis thunbergii DC. Rare on foredune sec. 27. 913.

Hamamelidae
Hamamelidales

HAMAMELIDACEAE

Hamamelis virginiana L. Frequently scattered through oak woods. 400, 925.

Urticales

URTICACEAE

Pilea pumila (L.) Gray. Frequent in cool, shaded, wet sites. 704, 949.

Myricales

MYRICACEAE

Comptonia peregrina (L.) Coult. Occasional in sandy, disturbed sites such as roadsides and clear-cuts. 408, 519.

Myrica gale L. Local in Lost Lakes bog-swamp. 796, 988.

Fagales

FAGACEAE

Fagus grandifolia Ehrh. Common in moist deciduous woods. 784.

Quercus alba L. Common on wooded dune ridges. 956.

Quercus borealis Michx. f. Common on wooded dune ridges and occasional in moist deciduous woods. 916.

Quercus velutina Lam. Common on old dune ridges. 365, 922, 957

BETULACEAE

Alnus rugosa (Du Roi) Spreng. Abundant in lowland sites on marginal sand apron, often forming dense stands. 885, 924.

Betula alleghaniensis Britt. Frequent in cedar swamp and near bog edges. 792.

Betula papyrifera Marsh. Common in both moist and wet deciduous woods. 327, 391, 783.

Ostrya virginiana (Mill.) K. Koch. Rare,in an open site along wooded bank behind foredune. 729, 917.

Caryophyllidae
Caryophyllales

MOLLUGINACEAE

Mollugo verticillata L. (Aug.) Local on mud flats of Nordhouse Lake. 842.

CARYOPHYLLACEAE

Arenaria serpyllifolia L. (mid May-late June) Common along roadsides. 334, 380, 389, 441.

Cerastium fontanum Baumg. (late June-mid July) Common in open sites and roadsides. 461, 473, 531.

Dianthus armeria L. (late June-mid Aug.) Local along old powerline clearing. 726.

Silene antirrhina L. (July) Occasional in old powerline clearing and roadsides. 458, 662.

Silene alba (late June-mid July) Local in open roadsides. 565.

Stellaria media (L.) Cyrill. (late June-mid July) Local in very moist shady sites of Nipissing trail. 415.

Polygonales

POLYGONACEAE

Polygonella articulata (L.) Meissn. (Sept.) Frequent on stabilized sand dunes and in local upland sites on the marginal dune apron near the bogs. 812, 928, 965.

Polygonum natans Eat. (mid July-late Aug.) Common in pools and at Nordhouse Lake. 699, 841, 876.

Polygonum punctatum Ell. (late Aug.-early Sept.) Local in alder thickets. 878, 936.

Rumex acetosella L. (mid May-mid July) Common in aspen woods and open sites 355, 419, 423, 444, 482a, 606, 620.

Rumex crispus L. Local in moist open sites. 567, 623.

Rumex obtusifolius L. Occasional in moist deciduous woods. 720.

Dilleniidae
Theales

GUTTIFERAE

Hypericum canadense L. Local in moist depressions along old powerline clearing. 719.

Hypericum kalmianum L. (mid July-early Aug.) Frequent in meadow and along foredune. 633, 652, 698, 753.

Hypericum perforatum L. (late June-late July) Roadsides and other open sites. 521, 667.

Triadenum virginicum (L.) Raf. (mid July-late Aug.) Frequent at edges of ponds and bogs. 879.

TILIACEAE

Tilia americana L. Rare tree in rich deciduous woods. Associated with sugar maples. One tree, however, was found in a very small deciduous vegetation island of secs. 33 and 34. 882.

Sarraceniales

DROSERACEAE

Drosera rotundifolia L. (mid-late Aug.) Rare on mossy logs and stumps where small stream crosses old power-line clearing near cedar swamp. 804.

Violales

VIOLACEAE

Viola affinis LeConte (May) Rare in moist deciduous woods. 353.

Viola cucullata Ait. (May) Common in cool shady, wet sites. 304, 307, 322, 343.

Viola pallens (Banks) Brainerd. (May) Local in alder thickets and cedar swamp. 306, 321, 374.

