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LANDSCAPE ECOSYSTEMS AND COVER TYPES OF THE RESERVE AREA AND ADJACENT LANDS OF THE HURON MOUNTAIN CLUB

by

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INTRODUCTION

The Huron Mountains, along and inland from the southern shore of Lake Superior, in the Upper Peninsula of Michigan (Figs. 1 and 2), exhibit a stunning diversity of hemlock-northern hardwood forest ecosystems, pine forests, and wetlands. A part of this magnificent mosaic of mountain and valley landscape was set aside in 1962 by the Huron Mountain Club as a Reserve Area. Both past and present accounts attest to the Area's importance as one of the prime examples of old-growth forest ecosystems in the Lake States region. The old-growth nature of the forest is emphasized by the presence of scattered individuals of very large size (Fig. 3).

Many mountains and nine lakes in addition to Lake Superior are within or adjacent to the Reserve Area. Terrestrial ecosystems in and around the Reserve range from the most rocky, dry, and exposed sites to forested swamps and marshes, a diversity of landscapes characteristic of many parts of the western half of Upper Michigan. Because logging was prevented or restricted in the Reserve, the forest and aquatic ecosystems are of special ecological interest and value.

The overall objective of our research was to identify, classify, and map the landscape ecosystem types of the Reserve Area and adjacent lands of special ecological interest (Fig. 2). The subdivision of this area into natural units provides a useful framework for research and management. In addition, the research provides detailed information on the biotic and physical diversity of the area. Our goal is to provide a system that expresses the interactive character of landscape ecosystems and their components of climate, physiography (landforms and water bodies), soil, plants, and animals. In addition to our primary effort in distinguishing landscape ecosystems, we have also mapped the existing vegetative cover types.

This research continues the long tradition of the Huron Mountain Club in furthering research in natural history and the biological and physical sciences. We believe that these maps and associated materials, as well as subsequent publications, will further research and provide a better understauding of the biotic and physical diversity of the area.

The Reserve Area

The history of the Reserve provides insights into the uniqueness of the area and the commitment of the Huron Mountain Club to conservation, as well as into research in biological and physical sciences. The Club, initiated as the Huron Mountain Shooting and Fishing Club in 1889, developed its holdings to approximately 18,000 acres along the southern shore of Lake Superior in Marquette County of Michigan's Upper Peninsula. In 1925, the Conservation Committee was established and represented the first formal commitment to preservation and management of the property. In 1929, the Conservation Committee elucidated the spirit of Club members that over the ensuing 50 years has fostered

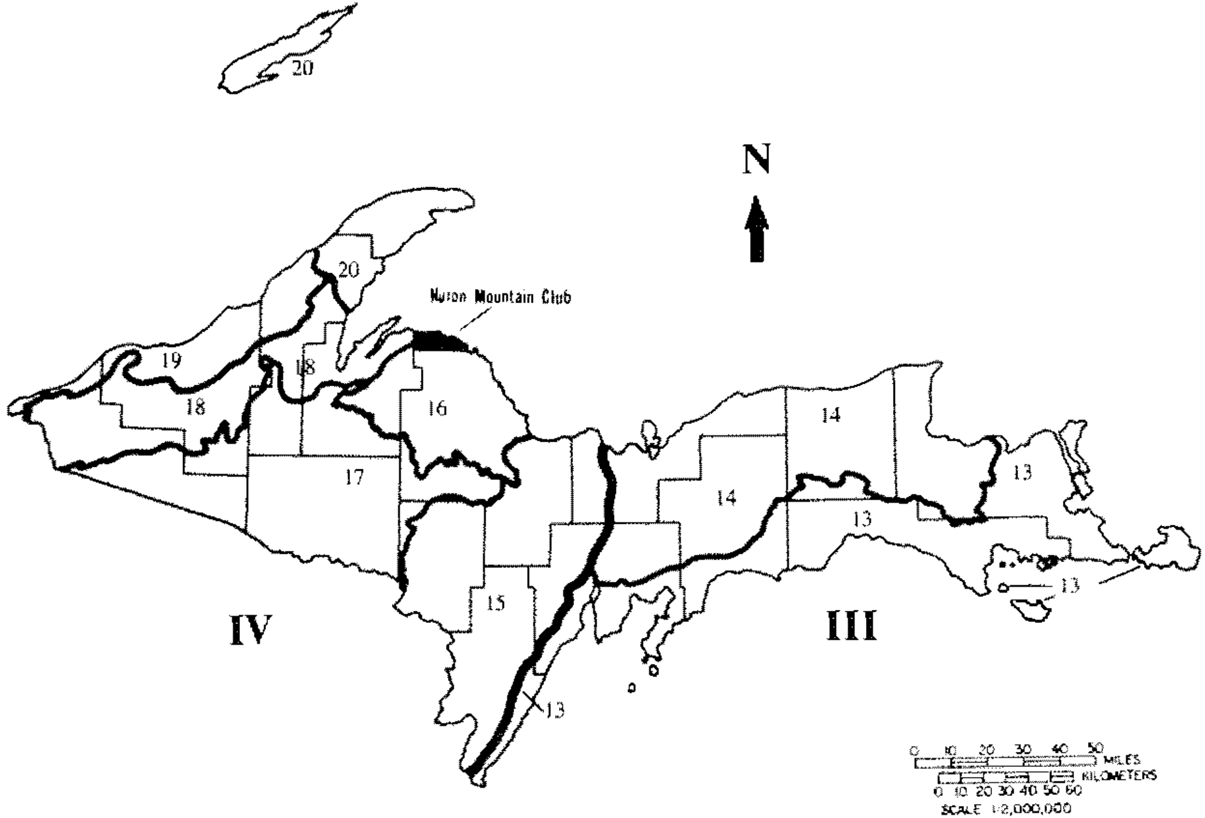

Fig. 1. Regional Landscape Ecosystems of Upper Michigan--showing the locations of Regions and Districts (modified from Albert et al. 1986). Regions: III--Eastern Upper Michigan, IV--Western Upper Michigan. Arabic numbers refer to Districts: 13--Mackinac, 14--Luce, 15--Dickinson, 16--Michigamme, 17--Iron, 18--Bergland, 19--Ontonagon, 20--Keweenaw.

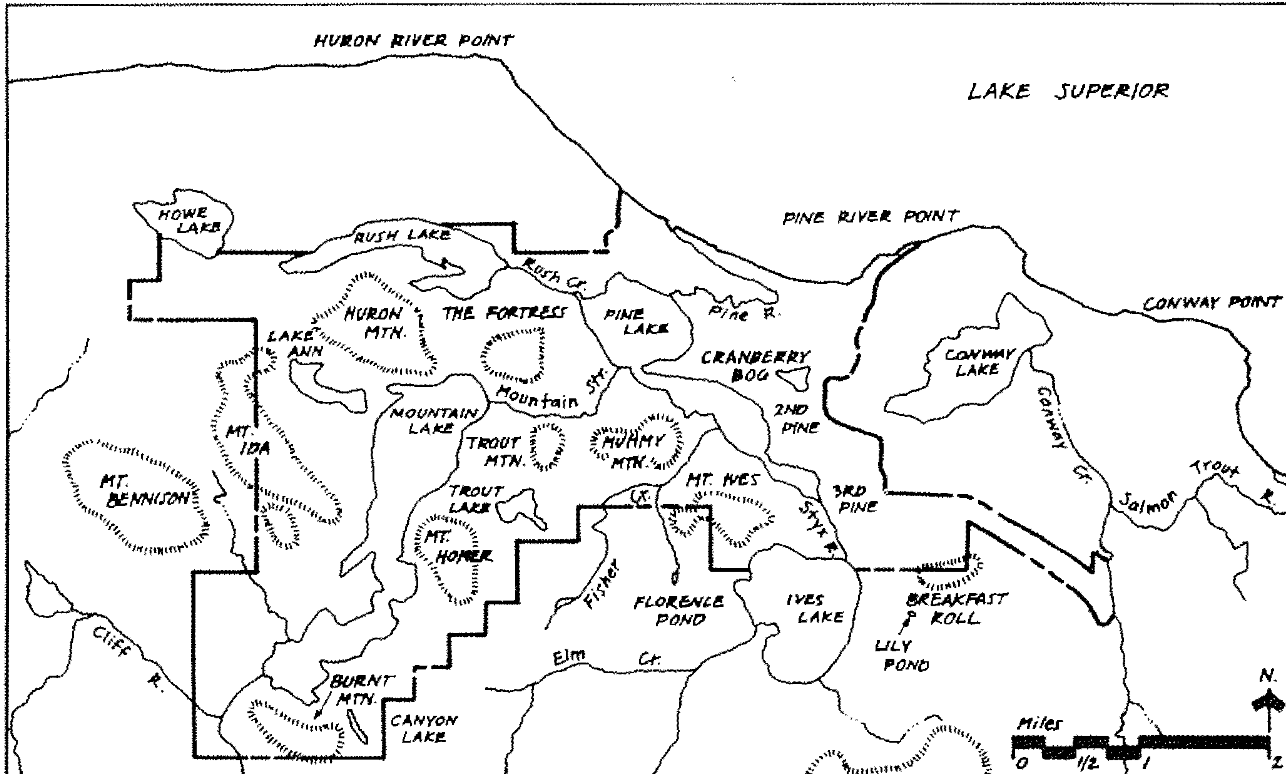

Fig. 2. The mapped area, comprising the Reserve Area and adjacent lands of the Huron Mountain Club, Marquette Co., Michigan.

Fig. 3. This exceptionally large basswood of the hemlock-northern hardwood forest is located in the SE 1/4 of Section 30 on a sandy flat east of Mountain Lake. Dennis Albert is shown measuring the diameter. Dimensions of this tree, recorded by Paul Thompson in 1971-72 (Wells and Thompson 1976), are as follows: diameter at breast height - 155.6 cm (45.5 in); girth 363 cm (143 in); height - 37.8 m (124 ft); crown spread- 18.9 m (62 ft).

research and conservation: "The Huron Mountain Club was originally founded and has since been maintained by a group of men and women of different interests and occupations who have found a common bond in the few months of every year spent at the club. This bond is their love of the still unspoiled natural beauty of the place."

The Club encouraged research by scientists, and in 1938 Professor Aldo Leopold of the University of Wisconsin visited the Club. His report (Huron Mountain Wildlife Foundation 1967) was valuable for its recommendations and provided the direction for preservation and management of the property. He observed:

> The scientific values arise from the fact that the Huron Mountain property will soon be one of the few large remnants of maple-hemlock forest remaining in a substantially undisturbed condition. All earth sciences must, in the long run, learn how to use land by referring to unused land as a base datum or starting point. Whoever owns such land will one day find it in demand for scientific investigations.

He also prophetically wrote:

> The size-scale of a wilderness area for scientific study greatly affects its value. A small area may be "natural" in respect to its plants, but wholly unnatural in respect of its mobile animals or water. However, mobile animals greatly affect plant life, so that a small virgin forest may appear to be natural when actually it has been profoundly affected by forces applied to animals, waters, or climate at points far distant.

The Huron Mountain Wildlife Foundation was established in 1955, and has actively continued to foster scientific research involving terrestrial and aquatic plants, fungi, birds, mammals, and the geology and hydrology of the area (Huron Mountain Wildlife Foundation 1967). In 1959, Dr. Stanley A. Cain, then Assistant Secretary of the Interior, proposed that the Michigan Natural Areas Council designate a new type of natural area: The "Nature Research Area." The membership of the Club in 1961 defined and established a "Preserved Area" (sometimes termed Reserved Area). The Michigan Natural Areas Council in 1961 recommended that the Huron Mountain property be designated as a Nature Reservation, and that within this reservation the Club's Reserved Area be designated as a Nature Research Area. In 1962, these designations and the boundaries of the Nature Research Area, approximately 8000 acres in size, were approved by the Club's Board of Directors (Huron Mountain Wildlife Foundation 1967, pp. 89-91). In this publication we refer to this tract as the Reserve or Reserve Area.

