persist clonally for centuries after colonization (Oinonen 1967).

In rare cases, the overstory of birch-aspen forests is largely just birch or aspen. Along the southwest shore of First Pine Lake lies a forest dominated by yellow and white birches (cover type 9). The only occurrence of aspen forest (cover type 8) in the Reserve Area lies near the gate northwest of First Pine Lake. This stand probably established by clonal reproduction from root suckers of a former aspen clone whose stems were destroyed by fire. Aspen also regenerates asexually after clearcutting, as is vividly demonstrated by small clearcuts northwest of the club compound.

Hemlock-Northern Hardwood Forests

(cover types 10, 11, 12, 13)

Hemlock-northern hardwood forests cover more area in the Huron Mountains than any other forest type. Nearly half of the old-growth forest of the mapped area is one of these types (Table 3). Hemlock-northern hardwood forests occupy a broad ecologically and spatially intermediate position in the landscape. Ecologically, they are largely restricted to mesic, protected sites that are not too dry, not too wet, and not too frequently disturbed. Spatially, they occur below the pine-oak and pine-hemlock-hardwood forests of the upper slopes and ridge tops but above the cedar-hemlock-hardwood and swamp forests of the depressions, low flats, and drainages--i.e., on north-facing and east-facing middle and lower slopes of the bedrock hills, on the drier portions of the flats east of Mountain Lake and south of Mummy Mountain, on the highland north of Second Pine and the gravel bar north of Ann Lake, on the peninsula southwest of Lumberman Bay, and in the valley of Mink Run. Soils of hemlock-northern hardwood forests are usually deep, are moderately well to well drained, and vary from low to high fertility. An acidic litter layer several centimeters thick covers roughly 85% of the forest floor; the remainder is areas of faster rates of plant decomposition that have mineral soils (A horizons) at the surface.

Five tree species--hemlock, sugar maple, yellow birch, basswood, and red maple--make up most of the overstory of hemlock-northern hardwood forests. A minor portion of the forest canopy is white pine, northern white-cedar, red oak, and white spruce. In addition, hop-hornbeam, striped maple, and balsam fir are common small trees of this forest that rarely if ever grow large enough to become part of the canopy. These twelve species of the large and small tree layers produce abundant seed that regenerates to form the most diverse and abundant tree reproduction layer of any forest type in the Huron Mountains. Common as both seedlings and saplings are sugar maple, striped maple, hop-hornbeam, hemlock, balsam fir, and basswood. Red maple, yellow birch, and red oak are common as seedlings but not as saplings; and white pine, white spruce, and northern white-cedar are rare to infrequent in the tree seedling layer. Other tree species which sometimes occur in the seedling layer include mountain maple, bigtooth aspen, white ash, paper birch, black ash, black cherry, and showy mountain ash. The abundance of woody regeneration is strongly affected by the proportion of hemlock in the overstory; combined coverage of the tree seedling and sapling layers ranges from 30-80% under pure hardwood overstories to less than 1%

under dominantly hemlock overstories (Figs. 10 and 11).

Hemlock-northern hardwoods is considered to be the climax forest of the northern Lake States on mesic sites. Its dominant trees are shade tolerant, long-lived species capable of forming relatively stable, long-enduring, uneven-aged communities (Braun 1950, Spurr and Barnes 1980). It must be emphasized, however, that the hemlock-northern hardwood forest is a dynamic entity. Even in protected sites where fire is rare, the climax hemlock-hardwood forest that develops is continually changing in space and time: trees that are thrown or broken by wind, or that simply die in place, create gaps in the forest canopy where rapid regeneration takes place within the larger, relatively slow-changing forest (Runkle 1981). Furthermore, a significant portion of what can be called hemlock-northern hardwood forest in the Huron Mountains by tree composition shows evidence of being burned in the last 200-300 years. Charred stumps and snags, charcoal in the soil, and the presence of a few scattered bigtooth aspen and white birch (species that are almost exclusively established by fire) indicate that large areas of the present hemlock-northern hardwood forest were fire-established. This is not surprising considering that many of the dominant trees of this forest are fire opportunists (U.S. Department of Agriculture 1965). Hemlock, red maple, yellow birch, balsam fir, northern white-cedar, and white pine all seed aggressively into burned areas. Hop-hornbeam and basswood vigorously sprout back after fire. Even sugar maple, probably the least fire-adapted of all the hemlock-northern hardwood species, can colonize burned areas by virtue of long-distance dispersal of its winged seeds. Thus although the hemlock-northern hardwood forest is theoretically capable of sustaining itself in the absence of external disturbances like windthrow and fire, such disturbances are a normal part of this forest and, when of moderate to low frequency and intensity, do not necessarily prohibit its development or long-term maintenance.

The disturbance history of hemlock-northern hardwood forests is reflected in the composition of overstory trees, particularly hemlock. Hemlock forest (cover type 10), with greater than 75% relative dominance of hemlock in the overstory, is usually established by crown fires that largely destroyed the previous forest. Often roughly even-aged, hemlock forests usually have little understory development. Red maple and yellow birch are common associates of hemlock; sugar maple is infrequent, and fire-dependent pioneer species like bigtooth aspen and white birch may survive in small numbers for as long as 200 years after fire. Hemlock forest often replaces the white pine-hemlock-hardwood forest (cover type 6) or the birch-hemlock-red maple forest (cover type 7) when fire-free intervals are long enough. Gaps in hemlock forests are more often replaced by hardwoods than by hemlock, especially when deer browsing is heavy, so that hemlock forests tend to become more mixed with time.

Hemlock-dominated northern hardwood forest (cover type 11) varies from 40-75% hemlock in the overstory and often has a dense small tree layer of hemlock. Yellow birch and red maple are somewhat less common, and sugar maple and basswood somewhat more common, than in the hemlock type. White pine, red oak, white birch, and bigtooth aspen are sometimes present in the canopy, indicating occasional fire establishment of this forest type. The hemlock

Fig. 10. Sugar maple-dominated forest (cover type 13), showing the abundant coverage of the seedling and ground-cover layers.

Fig. 11. Hemlock-dominated forest (cover type 11), showing the low coverage of tree seedlings, shrubs, and herbaceous plants.

understory is often the result of past ground fires that removed low vegetation and reduced the litter layer or bared mineral soil, thereby allowing successful germination of hemlock, but that did not kill the larger trees. Hemlock-dominated northern hardwood forest often replaces the birch-hemlock-red maple type.

Hardwood-dominated northern hardwood forest (cover type 12) has 5-40% relative dominance of hemlock in the overstory. Bigtooth aspen and white birch are usually absent, sugar maple is abundant, and charcoal absent to infrequent, indicating that the current canopy is not fire-established, although fire may have originally brought in the hemlock two or more generations before. In addition, light ground fires may establish a dense hemlock understory beneath the predominantly hardwood overstory of this forest type.

Sugar maple-hardwood forest (cover type 13) has little or no hemlock (<5% relative dominance), but is almost pure sugar maple with a small component of basswood, yellow birch, striped maple, and hop-hornbeam. This hardwood forest is restricted to areas where crown and ground fires are rare or absent due to moist soils and nearby topographic firebreaks like ridges, lakes, and abrupt depressions. Because of their low fire frequencies and the great capacity of sugar maple to replace itself, forests of the maple-hardwood type may be among the few forests of the Huron Mountains that have remained relatively constant for thousands of years.

The ground cover of hemlock-northern hardwood forests is influenced by the amount of hemlock in the overstory. The most striking effect of relatively high densities of hemlock in the large or small tree layers is a marked reduction in areal coverage of the ground cover, and a concomitant moderate reduction in species diversity (compare Figs. 10 and 11). Low light levels, acidic, nutrient-poor litter, and reduced precipitation reaching the forest floor may all be responsible for this inhibitory effect on herb and shrub growth. Hemlock in the overstory also has an effect on ground-cover species composition. The *Goodyera* species group is largely restricted to those stands where hemlock is in great abundance, and the ground cover is correspondingly sparse. Because the members of this species group derive all or part of their nutrition from an association with an underground fungus, they are not nearly as dependent on light for photosynthesis as are most plants, and therefore are at a competitive advantage in the heavy shade cast by hemlock. In contrast, when hemlock is absent or nearly so, spring flowering herbs of the *Arisaema* and *Botrychium* groups tend to be proportionally more abundant in the ground cover, probably at least partly due to the high light levels available for plant growth before leaf flushing of the mostly deciduous canopy.

As expected, physical site factors (light, moisture, and nutrients) also affect the ground cover, particularly its species composition. For instance, the *Polygonatum* and *Gymnocarpium* groups become increasingly important as soil moisture increases, regardless of changes in light and nutrients. When both moisture and fertility increase, the *Botrychium*, *Arisaema*, and *Impatiens* groups increase in abundance. As moisture and light levels increase, so does the *Corylus* group, and as moisture and acidity increase, so does the *Coptis* group. On sites with less than average moisture (and usually nutrients), small numbers of the

Cladonia, *Vaccinium*, *Comandra*, and *Gaylussacia* groups may invade from nearby dry pine-hardwood forests, along with western fescue (*Festuca occidentalis*), large-leaved aster (*Aster macrophyllus*), and rice-grass (*Oryzopsis asperifolia*). Fire promotes establishment of the *Pteridium* group. The presence of large boulders provides microsites for mountain maple, prickly gooseberry (*Ribes cynosbati*), and the *Polypodium* species group. If mineral soil is exposed by recent tip-up mounds or by areas of soil creep on steep channel risers, weedy plants like red-berried elder (*Sambucus pubens*) and red raspberry (*Rubus strigosus*) may become locally abundant. Finally, a few species, members of the *Maianthemum* species group, seem to tolerate all sorts of site conditions and prosper throughout the range of site variation found in hemlock-northern hardwood forests of the Huron Mountains.

It should be noted that the effects of hemlock and the physical site on ground cover are often confounded. Hemlock-rich northern hardwood forests tend to occur on more exposed, dry, fire-prone sites, whereas hardwood-rich northern hardwood forests tend to occur on low, moist, fire-protected sites. However, when sugar maple and hemlock-dominated stands occur side-by-side on a homogeneous site, a strong hemlock effect on the ground cover is still seen.

Northern White-Cedar-Hemlock-Hardwood Forests
(cover types 14, 15, 17)

Northern white-cedar-hemlock-hardwood forests are closely associated with water. They occur adjacent to streams and lakes, or in low places where the water table is fairly close to the surface.

Hemlock-northern white-cedar forest (cover type 14) occurs near lakes. Nearly the entire western shore of Mountain Lake has an approximately 6 ft- (2 m) wide band of hemlock and northern white-cedar lying between the lake and the upland hemlock-northern hardwood forest. Waves lapping these shores create a moist environment and expose small areas of mineral soil, a combination ideal for germination and establishment of the small seeds of hemlock and cedar. Hemlock-cedar forest also occurs in larger patches at the east side of Ann Lake, at two locations along the east shore of Mountain Lake south of Dudley Point, and along the west sides of Canyon Lake and Lumberman Bay. In these locations, the forests are established by fire. Both hemlock and white-cedar can establish aggressively after fire (U.S. Department of Agriculture 1965). The sites of these stands are often quite dry and rocky, and the understory and ground cover are similar to that of the white pine-hemlock-hardwood forest (cover type 6) that normally establishes on such sites after fire. In fact, the chance proximity of a cedar swamp acting as a seed source is probably why cedar is so common in these forests but is infrequent or lacking in the more widespread pine-hemlock-hardwood type.

The northern white-cedar type (cover type 15) is almost entirely restricted to several sandy terraces nestled in the bends of Pine River. Elsewhere in the Huron Mountains, the moist soils, good water flow, and rich A horizons of these streamside terraces support a mixed northern white-cedar-hemlock-black ash forest (cover type 28). Along Pine River, fires originating in the surrounding jack pine

forest allowed establishment of almost pure white-cedar stands of high density. The heavy shade cast by the dense cedar canopy produces an understory and ground cover sparser than but otherwise similar to the diverse vegetation of streamside conifer-hardwood swamps (cf. cover type 28 in Swamp Forests section).

The yellow birch-hemlock-northern white-cedar-red maple forest type (cover type 17) is much more common than the hemlock-cedar or cedar types. It develops on somewhat poorly drained soils where the water table ranges from 10 to 24 inches (25-60 cm) below the surface during the growing season. Typical landscape positions include gently sloping stream terraces, the drier edges of conifer-hardwood wetlands, and isolated, shallow depressions on flat terrain. Hemlock is usually the dominant overstory tree of the yellow birch-hemlock-cedar-red maple forest. Red maple, yellow birch, and northern white-cedar are frequent associates, and sugar maple and balsam fir are often present, but in small numbers. Because fire is rare in these wet-mesic forests, and because the dominant trees are of moderate to high shade tolerance, the type can be considered a self-sustaining climax community. However, moderately high water tables inhibit deep rooting by trees and make them susceptible to windthrow, which if severe enough, could allow the establishment of pioneer species like bigtooth or trembling aspen, white ash, white birch, and balsam poplar. Yellow birch-hemlock-cedar-red maple forest is transitional between the hemlock-northern hardwood forests (cover types 4, 5, 6) of better drained sites and the conifer-hardwood swamp (cover type 28) of very poorly drained sites. It has more white-cedar but less sugar maple than hemlock-northern hardwoods, more sugar maple but less white-cedar than the conifer-hardwood swamp, and more red maple and yellow birch than both. Hemlock is the most common understory tree. The tree seedling layer has moderate amounts of balsam fir, striped maple, sugar maple, and hemlock, and small but significant amounts of red maple, yellow birch, and white ash. The *Gymnocarpium* and *Coptis* species groups flourish on the moist, moderately acid duff of the forest floor; the *Maianthemum* and *Polygonatum* groups are also common in the ground-cover layer.