Viola pubescens Ait. (May) Rare in wet woods. 340.

Viola sagittata Ait. (May) Local in very wet deciduous woods or meadow edges. 303, 315.

CISTACEAE

Helianthemum canadense (L.) Michx. (June) Occasional in open sites and oak woods. 501.

Hudsonia tomentosa Nutt. (mid June-early July) Occasional on open dunes behind foredune or near jack pines. 465.

Salicales

SALICACEAE

Populus balsamifera L. Occasional on foredune. 890.

Populus deltoides Marsh. Common on dunes near jack pines and around Nordhouse Lake. 758, 791, 838, 839.

Populus grandidentata Michx. Common in woods and at wood edges and roadsides. 328.

Populus tremuloides Michx. Occasional along roadsides and ponds in wet lowland hardwoods. 836.

Salix cordata Michx. Occasional on foredune near wooded slope. 407a.

Salix discolor Muhl. Frequent in jack pine stands. 754.

Salix glaucophylloides Fern. Frequent on dune pannes. 407, 853.

Salix interior Rowlee. Common on foredune and dune pannes. 390, 525, 860.

Salix rigida Muhl. Occasional along roadsides. 832.

Salix pedicellaris Pursh. Occasional along roadsides. 835.

Salix petiolaris Sm. Local in meadow. 650.

Capparales

CRUCIFERAE

Arabis lyrata L. (early May-late Aug.) Common on open dunes and along some roadsides. 329, 335, 433, 750, 892.

Barbarea vulgaris R. Br. (May) Occasional along roadsides. 331.

Berteroa incana (L.) DC. (late May-early June) Occasional along roadsides. 451, 556.

Cakile edentula (Bigel.) Hook. (mid July- late Aug.) Common on open flat sand especially between strand and foredune. 733, 861.

Lepidium campestre (L.) L. Br. (mid May-mid June) Occasional along roadsides. 330, 388.

Nasturtium officinale R. Br. Local in moist spot on old powerline clearing near cedar swamp. 990.

Ericales

ERICACEAE

Andromeda glaucophylla Link. Locally scattered in bogs of sec. 25. 958.

Arctostaphylos uva-ursi (L.) Spreng. (May) Common mat former on dunes near jack pines and other woody vegetation. 336, 759.

Chamaedaphne calyculata (L.) Moench. (late April-mid May) Abundant in bogs and open low places. 317, 325.

Epigaea repens L. (late April-early May) Common in oak woods. 300.

Gaultheria hispidula (L.) Muhl. Rare on logs in the cedar swamp and in the boundary clearing on its south side. 995.

Gaultheria procumbens L. (mid July-mid Aug.) Common throughout all forests, but absent in very wet sites. 585, 772.

Gaylussacia baccata (Wang.) K. Koch. Abundant in oak woods. 364, 810, 847, 901.

Vaccinium angustifolium Ait. Abundant in moist depressions, oak woods, and bogs. 316, 326, 599, 653, 900.

Vaccinium macrocarpon Ait. Occasional in *Sphagnum* depressions of bogs and jack pine stands. 845, 863.

Vaccinium myrtilloides Michx. (mid June-early July) Wet woods and moist open depressions. 596.

Vaccinium oxycoccus L. Local in bogs of sec. 25. 657.

PYROLACEAE

Chimaphila maculata (L.) Pursh. (late July-mid Aug.) Rare. Only found in jack pine stands. 855.

Chimaphila umbellata (L.) Bart. (late July-mid Aug.) Local in jack pine stands. 798.

Moneses uniflora (L.) Gray. (June) Rare. Small station observed in jack pine stand in sec. 33 and one individual along the wooded bank behind the foredune of sec. 27. 987.

Pyrola asarifolia Michx. (July) Occasional in moist deciduous woods. 563, 573.

Pyrola elliptica Nutt. (July) Local in jack pine stands. 740, 866.

Pyrola secunda L. (July) Occasional in woods edge just bordering open sand. 578.

MONTROPACEAE

Monotropa hypopithys L. (early June-mid Aug.) Common in moist deciduous woods. 523, 587, 875.