The remarkable diversity of aquatic and terrestrial systems and species of the Reserve is attested to by the Michigan Natural Areas Council subcommittee report of 1961 (Huron Mountain Wildlife Foundation 1967), by the many scientific papers and reports stemming from research on the area (Ibid 1967), and by an overview of the vegetation and flora of the Huron Mountains (Wells and Thompson 1976). The value of the Reserve also was emphasized by Dr. Eric Bourdo, eminent forester, botanist, and former Director of the Ford Forestry Center, Michigan Technological University (Huron Mountain Wildlife Foundation 1967):

> In the course of many years spent hiking through and working in the forests of the Upper Peninsula, I became thoroughly familiar with the virgin timber which once was widespread. I have "cruised" timber in the Upper Peninsula since 1939. I knew well the Misery Bay hardwood-hemlock tract when it represented more than 50,000 acres of unbroken wilderness, virtually all of which has since been cut. I personally "cruised" over 25,000 acres of "virgin" forest land in Baraga and Marquette counties, almost all of which has since been partially cut or clear cut.
>
> In view of all this background, it is my opinion that the Huron Mountain Club has preserved some of the best stands of "virgin" hardwoods and hemlock forest that I have ever seen. As you know, I have hiked extensively through the Club's "reserved area" as your guest. I believe that the stand of "cove northern hardwoods" immediately west of Pine Lake represents as fine a stand as I have ever measured. Several of the hemlock benches north of Mountain Lake fall into a similar category.
>
> Remnants such as these are of great scientific interest. On the one hand they serve as "natural areas," such as conservation groups elsewhere are trying to buy and preserve at great cost. However, the Club's reserved land is almost undisturbed, which certainly is not true of "natural areas" located in heavily populated regions. It is only in stands such as the Club has preserved that ecologists can study the interactions of the flora and fauna in truly climax communities. And it is only in such stands that both the forester and the ecologist can really study the levels of development which different kinds of stands are capable of attaining. Few practicing foresters are aware that a pure hardwood stand on middling-good soil is capable of producing over 20,000 board feet net per acre or that a pure hemlock stand on similar soil may attain 35,000 board feet per acre. Your reserved area, however, has living proof of the fact -- cathedral forests, as it were -- and the Club's efforts to preserve them deserves the commendation of scientists and foresters alike.

Conceptual Approach

The aim of our research is to provide an understanding of the three-dimensional (air-earth-organism) units of the landscape that we call **landscape ecosystem types**, or simply **ecosystems**. In the field, one can readily identify and distinguish as different landscapes the sandy beach ridges supporting jack pine and a nearby peat bog of black spruce and northern white-cedar trees. They differ not only in their plants and animals, but equally important in their form of the land (rolling upland ridges vs. depression), atmosphere (hot vs. cold), and soil parent material (sand vs. peat). Each such ecosystem type not only has **structure**, a predictable position in space and different form, but also complex interactions between its atmospheric, physiographic, soil, and biotic components that we term its **functioning**. In addition, each of these systems through time undergoes successional changes in its plant and animal composition under the influences of macro- and microclimate, plant and animal influences such as organic matter decomposition and herbivory, and natural forces such as fire and windstorm.

Thus, besides thinking about such a system's species, we also think holistically about these basic units of nature on the face of the earth -- whole systems and their structure and position in the landscape, their functioning, and their changes through time. This is the **ecosystem concept**: that the physical environment (termed site or habitat) and the biotic community of plants and animals are in dynamic interaction with one another and comprise an ecological system. The geographic nature of ecosystems was stressed by Rowe (1961) who defined an ecosystem as: "...a topographic unit, a volume of land and air plus organic contents extended areally over a particular part of the earth's surface for a certain time." Ecosystems are layered, volumetric segments of any landscape, in this case the Reserve, whose occurrence we have mapped, whose component parts we have described, and whose functioning and successional change can be described and documented over time. Each ecosystem type is named for its characteristic physiographic and soil features and for its late-successional or steady-state vegetation, e.g., "Flats and slopes; deep, well drained medium sand; Hemlock-Northern Hardwood/*Maianthemum*" (ecosystem type 7). The vegetation part of this name includes a dominant species or community of the overstory (e.g., hemlock or hemlock-northern hardwoods) and the most characteristic ecological species group (e.g., *Maianthemum*) of the ground-cover layer.

Because the species composition of an area changes over time (succession), we have necessarily had to recognize this "moving target" as best we can in characterizing the vegetation for each ecosystem. We have picked the stage where change is least (late successional time) under the set of abiotic conditions of microclimate, topography, and soil for each ecosystem. We term this the late-successional or steady-state vegetation, essentially the combination of species that would have occurred there under presettlement climatic and disturbance conditions of 500-1000 years ago. Fortunately, most of the Reserve is old-growth forest. We believe the present species composition in many ecosystem types is similar to that in presettlement time. Thus, we can use present composition as a guide in estimating the late-successional community most characteristic of each ecosystem. Not only is a given species composition characteristic of a particular set of abiotic conditions, but the kinds of disturbances (for example, high fire frequency vs. extremely low fire frequency) and the rate of successional change also are characteristic of such abiotic conditions.

Although patches of early successional vegetation may occur in a given ecosystem type, such patches do not show in our map of ecosystems. The basic ecosystem type has not changed, just some of the plants, associated microclimate, and animals in a small part of it have changed temporarily. Because this temporary change may be highly important to humans (for enjoyment as well as research and management) and other animals using such patches now (and for the next 10-50 years), we have also provided a map of the **existing** cover types (predominantly forest cover types) as well as the ecosystem type map.

The map of cover types is one that is conventionally used as a basis of management decisions in public and private forests. It is a map of the general composition of the overstory trees or other vegetation. By comparing this map with the ecosystem type map one can see that although they are quite similar, differences also occur. The maps are complementary. The specific cover types we map are a modified version of those currently in use by Ottawa National Forest, the closest large public forest tract to the Reserve. The procedures used in developing the cover type map are given below, and the cover types are described in detail below.

Classification and Mapping of Landscape Ecosystems

The major products of the research include a classification, description, and map of landscape ecosystem types of the Reserve Area. The classification is a logical division of the area into its natural ecological units, i.e., ecosystem types. The ecosystem map provides a spatial separation of these types. The process of classification is an iterative one whereby reconnaissance, field sampling, and test mapping are used to develop successive approximations of the classification. Towards the end of the process the entire area is mapped and through this process the ecosystem classification is given a final evaluation and refined as necessary.

Developing a classification and map involves considerable field and office research. Information on the physiography, soil, and vegetation of the area is gathered, ecosystem types are identified and described, successive approximations of the classification are developed and evaluated, and the area is mapped. Throughout the process, the study of physiography, soil, and vegetation proceed simultaneously in the field and office to the end of identifying, describing, and mapping the ecosystem types.

In Appendix A the key processes of sampling and mapping are described. The methods are similar to those used by Barnes et al. (1982), Pregitzer aud Barnes (1984), and Spies and Barnes (1985a) for other old-growth forests in the Upper Peninsula. Also, methods used in developing the map of existing forest cover types are presented.

Using the Maps

The ecosystem type map (Simpson et al. 1989a, 1990a) illustrates the remarkable diversity and geographic mosaic of ecosystems throughout the area. It is designed for wide usage, from aesthetic enjoyment of the landscapes to detailed scientific studies. Using both the ecosystem type descriptions and the map one can observe the occurrence of plant species and communities and their intimate relationship to physical environmental factors of physiography, microclimate, and soil. In the ecosystem **classification**, the types are arranged in ecological order and numbered consecutively from 1 to 50. A modified version of the classification is shown on the ecosystem color map (Simpson 1989a) due to space limitations. The classification can be used as a field key to identify the different ecosystems. Each ecosystem type is systematically described and contrasted with similar ones that might be confused with it. By hiking in the Reserve and using the map and ecosystem descriptions, one can compare the topography and vegetation of different ecosystems. Overall, we expect users will gain new insights into the interaction of plants and animals with their physical environment as well as animal-plant interactions.

The ecosystem map provides a framework for studying the occurrence of specific plant and animal species in the different ecosystem types. The map also provides the basis for detailed studies of individual species in a given ecosystem or different ecosystems. For example, the effects of deer browsing on hemlock seedling establishment can be studied in relation to ecosystem type and distance from roads, trails, or natural habitat features. Ecosystems most sensitive to fire, windstorm, or pest attack can be plotted and their causes studied in relation to their particular physical environment and vegetation.

The map of existing cover types (Simpson et al. 1989b, 1990b) is complementary with the map of ecosystem types. Variation in forest overstory composition can be compared within a given ecosystem type, i.e., what kind of disturbance vegetation is typical for a given ecosystem type. The occurrence of plant and animal species can be studied in relation to the existing vegetation of different kinds within a given ecosystem.

In the long run, successional changes of forest communities can be monitored. Because the geographic boundaries of the ecosystem types and forest cover types are mapped, the vegetative changes can be more definitively related to physical environmental factors of microclimate, slope position and aspect, and soil moisture and nutrients than if no spatial framework were available.

CLIMATE

Located at 46°52' north latitude and 87°50' west longitude, the Huron Mountains are situated in the Michigamme District of the Western Upper Peninsula Region (Fig. 1, Denton and Barnes 1988). The district is characterized by cool temperatures and low potential evapotranspiration. Because Lake Superior is to the north of the district, the prevailing southwesterly winds do not cross the lake before reaching the district. Thus the buffering effect of the lake on temperature extremes is not as pronounced as it is in the Keweenaw Peninsula.

The gradients in temperature-related variables are very strong within 2-3 miles of the lake and more gradual thereafter (Denton 1985). Data to describe that gradient within the mapped area of the Huron Mountains are lacking, but there are without doubt major differences between the compound area and 4 miles inland at the southern tip of Mountain Lake.

Table 1 gives ecologically important climatic statistics for three districts in the western Upper Peninsula: **Iron,** an interior district centered in Iron County; **Michigamme**, stretching from Lake Superior south into the northwestern one-third of Marquette County and adjacent Baraga County; and **Keweenaw**, including the northern two-thirds of the Keewenaw Peninsula and Isle Royale (Fig. 1). Differences occur within each variable in response to position of the land with respect to Lake Superior. Inland areas tend to be warmer in the summer and colder in the winter than do adjacent lake influenced areas. Growing season length, potential evapotranspiration, average temperature, and annual extreme minimum temperatures are consistent with this trend.

Table 1. Averages of climatic variables for 3 districts of the Western Upper Peninsula Region (Albert et al. 1986).

	Climatic Variable[1]				
	A	B	C	D	E
Keweenaw	134	110	430	14.4	-25
Michigamme	89	380	460	15.0	-32
Iron	87	380	470	15.0	-34

[1]Column headings A--Growing season length (days); B--Heat sum prior to the last spring freeze (°C-days); C--Potential evapotranspiration, May-September (mm); D--Average temperature, May to September (°C); E--Annual extreme minimum temperature (°C).

Lake influence also buffers daily temperature fluctuation, leading to fewer late spring and early fall frosts. "Heat sum prior to the last spring freeze" quantifies the incidence of late spring frost. The Keweenaw district has a noticeably lower heat sum than either of the other districts. Relative to the Iron district, the Michigamme district shows a slight but consistent lake effect in all of the variables.

Data for the city of Marquette for the 40-year period 1932-1971 show the annual average temperature to be 42.4° F (5.8° C) and the total annual precipitation to be 40 in (787 mm). Precipitation is evenly distributed throughout the year (Michigan Weather Service 1974).

PHYSIOGRAPHY AND LANDSCAPE ECOSYSTEMS

Compared with typical midwestern terrain, the Huron Mountains present a landscape of unusual variety: bedrock hills in sharp relief, intermontane lakes, and a diverse array of old-growth forests. Hidden from this first impression is an intricate network of ecological relationships that tie the plants of the forest to the physical landscape. This relationship between biota and the physical landscape is at the heart of the landscape ecosystem approach.

Physiography refers to the form and material composition of the land.

Physiography mediates the effects of climate on soil and biota at regional and local levels, and together physiography and climate influence the development of landscape ecosystems. Physiography and climate in combination affect the movement of energy, water, wind, soil particles, nutrient ions, and even plant propagules. Figure 4 shows the relationship of physiography and local landscape ecosystems on the northern portion of the mapped area. The local variation in physiography has been instrumental in forming a diverse pattern of landscape ecosystems, from jack pine on dry, sterile beach sands (ecosystem 2) to red maple, yellow birch, hemlock, and northern white-cedar on poorly drained flats with organic surface soil (ecosystem 48). On the well drained, loamy flood-deposit lying between these two extremes, is a hemlock-northern hardwood forest (ecosystem 8). Colonizing the beaches of Lake Superior (ecosystem 1), beach pea (*Lathyrus japonicus*) and sea rocket (*Cakile edentula*) lead a tenuous existence, rooted in sand that shifts with the waves of each storm. Let's examine further examples of physiographic influence.