Floodplain Forests
(cover types 18 and 19)

Floodplain forest (cover type 19) is comparatively rare in the Huron Mountain Club; the type is found only along lower portions of the Salmon Trout River and near the mouth of Mink Run. Floodplains have developed along these streams as the result of periodic flooding in the late winter-early spring season. Floods deposit fertile alluvium of sand, silt, and organic matter on the surrounding terraces. Floodplain forests are dominated by trees that compete well on these moist, highly fertile alluvial soils, but they must also be able to tolerate occasional inundation. The single most characteristic tree of the floodplain forest was American elm, which has nearly been eliminated by the Dutch elm disease that swept through Michigan's Upper Peninusla in the early 1970s. Many huge snags of this species still stand today, attesting to its former abundance. Several other

tree species shared dominance with American elm, and can be expected to increase in importance in the future--sugar maple, basswood, black ash, red ash, white spruce, balsam fir, northern white-cedar, and hemlock.

Death of the elms has accentuated the open tree canopy typical of floodplain forests. The high light levels reaching the forest floor promote dense understory growth of sugar maple, white spruce, and speckled alder. Sugar maple seedlings carpet the ground. The ground cover also has high coverage, with the *Arisaema* species group being especially characteristic--in fact, floodplains are the only places in the Huron Mountains that have a significant population of spring ephemerals. Many other plant species occur under these moist, fertile, well-lit conditions. Members of the *Botrychium*, *Impatiens*, *Gymnocarpium*, *Onoclea*, *Osmunda*, and *Corylus* groups are all common. The *Maianthemum* and *Polygonatum* groups occur to a small extent. Other species common in the floodplain forest, but rare or absent elsewhere, include bottlebrush grass (*Hystrix patula*), carrion-flower (*Smilax ecirrata*), wild leek (*Allium tricoccum*), cow-parsnip (*Heracleum maximum*), American bittersweet (*Celastrus scandens*), and nightshade (*Solanum dulcamara*).

Even rarer than the floodplain forest is the white ash forest type (cover type 18), which occurs in only two known locations (both west of the junction of the main road with the Conway Lake east road). Although not a true floodplain, this forest is characterized by alluvium that collects because surface drainage is obstructed. The moist, fertile alluvium creates an ideal seedbed for one of the rarest trees in the Huron Mountains--white ash. The present overstory is almost pure white ash of considerable size (10-16 in, 25-40 cm dbh), which is remarkable considering that the Huron Mountains are at the extreme northwestern limit of the range of this tree species (Little 1971). The ground cover includes moistnre- and fertility-loving plants of the *Impatiens* and *Gymnocarpium* groups, along with golden saxifrage (*Chrysosplenium americanum*), fowl manna grass (*Glyceria striata*), bitter cress (*Cardamine pensylvanica*), and skullcap (*Scutellaria lateriflora*).

Swamp Forests
(cover types 27, 28, 29)

Swamp forests are the wettest forest types in the Huron Mountains. High water tables in these forests discourage fire, but promote windthrow by their inhibition of the deep rooting needed to anchor trees firmly. Nearly continuous saturation of the forest floor also inhibits microbial decomposition of dead plant tissues so that thick layers of peat or muck accumulate. Swamps have abundant moisture for plant growth, but they vary greatly in oxygenation of their subsurface groundwater and in nutrient status of their organic soils. Accordingly, swamp forests range from stagnant, highly infertile, coniferous bog forests to well-aerated, highly fertile, deciduous swamp forests.

The least fertile wetland forest is the black spruce bog (cover type 27). Bog forests in the Huron Mountains develop on trapped depressions in the landscape where water flow is very slow. Restricted flow produces a low mineral and oxygen content, prime conditions for the successful invasion of sphagnum moss. Sphagnum moss forms thick spongy beds on top of the trapped water. The moss holds a lot of water and slowly decomposes into an extremely acid peat. As sphagnum peat accumulates, the wetland eventually is raised above the level where groundwater can be lifted upwards by capillarity. At this point, a true bog develops, since water and minerals are now supplied only from above by precipitation, exacerbating nutrient deficiencies. Atmospheric water input forms a water table perched above the relatively impermeable sphagnum deposits (Crum 1988).

Black spruce is better adapted to the wet, acid, oxygen-poor conditions of a mature sphagnum peatland than any other tree of the northern forest (Crum 1988). The overstory of the only two bog forests of the Huron Mountain Club (one located southwest of Lumberman Bay and the other northeast of Cranberry Bog [Fody 1989]) is almost entirely black spruce with only a small admixture of white pine, tamarack, and hemlock. Black spruce has a narrow crown and grows at low density, creating a very open canopy that allows many small black spruces to establish in the understory and tree seedling layers, along with a few hemlock, red maple, tamarack, white pine, yellow birch, and white birch. The open forest also supports a dense layer of ericaceous shrubs such as blueberry (*Vaccinium myrtilloides* and *V. angustifolium*), leatherleaf (*Chamaedaphne calyculata*), bog rosemary (*Andromeda glaucophylla*), swamp laurel (*Kalmia polifolia*), and Labrador tea (*Ledum groenlandicum*). The ground cover is highly distinctive but of low diversity and is composed of plants adapted to low oxygen and nutrients, but high moisture and light, such as members of the *Ledum*, *Drosera*, *Chamaedaphne*, and *Vaccinium* groups. Other common bog species are pink moccasin flower (*Cypripedium acaule*), twayblade (*Listera convallarioides*), creeping snowberry (*Gaultheria hispidula*), and, of course, sphagnum moss (*Sphagnum* spp.).

The most fertile wetland forest in the Huron Mountains is the black ash-elm deciduous swamp (cover type 29). Black ash swamps are associated with surface and subsurface drainages where water moves freely and is not trapped. Good water movement insures good inputs of oxygen, nutrients (in the form of silts, clays, organic matter, and dissolved ions), and moisture. The cool, wet, fertile ground of black ash swamps allows a moderate rate of plant decomposition, producing a finely decomposed muck at the surface that is never as thick as the coarser peat soils of spruce bogs. Black ash is the dominant overstory tree, and is mixed with an occasional elm or northern white-cedar. The ash canopy is moderately open, which sometimes encourages growth of an alder understory, but a woody understory is often absent. Likewise, with the exception of black ash, tree seedlings are uncommon. The favorable moisture, light, and nutrient environment supports a

luxuriant and diverse herbaceous ground cover. Best represented are the *Impatiens*, *Osmunda*, and *Onoclea* species groups; the *Botrychium*, *Gymnocarpium*, and *Carex* groups are also common. Other plants partial to the fertile muck of black ash swamps include marsh fern (*Thelypteris palustris*), wild mint (*Mentha arvensis*), yellow loosestrife (*Lysimachia thyrsiflora* and *L. terrestris*), bedstraw (*Galium trifidum*), meadow horsetail (*Equisetum pratense*), and the sedge *Carex hystericina*.

Conifer-hardwood swamps (cover type 28) occupy a broad middle ground between highly fertile black ash and highly infertile black spruce wetlands. Conifer-hardwood swamps vary considerably in their landscape position, rate of water movement, fertility, soil, and vegetation. Because of their great variability, these swamps occur in more places and cover a larger total area than do the more narrowly defined black spruce and black ash types. For ease of description, the continuum of conifer-hardwood swamp forests can be subdivided into three subtypes--infertile, moderately fertile, and fertile.

The infertile conifer-hardwood swamp develops in moderately deep depressions on flat sand and gravel deposits between Elm and Fisher creeks. There is little or no water movement, leading to the development of acidic peat soils. Sphagnum coverage ranges from 30 to 75%. A mixed overstory of hemlock, northern white-cedar, black spruce, yellow birch, and red maple is typical. Understories are quite diverse and are composed of yellow birch, winterberry (*Ilex verticillata*), red maple, hemlock, white pine, and black spruce. Red maple and hemlock are common as seedlings. Acidic site species groups like *Ilex*, *Ledum*, *Chamaedaphne*, *Vaccinium*, and *Coptis* are all common in the ground cover, and the *Woodsia* and *Gaylussacia* groups may even occur on dead logs propped well above the moist forest floor. *Onoclea*, *Osmunda*, and *Corylus* species groups occur in the more fertile pockets lacking sphagnum.

The moderately fertile conifer-hardwood swamp occurs in swampy troughs with subsurface water flow, on the fringes of more acidic wetland forests, and in small, shallow depressions on flat terrain. Water movement is slow to moderate in the swampy troughs and fringes, but virtually nil in the small depressions. Surface soils can be all muck or a mosaic of peat on hummocks and fallen logs and muck in pits and hollows. Sphagnum moss is absent to 1% in coverage. Northern white-cedar, hemlock, and black ash are the most important overstory trees; yellow birch, red maple, white spruce, trembling aspen, and balsam fir are also frequent. Understories range from absent to a moderately dense growth of balsam fir, white spruce, hemlock, black ash, yellow birch, and red maple. The overstory and understory species are well represented in the tree seedling layer, along with mountain maple and white ash. Tree bases, peaty mounds, and logs provide a microsite more acidic and less wet than the general level of the forest floor. Here thrives a ground flora of the *Ilex*, *Coptis*, *Corylus*, *Maianthemum*, and *Polygonatum* species groups. In contrast, fertile, wet hollows are home to the *Onoclea*,

Osmunda, *Arisaema*, and *Botrychium* groups.

The fertile conifer-hardwood swamp is a streamside feature in the landscape. When streams flow over steeper gradients, the swamp is confined to a relatively narrow band along the stream, although sometimes the stream may be broken up into a braided channel system by many small islands formed by clumps of northern white-cedar and hemlock. This can be seen at both the Mountain Lake and Pine Lake ends of Mountain Stream, and at the mouth of Fisher Creek. When stream gradients are shallow, a wide swampy band extends on both sides of the stream, such as in the Cedar Creek swamp that covers 45 acres (18 ha). In either case, water flow is rapid and surface soils are either a fertile muck or a deep, organic-matter-rich A horizon. Peaty mounds are rare, but the microtopography is still hummocky. Sphagnum is absent. Northern-white cedar and black ash are the two overstory dominants; hemlock, yellow birch, balsam fir, red maple, white pine, white spruce, and white ash are less frequent associates. Understory growth is absent in about half the cases. Where present, it is primarily alder and balsam fir, with an occasional hemlock, white-cedar, or mountain maple. Tree seedlings are rather sparse, with only black ash consistently present. The ground cover is very similar to that of the moderately fertile conifer-hardwood subtype, but differs in the the absence of the *Ilex* group and the presence of the *Impatiens* group, indicating somewhat better nutrient conditons.

As one moves from the conifer-hardwood swamps of trapped depressions to those bordering rapidly flowing streams, several factors change in a coordinated and directed fashion. Rate of water flow increases, fertility increases, amount of muck increases while the amount of peat and sphagnum decrease, the dominance of black ash increases as the dominance of hemlock decreases, and the importance of nutrient-demanding ground-cover species increase as that of acidophilic plants decrease. Despite these trends of variation, certain factors are common to all conifer-hardwood swamp forests. All have a mixture of conifer and hardwoods in the overstory, with conifers usually more numerous than hardwoods. Northern white-cedar is important in all types. Furthermore, all types have a hummocky microtopography created by accumulation of mineral and organic matter around logs, roots, and tree bases, which creates sharp variation in moisture and pH that results in a ground flora of moderate to high species diversity.

Miscellaneous Forests

(cover types 16, 20, 22)

A few forest types of the Huron Mountains do not fit any of the above categories. Perhaps the most interesting of these is the hemlock-mountain maple forest (cover type 20) growing in bedrock ravines. Because of the constant erosional disturbance of the ravine walls and floor, no overstory-sized trees grow within the ravine itself; rather, they lean over from the upland edge of the ravine

to create a relatively open canopy of hemlock, yellow birch, and sugar maple. The cool, moist air within the ravine favors vegetation much different from that of the surrounding uplands. A distinctive understory of striped maple, mountain maple, and red-berried elder clings to the lower walls and tops of large boulders. Striped and mountain maples are also abundant as tree seedlings, as are hemlock, yellow birch, and sugar maple. Moisture-loving plants of the *Corylus*, *Impatiens*, *Coptis*, and *Gymnocarpium* groups make up a large portion of the ground cover near the bottom. The *Polypodium* group is abundant on damp exposed rock, and members of the *Maianthemum*, *Polygonatum*, and *Botrychium* groups are often present in small numbers. Other species that do well on the moist bedrock and gravelly-cobbly surfaces are mosses and liverworts, golden saxifrage (*Chrysosplenium americanum*), bluebead-lily (*Clintonia borealis*), enchanter's nightshade (*Circaea alpina*), and a large variety of ferns: broad beech fern (*Thelypteris phegopteris*), Braun's holly-fern (*Polystichum braunii*), oak fern (*Gymnocarpium dryopteris*), glandular wood fern (*Dryopteris intermedia*), marginal shield-fern (*Dryopteris marginalis*), northern lady fern (*Athyrium filix-femina* subsp. *angustum*), common polypody (*Polypodium virginianum*), maidenhair spleenwort (*Asplenium trichomanes*), and brittle fern (*Cystopteris fragilis*).

Another forest type of small areal extent in the Huron Mountains is spruce-fir forest (cover type 16). Dense thickets of young white spruce and balsam fir regeneration are restricted to moist areas that have been heavily disturbed by clearcutting, windthrow, or fire. Very small stands of spruce-fir occur near Lake Superior above the sandstone cliffs of Pine River and Conway points where clear-cutting in the 1940s combined with frequent windthrows by storm winds off Superior have decimated the former hemlock-hardwood canopy. A larger spruce-fir forest, with some white pine, lies between Trout Lake and Fisher Creek on an area of low, moist outwash sands. Again, clearcutting in the late 1940s converted a late-successional white pine-hemlock-northern hardwood forest into a young stand of spruce and fir. Although better thought of as transient, early-successional communities on recently disturbed sites rather than true self-sustaining boreal forests, these spruce-fir stands do have a vegetation showing some boreal affinities, as described by Wells and Thompson (1976).