Monotropa uniflora L. (early July-mid Aug.) Common in moist deciduous woods. 586.

Primulales

PRIMULACEAE

Lysimachia lanceolata Walt. (mid July-early Aug.) Common in moist, open sites. 616, 647.

Lysimachia thyrsiflora L. (late June-early July) Frequent in open wet sites and alder thickets. 471, 669.

Trientalis borealis Raf. (mid May-late June) Common in moist deciduous woods and red pine woods at bog edges. 351.

Rosidae
Rosales

GROSSULARIACEAE

Ribes cynosbati L. Local in woods bordering open sand. 711.

SAXIFRAGACEAE

Mitella nuda L. (June) Locally scattered throughout cedar swamp. 376.

ROSACEAE

Amelanchier laevis Wieg. (May) Common in open woods near trails and roads. 310, 318, 610, 655.

Aronia prunifolia (Marsh.) Render. Frequent on edges of bogs and other wet sites. 385, 800, 847a, 926.

Fragaria virginiana Duchesne. (mid May-early June) Common on open ground and on wooded bank behind foredune. 305, 313, 382, 397, 534.

Geum aleppicum Jacq. Rare in woods just south of meadow. 773.

Potentilla anserina L. (late July-late Aug.) Occasional along edges of dune pools. 757.

Potentilla argentea L. (July) Frequent in open sites and roadsides. 492, 555, 659.

Potentilla norvegica L. (late July-mid Aug.) Occasional in moist sites in oak woods near dunes. 459.

Potentilla palustris (L.) Scop. Local on edges of ponds. 782.

Potentilla recta L. (July) Common along roadsides. 551.

Potentilla simplex Michx. (June) Common in grassy areas near Nordhouse Lake and meadow. 354, 427.

Prunus pensylvanica L. f. (late June-early July) Local on bank behind foredune. 728.

Prunus pumila L. (mid May-early June) Common on and near foredune. 337, 356, 723.

Prunus serotina Ehrh. (late May-mid June) Local in moist deciduous woods and edges of open sites. 854, 856.

Prunus virginiana L. (June) Frequent on edges of blowouts and jack pine stands. 360, 405, 790.

Rosa acicularis Lindl. (July) Local in grassy sites south of Nordhouse Lake. 611.

Rosa blanda Ait. (July) Local on foredune. 540.

Rosa palustris Marsh. (mid Aug.-early Sept.) Rare on edge of marsh. 886.

Rubus arundelanus Blanchard. Frequent on open grassy sites near Nordhouse Lake and meadow. 506, 787.

Rubus flagellaris L. Frequent on edges of open sites. 505.

Rubus hispidus L. (mid July-early Aug.) Common in wet sites and bogs. 541, 572, 597, 898.

Rubus strigosus Michx. Occasional in jack pine stands. 851.

Sorbus americana Marsh. Local in wet lowland woods. 931.

Spiraea latifolia (Ait.) Borkh. Local in meadow. 651.

LEGUMINOSAE

Lathyrus maritimus (L.) Bigel. (mid June-late July) Common on foredune and grassy dunes. 539, 755.

Medicago lupulina L. (early June-early July) Common along roadsides. 387, 516.

Melilotus alba Desr. (early July-late Aug.) Frequent on roadsides. 566.

Trifolium pratense L. (July) Occasional along roadsides. 636.

Trifolium repens L. (late June-late July) Frequent along roadsides and in shaded two-tracks. 425, 475, 547.

Vicia villosa Roth. (Sept.) Rare along roadsides. 969.

Myrtales

LYTHRACEAE

Rotala ramosior (L.) Koehne. (mid July-mid Aug.) Local on mud flats of Nordhouse Lake. 692.

ONAGRACEAE

Circaea alpina L. (late June-mid July) Common in moist to wet shaded sites. 412, 490, 528.

Oenothera biennis L. (mid July-early Sept.) Common in open sites and on foredune. 732, 889, 893.

Oenothera perennis L. (late June-mid Aug.) Frequent in open sunny sites. 456, 648, 763, 888.

Proteales

ELEAGNACEAE

Shepherdia canadensis (L.) Nutt. Local in shade of wooded bank behind foredune. 538.