We, being avid hikers, climb Huron Mountain (Fig. 2) and discover a rugged landscape of exposed bedrock, much of it more than 2.5 billion years old. Stunted white pine and red oak explore crevices and shallow depressions in the rock where small accumulations of soil provide the only source of moisture (ecosystem 29). We descend the mountain via its north face and find a well dissected slope of ridges and valleys. Erosion has carved these forms in sediment left by the last of the many glaciers of the Ice Age (ecosystem 22). The slope is covered by

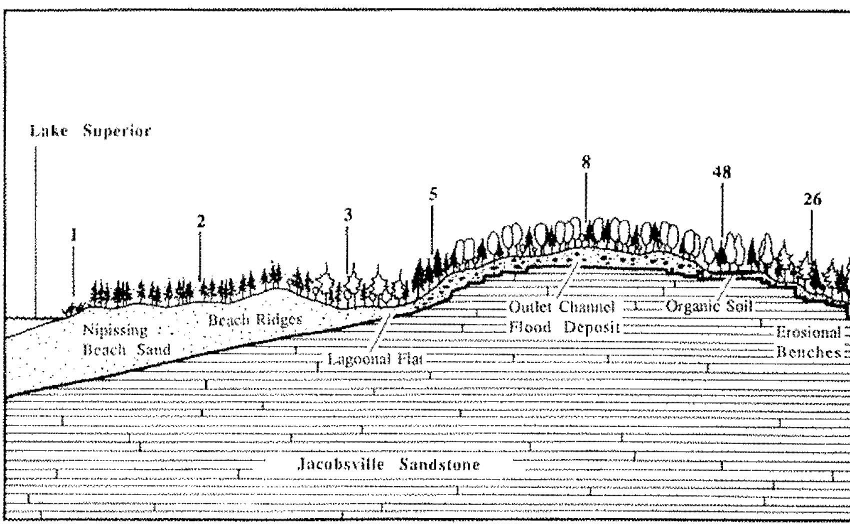

Fig. 4. Physiographic cross-section of the northern part of the mapped area showing the occurrence of landscape ecosystems. Descriptions of ecosystem types are given in the section: "Landscape Ecosystem Types of the Reserve Area and Adjacent Lands." Explanations of the landforms and geologic materials shown are given in the "Geologic History" section.

hemlock and sugar maple, yellow birch, and basswood.

Farther down the mountain, the terrain suddenly becomes flat, and sandstone bedrock is visible poking through a thin covering of soil. We have just stepped onto the floor of an ancient flood channel (ecosystem 26). The forest here features white birch, hemlock, and white pine, as well as small pockets of northern white-cedar. Abruptly, the flat terrain ends to the north, and the land drops precipitously where waters of the same flood carved deeply into the mountainside (ecosystem 36). Along this very steep slope hemlock clings to the slowly creeping mass of soil. Rush Lake lies at the bottom of the slope. At the lake margin, individuals of northern white-cedar lean out over the water (ecosystem 40).

On another day we may hike among the boulders and huge sugar maples between Howe and Rush Lake (ecosystem 25). Heading south towards Ann Lake, we pass through the dark, hemlock-dominated forest that lines the smooth trough separating Mt. Ida from Huron Mountain (ecosystem 27). Continuing along the north edge of Ann Lake, walking east, we climb an enormous mound of earth that stretches east almost as far as the lake. The forests change from white birch, red and white pine, and hemlock at the lake margin (ecosystem 38) to a mosaic of hemlock- and maple-dominated northern hardwoods on top of the mound (ecosystems 21 and 8). We have, on this day, retraced the path of a catastrophic flood that occurred 10,000 years before. At that time, the mound was only a gravel bar in a very large, turbulent river.

Thus physiography, soil, and vegetation are intimately bound together into these pieces of the landscape we call ecosystems. The physiography of the land, that so strongly controls ecosystem structure and function, is in turn the product of a series of events stretching into the remote past. Each event may, in turn, be understood as a set of geologic processes acting over a discrete period of time.

Recognizing this, an understanding of geologic history becomes a tool we may use to explain the origin of many ecosystem properties such as soil texture, soil depth, slope, and elevation. And more importantly still, geologic history allows us to understand the origin and distribution of landforms as parts of the larger landscape, and thus to understand better the distribution of local ecosystems across that landscape.

GEOLOGIC HISTORY

Bedrock Geology

The Huron Mountains are a range of Precambrian bedrock hills (Dorr and Eschman 1970). The metamorphic rock, much of it over 2.5 billion years old, is a part of the Canadian Shield and in the Huron Mountains has been differentially eroded to produce the current bedrock topography.

Streams flowing through the ancient Huron Mountains more than 600 million years ago buried much of the landscape under a thick blanket of sand. Over time the sand hardened into rock, the grains glued together by calcite (lime) and silica (silicon and oxygen), forming the familiar red and white sandstone we call Jacobsville Sandstone. Its red color comes from strongly oxidized iron pigments and the white from leaching of these pigments or by chemical reduction of the iron compounds. This sandstone may be found as high as 980 ft (300 m) in elevation, or 380 ft (115 m) above the level of Lake Superior. Although its outcropping in the Huron Mountains area is mainly in a narrow band along Lake Superior, the Jacobsville formation is quite extensive under Lake Superior and locally thousands of feet thick (Hamblin 1958). In the Huron Mountains, we see only its thin southern edge. Sandstone bedrock is not known to occur in the vicinity of Canyon Lake, or on the slopes of Burnt Mountain, or Mt. Benison. The contact between sandstone and crystalline bedrock can be seen at the base of the waterfall on Mountain Stream, east of Mountain Lake (Greg Wilson and Campbell Craddock, personal communication). Water flows on a streambed of bare sandstone above the falls and plunges to the crystalline bedrock surface below (Fig. 5). Water turbulence at the base of the falls causes relatively rapid erosion of the sandstone at its contact with crystalline bedrock, maintaining the almost vertical slope of the waterfall.

Glacial Geology

During the Pleistocene Ice Age (from approximately 2 million to 10 thousand years ago), the glaciers advanced and retreated over the Huron Mountains as many as 20 times, each time grinding and tearing away part of the mountains. As the ice approached from the north, the hard metamorphic backbone of mountains, such as Huron Mountain and Mt. Ives, forced the ice to slide up and over the ridges. Grooves and scratches (striations) in the bedrock caused by the glacial abrasion can be found on the up-ice sides of these mountain ridges.

Erosion of the down-ice mountain faces was more extensive. Thawing and refreezing caused the ice to adhere to the rock, and by freeze-thaw displacement, to open up already existing joints in the rock. As the ice moved away from the mountain, large blocks of the rock were torn free and entrained in the ice (Drewry 1986). The result today is the steep rugged wall of rock typical of the southern aspect of Huron, Ives, and Homer mountains. The soft sandstone was removed entirely from the south faces of these peaks, whereas it remains in large masses on the north slopes.

The final advance of the ice sheet in the Huron Mountains area came approximately 10,000 years ago. At its maximum extent the final "Marquette advance" of the glacier completely covered the Huron Mountains, moving as far south as the Yellow Dog Plains approximately three miles south of Burnt Mountain. To the west, the ice–trapped glacial Lake Duluth in the southwestern corner of the Superior basin. To the northwest of Lake Duluth on the Canadian plains was a huge lake at the margin of the ice called Lake Agassiz. At this time both lakes drained south to the ancestral Mississippi River (Farrand and Drexler 1985). However, the levels of both Lake Duluth and Lake Agassiz were higher in elevation than the valley floors of the Huron Mountains. A dam of glacial ice was the only obstruction to the flow of water east along the lowland bordering the

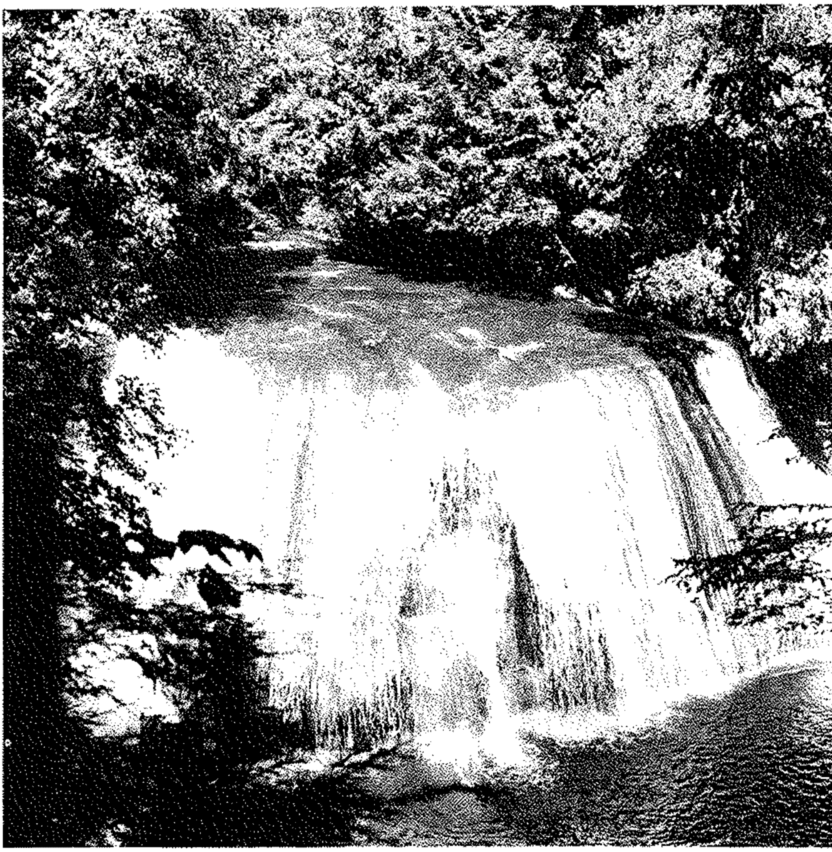

Fig. 5. The contrast between 600 million–year–old Jacobsville Sandstone and the 2.5 billion–year–old Canadian Shield bedrock can be found at the base of the waterfall on Mountain Stream, east of Mountain Lake.

Superior basin, through the Huron Mountains, and then south across the upper Peninsula to ancestral Lake Michigan (Lake Chippewa).

As the ice front melted back, low passageways developed, and water from Lake Duluth (and later both Agassiz and Duluth) poured east. In the vicinity of the Huron Mountains, the waters first flowed across the lowland immediately north of the Yellow Dog Plains. As the ice continued to retreat to the north, lower and lower passages through the mountains were uncovered and the water repeatedly shifted its course finding the easiest passage to the east (Drexler 1981). The actual paths that the water took are referred to as outlet channels, and the rapid drainage of glacial-lake waters through the Huron Mountains is called a catastrophic flood because of its sudden and violent nature.

The deep bedrock groove now occupied by the Cliff River was cut by this catastrophic flooding, as was the chasm that now holds Canyon Lake. Ann Lake, Howe Lake, Rush Lake, Trout Lake, and Pine Lake all occupy basins created or deepened by the erosion of these waters. The Mountain Lake basin existed prior to this event. We know this by the presence of glacial striations at the present water line near the central part of the lake.

The Ives Lake basin was the site of a much larger lake during this period. The deep sandy deposits of the lowlands of this basin are sediments of that lake. The present Ives Lake was filled with a large ice block at this time preventing sediment from filling in that area.

As the flood waters passed along the mountain faces, great volumes of rock were removed. The erosion on the north face of Huron Mountain proceeded in steps as the ice front retreated and lower channels were cut along the mountain. The result is a series of bedrock benches descending the mountain from the highest channel elevations of approximately 950 ft (290 m). A series of schematic diagrams (Figs. 6, 7) shows the action of these processes and their relationship to present landscape ecosystems.

The glacier as it retreated and exposed the ridge of Huron Mountain, formed a small outwash channel at the margin of the ice (Fig. 6A). During this time sandy glacial outwash sediment was deposited over the more clayey, ice-deposited glacial till. The initial flow of outlet-channel flood waters across the north slope of Huron Mountain occurred at ca. 950 ft (290 m). The flow of water was of much larger volume and higher velocity than the previous outwash channel and resulted in erosion of the sandstone bedrock (Fig. 6B). The glacier retreated farther as floodwater carved away at both ice and rock. Left behind was a series of erosional cuts and layers of sediment that would provide the basic form of the present landscape (Fig. 6C). These erosional and depositional forms have led to the development of a variety of landscape ecosystems (Fig. 7).