A final miscellaneous forest type, post-clearcutting hardwoods (cover type 22), covers thousands of acres in the Huron Mountains. Most of the present-day Huron Mountain Club forests outside of the Reserve Area were clearcut in the 1920s, 30s, and 40s before being acquired by the club (Manville 1942, Todd 1957, Huron Mountain Wildlife Foundation 1967). The largest blocks of these clearcuts occur adjacent to Huron River, Pine River, and Conway points, and between Ives and Mountain lakes. Maps and notes of the William Burt surveying party of 1844 clearly indicate that much of this area was a mature, mixed forest of hemlock, sugar maple, and yellow birch in presettlement times. Today, 40-70 years after

clearcutting, these areas support stands of sugar maple, red maple, and yellow birch, with smaller numbers of white ash, striped maple, hop-hornbeam, white birch, and balsam fir. Hemlock is conspicuously absent from those areas that were completely clearcut, being found only in small scattered patches of older trees that were not removed by the loggers. The inability of hemlock to regenerate naturally after cutting may be caused by several factors: (1) heavy winter browsing of hemlock by deer attracted to clearcuts within their deer yard (Westover 1971, Graham 1958, Frelich and Lorimer 1985); (2) greater advance regeneration of hardwoods before cutting, which responds to release faster than hemlock and tends to outgrow and suppress it (Hix and Barnes 1984); (3) the removal of the stems and logs that hemlock depends upon for suitable moist seedbeds (Hix and Barnes 1984); (4) reduction of the canopy cover needed to protect young hemlock trees from dessication and direct heat injury caused by excessive sunlight (U.S. Department of Agriculture 1965).

Compared to the overstory, the ground-cover vegetation is little affected by cutting. The *Maianthemum*, *Polygonatum*, *Coptis*, *Botrychium*, and *Gymnocarpium* species groups commonly found in old-growth hemlock-hardwood forests of the Huron Mountains are also the most common groups in the post-clearcutting hardwood forests. Occasionally, a few disturbance-adapted sedges, grasses, and weedy annual herbs do persist from the much larger populations that established during the first few years after clearcutting. Also, the loss of hemlock appears to lower the incidence of the *Goodyera* species group. Similar findings have been reported for 50-year-old clearcuts in old-growth, hemlock-maple forests of the Sylvania Recreation Area (Hix and Barnes 1984, Albert and Barnes 1987).

The structure of the post-clearcutting hardwood forest also differs markedly from the original old-growth hemlock-hardwood type. Clearcutting produces a high density of small trees of uniform age, stem thickness, and height that form a nearly unbroken canopy with little understory development beneath. This is in strong contrast to old-growth forests, where a low density of trees of uneven age and uneven size form a canopy broken by many gaps that allow good understory development beneath.

Landscape Ecosystem types of the Reserve Area and Adjacent Lands

Ecosystem Hierarchies

In the Climate, Geologic History, Forest History, Ecological Species Groups, and Vegetation sections, we have described the history and present nature of the components of ecosystems in the Huron Mountains. We have done so in order to provide a background so that one may better understand our application

of the landscape ecosystem approach to the Huron Mountains. The ecosystem map, classification, and descriptions bring the components of ecosystems together and express their reality as both functional and geographic entities.

In this section, we present the classification of ecosystem types, organized in a hierarchy according to such ecologically significant factors as slope steepness and soil depth, origin of landform, and vegetational structure (Table 4). As in previous ecosystem classifications (Barnes et al. 1982, Pregitzer and Barnes 1984, Spies and Barnes 1985a), physiographic factors such as soil depth and slope steepness provide the primary structure because of their relative permanence and their effects on radiation, moisture, and nutrient fluxes. Lower levels of the hierarchy may group ecosystem types on other criteria so that the most useful comparisons and contrasts are provided.

The ecosystem map is an organization of ecosystem types by their pattern in the landscape, and the classification hierarchy is another organization of the ecosystems according to their physiography, soil, and vegetation. The contexts that become apparent in each of these organizations help one to understand ecosystem form and function. As you read the ecosystem descriptions that appear after the classification, use the hierarchy and map as frameworks within which better to understand the physiographic, distributional, historical, and vegetative relationships among ecosystem types.

Landscape Ecosystem Type Descriptions

Brief synopses of physiography, soil, and vegetation are given to acquaint the reader with the general characteristics of each ecosystem type. More detailed quantitative information on the vegetation is available in Appendices B, C, and D. The physiographic information is tied closely to the discussion of geology presented in the Geologic History section.

Each ecosystem is named for its characteristic physiographic and soil features and by its late-successional ("climax") vegetation type. This vegetation type is designated by two terms: (1) the late-successional overstory type that would typically occur in old-growth forests (pre-settlement forest type), and (2) the most characteristic ecological species group(s) of the ground cover. For example: Hemlock-Northern Hardwood/*Polygonatum*.

Because of the old-growth nature of most of the Reserve Area, the presettlement late-successional vegetation typically occurs today in most of the ecosystems. However, if the existing overstory type happens not to be that of our predicted late-successional type (due to recent fire or windstorm) one would note this by examining the map of cover types and comparing it with the ecosystem map. The correspondence between ecosystem and cover type maps may also be examined using Appendices E and F. The procedures used in gathering information for the classification, description, and mapping of Landscape Ecosystems are contained in Appendix A.

Table 4. Classification of landscape ecosystem types of the Huron Mountain Club Reserve Area and adjacent lands[1]

	Percentage of the area[2]
UPLAND ECOSYSTEM TYPES	**95.0**
I. Deep soils (bedrock below 100 cm) and moderately deep soils (bedrock between 50 and 100 cm)	54.8
A. LEVEL TO GENTLY SLOPING (0-5%)	16.6
a. Beach landforms	8.3
1. Active, shifting sand; deep, somewhat excessively drained fine and medium sand; *Lathyrus-Cakile*	not mapped
2. Beach ridges; deep, excessively drained medium sand; *Jack Pine/Cladonia*	6.7
3. Beach ridges and flats; deep, somewhat excessively drained medium sand; Pine/*Pteridium*	0.6
4. Beach ridges; moderately deep, well drained gravelly and channery sand; Hemlock/*Maianthemum*	0.5
5. Beach ridges and flats; shallow to moderately deep, well drained sand, sandstone, or gravel substratum; Hemlock/*Maianthemum*	0.5
6. Beach ridges and flats; deep, moderately well drained sand; Pine/*Pteridium*	<0.1
b. Flats and mountain slopes	15.7
7. Flats and slopes; deep, well drained medium sand; Hemlock-Northern Hardwood/*Maianthemum*	6.3
8. Flats and slopes; deep, well drained loamy sand and gravel; Hemlock-Northern Hardwood/*Polygonatum*	5.6
9. Flats and slopes; deep, well drained sandy loam till; Sugar Maple-Hemlock-Northern Hardwoods/*Polygonatum*	0.2
10. Gentle slopes; deep, moderately well drained fine sand over sandy loam hardpan; Sugar Maple/*Polygonatum*	0.7
11. Flats; deep, moderately well drained medium sand; Hemlock/*Coptis*	1.6
12. Flats; deep to moderately deep, somewhat poorly drained sand to loamy sand; Hemlock-Red Maple-Yellow Birch/*Coptis*	1.3

[1] Arabic numbers in this classification are those found on the map of landscape ecosystem 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.

Table 4. (Continued.)

	Percentage of the area
c. Stream floodplains, terraces, and alluvial fans	1.6
13. Sandy stream terraces; deep, well to moderately well drained medium sand; Pine-Birch/*Pteridium*	0.2
14. Alluvial fans; deep, well drained sandstone gravel and sand; Sugar Maple/*Botrychium*	0.2
15. Sandy stream terraces; deep, moderately well drained loamy sand; Red Maple-Yellow Birch/*Botrichium*	0.4
16. Deltas; deep, moderately well drained fine sandy loam; Sugar Maple/*Botrychium*	0.2
17. Floodplains;deep, moderately well drained sand to sandy loam; Sugar Maple-Elm/*Arisaema*	0.2
18. Floodplains; deep, somewhat poorly drained two-storied alluvium; Northern White-Cedar/*Botrychium*	0.4
B. MODERATE SLOPES (6-30%)	29.2
19. Mountain slopes; west aspects, moderately deep, somewhat excessively drained medium sand; Red Pine/*Pteridium*	0.1
20. Mountain slopes; north and east aspects, deep, well drained medium sand; Hemlock/*Maianthemum*	3.0
21. Mountain slopes; all aspects, deep, well drained loamy sand; Hemlock-Northern Hardwood/*Polygonatum*	12.1
22. Mountain slopes; north and east aspects, deep, well drained loamy sand over sandy loam hardpan; Hemlock-Northern Hardwood/*Polygonatum*	9.9
23. Mountain slopes; north aspects, deep, well drained sandy loam; Sugar maple-Hemlock-Northern Hardwood/*Corylus*	1.8
24. Gravel bar with surface boulders; all aspects, deep, well drained loamy sand over gravel, upper slopes; Hemlock-Northern Hardwood/*Botrychium*	0.7
25. Gravel bar with surface boulders; north aspects, deep, well drained loamy sand over gravel, mid and lower slopes; Sugar Maple/*Botrychium*	1.6
C. STEEP SLOPES (31-90 %) (see ecosystem 36)	
II. Shallow soils (bedrock within 50 cm)	33.9
A. LEVEL TO GENTLE SLOPES (0-5%) IN SANDSTONE BEDROCK TERRAIN	3.8
26. Flood-scoured sandstone; all aspects, exposed topographic positions, shallow, well drained loamy sand; Mixed Conifer/*Pteridium*	2.7

Table 4. (Continued.)

	Percentage of the area
27. Flood-scoured sandstone; all aspects, protected topographic positions, shallow, well drained loamy sand; Hemlock/*Maianthemum*	1.1
B. MODERATE (6-30%) TO STEEP (>30%) SLOPES IN CRYSTALLINE BEDROCK TERRAIN	30.1
28. Narrow ridge-tops; rocky knolls and steep south slopes; shallow, somewhat excessively drained sandy loam, 10-30 % soil cover; Lichen-Juniper/*Woodsia*	4.0
29. Broad ridgetops and moderate south slopes; shallow, somewhat excessively drained sandy loam, 30-60 % soil cover; Pine-Oak/*Vaccinium*	12.0
30. Rocky lower slopes and protected positions; all aspects, shallow, well drained sandy loam, 60-90 % soil cover; Mixed Conifer-Hardwood/*Polypodium*	12.0
31. Thin stony soil; north and east aspects, shallow, well drained loamy sand; Hemlock-Northern Hardwood/*Polygonatum*	1.3
32. Bedrock valleys and concave areas in crystalline bedrock terrain; all aspects, deep to moderately deep, well drained loamy sand; Hemlock-Northern Hardwood/*Polygonatum*	0.7
33. Intermittent stream valleys in rocky terrain; all aspects, moderately deep, well to moderately well drained loamy sand; Hemlock-Northern Hardwood/*Botrychium*	0.1
III. Miscellaneous Ecosystems	6.3
A. MOUNTAIN TERRAIN	2.3
34. Ravines in bedrock slopes; shallow, moderately well drained loamy soil; Mountain Maple-Hemlock/*Botrychium*	0.2
35. Footslopes and intermittent stream valleys; all aspects, deep, well to moderately well drained, thin alluvial/colluvial surface; Sugar Maple-Hemlock-Northern Hardwood/*Botrychium*	2.1
B. RELICT CHANNELS	0.8
36. Steep terrace risers; usually north and east aspects, deep, well drained loamy sand on slopes greater than 50%; Hemlock/*Botrychium*	0.8
C. LAKE MARGINS	3.2
37. Fire prone north and east lake margins; deep, somewhat excessively drained medium sand; Red Pine/*Pteridium*	<0.1
38. Fire prone north and east lake margins; deep, well drained loamy sand; Birch-Aspen/*Pteridium*	2.9
39. Fire prone north and east lake margins; deep, moderately well drained sand to sandy loam; Mixed Conifer-Hardwood/*Botrychium*	0.3

Table 4. (Continued.)

	Percentage of the area
40. Lake margins; deep, moderately well drained sand to sandy loam; Northern White-Cedar-Hemlock/*Osmunda*	not mapped
WETLAND ECOSYSTEM TYPES	**4.9**
I. Trapped Drainages and Depressions	3.4
A. OPEN, NON-FORESTED WETLANDS	1.0
41. Very infertile shrub swamp on peat; Leatherleaf/*Chamaedaphne-Ilex*	0.3
42. Moderately fertile shrub swamp on thin peat over muck; Alder/*Osmunda-Carex*	0.2
43. Fertile shrub swamp on peat; Sweet Gale/*Myrica-Carex*	0.2
44. Fertile graminoid marsh on peat; *Carex-Onoclea*	0.3
B. FORESTED WETLANDS	2.4
45. Very infertile conifer swamp on peat; Black Spruce/*Ledum-Chamaedaphne*	0.3
46. Infertile conifer-hardwood swamp on peat; Conifer-Hardwood/*Ilex-Chamaedaphne*	<0.1
47. Fertile conifer-hardwood swamp on peat and muck; Conifer-Hardwood/*Osmunda-Onoclea*	1.7
48. Fertile upland muck depression; Hardwood-Conifer/*Onoclea-Ilex*	0.2
49. Very fertile deciduous swamp on muck; Black Ash/*Onoclea-Osmunda*	0.2
II. Streamside Ecosystems	1.5
50. Fertile shrub swamp on muck; Alder/*Osmunda-Onoclea*	1.5

ECOSYSTEM TYPE 1: ACTIVE, SHIFTING SAND; DEEP SOMEWHAT EXCESSIVELY DRAINED FINE AND MEDIUM SAND; *Lathyrus-Cakile*

PHYSIOGRAPHY AND SOIL

Characteristic of a narrow (5-20 m) shoreward band of the present Lake Superior beach that is subject to wave action only during the most violent storms. Lakeward, this ecosystem is limited by the frequent disturbance of waves of moderate intensity. Landward, it is limited by the storm wave-cut berm at its juncture with the pine forest; slopes 0-10%. North aspects.