Cornales

NYSSACEAE

Nyssa sylvatica Marsh. Local in moist deciduous woods and roadsides. 831.

CORNACEAE

Cornus canadensis L. (mid May-late June) Common in moist deciduous woods and red pine woods. 348, 413, 484, 781.

Cornus stolonifera Michx. (mid July-mid Aug.) Common in moist open sites, meadow and foredune. 362, 403, 788.

Celastrales

AQUIFOLIACEAE

Ilex verticillata (L.) Gray. (July) Occasional on pond edges and wet woods. 595, 598.

Nemopanthus mucronatus (L.) Trel. (May) Abundant surrounding bogs and other wet places. 309, 319, 654, 656.

EUPHORBIACEAE

Euphorbia polygonifolia L. (late July-mid Aug.) Occasionally forming a rosette on bare sand. 891.

Rhamnales

VITACEAE

Vitis riparia Michx. (late May-mid June) Common trailing on foredune and climbing on trees bordering open sand. 526, 722.

Sapindales

ACERACEAE

Acer rubrum L. Abundant in moist deciduous woods and wet lowland hardwoods. 786, 981.

Acer saccharum Marsh. Local in moist deciduous woods. 973, 984.

Acer spicatum Lam. Local in very moist woods near Nordhouse Lake. 848, 944.

ANACARDIACEAE

Rhus copallinum L. Rare. One small tree found beside Nurnburg Rd. 954.

Toxicodendron rydbergii (Small ex Rydberg) Greene. Common on foredune and wooded bank behind it. 972.

Geraniales

OXALIDACEAE

Oxalis stricta L. (early July-early Aug.) Local in moist woods near Nordhouse Lake. 621.

Linales

LINACEAE

Linum virginianum L. Local in moist jack pine stands. 850.

Polygalales

POLYGALACEAE

Polygala paucifolia Willd. (May) Common in moist deciduous woods, shaded bank behind foredune and cedar swamp. 302, 314, 324.

Umbellales

ARALIACEAE

Aralia hispida Vent. Local in open sites along FR 5356. 904.

Aralia nudicaulis L. (late May-early June) Occasional in woods bordering open dunes. 394, 712.

UMBELLIFERAE

Cicuta bulbifera L. (mid Aug.-early Sept.) Occasional in wet sites in moist deciduous woods. 762.

Cryptotaenia canadensis (L.) DC. Local in wet lowland hardwoods near Nordhouse Lake. 502.

Daucus carota L. (late July-late Aug.) Common along roadsides. 661, 830.

Osmorhiza claytoni (Michx.) Clarke. Local in rich deciduous woods under sugar maples. 983.

Taenidia integerrima (L.) Drude. (early June-mid July) Frequent in open sites in oak woods. 381, 530.

Asteridae
Gentianales

GENTIANACEAE

Bartonia virginica (L.) BSP. Local in wet lowland hardwoods. 779.

Gentiana andrewsii Griseb. (Sept.) Rare. Only a few plants in moist area at foot of wooded bank behind foredune. 937.

APOCYNACEAE

Apocynum androsaemifolium L. (mid July-early Aug.) Local along roadsides. 658.

ASCLEPIADACEAE

Asclepias incarnata L. Rare. Only one plant found in a wet area along new powerline clearing.

Asclepias syriaca L. (July) Common in protected sites on dunes and along roadsides. 625, 682, 801.

Lamiales

BORAGINACEAE

Cynoglossum boreale Fern. (late May-early June) Occasional in deciduous woods near open dunes. 393, 628.

Lithospermum caroliniense (Walt.) MacMill. (late May-mid July) Common along foredune. 406, 529.

LABIATAE

Lycopus uniflorus Michx. (early July-late Aug.) Common in wet shaded areas. 717, 727, 774, 887.

Mentha arvensis L. (July) Local in open sites around Nordhouse Lake and meadow. 694.

Monarda fistulosa L. (mid July-mid Aug.) Frequent in open sites near foredune. 701, 731.

Monarda punctata L. (Aug.) Frequent on grassy dunes. 713.