The vertical faces of the erosional cuts (risers) have weathered to smooth steep slopes today (Fig. 8), but 10,000 years ago they were rugged rock walls similar to the present wave-cut cliffs of Pine River Point along present-day Lake Superior (Compare Figs. 6B and 6C with Fig. 7). On the northeast face of Mt. Ida, above Ann Lake, and on the north face of Mt. Homer above Trout Lake the erosion was more brief, and only one large riser is present.

The waters of the outlet channels produced more than erosion. Rock that was torn from a mountain side or basin was carried in the flow and dropped down-

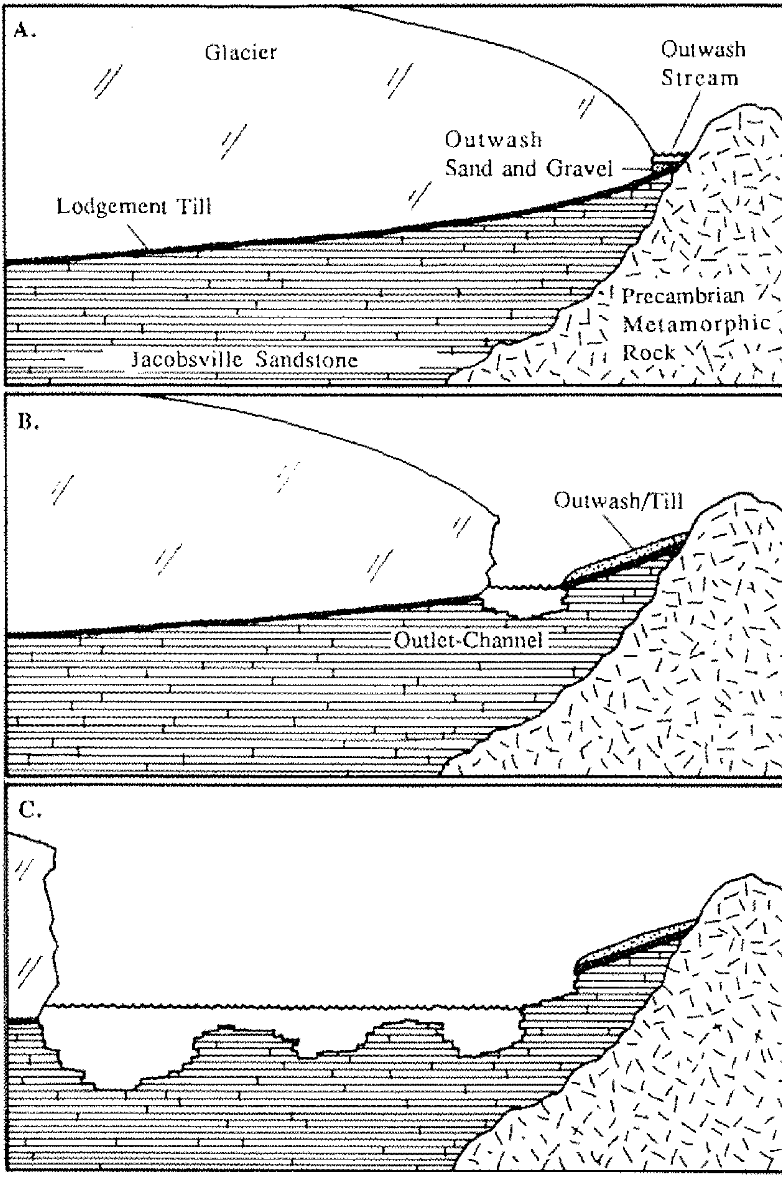

Fig. 6. Idealized representation of the events that immediately followed the retreat of the glacier from the north slope of Huron Mountain. A--Initial retreat of the ice-front, B--Initial outlet channel erosion, C--Ice-front and channel location at the time the Rush Lake basin was created. Vertical dimensions are exaggerated for clarity. See text under "Glacial Geology" for a more detailed explanation.

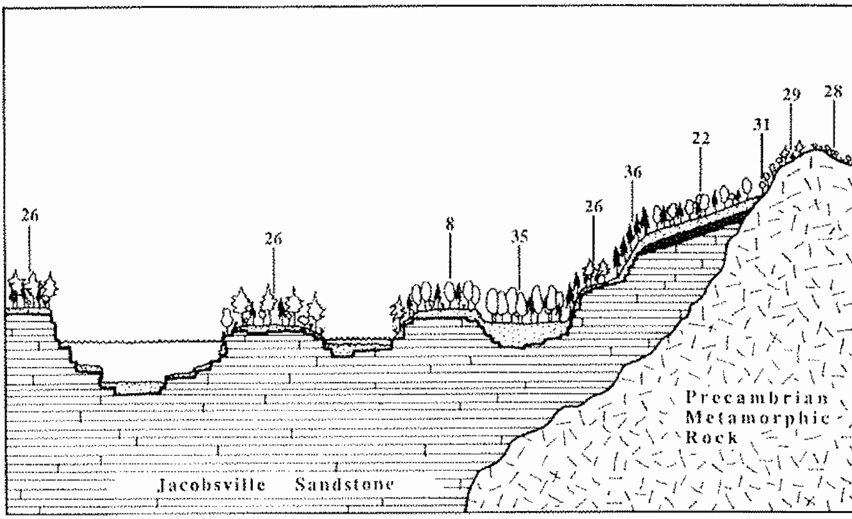

Fig. 7. Occurrence of landscape ecosystems in relation to physiography (Huron Mountain-Rush Lake area). See Figure 6 and text under "Glacial Geology" for an explanation of the geologic evolution of the landforms shown. Descriptions of ecosystem types are given in the section: "Landscape Ecosystem Types of the Reserve Area and Adjacent Lands."

stream. The highland east of Rush Lake and south of Rush Creek is strewn with small-car-sized boulders that were excavated from the Rush Lake basin. North of Lake Ann and south of Huron Mountain is a massive gravel bar nearly one-half mile (800 m) long and over 35 ft (10 m) high that was built as flood waters carved out the Ann Lake basin.

Not all land at low elevations was changed by the catastrophic flooding. The largest and most interesting of these places is the valley of Mink Run. The mountains to the west and north formed a barrier to the flood waters and left the glacier ice to melt gradually. The deep sandy glacial sediments of Mink Run valley were deposited by meltwater streams flowing towards the Mountain Lake basin. One can examine the terraces left by this glacial stream, high above the present stream level, and imagine the great volumes of water that flowed in Mink Run valley more than 9000 years ago. A similar glacial outwash landscape can be found in the Fisher Creek valley west of Mt. Ives.

The processes of glaciation and catastrophic flooding have left three basic types of sediments covering much of the land surface: flood deposits, glacial outwash, and glacial till. The material composition of each type is a product of the geomorphologic processes that deposited them. The coarse nature of flood deposits reflects the turbulence and power of the flood waters. Flood deposits are generally sandy in textnre and often contain rocks from 1 inch to 10 feet in diameter. Glacial outwash is similar to flood deposits in appearance but generally lacks the large rocks common in many of the flood deposits. Outwash was deposited by comparatively small streams that, due to their smaller size and lower velocity, lacked the competence to transport large rocks.

Fig. 8. Once a vertical face of exposed sandstone, the riser landforms are steep, smooth slopes today except where more erosion-resistant pieces of the sandstone bedrock protrude from the weathered surface.

Glacial till is material deposited directly by the ice sheet as it slides over the land. Till contains higher concentrations of clay particles than do flood deposits or outwash because these particles are not washed away by water during till deposition. In the Huron Mountains, till has a characteristic bright reddish-brown color derived from ground-up Jacobsville Sandstone.

Nipissing Lake Superior

The last major geologic event to modify the Huron Mountain landscape was the rise of the ancestral Lake Superior 6000 years ago to the Nipissing level. The original level of this lake was 605 ft (184 m), just over a yard higher than the current lake, yet wave-cut cliffs marking the former Nipissing shore line are found at an elevation of 640 ft (195 m), in some places over a mile inland. The reason for this paradox lies in what geologists call isostatic rebound. The land has increased in elevation over the last 10,000 years in response to the removal of the tremendous weight of the glacier. The Nipissing shoreline that is now at the elevation of 640 ft, was actually at an elevation of 605 ft during the time the lake existed.

The area now occupied by the Huron Mountain Club compound was under water during Lake Nipissing time, and the Pine Lake basin was a part of the larger lake. Conway Lake was also inundated by the waters of the Nipissing stage, and the Conway Point highland was an offshore island. The steep escarpment immediately north of the skeet field was a vertical cliff of bare sandstone, similar to the present wave-cut sandstone cliff of Pine River Point. A similar wave-cut cliff borders the former beach area east of the compound.

Most of the area that was once covered by Nipissing waters is now covered by deep sand that was brought into the area by wave action. As the crust rebounded and the lake receded towards its present position, the sand was built into ridges paralleling the shore. These ridges are still plainly visible in the pine forest surrounding the compound.

Recent Erosion, Deposition, and Soil Formation

In the years following the events of the Marquette glaciation and the Nipissing lake stage, the land has changed in response to the local erosion and deposition of sediment by the surface movement of water. With the retreat of the ice, the bare sediments of the mountain slopes were subject to rapid erosion by rain and snow-melt. In succeeding years, as vegetation stabilized the soil, rates of erosion decreased sharply but nevertheless have continued at a low level to the present day.

The combination of rapid initial erosion with the later, slower rates compounded over thousands of years, has produced the dissected northeast slope of Mt. Ida from an originally smooth surface of glacial sediment. Similarly, the dissected north slope of Huron Mountain (above the highest outlet channel elevation here of 950 ft) is the erosional remnant of a thick blanket of glacial outwash and till. The mixture of mineral soil and organic material that eroded from these slopes is typically deposited at the foot of the slope or in intermittent stream valleys. Such deposition led to the formation of moist, nutrient-rich soils that today support broadleaf deciduous forests and a variety of shrubs and herbs.

From Mountain Lake one sees the bare rock faces of the Fortress and Huron Mountain. These slopes received a covering of glacial sediment, yet on this steep terrain erosion acted more quickly and completely than on gentler slopes and stripped away all but scattered patches of sediment. A sequence of geologic processes--glacial plucking, deposition of glacial sediment, and sediment erosion--combined to create these diverse, barren, and rugged slopes.

While these erosional and depositional changes in the shape of the land surface were taking place, other changes below the surface were altering the landscape. Raw glacial sediments were slowly being changed as rainwater and organic acids from above percolated downward. Iron and aluminum compounds, organic matter, and very fine soil particles (silt and clay) were redistributed by the effect of the percolating water. These soil-forming processes act slowly, but as their effects accrue they change permanently the properties of the land as habitat for plants and animals. Soil integrates the influences of geology, climate, and organisms over very long periods of time. Today's diversity of plant species and communities is in large part a response to the diversity of geologic form, rock type, sediment, and soil. These entities are in turn a product of a diversity of geologic and geomorphic processes acting throughout thousands, millions, or billions of years.

FOREST HISTORY

Postglacial Migration of Tree Species

Tree species now common in the Huron Mountains were forced south during the Ice Age by the glacier and the colder climate. With the warming that began after the glacial maximum of 18,000 years ago, tree species extended their ranges northward and westward, a process referred to as migration. Understanding migration, and reconstructing the composition of forests of thousands of years ago, require the analysis of pollen accumulations in lake sediments.

The vegetation of the Huron Mountains 9500 years ago was quite different from that of today. The glacier was receding into the Superior basin, and jack pine, spruce, and white birch were colonizing the raw sediments. Sugar maple had reached the Michigamme Highlands to the south, and the nearest hemlock was hundreds of miles away to the east and south.

Between 9500 and 8000 years ago the forests were dominated by jack pine, white and black spruce, and white and yellow birch (Brubaker 1975). Red oak was somewhat more common than it is today, and sugar maple was present but probably not widely distributed.

On a continental scale, climates were as warm 9000 years ago as they are today (Imbrie and Imbrie 1986), but the remnants of the glacial ice mass in the

Hudson Bay region of Canada may have had a cooling effect in the northern Great Lakes region. The forest composition of 9000 years ago seems to indicate a drier and perhaps cooler climate than today. From the tremendous abundance of jack pine, one can infer that fire was more common than it is today.