Soil material is well sorted medium and fine sand. Somewhat excessively drained. No profile development. Sand unstable, wind and water transported. Slightly acid throughout.

Soil lacks profile development and in this respect is different from the soil of all other upland ecosystems. Surface organic accumulations are lacking due to wind and storm-wave action. Because the present beach is eroding landward into the jack pine forest, remnants of the B horizon material of the pine forest soil can be found at depths of 50-70 cm below the (present) surface.

VEGETATION: *Lathyrus-Cakile*

Beach pea (*Lathyrus japonicus*), sea-rocket (*Cakile edentula*), and evening-primrose (*Oenothera biennis*) make up 90% of the ground cover. Overstory is absent; the shrub layer may have scattered individuals of serviceberry (*Amelanchier* spp.), huckleberry (*Gaylussacia baccata*), or red maple in immediate proximity to the wave-cut berm. *Lathyrus* and *Cakile* are characteristic of the shorelines of the Great Lakes. *Oenothera* is a disturbance species of uplands usually indicating dry, disturbed conditions.

ECOSYSTEM TYPE 2: BEACH RIDGES; DEEP, EXCESSIVELY DRAINED MEDIUM SAND; Jack Pine/*Cladonia*

PHYSIOGRAPHY AND SOIL

Characteristic of gently rolling Nipissing beach ridges; slopes 0-10% over short distances, 1-2% over longer distances. All aspects.

Well sorted medium sand deposited by wave action. Excessively drained. E horizon distinct. Ortstein and fragipan absent. E horizon extremely to very strongly acid increasing to slightly acid within 50 cm.

Most similar to ecosystem 3 and distinguished from it by the lack of ortstein formation in the Bs horizon. Distinguished from ecosystem 4 by the presence of a medium sand surface and by the depth to bedrock exceeding 200 cm.

VEGETATION: Jack Pine/*Cladonia*

The overstory is dominated by jack pine with lesser amounts of red pine. Serotinous cones, early reproductive maturity, and high drought tolerance make jack pine ideally suited to the dry, frequently burned, sandy beach ridges. The canopy is relatively open and the understory is sparse, composed of red pine and white pine. The herbaceous layer has high coverage. *Cladonia*, *Pteridium*, *Gaylussacia*, and *Vaccinium* species groups indicate dry, infertile, relatively open, and frequently burned conditions.

ECOSYSTEM TYPE 3: BEACH RIDGES AND FLATS; DEEP, SOMEWHAT EXCESSIVELY DRAINED MEDIUM SAND; Pine/*Pteridium*

PHYSIOGRAPHY AND SOIL

Characteristic of gently rolling to level Nipissing beach ridges and lagoonal flats. Ecosystem 3 develops in sandy beach deposits that are lower in landscape position than ecosystem 2, or in areas where the sandstone bedrock is within approximately 2 m of the surface; slopes 0-10% over short distances, 0-2% over longer distances. All aspects.

Well sorted medium sand soil. Somewhat excessively drained. E horizon distinct. Ortstein present in Bs. Bh discontinuous if present. E horizon strongly acid. Slightly to medium acid in lower B.

Most similar to ecosystem 2 and distinguished from it by the presence of ortstein in the Bs, and by the greater depth of the E and Bs horizons. Distinguished from ecosystem 4 by the sand texture of the surface soil. Distinguished from ecosystem 7 by the lack of a continuous Bh horizon.

VEGETATION: Pine/*Pteridium*

Moisture availability is greater and fire frequency less than Ecosystem 2, favoring the growth of red pine and white pine. The overstory is dominated by red and white pine with lesser amounts of jack pine and red oak. The canopy is relatively open, and the herbaceous layer has high coverage. The understory is sparse, composed of scattered white pine and red pine saplings. *Pteridium*, *Vaccinium*, *Cladonia*, *Gaylussacia*, and *Maianthemum* species groups indicate dry to dry-mesic, infertile, relatively open, and frequently burned conditions.

ECOSYSTEM TYPE 4: BEACH RIDGES; MODERATELY DEEP, WELL DRAINED GRAVELLY AND CHANNERY SAND; Hemlock/*Maianthemum*

PHYSIOGRAPHY AND SOIL

Characteristic of gently rolling Nipissing beach ridges in areas where sandstone bedrock is within 100 cm of the surface. Soil is composed of wave-deposited sandstone fragments and sand; slopes 0-10% over short distances, 1-2% over longer distances. All aspects.

Soil is composed of channery to gravelly loamy sand interlayered with well sorted medium sand. Well drained. E horizon present. Weak ortstein occasionally present. Gravelly to channery soil is due to presence of decomposing sandstone beach shingle. E horizon extremely to very strongly acid, Bs very strongly to strongly acid.

Most similar to ecosystems 2, 3, and 6 and distinguished from them by the presence of bedrock within 100 cm of the surface and by the gravelly/channery soil. Distinguished from all other ecosystems by the beach ridge physiography.

VEGETATION: Hemlock/*Maianthemum*

The overstory is dominated by hemlock and red maple with lesser amounts of white pine, white birch, and yellow birch. Fires burn into this mesic site from adjacent jack pine forests to the west (Ecosystem 2). As a result, the intensity and frequency of fire have been greatest in the western portion of this ecosystem--most easily seen in the presence of such fire species as white pine and white birch in these areas--and progressively less intense and frequent as one moves east. Hemlock is fire-established in this ecosystem also but can exploit light ground fires, unlike white pine and white birch; thus hemlock is important throughout the extent of the ecosystem. The canopy is relatively dense and the herbaceous layer has very low coverage. The understory is sparse, composed of scattered hemlock, striped maple, red maple, and balsam fir saplings. The *Maianthemum* and *Goodyera* species groups indicate dry-mesic to mesic, infertile, heavily shaded conditions. The *Pteridium* group indicates the past occurrence of fire.

ECOSYSTEM TYPE 5: BEACH RIDGES AND FLATS; SHALLOW TO MODERATELY DEEP, WELL DRAINED SAND, SANDSTONE, OR GRAVEL SUBSTRATUM; Hemlock/*Maianthemum*

PHYSIOGRAPHY AND SOIL

Characteristic of the transition zone between Nipissing beach-sand areas and adjacent ecosystems. Sandstone bedrock may be within 100 cm of the surface; slopes 0-10% over short distances, 1-2% over longer distances. All aspects.

Medium sand soil overlying sandstone bedrock or coarse gravel and cobble substratum. Well drained. E horizon present at surface. Weak ortstein present in B. E horizon extremely to very strongly acid, B very strongly to strongly acid.

Most similar to ecosystem 4 and distinguished from it by the lack of a channery and gravelly soil. Ecosystem 5 forms a transition between beach ecosystems and hemlock-northern hardwood ecosystems further inland. A relatively thin veneer of Nipissing age beach/lacustrine sand overlies Precambrian age sandstone bedrock or late Pleistocene age coarse gravel to boulder deposits.

VEGETATION: Hemlock/*Maianthemum*

Ecosystem 5 forms a transition between the dry, frequently burned pine ecosystems (2 and 3) and the mesic, infrequently burned hemlock-northern hardwood ecosystem 8. Its vegetation shows its transitional nature. Moderate fire frequencies and intensities produce a mixed stand, including hemlock and red maple with lesser amounts of white pine, red pine, and white birch. The canopy is relatively

dense. The understory is sparse, composed of scattered hemlock and striped maple saplings. The herbaceous layer has very low coverage. The *Maianthemum* and *Goodyera* species groups indicate dry-mesic to mesic, infertile, heavily shaded conditions. The *Pteridium* group indicates the past occurrence of fire.

ECOSYSTEM TYPE 6: BEACH RIDGES AND FLATS; DEEP, MODERATELY WELL DRAINED MEDIUM SAND; Pine/*Pteridium*

PHYSIOGRAPHY AND SOIL

Characteristic of gently rolling Nipissing beach ridges and flats; slopes 0-10% on small scale, 1-2% on large scale. All aspects.

Well sorted medium sand. Moderately well drained. Water table within 50 cm of the surface. E horizon distinct. Ortstein and fragipan absent. E horizon very strongly acid. B and C horizons slightly acid to neutral below 50 cm.

Most similar to ecosystem 3 and distinguished from it by a higher water table and a lack of ortstein formation in the B horizon. Distinguished from ecosystem 2 by a higher water table and poorer soil drainage (in beach ridge areas this is particularly true of the troughs).

VEGETATION: Pine/*Pteridium*

Most of the land area of this ecosystem is outside of the mapping area to the west of the Club compound. The area has been extensively clearcut and little remains of the presettlement vegetation. The small portion of this ecosystem that is in the mapping area has an overstory dominated by red and white pine with lesser amounts of red oak. Cut-over areas have an overstory dominated by disturbance species typical of moist sites such as paper birch, trembling aspen, balsam fir, and red maple. The presettlement forest was fire-established, even-aged, and typically lacked a well developed understory, whereas the forest that has regenerated following cutting may have a moderate to dense understory of balsam fir and red maple. The herbaceous layer usually has high coverage. *Pteridium*, *Vaccinium*, *Maianthemum*, and *Coptis* species groups indicate mesic to wet-mesic, infertile, relatively open conditions. The more fire-dependent *Gaylussacia* and *Cladonia* species groups were probably common prior to cutting.

ECOSYSTEM TYPE 7: LEVEL TO GENTLY SLOPING WATER-LAID SANDS; DEEP, WELL DRAINED MEDIUM AND COARSE SANDS; Hemlock-Northern Hardwood/*Maianthemum*

PHYSIOGRAPHY AND SOIL

Characteristic of flats and gentle slopes in deep, well sorted glacial outwash or late Pleistocene flood deposits; slopes 0-5%. All aspects.

Soil material is well sorted medium and coarse waterlaid sands. Well drained. E horizon distinct. Bh present. Ortstein common. E horizon extremely to very strongly acid, increasing to medium to slightly acid in lower B.

Most similar to ecosystem 20 and distinguished from it by slopes less than 6%. Distinguished from ecosystem 3 by the stronger and more uniform development of ortstein in the Bs horizon and more common occurrence of accumulations of illuvial humus. Distinguished from ecosystems 8 and 9 by the sand textures. Distinguished from ecosystem 12 by the lack of mottling in the upper 50 cm. Distinguished from ecosystem 11 by the relatively higher landscape position and better soil drainage.

VEGETATION: Hemlock-Northern Hardwood/*Maianthemum*

The overstory can be dominated by either hemlock or sugar maple or any combination of the two with lesser amounts of yellow birch, red maple, and basswood. Hemlock-dominated stands are often the result of post-fire hemlock establishment decades or centuries before. Hemlock-dominated cover types are present on 59% of the areal extent of the ecosystem. The canopy is relatively dense, becoming more dense as the amount of hemlock in the overstory increases. Sugar maple, striped maple, and hemlock are common in the understory. The herbaceous layer has low coverage. *Maianthemum* and *Polygonatum* species groups indicate dry-mesic to mesic, moderately infertile to infertile, shaded conditions.

ECOSYSTEM TYPE 8: LEVEL TO GENTLY SLOPING AREAS OF WATER-LAID LOAMY SAND AND GRAVEL; DEEP, WELL DRAINED LOAMY SAND TO SAND; Hemlock-Northern Hardwood/ *Polygonatum*

PHYSIOGRAPHY AND SOIL

Characteristic of flats and gentle slopes in deep, moderately well sorted late Pleistocene flood deposits or glacial outwash; slopes 0-5%. All aspects.

Soil material is pebbly to cobbly loamy sand to sand throughout. Well drained. B horizon frequently cemented by ortstein. Usually an E horizon at the surface. Strong to medium acid throughout profile.

Most similar to ecosystem 21 and distinguished from it by slopes less than 6%. Distinguished from ecosystems 7 and 11 by the loamy sand texture of the surface soil and the higher rock content. Distinguished from ecosystem 12 by the lack of mottling in the upper 50 cm. Distinguished from ecosystems 9 and 10 by the lack of sandy loam lower soil horizons.

VEGETATION: Hemlock-Northern Hardwood/*Polygonatum*

The overstory may be dominated by either hemlock or sugar maple or any combination of the two and lesser amounts of yellow birch and basswood. Fire is often important in the establishment of hemlock. Hemlock-dominated cover types occur on 47% of the ecosystem. The canopy is relatively dense, becoming more dense as the amount of hemlock in the overstory increases. Hemlock, sugar maple, hop-hornbeam, and balsam fir are common in the understory. The herbaceous layer has low coverage. *Polygonatum* and *Maianthemum* species groups are common with the *Botrychium* group present where A horizons occur. These groups indicate mesic, moderately infertile to moderately fertile, shaded conditions.

ECOSYSTEM TYPE 9: LEVEL TO GENTLY SLOPING SANDY LOAM TILL; DEEP, WELL DRAINED SANDY LOAM; Sugar Maple-Hemlock-Northern Hardwood/*Polygonatum*

PHYSIOGRAPHY AND SOIL

Characteristic of flats and gentle slopes composed of sandy loam lodgement till covered by a thin cap of ablation till or waterlaid loamy sand and gravel. Sandstone bedrock usually at moderate depth; slopes 2-10%. All aspects.

Soil material is sandy loam with minor amount of gravel. Well drained. E or A horizon at surface. B horizon weakly developed, ortstein rarely present. Extremely acid to very strongly acid E horizon, very strongly to strongly acid in B.