Prunella vulgaris L. (July) Common in roadsides and other open sites. 421, 428, 482, 517, 546.

Satureja vulgaris (L.) Fritsch. Common in open sites. 467, 493, 672.

Scutellaria lateriflora L. Common in wet lowland hardwoods. 770, 806.

Stachys hyssopifolia Michx. (July) Local on banks of Nordhouse Lake. 696.

Plantaginales

PLANTAGINACEAE

Plantago lanceolata L. Occasional along open roadsides. 462, 496.

Plantago rugellii Decne. Occasional along open roadsides. 462a, 495.

Scrophulariales

OLEACEAE

Fraxinus pennsylvanica Marsh. Frequent in both moist and wet deciduous woods and around Nordhouse Lake. 612.

SCROPHULARIACEAE

Melampyrum lineare Desr. (late June-late Aug.) Common in oak woods. 417, 518, 550.

Mimulus ringens L. (mid-late July) Local in wet sites in moist deciduous woods. 624.

Pedicularis canadensis L. (late May-mid June) Frequent in oak woods and wooded bank behind foredune. 344, 361, 398.

Verbascum thapsus L. (late July-late Aug.) Local in dry open sites. 721.

Veronica arvensis L. (mid May-early July) Local along roadsides. 557.

Veronica scutellata L. (July) Occasional in wet shaded sites. 470, 561, 645.

OROBANCHACEAE

Conopholis americana (L.) Wallr. Common in moist deciduous woods. 429, 488, 536.

Epifagus virginiana (L.) Bart. Common under beeches in moist deciduous woods. 840, 941.

Campanulales

CAMPANULACEAE

Campanula rotundifolia L. (late June-late July) Common on blowouts and foredune and in woods near open sand. 454, 577.

Lobelia cardinalis L. (Aug.) Local in wet lowland hardwoods and in old powerline clearing near cedar swamp. 807.

Lobelia kalmii L. (Aug.) Local on edges of dune pools. 736.

Lobelia spicata Lam. (July) Frequent in moist open grassy sites. 498, 618, 646.

Rubiales

RUBIACEAE

Cephalanthus occidentalis L. (Aug.) Local on edge of Nordhouse Lake. 829.

Galium pilosum Ait. (Aug.) Local in moist jack pine stands. 747.

Galium tinctorium L. Occasional in open wet sites. 600, 734.

Galium triflorum Michx. (June) Common in both moist and wet woods. 411, 442, 453, 477.

Houstonia canadensis Willd. (late May-late June) Common in moist open sites and surrounding woods. 352, 386, 420, 522.

Mitchella repens L. (early-mid July) Common in moist deciduous woods. 491, 874.

CAPRIFOLIACEAE

Diervilla lonicera Mill. (late June-mid July) Common in oak woods and base of wooded slope behind foredune. 463, 527.

Linnaea borealis L. (early June-mid July) Common near edges of open sand and moist areas in woods behind dune front. 392, 466.

Lonicera canadensis Marsh. Occasional on wooded bank behind foredune and in deciduous woods. 527, 976.

Lonicera dioica L. Occasionally growing among the shrubs on wooded bank behind the foredune. 396.

Viburnum acerifolium L. (June) Frequent in woods bordering open sand. 430, 524.

Viburnum cassinoides L. Common on edges of bogs and other wet areas. 895.

Asterales

COMPOSITAE

Achillea millefolium L. (mid June-early July) Local in open sites near dunes and jack pine stands. 414, 497.

Anaphalis margaritacea (L.) Benth. & Hook. (early Aug.-early Sept.) Frequent near foredune and in jack pine stands. 725, 843.

Antennaria plantaginifolia (L.) Richards. (May) Frequent in open sites. 311, 333.

Artemisia caudata Michx. (late July-Sept.) Common on open dunes and foredune. 814.

Aster laevis L. (Sept.) Common in moist open sites and jack pine stands. 915, 929, 966.

Aster lateriflorus (L.) Britt. (late Aug.-Sept.) Common in open moist sites and roadsides. 899, 934, 971.

Aster macrophyllus L. (Sept.) Common on wooded bank behind foredune. 910, 914.