By 6000 years ago black and white spruce had withdrawn to local wetlands and to the boreal forests of Canada. Jack pine had decreased in abundance near to its present level. Sugar maple had increased in abundance as had white pine, and together they probably dominated much of the upland forest. Although most of the forest trees we now find commonly in the Huron Mountains were present 6000 years ago, hemlock was notably absent. It did not arrive until approximately 5000 years ago, after which time it quickly became a common species (Brubaker 1975).

Logging

The white pine logging boom of the late 19th and early 20th centuries left an indelible mark on the forests of the Huron Mountains. The volume of timber removed was minor in comparison to that removed from the Kingston Plains to the east, but mute testimony to that cutting can still be found in the resinous stumps of the white pine that have failed to rot completely away even after 80 to 100 years.

In the Huron Mountains, large tracts in the Ives basin were cut for white pine. Cutting also occurred on the land north of Rush Lake and the peninsula east of Pony Lake. The watersheds of Mink Run and the Cliff River were also cut in the 1890s. Approximately 1250 acres (500 hectares), or 20% of the non-lake portion of the Reserve Area was selectively cut for white pine during these years, although white pine was common in only 100 of the 1250 acres. Many large white pine, including the state champion, still tower over the hemlocks and maples north of Fisher Creek and south of Mummy Mountain.

Between 1910 and the late 1930s, little timber was logged in the vicinity of the Huron Mountain Club. Only along Lake Superior, north of Rush Lake, did any cutting take place. At this time, vast tracts of virgin sugar maple, hemlock, and yellow birch clothed the hills south and west of Mountain Lake and Ives Lake, and on Conway Point and Pine River Point. Starting in 1939 and continuing into the late 1950s, many thousands of these acres of hemlock-northern hardwood forest were clearcut. Much of the northern hardwood forest of the Ives basin, Pine River Point, and Conway Point were cut during this time, in most cases prior to their ownership by the Huron Mountain Club. Thus, the hemlocks and maples of the Reserve Area were, only a few decades ago, part of a more extensive old-growth forest.

Fire as an Agent of Forest Change

Fire is known to have affected 350 acres (142 ha) out of the 6600 acres (2650 ha) Reserve over the last century, despite human efforts (Todd 1959). Judging from the distribution of post-fire vegetation, this figure is undoubtedly an underestimate. Documented fires include Burnt Mountain in 1894. The south slope of Trout Mountain burned the same year, and the north shore of Second Pine Lake burned six years later. The peak of the Fortress burned in 1929, the same year that two fires on the northwest slope of Huron Mountain burned 60 acres (24 ha). The north shore of Canyon Lake burned in 1934. In the dry summer of 1988, a fire broke out on the bedrock ridge south of Lily Lake but was quickly extinguished.

By sifting carefully through the organic matter of the forest floor, one regularly finds pieces of charcoal that are the evidence of past fire. Trees such as white birch, white pine, and red pine, which line the northern and eastern shores of the Pine Lakes, mark the sites of past fires. The small seeds of these trees require bare, exposed soil for the roots to penetrate and the seedlings to establish themselves. They also require full sunlight and hence thrive in large openings made by fire. Even hemlock, long regarded as a denizen of cool and moist areas, aggressively colonizes burned-over land. The "Cathedral" forest on the north slope of Huron Monntain and the hemlocks of the east slope of the Fortress both originated following fire.

Human-Induced and Natural Change

Forest ecosystems change by the processes of nature and through human activities, but the two types of change have very different effects on the composition of forest vegetation. Pine and hemlock exploit wildfires aggressively yet are rare in northern hardwood forests that regenerate after clearcutting. The 40-year-old forest of Pine River Point, clearcut in the 1940s, is a sea of young maple, birch, and white ash. Hemlock, once abundant, is now represented by only scattered individuals left by the loggers. Similarly, the failure of hemlock to regenerate following clearcutting in hemlock-dominated forests of the Sylvania Recreation Area has been documented by Hix and Barnes (1984).

The present mosaic of forest communities of the Reserve Area has developed over many centuries, largely through the agent of fire. Human-induced change, in the form of clearcutting, has altered both the time scale and the nature of forest change, creating uniformity and eliminating species not adaptable to such methods. Hemlock will not return to the clearcut areas of Pine River Point in our lifetime or our children's lifetimes. White pine, removed from the peninsula east of Pony Lake, will not return again until another fire sweeps across the peninsula.

The Reserve Area of the Huron Mountain Club is a non-renewable resource. It increases in scientific as well as aesthetic value every year as the world around it changes. Aldo Leopold realized this in 1938 when he wrote, "..the Club has not only a unique property, but a large opportunity for public service in science and conservation."

VEGETATION

Regional Vegetation

Forests of the Huron Mountains are located in the Hemlock-White Pine-Northern Hardwoods region (hereafter termed Hemlock-Northern Hardwoods region) of Braun (1950, pp. 332-440). Such a generalized community-type name is used for convenience in identifying similar vegetation over a large area, in this case the northern part of the central and eastern United States, in comparison to that of an adjacent area. The so-called Hemlock-Northern Hardwoods region extends from northern Minnesota and extreme southeastern Manitoba through the upper Great Lakes region and eastward across southern Canada and New England, including much of the Appalachian Plateau in New York and northern Pennsylvania. This huge geographic area supports a mosaic of deciduous (hardwood), mixed coniferous-hardwood, and conifer forests and is obviously extremely diverse. Yet it has a repeating pattern of ecosystems and community types. The importance of both conifers and hardwoods reflects the transitional character of the region, which is bounded on the north by evergreen spruce-fir forests and on the south by deciduous beech-sugar maple and oak-hickory forests.

Braun divided forests of the Hemlock-Northern Hardwoods region into six sections, and the Huron Mountain area is located within her Superior Upland section. This area corresponds roughly to the physiographic province of that name (Fenneman 1938). In the classification of regional landscape ecosystems of Michigan, the Huron Mountain area is in the Michigamme District of the Western Upper Michigan Region (Albert et al. 1986, Fig. 1).

Vegetation of the Superior Upland is similar to that of Braun's other sections in its mosaic of hardwood, conifer, and mixed conifer-hardwood communities. However, it differs from all the more eastern sections by the absence of beech and by the greater abundance of basswood (Braun 1950, p. 365). To the west in Minnesota, basswood continues to increase and hemlock becomes absent. Swamp and bog communities are also similar to those of the eastern sections, although black spruce is less common to the east. Although noting a general similarity of Huron Mountain vegetation to that of other old-growth forests of the Superior Upland in Michigan and Wisconsin, Braun observed that they differed topographically and vegetationally from one another.

Of the vegetation of the Reserve, Braun (1950, p. 367) stated: "The highly diversified topography of the area, which includes lake terraces, river and ravine flats and terraces, mountain slopes of differing directions and steepness, as well as cliffs and swamps, results in a number of unlike forest communities together with gradational intermediate communities." An overview of the vegetation of the Huron Mountains is presented below.

Vegetation of the Reserve Area and Adjacent Lands

Ecological Species Groups

Before considering the existing vegetation of the Reserve Area, a discussion of ecological species groups is in order. In addition to tree species of the overstory and understory layers, groups of shrub and herb species of the ground-cover layer were used to identify and map the ecosystem types. An understanding of this species group approach and the specific groups recognized in the Huron Mountains is needed to appreciate more fully the cover types and the ecosystem types.

Herbs, shrubs, and tree seedlings can be extremely useful in indicating the levels of moisture, nutrients, light, and acidity of an area. Based on the similarity of their site requirements, species may be arranged into groups of similar ecological requirements, i.e., ecological species groups, for the purpose of characterizing site conditions. The presence and abundance of these groups are used together with physiography, soil, and overstory trees to distinguish and map ecosystem types (Pregitzer and Barnes 1982, Spies and Barnes 1985b).

Each species group is indicative of a particular range of soil moisture, fertility, acidity, and light intensity. These relationships are described below. Groups were drawn up initially based on our experience in the field. A tabular arrangement of species occurrence by ecosystem plot was then employed to evaluate these groupings based on field data. In Table 2 the species groups are shown in an order indicating their approximate relationship along moisture and fertility gradients. In Appendices C and D, the occurrence of ecological species groups in the landscape ecosystems is presented.

The ecological species groups were developed based on our experience in the mapped area and adjacent lands. They show many similarities to the ecological species groups developed in western upper Michigan for the Cyrus McCormick Experimental Forest (Pregitzer and Barnes 1982) and for the Sylvania Recreation Area (Spies and Barnes 1985b). However, the differences among the three sets of species groups are substantial enough that the use of the groups and site interpretations presented here should be restricted to the mapped area and adjacent lands.

The Characteristics of Ecological Species Groups as Indicators of Habitat Conditions

A brief description of the group and its occurrence in relation to soil moisture, soil fertility, and light are presented below. Species within a group are listed in order of their usefulness and frequency of occurrence.

Upland Species Groups

1. *Cladonia* Group

    Cladonia rangiferina (L.) Wigg.
    C. arbuscula (Wallr.) Rabenh.
    C. mitis Sandst.
    Carex pensylvanica Lam.
    Deschampsia flexulosa (L.) Beauv.
    Danthonia spicata (L.) R. & S.
    Melampyrum lineare Desr.

Characteristic of very dry, infertile soils. Found commonly on both deep, dry infertile sands, and on thin, dry, infertile soils. *Cladonia arbuscula* and *C. mitis* are very similar in appearance to *C. rangiferina* and the three may occur together.

Table 2. Ecological species groups--arranged in an order indicating their relationships along moisture and fertility gradients.

Upland Species Groups

I. Groups characteristic of dry sites - listed in approximate order of increasing moisture.

1. *Cladonia*
2. *Gaylussacia*
3. *Woodsia*
4. *Lathyrus*
5. *Comandra*

II. Groups characteristic of moist sites

A. Group characteristic of infertile soils

6. *Coptis*

B. Groups characteristic of moderately infertile to fertile soils - listed in approximate order of increasing fertility.

7. *Polygonatum*
8. *Corylus*
9. *Gymnocarpium*
10. *Botrychium*
11. *Impatiens*
12. *Arisaema*

III. Groups occurring over a broad range of soil moisture

13. *Vaccinium*
14. *Pteridium*
15. *Maianthemum*
16. *Goodyera*
17. *Polypodium*

Wetland Species Groups

I. Groups characteristic of wet, poorly drained sites - listed in approximate order of increasing soil fertility.

1. *Ledum*
2. *Drosera*
3. *Chamaedaphne*
4. *Ilex*
5. *Carex*
6. *Myrica*
7. *Osmunda*
8. *Onoclea*

2. *Gaylussacia* group

Gaylussacia baccata (Wang.) K. Koch
Polygala paucifolia Willd.
Epigaea repens L.

Similar to the *Cladonia* group but generally restricted to deep, dry, infertile, sandy soil.

3. *Woodsia* group

Woodsia ilvensis (L.) R. Br.
Selaginella rupestris (L.) Spring
Rhus glabra L.
Corydalis sempervirens (L.) Pers.
Aquilegia canadensis L.
Agropyron trachycaulum (Link) Malte
Agrostis hyemalis (Walter) BSP.
Aralia hispida Vent.
Juniperus communis var. *depressa* Pursh
Prunus serotina Ehrh.
Prunus virginiana L.
Solidago nemoralis Aiton
Arctostaphylos uva-ursi (L.) Sprengel
Potentilla tridentata Aiton
Lechea intermedia Britton
Rubus setosus Bigelow
Antennaria neglecta Greene
Antennaria plantaginifolia (L.) Richards
Saxifraga virginiensis Michaux
Opuntia fragilis (Nutt.) Haw.
Cardamine parviflora L.

Found almost exclusively in areas of thin, dry, infertile soil of limited areal extent, in exposed topograpic positions. Not as tolerant of the extremes of dryness as are the species of the *Cladonia* group.

4. *Lathyrus* Group

Lathyrus japonicus Willd.
Cakile edentula (Bigelow) Hooker
Ammophila breviligulata Fern.
Deschampsia cespitosa (L.) Beauv.

Characteristic of the shores of the Great Lakes. Typical of unstable, deep, dry sand.

5. *Comandra* Group

Comandra umbellata (L.) Nutt.
Campanula rotundifolia L.