Most similar to ecosystem 10 and distinguished from it by presence of sandstone bedrock within 200 cm of the surface and the absence of a fragipan. Distinguished from all other ecosystems by the presence of sandy loam lodgement till within 50 cm of the surface on flat to gently sloping terrain.

VEGETATION: Sugar Maple-Hemlock-Northern Hardwood/*Polygonatum*

The overstory is dominated by sugar maple or hemlock with lesser amounts of yellow birch and basswood. Hemlock dominance on 42% of the areal extent of the ecosystem (see cover types 10 and 11, Appendix E) is the result of ground fires of low intensity, sufficient to prepare a seedbed for hemlock germination and establishment. The canopy is relatively dense. Hop-hornbeam, sugar maple, and hemlock are common understory trees. The herbaceous layer has moderate coverage. *Polygonatum*, *Botrychium*, and *Maianthemum* species groups indicate mesic, moderately infertile to moderately fertile, shaded conditions.

ECOSYSTEM TYPE 10: GENTLY SLOPING WATERLAID SANDS OVER TILL; DEEP, MODERATELY WELL DRAINED FINE SAND OVER SANDY LOAM HARDPAN; Sugar Maple/*Polygonatum*

PHYSIOGRAPHY AND SOIL

Characteristic of gentle slopes with waterlaid fine sandy surfaces over sandy loam to sandy clay loam till; slopes 2-10%. Usually north and east aspects.

Fine sand to fine sandy loam in the upper 100 cm. Sandy loam to sandy clay loam below 100 cm in lower B and C horizons. Moderately well drained to well drained. E or A horizon present at surface. Ortstein and fragipan present in B. Very strongly to strongly acid throughout.

Most similar to ecosystem 9 and distinguished from it by the fine sandy loam fragipan and the till substratum. Distinguished from all other ecosystems by the presence of a fine sandy loam fragipan and low rock content in the surface layer.

VEGETATION: Sugar Maple/*Polygonatum*

The overstory is dominated by sugar maple with lesser amounts of hemlock, yellow birch, and basswood. The dominantly sugar maple-hardwood overstory is evidence of the absence of fire from the area for a considerable period of time. The canopy is relatively dense. The herbaceous layer has moderate coverage. Sugar maple, striped maple, and hop-hornbeam are common understory trees. *Polygonatum*, *Maianthemum*, and *Botrychium* species groups indicate mesic, moderately infertile to moderately fertile, shaded conditions.

ECOSYSTEM TYPE 11: LEVEL TO GENTLY SLOPING WATER-LAID SANDS; DEEP, MODERATELY WELL DRAINED MEDIUM SAND; Hemlock/*Coptis*

PHYSIOGRAPHY AND SOIL

Characteristic of flats in well sorted glacial outwash or late Pleistocene flood deposits. Located in broad flats of relatively low landscape position and little local relief; slopes 0-5%. All aspects.

Soil composed of waterlaid medium sand. Moderately well drained. E horizon distinct. Bh usually present. Ortstein common. E horizon extremely to very strongly acid, increasing to medium to slightly acid in lower B.

Most similar to ecosystems 7 and 8 and distinguished from them by the lower landscape position, often adjacent to streams, lakes, or wetlands. Occasionally on sandy stream terraces adjacent to but slightly higher than ecosystem 15 terraces. Distinguished from ecosystem 6 by the development of ortstein in the Bs horizon and more common occurrence of accumulations of illuvial humus.

VEGETATION: Hemlock/*Coptis*

The overstory is dominated by hemlock with lesser amounts of sugar maple, yellow birch, and red maple. Despite the moderately well drained nature of the soil, fire has been a very important factor in the establishment of hemlock. Hemlock dominated cover types are present on 66% of the ecosystem. The canopy is dense. Hemlock, balsam fir, and striped maple are common in the understory. The herbaceous layer has low coverage. *Coptis*, *Polygonatum*, *Corylus*, and *Maianthemum* species groups indicate mesic to wet-mesic, infertile, shaded conditions. The common occurrence of the *Pteridium* species group indicates that fire has affected a large part of this ecosystem.

ECOSYSTEM TYPE 12: LEVEL TO GENTLY SLOPING AREAS OF WATER-LAID SAND; DEEP TO MODERATELY DEEP, SOMEWHAT POORLY DRAINED SAND TO LOAMY SAND; Hemlock-Red Maple-Yellow Birch/*Coptis*

PHYSIOGRAPHY AND SOIL

Characteristic of low flats with seasonally high water table; slopes 0-2%. All aspects.

Soil material is medium sand to loamy sand. Somewhat poorly drained. A horizon if present is discontinuous. E horizon usually present at surface. Ortstein and fragipan common but not diagnostic. E and upper B horizons strongly to very strongly acid. Parent material variable.

Usually occurs as wet depressions in ecosystems 7, 8, 10, or 11 and distinguished from these ecosystems by the presence of mottling in the upper 50 cm of the profile. Distinguished from ecosystem 35 by the lack of a continuous A horizon and the more acid surface soil.

VEGETATION: Hemlock-Red Maple-Yellow Birch/*Coptis*

The overstory is dominated by hemlock, red maple, sugar maple, and yellow birch. Red maple replaces sugar maple as the most important hardwood in most areas of the ecosystem (in comparison to typical hemlock-northern hardwood forest), particularly in the larger size classes. Hemlock and yellow birch regeneration on logs, always a factor in hemlock-northern hardwood forests, is of particular importance here where fire is absent. The canopy is relatively dense. The understory is sparse, composed of occasional sugar maple, hemlock, striped maple, balsam fir, and basswood saplings. Coverage of the herbaceous layer is low. *Coptis*, *Gymnocarpium*, *Corylus*, *Maianthemum*, and *Botrychium* species groups indicate wet-mesic, moderately fertile to moderately infertile, shaded conditions.

ECOSYSTEM TYPE 13: SANDY STREAM TERRACES ADJACENT TO PINE ECOSYSTEMS; DEEP, WELL TO MODERATELY WELL DRAINED MEDIUM SAND; Pine-Birch/*Pteridium*

PHYSIOGRAPHY AND SOIL

Stream terraces in the floodplain of the Pine River; slopes 0-2%. All aspects.

Water-laid medium sand. Well to moderately well drained. A or E horizon at surface. Ortstein lacking in B horizon. Very strongly to extremely acid at surface, increasing to slightly acid within 75 cm.

Very similar to ecosystem 15 and distinguished from it by its occurrence adjacent to frequently burned beach ridge ecosystem 2. Similar to ecosystem 16 and distinguished from it by the stream terrace landform. May occur next to ecosystem 18 and is distinguished from it by having a higher landscape position further from the stream and by the thinner, weaker A horizon.

VEGETATION: Pine-Birch/*Pteridium*

The overstory is dominated by white pine and red pine and white birch with lesser amounts of northern white-cedar and jack pine. White and red pine are not usually found in moist streamside environments and occur here as the result of fire that originated in the surrounding jack pine forest. The canopy is relatively open. Coverage of the understory layer is low. Coverage of the herbaceous layer is high. *Pteridium*, *Vaccinium*, and *Maianthemum* species groups indicate dry-mesic to mesic, moderately infertile, frequently burned conditions.

ECOSYSTEM TYPE 14: ALLUVIAL FANS; DEEP, WELL DRAINED SANDSTONE GRAVEL AND SAND; Sugar Maple/*Botrychium*

PHYSIOGRAPHY AND SOIL

Sand and gravel alluvial fans formed at the mouths of sandstone bedrock ravines; slopes 2-30% All aspects.

Soil is composed predominantly of alluvial sandstone fragments. Fine fraction is sand to loamy sand. Well drained. Fans are subirrigated by intermittent streams flowing in the ravine bottom. Usually a very weak A horizon at the surface. B horizon absent. Ortstein and fragipan absent. Weakly acid at surface. Strongly acid below.

Most similar to ecosystem 4 and distinguished from it by the alluvial fan landform and the absence of bedrock within 200 cm of the surface. Similar to ecosystems 24 and 25 and distinguished from them by the absence of surface boulders. Distinguished from all other ecosystems by the abundance of sandstone channers and pebbles in the parent material.

VEGETATION: Sugar Maple/*Botrychium*

The overstory is dominated by sugar maple with occasional hemlock, yellow birch, and basswood. Maple-dominated cover types are present on 89% of the areal extent of the ecosystem. The canopy is moderately dense. The understory is relatively dense, composed of sugar maple, hop-hornbeam, and striped maple. Coverage in the herbaceous layer is moderate. *Botrychium*, *Arisaema*, *Polygonatum*, and *Maianthemum* groups indicate mesic, relatively fertile, shaded conditions.

ECOSYSTEM TYPE 15: SANDY STREAM TERRACES; DEEP, MODERATELY WELL DRAINED LOAMY SAND; Red Maple-Yellow Birch/*Botrychium*

PHYSIOGRAPHY AND SOIL

Low stream terraces in the floodplains of major streams; slopes 0-1%. All aspects.

Soil composed of loamy sand to sand alluvium to a depth of 100 cm. May overlie coarse gravelly alluvium. Moderately well drained. A horizon common. B horizon usually absent. Strongly to slightly acid throughout.

Most similar to ecosystem 17 and distinguished from it by occurring higher in the watershed in areas of greater stream gradient. Distinguished from ecosystem 16 by the lower, more frequently flooded landscape position. Distinguished from ecosystem 18 by the lack of a thick mucky Oa or A horizon.

VEGETATION: Red Maple-Yellow Birch/*Botrychium*

The overstory is dominated by red maple, yellow birch, and sugar maple with small amounts of hemlock. The canopy is moderate in closure. Sugar maple dominates the understory. Coverage of the herbaceous layer is moderate to high. *Botrychium* and *Arisaema* species groups indicate wet-mesic, fertile, moderately shaded conditions.

ECOSYSTEM TYPE 16: DELTAS; DEEP, MODERATELY WELL DRAINED FINE SANDY LOAM; Sugar Maple/*Botrychium*

PHYSIOGRAPHY AND SOIL

Delta of Mink Run, composed of sandy and gravelly alluvium: slopes 0-1%. All aspects.

Sandy loam and loamy sand alluvium. Coarse gravelly alluvium may occur below 100 cm. Moderately well drained. A horizon typical. B horizon absent or

showing slight oxidation in higher central area of delta. Ortstein absent. Slightly acid to neutral throughout.

Similar to ecosystems 15 and 17 and distinguished from them by the delta landform. Distinguished from ecosystem 18 by the lack of a thick mucky Oa or A horizon at the surface. Distinguished from ecosystem 7 by the loamy soil. Distinguished from ecosystem 8 by the lack of pebbles and cobbles in the soil.

VEGETATION: Sugar Maple/*Botrychium*

With the floodplain of Mink Run to the west, a conifer hardwood swamp to the north, and Mountain Lake to the east and south, the delta of Mink Run has been protected from fire. The absence of fire has allowed the development of a forest dominated by sugar maple with lesser amounts of basswood. The canopy is moderate in closure. The understory is very dense, dominated by sugar maple. Coverage of the herbaceous layer is moderate. *Botrychium*, *Arisaema*, *Corylus*, *Gymnocarpium*, and *Polygonatum* species groups indicate mesic, fertile, moderately shaded conditions.

ECOSYSTEM TYPE 17: FLOODPLAINS; DEEP, MODERATELY WELL DRAINED SAND TO SANDY LOAM; Sugar Maple-Elm/*Arisaema*

PHYSIOGRAPHY AND SOIL

Low stream terraces within the floodplains of major streams; slopes 0-1%. All aspects.

Soil material is sand to sandy loam alluvium. Coarse gravelly alluvium may occur below 100 cm. Moderately well drained. A horizon common at surface. B horizon usually absent or expressed as slight oxidation only. Neutral to slightly acid throughout.

Similar to ecosystem 16 and distinguished from it by having a position immediately adjacent to the stream and thus subject to more frequent flooding. Similar to ecosystem 15 but occurs along lower gradient stretches downstream of ecosystem 15. Distinguished from ecosystem 18 by the lack of a thick mucky Oa or A horizon.

VEGETATION: Sugar Maple-Elm/*Arisaema*

The overstory is dominated by sugar maple with lesser amounts of basswood, yellow birch, and American elm. American elm was once a principal dominant but has become rare due to Dutch elm disease and phloem necrosis. The large number of dead elms still standing along the Salmon Trout River attests to the former importance of this species. The canopy is moderate in closure. Sugar maple dominates the understory. Coverage of the herbaceous layer is moderate to high. *Arisaema*, *Botrychium*, *Gymnocarpium*, *Impatiens*, and *Corylus* species groups indicate mesic to wet-mesic, very fertile, moderately shaded conditions.

ECOSYSTEM TYPE 18: FLOODPLAINS; DEEP, SOMEWHAT POORLY DRAINED TWO-STORIED ALLUVIUM; Northern White-Cedar/ *Botrychium*

PHYSIOGRAPHY AND SOIL

Characteristic of the floodplains of braided streams, in areas of low stream gradients adjacent to lakes; slopes 0-1%. All aspects.

Very high organic-matter sandy loam to muck surface over coarse alluvial sands and gravels. Somewhat poorly drained. Water table within 30 cm of the surface throughout the year.

A horizon of alluvial sand and organic matter. C horizon of water-laid sand and gravel. B horizon absent. Slightly acid to neutral throughout.

Distinguished from other upland streamside ecosystems by the continuously high water table (15-30 cm) and the very high organic-matter sandy loam to muck surface soil. Occurs in a similar position, but usually upstream of ecosystem 50 in areas of higher stream gradient and lower water table.