Aster tradescanti L. (late Aug.-Sept.) Common in open, moist sandy sites near Nordhouse Lake and dune pools. 748, 862, 952, 967.

Aster vimineus Lam. (late Aug.-Sept.) Frequent in open sites. 844, 953, 964.

Bidens frondosa L. (late Aug.-Sept.) Occasional in wet open sites. 959.

Centaurea maculosa Lam. (early July-late Aug.) Abundant in open sites and along roadsides. 666, 730, 828.

Chrysanthemum leucanthemum L. (July) Frequent along roadsides. 553, 564.

Cichorium intybus L. (mid July-late Aug.) Frequent along roadsides. 826.

Cirsium pitcheri (Torr.) T. & G. (late June-Sept.) Frequent on slightly stabilized dunes near blowouts and foredune. 631.

Cirsium vulgare (Savi) Tenore. (Aug.) Occasional along roadsides and jack pine stands. 789, 834.

Erigeron strigosus Muhl. (late July-late Aug.) Frequent in open sites. 629, 724, 780.

Eupatorium perfoliatum L. (Aug.) Local in moist sand near dune pools. 756.

Hieracium aurantiacum L. (June) Common in open sites and along roadsides. 379, 418, 532, 549.

Hieracium canadense Michx. (late Aug.-early Sept.) Occasional in moist open areas. 764.

Hieracium venosum L. (late June-mid July) Common in open sites. 416, 615.

Hypochaeris radicata L. (late July-early Aug.) Local along roadsides. 660.

Krigia virginica (L.) Willd. (mid June-early July) Local along open trails. 345, 366.

Prenanthes alba L. (Sept.) Local in open moist sites of old powerline and foredune. 906, 961.

Rudbeckia hirta L. (Aug.) Rare on dune pannes. 735.

Senecio pauperculus Michx. (early July-early Aug.) Common in moist sandy soil. 457, 535, 697.

Solidago caesia L. (Sept.) Common in moist open sites. 911, 939, 960, 963, 970.

Solidago canadensis L. (late Aug.-early Sept.) Occasional on moist open dunes. 811.

Solidago graminifolia (L.) Salisb. (mid-late Aug.) Frequent by dune pools and pannes. 746.

Solidago nemoralis Ait. (Sept.) Common in moist open sites. 923, 927, 935, 951, 960a, 962.

Solidago rugosa Mill. (Sept.) Occasional along roadsides. 970.

Solidago spathulata DC. (Sept.) Frequent on foredune. 907, 912.

Taraxacum officinale Weber. (mid May-early June) Occasional along roadsides and in open sites. 312.

Tragopogon dubius Scop. (June) Frequent on open sites and along roadsides. 410, 520.

Liliopsida
Alismatidae
Alismatales

ALISMATACEAE

Alisma plantago-aquatica L. (mid July-early Aug.) Local on mud flats around Nordhouse Lake. 693.

Najadales

JUNCAGINACEAE

Triglochin maritimum L. Local on edges of dune pools. 741, 809.

POTAMOGETONACEAE

Potamogeton spirillus Tuckerm. Local in Nordhouse Lakes. 839.

Commelinidae
Juncales

JUNCACEAE

Juncus balticus Willd. Local in dune pools. 626, 742, 744.

Juncus brachycephalus (Engelm.) Buch. Common in wet open sites and roadsides. 464, 511, 644, 690, 827.

Juncus effusus L. Common in open wet sites. 460, 474, 509, 671.

Juncus tenuis Willd. Frequent in moist open sites. 487, 494, 673.

Cyperales

CYPERACEAE

Carex bebbii (Bailey) Fern. Occasional in moist woods. 676, 761.

Carex brunnescens (Pers.) Poir. Frequent in wet shaded sites. 670, 707.

Carex buxbaumii Wahl. Occasional in moist sites near open dune margin. 435.

Carex cephalantha (Bailey) Bickn. Frequent in moist sites of powerline clearing sec. 25. 476.

Carex crinita Lam. Common in wet open sites and edges of bogs and ponds. 379a, 440, 489, 583.