Symphoricarpos albus (L.) Blake
Chimaphila umbellata (L.) Bart.
Diervilla lonicera Miller
Rosa acicularis Lindley
Satureja vulgaris (L.) Fritsch.
Amelanchier interior Nielsen
Ribes oxyacanthoides L.
Lonicera dioica L.
Salix humilis Marsh.

Habitat preference similar to the *Woodsia* group but less tolerant of extremes of drought associated with very thin soils.

6. *Coptis* Group
Coptis trifolia (L.) Salisb.
Cornus canadensis L.
Pyrola elliptica Nutt.
Mitella nuda L.
Oxalis acetosella L.
Moneses uniflora (L.) A. Gray

Characteristic of wet-mesic, extremely acid, infertile, shaded conditions. Occasionally found associated with sphagnum wetlands.

7. *Polygonatum* Group
Polygonatum pubescens (Willd.) Pursh
Lycopodium lucidulum Michaux
Smilacina racemosa (L.) Desf.
Mitchella repens L.

Characteristic of mesic, infertile to moderately fertile, shaded sites. Less tolerant of dry conditions than the *Maianthemum* species group.

8. *Gymnocarpium* Group
Gymnocarpium dryopteris (L.) Newm.
Athyrium filix-femina subsp. *angustum* (Willd.) Clausen
Sambucus pubens Michaux
Carex arctata Boott
Dryopteris carthusiana (Villars) H.P. Fuchs

Typical of more moist sites than is the *Polygonatum* group. A common group in tree-fall gaps with moist soil.

9. *Corylus* Group
Corylus cornuta Marsh.
Rubus parviflorus Nutt.
Adenocaulon bicolor Hooker

Consistently associated with relatively high levels of moisture and light. Most common in moist, moderately fertile soil in tree–fall gaps. Also common near roads and trails, or in moist soil after selective logging.

10. *Botrychium* Group

Botrychium virginianum (L.) Swartz
Viola pubescens Aiton
Melica smithii (Gray) Vasey
Dirca palustris L.
Actaea pachypoda Ell.
Osmorhiza claytonii (Michaux) C.B. Clarke
Brachyelytrum erectum (Roth) Beauv.
Aralia racemosa L.
Osmorhiza chilensis Hooker & Arn.
Uvularia grandiflora Sm.
Thelypteris phegopteris (L.) Slosson
Galium triflorum Michaux
Hepatica americana (DC.) Ker

Characteristic of nutrient-rich soil that has water available for plant growth throughout the growing season. However, these species may occasionally be found on moist, strongly acid, infertile soil.

11. *Impatiens* Group

Impatiens capensis Meerb.
Circaea lutetiana L.
Rubus pubescens Raf.
Carex crinita Lam.
Carex stipata Willd.
Matteuccia struthiopteris (L.) Todaro

Characteristic of wet-mesic, very fertile soil; usually receiving alluvial or colluvial inputs of organic matter and fine mineral particles. Never found on strongly acid forest soil.

12. *Arisaema* Group

Arisaema triphyllum (L.) Schott
Dicentra cucullaria (L.) Bernh.
Claytonia caroliniana Michaux
Trillium cernuum L.
Sanguinaria canadensis L.
Dentaria diphylla Michaux
Allium tricoccum Aiton
Panax trifolius L.
Caulophyllum thalictroides (L.) Michaux
Laportea canadensis (L.) Wedd.
Urtica dioica L.

Indicates very fertile conditions with abundant water available for plant growth throughout the growing season. Found in the most fertile footslope situations, along intermittent streams, and in the floodplains of major streams. Not quite as demanding of water as the species of the *Impatiens* group, but they are even better indicators of high soil fertility.

13. *Vaccinium*

    Vaccinium angustifolium Aiton
    Vaccinium myrtilloides Michaux
    Gaultheria procumbens L.

Consistently associated with extreme acidity and high light levels. Occupies a broad range of soil moisture conditions but most commonly found at the two extremes: dry exposed bedrock or deep sand, and sphagnum swamps.

14. *Pteridium* Group

    Pteridium aquilinum (L.) Kuhn

Excellent indicator of fire on a variety of soil types. Generally associated with high light intensity but may persist in dense hemlock forests for centuries following a fire.

15. *Maianthemum* Group

    Maianthemum canadense Desf.
    Dryopteris intermedia (Muhl.) A. Gray
    Streptopus roseus Michaux
    Acer pensylvanicum L.
    Trientalis borealis Raf.
    Aralia nudicaulis L.
    Lonicera canadensis Marsh.

Most common group of upland ecosystems. Tolerant of broad range of site conditions. Absent only on poorly drained and extremely well drained soils.

16. *Goodyera* Group

    Goodyera repens (L.) R. Br.
    Goodyera tesselata Lodd.
    Monotropa uniflora L.
    Monotropa hypopithys L.
    Corallorhiza maculata Raf.
    Corallorhiza striata Lindley

Saprophytic plants indicative of very low light levels, usually strongly to extremely acid soil, dry-mesic to wet- mesic site conditions.

17. *Polypodium* Group

    Polypodium virginianum L.
    Asplenium trichomanes L.

Occur in topographically protected areas where crystalline bedrock is exposed at the surface, usually attached to the rock surface with little or no visible soil. Variation in the moisture of the rock surface is extreme.

Wetland Species Groups

1. *Ledum* Group

    Ledum groenlandicum Oeder.
    Kalmia polifolia Wang.
    Sarracenia purpurea L.

Restricted to wet, extremely acid, very infertile sphagnum mats, with high light intensity. Seldom found outside of these areas.

2. *Drosera* Group

    Drosera rotundifolia L.
    Vaccinuum oxycoccus L.

Highly specific to the acid, sphagnum hummocks around tree and shrub bases. Characteristic of low nutrient conditions and high light intensity.

3. *Chamaedaphne* Group

    Chamaedaphne calyculata (L.) Moench.
    Smilacina trifolia (L.) Desf.
    Carex oligosperma Michaux
    Carex trisperma Dewey
    Andromeda glaucophylla Link.

Similar in site preference to *Ledum* group and are frequently found growing side by side. Not as restricted in occurrence, commonly found under strongly and very strongly acid conditions.

4. *Ilex* Group

    Ilex verticillata (L.) A. Gray
    Nemopanthus mucronatus (L.) Loes.

Characteristic of wet soil and high light intensity under a variety of nutrient and pH conditions. Most commonly found around the edges of wetlands.

5. *Carex* Group

    Carex rostrata Stokes
    Carex lasiocarpa Ehrh.
    Equisetum fluviatile L.
    Triadenum fraseri (Spach) Gl.

Characteristic of fertile to moderately fertile, high light intensity conditions. Water table usually at or very near the surface throughout the growing season.

6. *Myrica* Group

Myrica gale L.
Spiraea alba Duroi

Characteristic of fertile, circumneutral, high light intensity conditions. Tolerant of inundation for prolonged periods.

7. *Osmunda* Group

Osmunda regalis L.
Osmunda cinnamomea L.
Lycopus americanus Muhl.
Alnus rugosa (Duroi) Sprengel
Caltha palustris L.

Most commonly found associated with nutrient-rich, circum-neutral organic muck. Moist to wet, very fertile conditions.

8. *Onoclea* Group

Onoclea sensibilis L.
Iris versicolor L.
Thalictrum dasycarpum Fisch. & Ave-Lall.
Cornus stolonifera Michaux
Eupatorium maculatum L.

Characteristic of wet to moist, extremely fertile conditions. Not at all tolerant of acid, infertile conditions. May be found in moist, fertile upland soil adjacent to wetlands.

Cover Type Descriptions

The following discussion of the local plant communities of the Huron Mountains is structured around the 29 cover types of our classification of existing vegetation (Table 3). The cover type map shows the spatial distribution of existing vegetative cover types in the Reserve Area and adjacent lands. In forests the "cover" is the dominant overstory tree community. In nonforested areas (marshes, shrub swamps, meadows, and beaches) the cover is herbs, shrubs, mosses, and lichens.

Although this section focuses on cover type vegetation, ecological relationships of plants with their physical environment are also emphasized. Vegetation of the 50 landscape ecosystem types is not explicitly discussed here, but can be easily determined by referring to appendices E and F, which detail the correspondence of cover types with ecosystem types. Vegetation of the ecosystem types is also described under "Landscape Ecosystem Type Descriptions" in the section titled "Landscape Ecosystems of the Reserve Area and Adjacent Lands."

In some cases, the map boundaries of ecosystem types and cover types are equivalent. This correspondence is particularly true of the wetland areas and

Table 3. Classification of the cover types of the Huron Mountain Club Reserve Area and adjacent lands[1]

	Percentage of the area[2]
UPLAND COVER TYPES	94.3
A. Pine	7.3
1. Jack Pine	5.5
Greater than 75% relative dominance of jack pine. Characteristic of very dry, sterile, deep sand in areas where fire is frequent.	
2. Red Pine	0.7
Greater than 75% relative dominance of red pine. Characteristic of slightly moister sand than type 1. Moderate to high fire frequency.	
3. Red and White Pine	1.1
Overstory composed of mixed red and white pine and a minor component of red oak (<25 % relative dominance). Habitat similar to type 2.	
B. Lichen-Juniper, Pine-Oak, and Pine-Hemlock-Hardwood	30.0
4. Lichen-Juniper	3.9
Dominated by foliose and crustose lichens and *Juniperus communis* var. *depressa*. Less than 20% tree cover. Characteristic of very thin, droughty soil in exposed topographic positions on crystalline bedrock terrain.	
5. Pine-Oak	12.4
Mixed white pine and red oak with lesser amounts of red pine. Open canopy forest with greater than 20% tree cover. Characteristic of thin, droughty soil or deep sand.	

[1] Arabic numbers in the classification are those found on the map of cover types.

[2] Percentage based on a mapped area of 3193.5 ha (7891.3 ac) covering the Reserve Area and adjacent lands of the Huron Mountain Club. Plantations and developed land (0.4%) and beach sand (0.3%) are not included in the classification.

Table 3. (Continued)

	Percentage of the area
6. White pine-Hemlock-Hardwood	13.7
Dominated by a mixture of hemlock, red maple, white pine, white birch, and northern hardwoods. Closed canopy forest. Characteristic of rock habitat; less dry and less frequently burned than types 4 and 5.	
C. Birch - Aspen	2.9
7. Birch-Hemlock-Red Maple	2.9
Dominated by a mixture of species that regenerate well on moist soil after fire: white birch, hemlock, yellow birch, red maple, white pine, and bigtooth or trembling aspen. Both types 6 and 7 will, in the absence of fire, succeed toward hemlock or hemlock-northern hardwood vegetation (Types 10 or 11).	
8. Aspen	<0.1
Greater than 75% relative dominance of bigtooth or trembling aspen. Stands of aspen are clonal, the result of suckering of stems from roots following fire or clearcutting that kills the parent tree.	
9. Birch	<0.1
Greater than 75% relative dominance of yellow birch and white birch. Establishes on moist soil following fire.	
D. Hemlock-Northern Hardwood	49.6
10. Hemlock	5.5
Greater than 75% relative dominance of hemlock. Established following fire on well to moderately well drained soil. The Hemlock type often replaces the Birch or Aspen types in succession.	
11. Hemlock-dominated Hemlock-Northern Hardwood	24.2
Hemlock relative dominance between 40 and 75%. Sugar maple, yellow birch, and basswood are common overstory tree species. Usually deep, moist soil. Fire may be important in establishing hemlock.	
12. Hardwood-dominated Hemlock-Northern Hardwood	17.4
Hemlock relative dominance between 5 and 40%. Characteristic of areas with deep, moist soil and very low fire frequency. Sugar maple, yellow birch, and basswood are common overstory tree species.	