VEGETATION: Northern White-Cedar/*Botrychium*

Northern white-cedar dominates the overstory. Northern white-cedar typically establishes on old logs or on fresh sediment left by spring flood waters. Along the Pine River however, it has seeded in and established after fire, which burned into the floodplain from the surrounding jack pine forest. Hemlock, basswood, and yellow birch are common associates. The canopy is typically dense. The understory layer is sparse, typically composed of balsam fir, northern white-cedar, and mountain maple. Coverage of the herbaceous layer is low to moderate. The *Botrychium, Arisaema, Impatiens, Corylus,* and *Gymnocarpium* species groups indicate wet-mesic, very fertile, shaded conditions.

ECOSYSTEM TYPE 19: MOUNTAIN SLOPES; MODERATELY DEEP, SOMEWHAT EXCESSIVELY DRAINED MEDIUM SAND; Red Pine/ *Pteridium*

PHYSIOGRAPHY AND SOIL

Characteristic of crystalline bedrock mountain slopes with a veneer of water-laid sand; slopes 10-25%. West aspects.

Soil material medium and coarse sands throughout. Bedrock at depth of less than 2 m. Somewhat excessively drained. E horizon at surface. Ortstein common in B. Somewhat excessively drained. Extremely to very strongly acid E horizon, strongly to slightly acid in B.

Most similar to ecosystem 20 and distinguished from it by the westerly aspect and the presence of bedrock within 200 cm of the surface. Distinguished

from ecosystem 21 by the well sorted medium to coarse sand texture. Distinguished from ecosystem 3 by the mountain physiography.

VEGETATION: Red Pine/*Pteridium*

Dry, sun- and wind-exposed site conditions lead to frequent fires. The overstory is dominated by red and white pine with lesser amounts of bigtooth aspen, white birch, hemlock, and white spruce. The canopy is relatively open. The understory is composed of red maple, hemlock, white spruce, and white pine. The present overstory established after fire and is being slowly replaced by the more understory tolerant red maple, hemlock, and white spruce. The frequency of fire in the past seems to have been sufficient to maintain pine dominance. All areas of this ecosystem at present have a pine-dominated overstory. Coverage in the herbaceous layer is low. *Pteridium* and *Cladonia* species groups indicate dry to dry-mesic, infertile, relatively open conditions.

ECOSYSTEM TYPE 20: MOUNTAIN SLOPES; DEEP, WELL DRAINED MEDIUM SAND; Hemlock/*Maianthemum*

PHYSIOGRAPHY AND SOIL

Characteristic of sandstone or crystalline bedrock mountain slopes with a veneer of deep well-sorted late Pleistocene flood deposits or glacial outwash; slopes 5-10%. North and east aspects.

Soil material is medium sand throughout. Very few pebbles or cobbles. Well drained. B horizon usually cemented by ortstein. E horizon at surface. Very strongly acid E grading to slightly acid C horizon.

Most similar to ecosystem 7 and distinguished from it by slopes greater than 5%. Distinguished from ecosystem 19 by north or east aspect and slopes less than 10%. Distinguished from ecosystem 21 by the well-sorted medium sand texture.

VEGETATION: Hemlock/*Maianthemum*

The overstory is usually dominated by hemlock with lesser amounts of sugar maple, yellow birch, and red maple.

Hemlock-dominated cover types occur on 67% of the areal extent of the ecosystem due to the widespread influence of fire. The canopy is relatively dense, and the understory is sparse, composed of scattered hemlock and striped maple saplings. The coverage of the herbaceous layer is low. *Maianthemum*, *Polygonatum*, and *Gymnocarpium* species groups indicate dry-mesic, infertile, heavily shaded conditions.

ECOSYSTEM TYPE 21: MOUNTAIN SLOPES; DEEP, WELL DRAINED LOAMY SAND; Hemlock-Northern Hardwood/*Polygonatum*

PHYSIOGRAPHY AND SOIL

Characteristic of sandstone and crystalline bedrock mountain slopes with a veneer of deep, moderately well-sorted late Pleistocene flood deposits or glacial outwash; slopes 5-30%. All aspects.

Soil material is pebbly to cobble sandy loam to sand throughout. Well drained. B horizon frequently cemented by ortstein. Usually an E horizon at the surface. Strong to medium acid throughout profile.

Most similar to ecosystem 8 and distinguished from it by slopes greater than 5%. Distinguished from ecosystem 22 by the less dissected slopes and the lack of a fragipan. Distinguished from ecosystems 19 and 20 by the gravelly loamy sand to sand surface soil.

VEGETATION: Hemlock-Northern Hardwood/*Polygonatum*

The overstory can be dominated by either hemlock or sugar maple or any combination of the two. As in many hemlock-northern hardwood ecosystems, hemlock dominance and fire influence are closely related (see ecosystems 7, 8, 9, 11, 20, 22, and 24). Hemlock-dominated cover types are present on 55% of the ecosystem. Yellow birch, basswood, and red maple may occur in lesser amounts. The canopy is relatively dense, becoming more dense as the amount of hemlock increases. Hemlock, hop-hornbeam, and sugar maple are common in the understory. The herbaceous layer has low coverage. *Polygonatum*, *Maianthemum*, *Goodyera*, and *Botrychium* species groups indicate mesic to dry-mesic, moderately infertile to moderately fertile, shaded conditions.

ECOSYSTEM TYPE 22: MOUNTAIN SLOPES; DEEP, WELL DRAINED LOAMY SAND OVER SANDY LOAM HARDPAN; Hemlock-Northern Hardwood/*Polygonatum*

PHYSIOGRAPHY AND SOIL

Characteristic of sandstone and crystalline bedrock mountain slopes covered by glacial outwash over lodgement till, slopes well-dissected; slopes 5-30%. North and east aspects.

Loamy sand to sand surface soil. Sandy loam hardpan at depth of less than 2 meters. Well drained. E horizon at surface. Ortstein common in B. Fragipan common at boundary of water-laid sand and till. Extremely acid to strongly acid E horizon, strongly to medium acid in B.

Very similar to ecosystem 23 and distinguished from it by greater slope

dissection and generally coarser surface soil. Similar to ecosystems 8 and 9 and distinguished from them by slopes greater than 5%. Distinguished from ecosystems 19 and 20 by the gravelly loamy sand to sand surface soil. Distinguished from ecosystem 21 by the presence of a sandy loam fragipan and by the greater slope dissection.

VEGETATION: Hemlock-Northern Hardwood/*Polygonatum*

The overstory can be dominated by either hemlock or sugar maple or any combination of the two. Hemlock-dominated cover types are present on 61% of the area. Yellow birch, basswood, or red maple may occur in lesser amounts. On the extreme western portion of the north slope of Huron Mountain, ecosystem 22 has a birch-hemlock-red maple cover type (7), indicating relatively recent fire. The canopy is relatively dense, becoming more dense as the amount of hemlock in the overstory increases. Hemlock, sugar maple, and hop-hornbeam are common in the understory. The herbaceous layer has low coverage. *Polygonatum*, *Maianthemum*, and *Goodyera* species groups indicate mesic to dry-mesic, moderately infertile to moderately fertile, shaded conditions.

ECOSYSTEM TYPE 23: MOUNTAIN SLOPES; DEEP, WELL DRAINED SANDY LOAM; Sugar maple-Hemlock-Northern Hardwood/*Corylus*

PHYSIOGRAPHY AND SOIL

Characteristic of sandstone and crystalline bedrock mountain slopes with silty glacial outwash over lodgement till, slopes poorly dissected; slopes 5-30%. North aspects.

Loamy sand to sandy loam surface soil. Sandy loam hardpan at depth of less than 1.5 m. Well drained. A or E horizon at surface. Ortstein common in B. Fragipan common at boundary of water-laid sand and till. Strongly to medium acid E horizon, medium acid to slightly acid in B.

Very similar to ecosystem 22 and distinguished from it by the greater content of silt in the surface soil (small depressions and drainages are usually moderately well drained, with thin silt loam accumulations at the surface) and by less slope dissection. Similar to ecosystems 8 and 9 and distinguished from them by slopes greater than 5%. Distinguished from ecosystems 19 and 20 by the gravelly loamy sand to sandy loam surface soil and the presence of a fragipan.

VEGETATION: Sugar maple-Hemlock-Northern Hardwood/*Corylus*

The amount of soil moisture is higher and the frequency and intensity of fire lower than in ecosystems 20, 21, and 22. The overstory is dominated by sugar maple and hemlock, with hemlock being relatively less important than in

ecosystem 22. Hemlock dominated cover types are present on only 26% of the ecosystem. Yellow birch, red maple, or basswood may occur in lesser amounts. The canopy is relatively dense, becoming more dense as the amount of hemlock in the overstory increases. Hemlock, hop-hornbeam, and sugar maple are common in the understory. Abundant soil moisture and the position of this ecosystem two miles south of the winter deer yards seem to favor vigorous hemlock regeneration. The herbaceous layer has moderate to low coverage. *Corylus*, *Polygonatum*, *Botrychium*, *Gymnocarpium*, and *Goodyera* species groups indicate mesic, moderately fertile, shaded conditions.

ECOSYSTEM TYPE 24: GRAVEL BAR WITH SURFACE BOULDERS; DEEP, WELL DRAINED LOAMY SAND OVER GRAVEL, UPPER SLOPES; Hemlock-Northern Hardwood/*Botrychium*

PHYSIOGRAPHY AND SOIL

Characteristic of moderately well sorted sand and gravel deposited by extremely high energy flood waters. Ground surface littered with boulders from 1-5 m in diameter. Upper slope positions; slopes 2-10%. All aspects.

Soil material is cobbly loamy sand to sand throughout. Sandstone boulders at surface and buried in soil. Well drained. B horizon frequently cemented by ortstein. Usually an E horizon at the surface. Extremely acid to strongly acid at surface, strongly to medium acid below.

Very similar to ecosystem 25 and distinguished from it by the upper slope or ridge top landscape position. Similar to ecosystem 8 and distinguished from it by the presence of boulders at the surface.

VEGETATION: Hemlock-Northern Hardwood/*Botrychium*

The overstory is dominated by hemlock and sugar maple. Basswood and yellow birch are also present. Boulders provide an important microsite for hemlock and yellow birch establishment (Fig.12). Fire has had extensive influence in that portion of ecosystem 24 occurring immediately south of Rush Creek. Hemlock achieves very high dominance in these areas. In total, hemlock-dominated cover types are present on 81% of the ecosystem. The canopy is dense, and the understory is sparse, composed of scattered hop-hornbeam, striped maple, and hemlock saplings. Coverage in the herbaceous layer is low. The *Botrychium*, *Polygonatum*, and *Maianthemum* species groups indicate mesic, moderately fertile, shaded conditions.

ECOSYSTEM TYPE 25: GRAVEL BAR WITH SURFACE BOULDERS; DEEP, WELL DRAINED LOAMY SAND OVER GRAVEL, MID- AND LOWER SLOPES; Sugar Maple/*Botrychium*

PHYSIOGRAPHY AND SOIL

Characteristic of moderately well-sorted sand and gravel deposited by extremely high-energy flood waters. The ground surface is littered with boulders from 1-5 m in diameter. Mid and lower slope positions; slopes 2-10%. North aspects.

Soil material is cobbly loamy sand to sand throughout. Well drained. Sandstone boulders at surface and buried in soil. B horizon weakly developed, ortstein absent. Usually an A horizon at the surface. Medium to slightly acid at surface, strongly acid below.

Fig. 12. Ecosystem 24. Boulders provide an important microsite of hemlock establishment. South of Rush Creek (SW 1/4 Sec 20 T52N R28W).

Most similar to ecosystem 24 and distinguished from it by the low and mid slope position. Distinguished from ecosystems 8 and 21 by the presence of large boulders at the surface.

VEGETATION: Sugar Maple/*Botrychium*

The overstory is dominated by sugar maple with lesser amounts of hemlock (26% hemlock-dominated cover types), yellow birch, and basswood. Fire has been rare or absent from this ecosystem. The canopy is moderate in closure. Sugar maple, striped maple, and hop-hornbeam are characteristic in the understory. Where striped maple, hemlock, and yellow birch occur, they have established on the exposed rock surface of boulders. Coverage in the herbaceous layer is moderate to high. *Botrychium*, *Corylus*, *Gymnocarpium*, *Polygonatum*, and *Polypodium* species groups indicate mesic, moderately fertile, moderately shaded conditions.

ECOSYSTEM TYPE 26: FLOOD SCOURED SANDSTONE, EXPOSED TOPOGRAPHIC POSITIONS; SHALLOW, WELL DRAINED LOAMY SAND; Mixed Conifer/*Pteridium*

PHYSIOGRAPHY AND SOIL

Characteristic of level to gently sloping areas of sandstone bedrock that were scoured by late Pleistocene flood waters. Sediment accumulation thin over bedrock. Weathering of sandstone bedrock may be an important source of soil material. Exposed topographic positions next to lakes or high on mountain slopes; slopes 0-10%. All aspects.

Soil material is gravelly to channery loamy sand. Well drained. A or E horizon at surface. A horizons are the temporary result of the release of basic nutrients from organic matter by fire and the resultant stimulation of soil faunal activity. B horizon weakly developed, ortstein absent. Very strongly acid throughout.

Very similar to ecosystem 27 and distinguished from it by the exposed topographic positions. Distinguished from ecosystem 8 by the presence of bedrock within 50 cm of the surface.

VEGETATION: Mixed conifer/*Pteridium*

The overstory is dominated by hemlock, red maple, white pine, red pine, red oak, and white birch. This mix of overstory species indicates relatively frequent fires. In much of the area of this ecosystem, white pine is no longer an important component, having been removed by logging in the 1890s. Red pine was then, and is now, restricted to areas of the ecosystem that abut wind-exposed lakeshores where fire has been historically a more common event. The canopy is moderate in

closure. Red maple, balsam fir, and hemlock are characteristic of the understory. Coverage in the herbaceous layer is moderate. *Pteridium*, *Vaccinium*, *Polygonatum*, and *Goodyera* species groups indicate dry-mesic, infertile, shaded to moderately open, frequently burned conditions.