Carex cumulata (Bailey) Fern. Ditch along Nurnburg Rd. sec. 36. 508.

Carex eburnea Boott. Occasional in moist area between foredune and wooded bank. 581.

Carex emmonsii Dewey. Occasional in moist deciduous woods. 702.

Carex flava L. Frequent in moist open sites and near dune pools. 649, 749.

Carex folliculata L. Common in wet woods and bogs. 358, 367, 378, 452, 708.

Carex interior Bailey. Occasional in wet shaded sites. 373.

Carex intumescens Rudge. Common in bogs and wet open sites. 378a, 483, 604.

Carex lanuginosa Michx. Occasional in meadow. 560.

Carex laxiflora Lam. Common in moist sites between wooded bank and foredune and along roadsides. 576b, 580, 709.

Carex lupulina Willd. Common in open wet sites and alder thickets. 469, 602, 868.

Carex lurida Wahl. Frequent in moist woods and open sites. 672, 871.

Carex oligosperma Michx. Occasional in bogs. 665.

Carex pensylvanica Lam. Abundant on forested dune ridges. 974, 979.

Carex tenera Dewey. Abundant in moist open sites. 436, 486, 602a.

Carex trisperma Dewey. Occasional in moist shaded sites. 449, 718.

Carex tuckermanii Dewey. Local in moist to wet woods. 769, 930.

Carex viridula Michx. Local in grassy margin surrounding Nordhouse Lake. 950.

Cyperus schweinitzii Torr. Frequent on grassy dunes. 743.

Dulichium arundinaceum (L.) Britt. Frequent on pond edges and in wet deciduous woods. 825, 872.

Eleocharis acicularis (L.) R. & S. Local on mud flats of Nordhouse Lake. 688.

Eleocharis elliptica Kunth. Local in meadow and dune pools. 350, 985.

Eleocharis obtusa (Willd.) Schultes. Local on mud flats on Nordhouse Lake. 687.

Eleocharis smallii Britt. Local on mud flats of Nordhouse Lake. 942.

Eriophorum virginicum L. Common in bogs. 819.

Scirpus americanus Pers. Occasional in dune pools and wet areas of the open dunes of secs. 32 and 33. 852.

Scirpus atrovirens Willd. Common in bogs and wet open sites. 468, 569, 592, 663, 674.

Scirpus cyperinus (L.) Kunth. Common in pools and wet deciduous woods and bogs. 777, 813, 869b.

GRAMINEAE

Agropyron repens (L.) Beauv. Common in open sites and roadsides. 446, 500, 640.

Agropyron trachycaulum (Link) Malte. Frequent in clearcut. 515.

Agrostis hyemalis (Walt.) BSP. Frequent on dune pannes and near Nordhouse Lake. 689, 816.

Agrostis perennans (Walt.) Tuckerm. Frequent in moist open sites and roadsides. 614, 897.

Ammophila breviligulata Fern. Abundant on grassy dunes. 634.

Andropogon scoparius Michx. Frequent on grassy dunes. 818.

Brachyelytrum erectum (Roth) Beauv. Occasional in mixed deciduous woods. 706.

Bromus inermis Leysser. Common along roadsides. 383, 514, 544.

Calamagrostis canadensis (Michx.) Beauv. Common in wet open sites and bogs. 437, 543, 570, 638, 678, 817.

Calamovilfa longifolia (Hook) Scribn. Abundant on the foredune and recently stabilized dunes. 635.

Cinna latifolia (Goepp.) Criseb. Frequent in wet woods. 605, 870b.

Dactylis glomerata L. Common along roadsides. 450, 512.

Danthonia spicata (L.) R. & S. Common along roadsides and disturbed and open sites. 499, 507, 603, 641, 675.

Deschampsia flexuosa (L.) Beauv. Common along open trails and in oak woods. 363, 445, 480, 504, 568, 677.

Elymus canadensis L. Frequent on foredune and stable sand near woods. 714, 905.

Festuca saximontana Rydb. Frequent along open trails and roadsides. 545, 571.

Glyceria borealis (Nash) Batch. Frequent in wet shaded sites. 576, 870.