Table 3. (Continued)

	Percentage of the area
13. Sugar Maple-Hardwood	2.5
Less than 5% relative dominance of hemlock. Greater than 75% relative dominance of sugar maple. Basswood and yellow birch also occur. Characteristic of areas protected from fire.	
E. Wet Site Conifer and Conifer-Hardwood types	2.4
14. Northern White-Cedar-Hemlock	0.7
Mixed northern white-cedar and hemlock greater than 75% relative dominance. Characteristic of narrow lake margins; most frequently on western shores (not mapped due to narrow width). May occur on burned-over land adjacent to lakes and wetlands.	
15. Northern White-Cedar	0.1
Greater than 75% relative dominance of northern white-cedar. Fire established. Largely restricted in occurrence to low terraces of the Pine River, due to fires originating in the adjacent jack pine forest.	
16. Balsam Fir-White Spruce	0.3
Greater than 75% relative dominance of balsam fir and white spruce. Characteristic of moist or wet sites disturbed by fire, cutting, or windthrow.	
17. Hemlock-Red Maple-Yellow Birch-Northern White-Cedar	1.3
A common cover type in somewhat poorly drained soils. Yellow birch and red maple increase in importance in comparison to adjacent well drained areas, and sugar maple, if present at all, is a minor component. Hemlock density and basal area is quite variable. Northern white-cedar is a minor component.	
F. White Ash and Elm-Sugar Maple-Basswood	0.2
18. White Ash	<0.1
Greater than 75% relative dominance of white ash. A very infrequent type that establishes in rich alluvial areas following disturbance.	
19. Elm-Sugar Maple-Basswood	0.2
Dominated at present by sugar maple and basswood. American elm was more than 50% relative dominance prior to its demise due to Dutch elm disease and phloem necrosis. Balsam fir and northern white-cedar are occasionally present. Characteristic of river floodplains.	

Table 3. (Continued)

	Percentage of the area
G. Miscellaneous Types	1.9
20. Hemlock-Mountain maple	0.2
Open canopy forest of hemlock, mountain maple, striped maple, and yellow birch. Exclusive to bedrock ravines.	
21. Open Meadow	<0.1
Dominated by grasses and low herbaceous plants. Maintained by mowing.	
22. Post-Clearcutting Hardwoods	1.7
Mixture of sugar maple, red maple, yellow birch, and white ash that established after clearcutting.	
WETLAND COVER TYPES	5.2
A. Open Wetland	2.6
23. Leatherleaf	0.3
Greater than 75% coverage of *Chamaedaphne calyculata. Ilex verticillata* may be dominant where cover type 23 abuts an upland area. Less than 5% coverage of trees. Acid shrub swamps.	
24. Sweet Gale-Spirea	0.2
Greater than 75% coverage of *Myrica gale* and *Spiraea alba. Myrica* usually dominant. Circumneutral shrub swamp commonly at lake and stream margins. Less than 10% coverage by trees.	
25. Sedge-Cattail	0.3
Greater than 90% coverage of *Carex* species. *Typha* clones may be interspersed. Circumneutral marshes.	
26. Alder	1.8
Greater than 75% coverage of *Alnus rugosa.* Up to 25% coverage by tree species; black ash, northern white-cedar, red maple, and white pine. Neutral to strongly acid shrub swamps. Stream and lake margins, and trapped drainages.	

Table 3. (Continued)

	Percentage of the area
B. Forested Wetland	2.6
27. Black Spruce	0.3
Greater than 75% relative dominance of black spruce. Characteristic of trapped drainages with extremely acid soil.	
28. Conifer-Hardwood	2.0
Dominated by a mixture of wet-site conifer and hardwood species; northern white-cedar, black ash, white spruce, yellow birch, and balsam fir. Characteristic of moderately fertile to fertile swamps	
29. Black Ash-Elm	0.3
Black ash over 50% relative dominance. American elm was a former associate. Northern white-cedar occasionally present. Characteristic of very fertile swamps.	

those of exposed crystalline bedrock. An example is ecosystem 28, topographically exposed crystalline bedrock with little or no soil, which consistently has a lichen-juniper cover type (cover type 4). Conversely, cover type 4 is almost entirely restricted in occurrence to ecosystem 28.

In other areas, such as those dominated by hemlock-northern hardwood cover types, the correspondence between ecosystem and cover types is less exact. This is often due to the occurrence of disturbances (fire, cutting, disease, herbivory, and windthrow) that do not act uniformly in time and space over the extent of the ecosystem type. The result is a mosaic of several cover types on a single ecosystem type, reflecting the disturbance history of that ecosystem. Because disturbance histories differ among ecosystems, different ecosystems will have different mosaics of vegetation. For example, neither ecosystem 20 nor ecosystem 35 is characterized by a single cover type--the first is a mosaic of six cover types and the second is a mosaic of eight cover types. Because ecosystem 20 is drier and more fire-prone than ecosystem 35, fire has affected a larger portion of that ecosystem and has produced a vegetation mosaic more dominated by fire-influenced cover types. Hence, even though both these ecosystem types are dominated by the same hemlock-northern hardwood cover types (10, 11, 12, 13), the fire-influenced, hemlock-dominated types (10 and 11) compose 67% of ecosystem 20 but only 31% of ecosystem 35 (Appendix E).

Table 3 presents a classification and brief descriptions of the 29 existing vegetation types that occur on the cover type map. The following is a discussion of the flora, vegetational composition and structure, landscape position, physical environment, and disturbance history of the mapped cover types.

Nonforested Areas

(cover types 4, 21, 23, 24, 25, 26)

Although forests predominate in the Huron Mountains, a significant portion of the landscape remains treeless. Typical of recently glaciated areas, lakes and ponds are in abundance, covering more than 2000 acres (800 ha) on Huron Mountain Club property alone. Most of these bodies of water are deep enough that only their shallower margins support any vegetation, which includes submergent plants like water lobelia (*Lobelia dortmanna*), quillworts (*Isoetes* spp.), and water-milfoils (*Myriophyllum* spp.), floating plants like duckweed (*Lemna minor*), fragrant water-lily (*Nymphaea odorata*), and several pondweeds (*Potamogeton* spp.), and emergents like bulrushes (*Scirpus* spp.), and spike-rushes (*Eleocharis* spp.). Shallow, sandy-bottomed waters of Mountain, Howe, and Pine lakes, and the northern one-third of Cranberry Bog show the best development of such aquatic plant communities.

Wave action and fluctuating lake levels have combined to create a treeless zone, often only 3 ft (1 m) wide, between the water of the inland lakes and the surrounding forested uplands. Sweet gale (*Myrica gale*), speckled alder (*Alnus rugosa*), and royal fern (*Osmunda regalis*) are perhaps the most common plants in this transitional lake border community.

Some of the shallowest ponds and lake areas have become partially or even completely covered by a mat of herbs and shrubs. These marshes and shrub swamps vary greatly in their vegetation. The more fertile wetlands with better aeration and higher pH (cover types 24, 25, 26) are dominated by shrubs such as sweet gale and speckled alder and herbs like cattails (*Typha* spp.), sedges (*Carex hystericina*, *C. rostrata*, *C. lasiocarpa*, *C. vesicaria*), bur-reeds (*Sparganium* spp.), royal and cinnamon ferns (*Osmunda regalis* and *O. cinnamomea*), sensitive fern (*Onoclea sensibilis*), blue flag (*Iris versicolor*), rattlesnake grass (*Glyceria canadensis*), water horsetail (*Equisetum fluviatile*), three-way sedge (*Dulichium arundinaceum*), marsh cinquefoil (*Potentilla palustris*), marsh St. John's-wort (*Triadenum fraseri*), and bugle-weed (*Lycopus uniflorus*). Infertile, nonforested wetlands (cover type 23) in the Huron Mountains are invariably dominated by leatherleaf (*Chamaedaphne calyculata*), a good indicator of acid conditions. Sphagnum moss, sedges (*Carex oligosperma* and *C. trisperma*), cranberries (*Vaccinium macrocarpon* and *V. oxycoccos*), sundews (*Drosera rotundifolia*), and bog rosemary (*Andromeda glaucophylla*) are other acidophiles found in these stagnant wet areas.

All of the above situations lack trees for the same reason: the water table is at or very near the surface year round, and none of the tree species native to the Huron Mountains can tolerate submergence of their root systems for long periods of time. Other areas, however, lack trees for different reasons. One example is the sandstone cliffs of Pine River and Conway points. Undercutting by storm waves and the force of gravity on these nearly vertical slopes continually disrupt the substratum and prevent plant growth of any kind. Similar continual disturbance by waves and wind of the sandy beaches of Pine River and Salmon Trout bays has created a vegetation-free zone immediately adjacent to the lake, and an herb-dominated zone a little farther inland. In this latter zone, rooting by beach grass (*Ammophila breviligulata*), sea-rocket (*Cakile edentula*), evening primrose (*Oenothera biennis*), and beach pea (*Lathyrus japonicus*) has temporarily stabilized the shifting sands, but not long enough for the successful establishment of trees.

The largest upland treeless areas in the Huron Mountains are the mountains themselves. The narrow ridge tops and steep south slopes of most of the mountains have patches of exposed crystalline bedrock where trees are very sparse to absent (cover type 4). In these areas, only scattered cracks on the ridge tops and small benches on the steep cliffs retain any appreciable amount of soil. Where cracks are few and shallow, or slopes the steepest, what soil that is held is of insufficient volume for growth of tree-sized plants. Severe erosion by water, especially in early postglacial times (see Geologic History section), coupled with extremely slow weathering of the hard metamorphic bedrock, are responsible for the thin or absent soils. A diverse flora adapted to the dry, high light, and thin soil environment of these areas includes several species found nowhere else in the Huron Mountains. Reindeer moss (*Cladonia rangiferina*) and many foliose and crustose lichens have gained a precarious foothold on bedrock areas without soil. The small cracks and benches support dwarfed individuals of red pine, white pine, and red oak. Juniper (*Juniperus communis* var. *depressa*) and low sweet blueberry (*Vaccinium angustifolium*) are the most common shrubs. Other herbs and shrubs growing on microsites with soil include the members of the *Cladonia*, *Vaccinium*, and *Woodsia* species groups, and to a smaller extent the *Comandra* group (see Ecological Species Groups section for discussion and listings of species groups).

A final nonforested type is open meadow (cover type 21). No natural meadows exist in the Huron Mountain Club. All known examples are human-made--the result of removal of trees, sowing of sod-forming grasses, and repeated mowing of shrub and tree regeneration. The majority of plants in these meadows are weedy European species, which are highly adapted to the repeated disturbances experienced by crop or grazing land, and which were introduced by early settlers. Four grasses--timothy (*Phleum pratense*), redtop (*Agrostis gigantea*), orchard grass (*Dactylis glomerata*), and smooth brome (*Bromus inermis*)--and a few herbs--thistle (*Cirsium arvense*), goat's beard (*Tragopogon pratensis*), yellow and orange hawkweeds (*Hieracium* spp.), and common buttercup (*Ranunculus acris*)--make up the bulk of the vegetation. Moister sections of the large Ives Lake meadow (which were originally black ash-elm swamp) have a profusion of two native wetland species--blue flag (*Iris versicolor*) and Canada anemone (*Anemone canadensis*).

Forested Areas

The cool temperate climate of northern Michigan is conducive to forest development on all but the wettest or the most frequently disturbed sites. In fact, excluding lakes, greater than 90% of the Huron Mountain landscape is forested. From the summit of Huron Mountain one cannot help but note the luxuriant mantle of green canopy that stretches inland from the Superior shoreline as far as the eye can see. At first glance the appearance is of uniformity, but closer inspection reveals subtle variation. For one thing, the greens are not all of one shade, but are variously modified by tints of grey, blue, and yellow. Differences in tree crown shape lend a heterogeneous texture to the upper surface of the forest, with some crowns conical in form, some billowy and spherical, others ragged and wind-sculpted. Density and height of the forest vegetation also vary. Trees high up the mountain slopes are often widely separated and stunted, trees on lower slopes and flats dense and tall. All of this suggests a heterogeneous forest vegetation resulting from a mixture of trees of different species, form, and size. Moreover, this diverse mixture is patterned. The different trees are not randomly intermingled; instead, patches of particular combinations of trees recur again and again across the landscape. These recurring combinations are recognized as forest community types and the patchwork mosaic they constitute can be mapped, as in our cover type map. Finally, and most significantly, the various forest communities themselves are distributed in a meaningful, patterned manner. A given forest community type does not occur just anywhere, but usually is restricted to certain kinds of positions in the landscape (Figs. 4, 7). Since landscape position in turn influences soil development, water flow, and microclimate, distinct ecological units of forest vegetation and the associated physical environment can be recognized and mapped, as we have done in our landscape ecosystem map.

For convenience, the diverse forest communities of the Huron Mountains can be classified into eight major types: pine, pine-oak, white pine-hemlock-hardwood, birch-aspen, hemlock-northern hardwood, northern white-cedar-hemlock-hardwood, floodplain, and swamp. Each of these major forest types comprises one or more of our mapped cover types, as noted parenthetically in the text. The forest types will be treated in the order listed above, which essentially follows a soil moisture gradient from extremely dry (pine forests) to very wet (swamp forests).