ECOSYSTEM TYPE 27: FLOOD-SCOURED SANDSTONE, PROTECTED TOPOGRAPHIC POSITIONS; SHALLOW, WELL DRAINED LOAMY SAND; Hemlock/*Maianthemum*

PHYSIOGRAPHY AND SOIL

Characteristic of level to gently sloping areas of sandstone bedrock that were scoured by the late Pleistocene flood waters. Sediment accumulation thin over bedrock. Protected topographic positions; slopes 0-10%. All aspects.

Soil material is gravelly to channery loamy sand. Well drained. E horizon at surface. B horizon weakly developed, ortstein absent. Extremely acid to very strongly acid E horizon, very strongly to strongly acid in B.

Very similar to ecosystem 26 and distinguished from it by the protected topographic position. Distinguished from ecosystems 8 and 21 by the presence of bedrock within 50 cm of the surface.

VEGETATION: Hemlock/*Maianthemum*

The overstory is dominated by hemlock with lesser amounts of sugar maple, red maple, yellow birch, and basswood. Hemlock-dominated cover types occur on 78% of the ecosystem. The canopy is relatively dense. The understory is sparse, composed of scattered hemlock saplings. Coverage in the herbaceous layer is low. *Maianthemum*, *Polygonatum*, and *Goodyera* species groups indicate mesic, infertile, heavily shaded conditions.

ECOSYSTEM TYPE 28: NARROW RIDGE TOPS, ROCKY KNOLLS, AND STEEP SOUTH SLOPES; SHALLOW, SOMEWHAT EXCESSIVELY DRAINED SANDY LOAM; Lichen-Juniper/*Woodsia*

PHYSIOGRAPHY AND SOIL

Rugged exposed crystalline bedrock terrain where the mantle of glacial sediment has been removed by erosion. Narrow ridge top and steep south slope topographic positions are common; slopes 10% to vertical. Usually south and west aspects.

Sandy loam colluvium, windblown silt, and fibric to hemic organic accumulations occur in depressions and cracks in bedrock. Somewhat excessively

drained. Soil formation minimal. Maximum soil depth 10-40 cm. Extremely to strongly acid throughout.

Most similar to ecosystem 29 and distinguished from it by the steeper topography and by having greater than 70% of the surface area in exposed bedrock.

VEGETATION: Lichen-Juniper/*Woodsia*

The dominant cover is one of crustose and foliose lichens and ground juniper interspersed with bare rock. The sparse overstory is dominated by white pine, red oak, and red pine. Trees are short and stunted, and the canopy is very open. Figure 13 shows the exposed rock and stunted low growth of trees and shrubs characteristic of this ecosystem. The understory is dominated by red oak. *Woodsia*, *Cladonia*, *Comandra*, *Vaccinium*, and *Maianthemum* species groups have very high coverage in areas where soil accumulates. These species groups indicate a highly variable environment: extremely dry to dry-mesic, very infertile to moderately infertile, very open conditions.

ECOSYSTEM TYPE 29: BROAD RIDGE TOPS AND MODERATE SOUTH SLOPES; SHALLOW, SOMEWHAT EXCESSIVELY DRAINED SANDY LOAM; Pine-oak/*Vaccinium*

PHYSIOGRAPHY AND SOIL

Rugged exposed crystalline bedrock terrain where the mantle of glacial sediment has been removed by erosion. Broad ridge top and moderate south slope topographic positions are common: slopes 10-80%. Usually south and west aspects.

Sandy loam to loamy sand colluvium. Aeolian and organic accumulations exist here but are of minor importance. Somewhat excessively drained. Bedrock is exposed on from 40 to 70% of the surface area. E horizon distinct. Ortstein and fragipan rare. Maximum soil depth 15-50 cm. Extremely acid to medium acid E horizon, strongly acid to slightly acid B horizon.

Most similar to ecosystem 28 and distinguished from it by having less steep and convex topography and by having less than 70% of the area surface in exposed bedrock. Distinguished from ecosystem 30 by having more exposed topographic positions and by having more than 40% of the area surface in exposed bedrock.

VEGETATION: Pine-oak/*Vaccinium*

The overstory is dominated by white pine, red oak, and red pine. Trees are short, and the canopy is open. Charred wood is commonly found in areas of this ecosystem, indicating that fire is a common event. In the background of the photograph in Figure 13 is the low pine-oak forest of ecosystem 29. The understory

Fig. 13. Western portion of the ridge of Huron Mountain, showing ecosystem 28 in the foreground with lichen-juniper cover, and ecosystem 29 in the background with stunted pine and oak vegetation (SW 1/4 Sec 24 T52N R29W).

is composed of red oak, white pine, red maple, and hemlock. *Vaccinium*, *Cladonia*, *Woodsia*, *Comandra*, and *Maianthemum* species groups are common on areas where soil is present. Crustose and foliose lichens cover most of the exposed rock. This association indicates a highly variable environment: dry to dry-mesic, very infertile to moderately infertile, open conditions.

ECOSYSTEM TYPE 30: ROCKY LOWER SLOPES AND PROTECTED POSITIONS; SHALLOW, WELL DRAINED SANDY LOAM; Mixed Conifer-Hardwood/*Polypodium*

PHYSIOGRAPHY AND SOIL

Rugged crystalline bedrock terrain of protected topographic positions where the mantle of glacial sediments has been largely removed by erosion or where large boulders have accumulated in a footslope position; slopes 10-60%. Steep north aspects or low topographic positions of other aspects.

Soil material is sandy loam to loamy sand colluvium and drift. Well drained. Bedrock exposed on less than 40% of the area surface. E horizon distinct, 8-15 cm. B horizon may be cemented by ortstein. Maximum soil depth 20-50 cm. Extremely to very strongly acid at surface, strongly acid to medium acid in B.

Very similar to ecosystem 31 and distinguished from it by the lower content of organic matter in the soil. Similar to ecosystem 29 and distinguished from it by the more protected topographic position and by the greater coverage of the soil mantle (more than 60% of the area surface). Larger soil volume and the presence of an ortstein layer result in greater water-holding capacity than ecosystems 28 and 29.

VEGETATION: Mixed Conifer-Hardwood/*Polypodium*

The greater moisture-holding capacity of the soil and less frequent fires (as compared to ecosystems 28 and 29) allow the establishment and growth of a more diverse mixture of conifer and hardwood species. The overstory is composed of hemlock, white pine, red oak, red maple, sugar maple, and northern white-cedar. Overstory trees tend to be somewhat stunted in comparison to the same species growing in deeper-soil ecosystems. The canopy is relatively open. Striped maple, sugar maple, and hemlock are characteristic of the understory. Coverage in the herbaceous layer is moderate to high in areas where soil is present. Moss covers most exposed bedrock. *Polypodium*, *Maianthemum*, and *Polygonatum* species groups indicate mesic, infertile, and moderately open conditions.

ECOSYSTEM TYPE 31: THIN STONY SOIL IN PROTECTED TOPOGRAPHIC POSITIONS; SHALLOW, WELL DRAINED SANDY LOAM; Hemlock-Northern Hardwood/*Polygonatum*

PHYSIOGRAPHY AND SOIL

Characteristic of rugged crystalline bedrock terrain of relatively protected topographic positions. Most of the cover of glacial sediments has been removed by erosion and a thin cover redeposited by alluvial and colluvial processes; slopes 5-40%. North and east aspects and scoured bedrock flats.

Soil material is loamy sand to sandy loam colluvium and drift. Well drained. Bedrock usually exposed on less than 40% of the area surface. A horizon usually present. Ortstein and fragipan absent. Maximum soil depth 20-50 cm. Strongly to medium acid throughout.

Most similar to ecosystem 30 and distinguished from it by the higher organic matter content of the soil. Distinguished from ecosystems 8, 9, 10, 21, 22, and 23 by the presence of crystalline bedrock within 50 cm of the surface.

VEGETATION: Hemlock-Northern Hardwood/*Polygonatum*

The overstory is dominated by hemlock and sugar maple with lesser amounts of basswood, red maple, and yellow birch. Overstory trees tend to be somewhat stunted in comparison to the same species growing in deeper soil ecosystems. The absence of pine and oak indicate moisture conditions and less frequent fire than ecosystem 30. Sugar maple, striped maple, hop-hornbeam, and hemlock are characteristic of the understory. Coverage in the herbaceous layer is moderate to high in areas where soil is present. *Polygonatum*, *Gymnocarpium*, *Botrychium*, and *Corylus* species groups indicate mesic, moderately fertile, moderately open conditions.

ECOSYSTEM TYPE 32: BEDROCK VALLEYS AND CONCAVE AREAS IN CRYSTALLINE BEDROCK TERRAIN; DEEP TO MODERATELY DEEP, WELL DRAINED LOAMY SAND; Hemlock-Northern Hardwood/*Polygonatum*

PHYSIOGRAPHY AND SOIL

Bedrock valleys and concave areas in rugged crystalline bedrock terrain where the cover of soil is both deeper and more continuous than in the surrounding areas; slopes 5-40%. All aspects.

Soil material is loamy sand drift and colluvium. Well drained. A or E horizon at surface, 5-15 cm. Ortstein present in B. Soil depth 40-100 cm. Extremely to very strongly acid at surface, strongly acid in B.

Thin (<50 cm) sandy loam to loam, colluvial /alluvial surface soil. Substratum variable, sand to sandy loam. Well drained to moderately well drained. A horizon present. B horizon variable. Ortstein common. Fragipan rare. A horizon medium acid to neutral. B horizon and parent material medium to very strongly acid.

Similar to ecosystem 15, 16, and 17 and distinguished from them by the thin colluvial/alluvial surface layer, and by its occurrence outside of the floodplains of perennial streams. Distinguished from other upland ecosystems by its topographic position and the presence of an A horizon.

VEGETATION: Sugar Maple-Hemlock-Northern Hardwood/*Botrychium*

The overstory is usually dominated by sugar maple and other hardwoods. Occasionally, due to fire that originates in surrounding ecosystems, the overstory may be primarily hemlock with lesser amounts of sugar maple, yellow birch, and basswood. The canopy is moderate to dense. Sugar maple, striped maple, hemlock, and hop-hornbeam are the most common species in the understory. Coverage in the herbaceous layer is moderate. *Botrychium*, *Gymnocarpium*, *Corylus*, *Arisaema*, and *Impatiens* species groups indicate mesic to wet-mesic, fertile, shaded conditions.

ECOSYSTEM TYPE 36: STEEP TERRACE RISERS; DEEP, WELL-DRAINED LOAMY SAND ON SLOPES GREATER THAN 50%; Hemlock/*Botrychium*

PHYSIOGRAPHY AND SOIL

Characteristic of the steepest portion of relict terraces. Risers were originally vertical or near-vertical cuts in the sandstone bedrock carved by the waters of the late Pleistocene catastrophic flooding (in the mountains) or by wave action of Nipissing Lake Superior (near Lake Superior). Since this time, risers have weathered to smooth steep slopes (50-90% slope). Best developed on the north face of Huron Mountain. North and east aspects.

Gravelly loamy sand. Well to moderately well drained. Soil formed from sandstone debris weathered from the riser wall. Poorly developed due to high rate of natural erosion. E or A horizon indistinct. Ortstein and fragipan absent. Very strongly to strongly acid throughout.

Because of the extremely steep slopes, risers have high rates of soil erosion and gravitational soil creep. Trees in these areas have J-shaped stems at the base recording the rapid (on a geological time scale) mass movement of material down slope. Most similar to ecosystems 19, 20, 21, and 22 and distinguished from them by slopes greater than 50%. Distinguished from ecosystems 28, 29, 30, and 31 by the lack of exposed crystalline rock.

VEGETATION: Hemlock/*Botrychium*

The overstory is hemlock-dominated with rare individuals of yellow birch and sugar maple. Surface runoff on the steep slopes and the downward movement

of the soil itself produce areas where mineral soil is exposed. This provides a seedbed for hemlock establishment. Hemlock-dominated cover types are present on 82% of the ecosystem. While basal area coverage of hemlock is high, the steep slope provides for greater light penetration of the canopy than would occur on lesser slopes. The canopy is moderate in closure. Sugar maple, hemlock, and striped maple are common in the understory. Coverage in the herbaceous layer is moderate to high. *Botrychium*, *Polygonatum*, *Corylus*, *Goodyera*, and *Gymnocarpium* species groups indicate mesic, moderately fertile, shaded conditions.

ECOSYSTEM TYPE 37: FIRE-PRONE NORTH AND EAST LAKE MARGINS; DEEP, SOMEWHAT EXCESSIVELY DRAINED MEDIUM SAND; Red Pine/*Pteridium*

PHYSIOGRAPHY AND SOIL

Characteristic of deep water-laid sand deposits on north and east shores of inland lakes; slopes 0-6%. South and west aspects.

Well sorted medium sand. Somewhat excessively drained. E horizon distinct. Ortstein present in B. Fragipan absent. Extremely acid at surface, increasing to medium to slightly acid in the lower B.

Most similar to ecosystem 2 and 3 and distinguished from them by absence of beach ridge physiography. Further distinguished from ecosystem 2 by the presence of ortstein cementation in the B horizon. Distinguished from ecosystems 38, 39, and 40 by the deep medium sand soil profile.

VEGETATION: Red pine/*Pteridium*

Fire occurs frequently, leading to an overstory dominated by red pine. The canopy is moderately open. The understory is composed of white pine and striped maple. Coverage in the herbaceous layer is high. *Pteridium*, *Comandra*, *Gaylussacia*, *Cladonia*, and *Vaccinium* species groups indicate dry, infertile, relatively open, frequently burned conditions.