Glyceria canadensis (Michx.) Trin. Common in wet shaded sites and ponds. 601, 869a, 870a.

Koeleria macrantha (Ledeb.) Schultes Frequent on grassy dunes. 434, 820.

Oryzopsis pungens (Sprengel) Hitch. Occasional in oak woods. 448.

Oryzopsis asperifolia Michx. Common in moist deciduous woods. 559, 630, 681.

Panicum columbianum Scribn. Frequent in jack pine stands. 738.

Panicum lindheimeri Nash. Occasional in open two-tracks. 668.

Panicum meridionale Ashe. Occasional in open wet sites. 455.

Panicum praecocius Hitch. & Chase. Frequent in open area around Nordhouse Lake. 619, 684.

Panicum virgatum L. Common in open moist sites including dune pannes. 438, 503, 683, 739, 943.

Phleum pratense L. Frequent along roadsides and open sites. 447, 481, 513.

Poa compressa L. Common along trails and two-tracks. 472, 594, 639, 642, 664.

Setaria viridis (L.) Beauv. Occasional on roadsides. 833.

Spartina pectinata Link. Common in moist open sites on meadow and around Nordhouse Lake. 637, 686.

Typhales

TYPHACEAE

Typha angustifolia L. Abundant in marshes. 608, 705.

Arecidae
Arales

ARACEAE

Arisaema triphyllum (L.) Schott. (mid May-early June) Frequent in wet woods, moist shaded sites, and cedar swamp. 308, 323.

Calla palustris L. Local in bog-swamp near Lost Lakes. 980, 989.

LEMNACEAE

Lemna minor L. Local in ponds and alder thickets. 766.

Liliidae
Liliales

LILIACEAE

Clintonia borealis (Ait.) Raf. Occasional in moist deciduous woods. 821.

Erythronium americanum Der. Local in rich deciduous woods under sugar maples. 977.

Lilium philadelphicum L. (late June-early July) Rare. A few scattered plants found on foredune sec. 27. 537.

Maianthemum canadense Desf. (June) Occasional in deciduous woods bordering open sand. 401.

Medeola virginiana L. (early-late June) Frequent in moist deciduous woods and cedar swamp. 347, 371, 562.

Polygonatum pubescens (Willd.) Pursh. Occasional in moist deciduous woods. 346, 404.

Smilacina stellata (L.) Desf. Frequent in border zone between woods and open sand. 402.

Zigadenus glaucus (Nutt.) Nutt. (mid June-mid July) Frequent in protected sites near jack pine stands. 432, 533.

IRIDACEAE

Iris versicolor L. Frequent in open water of bogs, alder thickets and ponds. 431, 485, 574, 591, 609.

SMILACACEAE

Smilax hispida Torr. Occasional in moist deciduous woods. 767, 948.

Orchidales

ORCHIDACEAE

Corallorhiza maculata Raf. (late July-mid Aug.) Occasional in moist deciduous woods, cedar swamp and jack pine stands. 846, 865.

Corallorhiza trifida Chat. (late May-early June) Local in cedar swamp and on bank behind foredune. 372.

Cypripedium acaule Ait. (early May-early June) Frequent in oak woods. 357, 409.

Cypripedium arietinum R. Br. Local in jack pine stands. 751, 986.

Goodyera oblongifolia Raf. (late July-mid Aug.) Rare. Jack pine stands only. 864.

Goodyera pubescens (Willd.) R. Br. (late July-mid Aug.) Local in rich deciduous woods. 765.

Goodyera repens (L.) R. Br. (mid July-mid Aug.) Local in jack pine stands and cedar swamp. 808.

Habenaria clavellata (Michx.) Spreng. (mid July-mid Aug.) Occasional in wet deciduous woods. 902.

Habenaria hyperborea (L.) R. Br. (July) Local in trough between foredune and wooded bank. 575.

Habenaria lacera (Michx.) Lodd. (early July-early Aug.) Moist deciduous woods. 700.

Listera cordata (L.) R. Br. Rare only in cedar swamp. 991.

Spiranthes cernua (L.) Rich. (late Aug.-early Sept.) Rare. Cluster of plants found along Nurnburg Rd. 894.

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