Pine Forests

(cover types 1, 2, 3)

Relatively pure pine forests in the Huron Mountains occur on fire-prone sites with deep sand soils. All three pines native to Michigan--jack, red, and white--are important in this forest type. Pines are dependent on fire for their establishment and perpetuation. They seed in after fire destroys the previous overstory (often pine) and burns the forest floor to expose patches of thin litter or even bare mineral soil. The high light levels, reduced litter, and nutrient-rich ash produced by fire create a favorable seed bed for pine regeneration, but one that lasts only a few years (Chrosciewicz 1974, Simard et al. 1983). As a result, the pine overstory that develops is even-aged and of approximately uniform height. Because pines are intolerant of shaded conditions, no second generation pine understory is able to form under the first generation pine overstory, which is why new fires are needed to perpetuate the forest type. The sites pine forests occupy often do experience regularly recurring fires, maintaining the pine community as the fire-climax vegetation of the site.

Pine forests have a dense herb and small shrub layer, with very high coverage but relatively low species diversity. Species of the *Cladonia*, *Gaylussacia*, *Pteridium*, and *Vaccinium* species groups typically occur. These plants are all tolerant of infertile, dry soils, and many of them are clonal perennials with extensive underground root systems that survive all but the hottest fires. Vigorous sprouting from these root systems after fire quickly reestablishes the lower vegetation layers. In contrast to the ground cover, the tree seedliug layer is sparsely populated, with only a few scattered red maple, red oak, and white pine.

Of the three pines, jack pine is most adapted to frequent fires. It has evolved such traits as serotinous cones, highly flammable foliage, persistent lower branches, rapid early growth and maturation, and short life span that function both to promote frequent fire and to aid in the rapid recovery of the jack pine forest after fire. Typically, fire will completely destroy the jack pine overstory, and regeneration occurs via seeds released by heat-opened cones of the dead trees. On the Huron Mountain Club, jack pine forest (cover type 1) is exclusively found within 3300 ft (1000 m) of Lake Superior in the vicinity of the club compound (Fig. 9). Here, hot dry winds from the Yellow Dog Plains to the south, combined with deep (> 6 ft or 2 m) sandy soils that hold little moisture, produce droughty conditions conducive to frequent initiation aud spread of fire. Jack pine was one of the very first trees to migrate into the Huron Mountain area after the last glaciers retreated, and it is quite possible that the jack pine community surrounding the compound has repeatedly regenerated itself following scores of fires during the last 10,000 years.

Red and white pines, although also adapted to fire, use a different strategy than jack pine. These pines do not have serotinous cones, are long-lived, thick-barked, relatively slow-growing, and prune their dead lower branches well. Larger individuals are fairly fire-resistant, and it is likely that a few will survive most fires. Thus, rather than seeding in from cones of many fire-killed trees, as jack pine does, a relatively few red or white pine survivors produce large crops of cones that seed into the surrounding burnt area. This strategy does not work well when fires are too frequent, for it takes many years for red and white pine to grow to a fire-resistant size. Consequently, compared to jack pine forest, red pine (cover type 2) and red pine-white pine (cover type 3) forests occur on somewhat moister soils where fires burn less frequently. Like jack pine sites, these areas are still sandy and dry, and usually exposed to the wind. Red pine groves, such as the Norways or at the Iliad, occur frequently on the north and east shores of the larger inland lakes, where they bear the brunt of the prevailing southwest winds. Red and white pine forests also occur on the sandy Nipissing deposits along Lake Superior, notably west and north of Pine River, north of Conway Lake, and on several of the sandy beach ridges rising above the large wetland south of Salmon Trout Bay. In all these cases, the water table is nearer the surface than it is in the jack pine forest. In these forests, scattered fire-scarred old pines, veterans of previous fire, attest to the seed tree strategy at work.

Fig. 9. Jack pine forests dominate much of the former beach sand of Nipissing Lake Superior in the northern part of the Club.

Pine-Oak Forest
(cover type 5)

Pine-oak forest (cover type 5) is almost entirely restricted to ridges and steeper slopes of the crystalline bedrock mountains. It is closely related to and grades into the open lichen-juniper community (cover type 4) described in the Nonforested Areas section, but is characterized by a more continuous soil cover and less exposed bedrock than the open rock community. Soils are thin and rocky and drain rapidly because of their high or steep position in the landscape. Dry soil and exposure to wind and sun create a high frequency of fire, leading to a forest overstory dominated by fire-adapted species like white pine and red oak, and to a lesser extent red pine. Also present, but in much smaller amounts, are white birch, bigtooth aspen, red maple, northern white-cedar, hemlock, and white ash. The overstory trees are often stunted relative to their potential size on sites with deep soil, due to inhibition of rooting. In addition, the relentless winds affect tree growth. The effect of wind is most easily observed for white pine, where the branches emanating from the windward side of the tree have turned and grown in the downwind direction, giving the trees dramatically asymmetric profiles.

Commonly, pine-oak forest is interrupted by scattered patches of open lichen-juniper community, creating a low density forest with clumped distribution of trees. The open, patchy pine-oak canopy growing on broken, rocky topography does not carry a fire as well as denser pine forest canopies on flat terrain; therefore, fire, though very common in the pine-oak forest, usually burns spottily, leaving clumps of unscathed trees. Patchy burning produces a forest overstory less even-aged and of less uniform height than that of pine forests. Another interesting difference between pine-oak and pine forests is the much greater importance of red oak in the former. Although no one really understands why this is so, the ability of red oak to sprout from its root collar after losing its above-ground portion to fire may give it a competitive advantage on bedrock areas with little soil. Many of the bushy clumps of red oak stems that are so common on the rocky hills of the Huron Mountains are likely only the latest generation of young sprouts from ancient root systems.

The shade intolerance of the overstory trees of pine-oak woodland precludes the development of any true pine-oak understory. Understory-sized individuals of red pine, white pine, and red oak do occur, but only in areas without an overstory canopy. Enough light penetrates the relatively open canopy for growth of an abundant shrub layer, composed of juniper (*Juniperus communis* var. *depressa*), cherries (*Prunus* spp.), blueberries and bilberries (*Vaccinium* spp.), and juneberries (*Amelanchier* spp.). Tree seedlings are moderately common, mostly red maple and red oak with lesser numbers of hop-hornbeam, white pine, and striped maple. Members of the *Woodsia*, *Vaccinium*, *Cladonia*, and *Comandra* species groups are well represented in the ground cover; members of the *Maianthemum* group may also occur at low coverage. Small pools and organic deposits in deeper rock crevices may even support wetland plant species. The high species diversity of the ground cover results from two factors--the rugged microtopography of these bedrock areas, which produces high variation in soil moisture and thickness, and the patchy distribution of trees, which produces high variation in ground-level light intensity. The variation in physical environment can be abrupt, so that dryland plants like red pine and juniper can be found growing only a few feet from wetland plants like leatherleaf (*Chamaedaphne calyculata*) and winterberry (*Ilex verticillata*).

White Pine-Hemlock-Hardwood Forest

(cover type 6)

White pine-hemlock-hardwood forest (cover type 6) differs considerably from pine-oak forest. Although typically growing next to pine-oak forest on the bedrock mountains, pine-hemlock-hardwood forest avoids the steeper west and south slopes and the narrow ridge tops favored by pine-oak and instead occurs on upper north slopes, on lower south and west slopes, and on broad, flat ridge tops. Also unlike pine-oak, white pine-hemlock-hardwoods occurs on sandstone bedrock features such as the Rush Lake peninsula, the plateau immediately north of Rush Lake, and the sandstone benches on the northwest slope of Huron Mountain. On all these sites, soil cover is continuous, other than occasional small bedrock outcrops or large boulders, and soils are moderately thin. Because of its more continuous soil cover, lower slope positions, less steep slopes, and north-facing aspects, white pine-hemlock-hardwood forest retains more soil moisture and receives less solar radiation and wind than does pine-oak forest.

Like pine and pine-oak forests, the white pine-hemlock-hardwood forest type is established by fire. It burns less frequently than pine or pine-oak, however, due to its relatively moister and better protected landscape positions. White pine-hemlock-hardwoods also has a more diverse mix of overstory tree species than the drier forest types. As expected, fire-dependent species are important in the overstory: white birch, white pine, and bigtooth aspen are common; red oak and red pine also occur, but at much lower relative densities than in pine-oak forest. Less expected is the importance of opportunistic species like yellow birch, red maple, northern white-cedar, and eastern hemlock. These trees have broad site tolerances and occur in many areas where fire is rare, but all can aggressively establish on recent burns if a seed source is nearby and the site is not too dry. Hemlock is so efficient at post-fire establishment that it often is the dominant tree of this forest type. During an unusually long interval between fires (over 200 years) white pine-hemlock-hardwood forest may succeed to a white pine-hemlock-northern hardwood climax forest (see Hemlock-Northern Hardwood Forest section).

Unlike pine-oak forest, the overstory of white pine-hemlock-hardwood forest develops a closed canopy, and the trees are only slightly stunted compared to their size on better sites. Also unlike pine-oak, a distinct understory and small tree layer of shade tolerant species usually develops--primarily hemlock, red maple, striped maple, hop-hornbeam, and sugar maple. A third difference results from the less patchy canopy and soil cover of pine-hemlock-hardwoods, which produces less microsite variability of light, soil volume, and moisture than is true of pine-oak forest. This in turn creates lesser species diversity in the shrub and ground-cover layers. For instance, members of the *Cladonia* and *Woodsia* groups are nearly absent, and the *Comandra* and *Vaccinium* groups are confined to infrequent sunlit areas of thin soil over bedrock. The *Polypodium* group is frequent on shaded rock surfaces, but only plants of the *Pteridium* and *Maianthemum* groups are common on the forest floor. On somewhat moister sites the *Polygonatum* group becomes important. Bilberry (*Vaccinium membranaceum*) and marginal shield-fern (*Dryopteris marginalis*) are locally common. When the canopy has a large hemlock component, the ground-cover, tree seedling, and shrub layers become very sparse.

White pine-hemlock-hardwoods is not completely confined to mountain slopes and ridges and sandstone outcroppings in the Huron Mountains. As a result of fire, this forest is also growing on relatively deep deposits of sand or loamy sand. Examples include portions of the north shore of Second Pine and Third Pine (which burned in 1900), several small points projecting into Mountain Lake (which have white pine stumps from selective cutting late in the 19th century), and a magnificent white pine grove on both sides of Fisher Creek near the Reserve Area boundary. In this last stand, approximately 45 large white pine tower above a mixture of hemlock, yellow birch, red maple, white spruce, northern white-cedar, sugar maple, and a few remnant bigtooth aspen and white birch. Some of the pines exceed 40 in (100 cm) in diameter and 130 ft (40 m) in height.

Birch-Aspen Forests

(cover types 7, 8, 9)

Birch-aspen forests occur adjacent to the inland lakes of the Huron Mountains on flat to gently sloping sites with deep, moist soils. Birch-aspen only occasionally occurs on the bedrock mountains where white pine-hemlock-hardwoods is so common.

Like all the forests so far discussed, birch-aspen forests are fire-established. The most prevalent type of birch-aspen forest, birch-hemlock-red maple forest (cover type 7), has a mixture of fire-dependent trees (white birch, bigtooth and trembling aspen, white pine) and fire-opportunistic trees (hemlock, yellow birch, red maple, balsam fir) in its overstory. This is similar to the overstory of white pine-hemlock-hardwood forest, but with more birch and balsam fir, and less pine. Because of the moist soils of birch-aspen sites, fire burns rather infrequently. Only the proximity of drying lake winds makes these sites different from the adjacent areas farther inland that support late-successional forests, and during longer intervals between fire, birch-aspen forests will succeed to one of the climax hemlock-northern hardwood types (see next section).

Birch-hemlock-red maple forest has a moderate to dense understory of hemlock, red maple, sugar maple, and balsam fir, shade tolerant tree species that can eventually replace the original post-fire overstory. The ground-cover and tree seedling layers resemble those of nearby hemlock-hardwood forests on similar soils, the only major difference being the much greater abundance of bracken fern (*Pteridium aquilinum*) in the birch-hemlock-red maple type. Bracken fern is an extremely aggressive colonizer of newly burned areas on deeper soils, and it may