ECOSYSTEM TYPE 38: FIRE-PRONE NORTH AND EAST LAKE MARGINS; DEEP, WELL DRAINED LOAMY SAND; Birch-Aspen/*Pteridium*

PHYSIOGRAPHY AND SOIL

Characteristic of north and east lake shores with loamy sand and gravel surface soil; slopes 0-10%. South and west aspects.

Soil composed of loamy sand to sandy loam. Well drained. E horizon distinct. Ortstein common in B. Strongly acid throughout.

Similar to ecosystem 8 and distinguished from it by its occurrence on lake edges. Distinguished from ecosystem 37 by the loamy sand to sandy loam texture

of the lower soil. Distinguished from ecosystem 40 by its occurrence on more exposed north and east shores. Distinguished from ecosystem 39 by the lack of mottling in the soil profile.

VEGETATION: Birch-Aspen/*Pteridium*

East and north lake shores receive the brunt of the prevailing west and south winds as they come off the lake. The drying effect of these winds is pronounced and leads to increased fire frequencies relative to a similar soil type further inland. The overstory is variable, composed of species that establish following fire such as white birch, bigtooth and trembling aspen, white pine, red pine, and hemlock. The canopy is moderately open when birch or pine dominate the overstory, often very dense when hemlock is dominant. The understory is usually dominated by white pine or hemlock. Coverage in the herbaceous layer may be low to high (dense canopy coverage corresponds to low coverage in the herbaceous layer). *Pteridium*, *Vaccinium*, *Polygonatum*, and *Maianthemum* species groups indicate dry-mesic, infertile, relatively open conditions.

ECOSYSTEM TYPE 39: FIRE-PRONE NORTH AND EAST LAKE MARGINS; DEEP, MODERATELY WELL DRAINED SAND TO SANDY LOAM; Mixed Conifer-Hardwood/*Botrychium*

PHYSIOGRAPHY AND SOIL

Characteristic of low-lying, moist north and east lake shores; slopes 0-2%. South and west aspects.

Sand to sandy loam soil. Moderately well drained. A horizon at surface. Ortstein and fragipan absent. Mottling in the lower B horizon. Usually slightly acid to neutral throughout. Sandy mounds may have extremely to very strongly acid surface.

Very similar to ecosystem 38 and distinguished from it by its lower-lying position at the lake margin and the presence of mottling below 40 cm in the soil profile. Distinguished from ecosystem 40 by its occurrence on northern and eastern lake margins. Distinguished from ecosystem 35 by its occurrence on lake margins.

VEGETATION: Mixed Conifer-Hardwood/*Botrychium*

The overstory is composed of a mixture of balsam fir, white birch, red maple, hemlock, and sugar maple. The presence of balsam fir and white birch indicates relatively frequent disturbance by fire in comparison to similarly moist ecosystems in more protected topographic positions, such as ecosystem 35. As it occurs on the landscape, ecosystem 39 is surrounded by or occurs downwind (east) of the drier, and more easily burned type 38. Fires probably originate in the drier ecosystem and burn into ecosystem 39. The canopy is moderate in closure. Balsam fir dominates the understory. Coverage in the herbaceous layer is moderate to high. *Botrychium*, *Gymnocarpium*, *Polygonatum*, *Coptis*, and *Pteridium*

species groups indicate frequently burned, mesic to wet-mesic, fertile to infertile, moderately open conditions.

ECOSYSTEM TYPE 40: LAKE MARGINS; DEEP, MODERATELY WELL DRAINED SAND TO SANDY LOAM; Northern White Cedar-Hemlock/*Osmunda*

PHYSIOGRAPHY AND SOIL

Characteristic of a very narrow band (1-3 m) along south and west lake shores; slopes 0-2%. North and east aspects.

Soil material sandy loam to sand. Well to moderately well drained. Very little soil development.

Restricted to the immediate lake margin usually along south and west shores of inland lakes. Soil physical and chemical properties are less important factors here than are gross environmental effects caused by the close proximity of the lake such as: depth to the water table, wave swash during storm events, and air and soil microclimatic moderation.

VEGETATION: Northern white-cedar-Hemlock/*Osmunda*

The overstory is composed of a mixture of northern white-cedar and hemlock. Wave action during heavy winds may bare soil and allow the establishment of both northern white-cedar and hemlock. The canopy is moderate to high in closure but the lake boundary provides an edge through which light can penetrate, and coverage in the herbaceous layer is moderate. A mixture of wetland and upland species groups are characteristic of lake margins; *Osmunda*, *Botrychium*, *Gymnocarpium*, and *Maianthemum* are examples. This mixture of ecological species groups indicates an environment highly variable over very short distances; wet-mesic to mesic, moderately fertile and moderately open conditions are common.

ECOSYSTEM TYPE 41: VERY INFERTILE SHRUB SWAMP ON PEAT; Leatherleaf/*Chamaedaphne-Ilex*

PHYSIOGRAPHY AND SOIL

Characteristic of organic mats covering small ponds or shallow lake-edges. Microtopography very minor; some sphagnum accumulation around the shrub stem bases. Slopes level to 1%.

Soil is a mat of woody-sphagnum peat. Poorly decomposed (fibric) surface. Moderately decomposed (hemic) material below. Organic material derived from shrub vegetation and sphagnum moss. Very poorly drained. Extremely acid throughout.

The high density of shrub stems and their small size prevents the sphagnum hummocks around the stem bases from producing microtopography as

pronounced as in ecosystems 45, 46, and 47. Distinguished from ecosystems 42, 43, and 44 by the extremely acid soil pH. Distinguished from ecosystem 47 by the woody-sphagnum peat and the absence of muck depressions.

VEGETATION: Leatherleaf/*Chamaedaphne-Ilex*

The overstory and understory layers are typically absent to very sparse, but may include scattered individuals of red maple, hemlock, yellow birch, black spruce, white pine, and white birch. Coverage in the shrub layer is very high. *Chamaedaphne calyculata*, *Ilex verticillata*, and *Myrica gale* may be abundant. Coverage and species richness in the herbaceous layer is moderate to low due to the domination of relatively few species of clonal shrubs. *Chamaedaphne*, *Drosera*, and *Ilex* species groups indicate very infertile, very poorly drained, open conditions.

ECOSYSTEM TYPE 42: MODERATELY FERTILE SHRUB SWAMP ON THIN PEAT OVER MUCK; Alder/*Osmunda-Carex*

PHYSIOGRAPHY AND SOIL

Trapped depressions where water movement is slow. May occur along the borders of other wetland types that have very slow water movement. Sphagnum mounds around tree and shrub bases are the only microtopography. Slopes level to 1%.

Peat and muck soil derived from sphagnum, shrub, and herbaceous vegetation. Poorly decomposed (fibric) at the surface. Moderately and well decomposed material below (hemic and sapric). Very poorly drained. Medium to slightly acid throughout. The sphagnum mat does not produce extremely acid conditions. Decomposition is moderate, and muck is within 20 cm of the surface.

Most similar to ecosystem 50 and distinguished from it by the presence of sphagnum peat at the surface. Also distinguished from ecosystems 44 and 49 by the presence of sphagnum peat at the surface. Distinguished from ecosystem 47 by the absence of muck depressions. Distinguished from 41 by the medium to slightly acid soil.

VEGETATION: Alder/*Osmunda-Carex*

The overstory, if present, is very sparse. White pine, red maple, and white birch may be present. Alder, or occasionally winterberry, form the shrub layer. Coverage in the herbaceous layer is high. Species richness in the herbaceous layer is moderate to high. *Osmunda*, *Carex*, *Onoclea*, and *Chamaedaphne* species groups indicate moderately fertile, very poorly drained, open conditions.

ECOSYSTEM TYPE 43: FERTILE SHRUB SWAMP ON PEAT:
Sweet Gale/*Myrica-Carex*

PHYSIOGRAPHY AND SOIL

Characteristic of lake and stream edges. Slopes level to 1%. Soil may be sedge/woody peat (fibric) or thin muck accumulation over sand. Very poorly drained. Medium acid to neutral throughout.

Moving water is a necessity for this ecosystem to develop. High rates of biomass production of the shrub and graminoid vegetation (as compared to sphagnum moss), combined with moderate to high rates of decomposition frequently produce a sedge/woody peat surface soil horizon. In lake margins, organic accumulation may not occur except for a very thin layer of finely decomposed muck over sand. Lateral water movement is moderate (lake edge) to high (stream edge).

May occur adjacent to ecosystem 50 and is distinguished from it by the peat or very shallow muck over sand soil. Distinguished from ecosystem 44 by the greater content of woody material in the peat.

VEGETATION: Sweet gale/*Myrica-Carex*

The overstory is absent. The tall shrub layer may have scattered individuals of alder, red maple, white pine, and yellow birch. The low shrub layer is dominated by *Myrica gale*. Coverage in the herbaceous layer (including most shrubs below 50 cm) is high. Species richness in the herbaceous layer is moderate to low due to intense competition from relatively few species of clone-forming plants such as *Myrica* and *Carex* spp. and very little microsite variation. *Myrica*, *Carex*, and *Osmunda* species groups indicate fertile, very poorly drained, open conditions.

ECOSYSTEM TYPE 44: FERTILE GRAMINOID MARSH ON PEAT;
Carex-Onoclea

PHYSIOGRAPHY AND SOIL

Characteristic of upland depressions with slow drainage. Also occurs along lake edges and edges of other wetlands where water is moving slowly into a lake or wetland basin. Sedge tussocks provide the only microtopography. Slopes level to 1%.

Surface horizon poorly decomposed (fibric). Subsurface horizon sapric when organic accumulations are thick (>50 cm). Thin organic deposits, usually in lake-edge situations, may be sapric throughout. Horizons of woody peat may be present in thick organic profiles. Very poorly drained. Medium acid to neutral throughout.

High rates of biomass production of the graminoid vegetation (as compared to sphagnum moss), combined with moderate to high rates of decomposition produce a sedge peat surface soil horizon. Lateral water movement is moderate (lake edge position) to slow (depression).

May occur adjacent to ecosystem 43 and is distinguished from it by the lesser content of woody material in the peat. Also distinguished from other wetland ecosystems by the sedge-peat soil.

VEGETATION: *Carex-Onoclea*

The overstory, if present, is very sparse. White pine and red maple may be present. The shrub layer is typically absent. Coverage in the herbaceous layer is high. Species richness in the herbaceous layer is moderate to low due to intense competition from relatively few species of clone-forming graminoids and very little microsite variation. *Carex*, *Onoclea*, and *Osmunda* species groups indicate very fertile, very poorly drained, open conditions.

ECOSYSTEM TYPE 45: VERY INFERTILE CONIFER SWAMP ON PEAT; Black Spruce/*Ledum-Chamaedaphne*

PHYSIOGRAPHY AND SOIL

Characteristic of lake edge sloughs and undrained depressions in flats with very slow water movement. Sphagnum mounds around tree bases provide the only microtopography. Slopes level to 1%.

Deep, extremely acid sphagnum peat is continuous over the surface. Surface horizon poorly decomposed (fibric). Moderately decomposed (hemic) material may extend to a depth greater than 100 cm. Organic material derived from sphagnum and woody debris. Very poorly to poorly drained. Extremely acid throughout.

The microtopography of sphagnum hummocks built up around tree bases is more pronounced than in ecosystem 41. Also distinguished from ecosystem 41 by the lower water table. Distinguished from ecosystems 42, 46 and 47 by the absence of sapric material within the upper 50 cm. Distinguished from all other wetland ecosystems by the extremely acid sphagnum peat.

VEGETATION: Black Spruce/*Ledum-Chamaedaphne*

The overstory and understory are dominated by black spruce. Hemlock, balsam fir, white pine, yellow birch, and red maple may also be present in low numbers. Black spruce dominates the understory as well. Coverage and species richness in the herbaceous layer is low to moderate. *Ledum*, *Chamaedaphne*, *Vaccinium*, and *Drosera* species groups indicate very infertile, very poorly drained, moderately open conditions.

ECOSYSTEM TYPE 46: INFERTILE CONIFER-HARDWOOD SWAMP ON PEAT; Conifer-Hardwood/*Ilex-Chamaedaphne*

PHYSIOGRAPHY AND SOIL

Characteristic of shallow depressions in low-lying outwash and lacustrine sand deposits. Sphagnum mounds around tree bases provide the only microtopography. Slopes level to 1%.

Soil is sphagnum and woody peat over muck and sand. Surface horizons poorly decomposed (fibric). Below this and above the sand substratum are thin, moderately to well decomposed horizons (hemic and sapric). Very poorly drained to poorly drained. Extremely acid in surface peat. Subsurface muck and sand substratum are variable, extremely to strongly acid.

The increased lateral drainage due to the presence of sand within 50 cm of the surface may moderate the extreme acidity and infertility usually characteristic of sphagnum peat.

Very similar to ecosystem 47 and distinguished from it by the absence of muck depressions and the presence of sphagnum peat surface soil. Distinguished from ecosystem 45 by the presence of a sapric organic layer within 20 cm of the surface. Distinguished from ecosystems 48 and 49 by the extremely acid, sphagnum peat surface. Infrequent in the mapped area; there are a number of occurrences of this ecosystem outside of the mapped area in the Ives basin. South of Elm Creek and north of the southern portion of the Ives Loop road is a large area of ecosystem 46. It can also be found in the long depression that feeds the waters of Canyon Lake northeast to Fisher Creek.

VEGETATION: Conifer-Hardwood/*Ilex-Chamaedaphne*

The overstory is composed of a mixture of conifer and hardwood species. Hemlock, northern white-cedar, black spruce, red maple, yellow birch, and balsam fir may all be present. The understory is composed of a mixture of these species. Coverage and species richness in the herbaceous layer is moderate. *Ilex*, *Chamaedaphne*, and *Coptis* species groups indicate infertile, very poorly drained, moderately open conditions.

ECOSYSTEM TYPE 47: FERTILE CONIFER-HARDWOOD SWAMP ON PEAT AND MUCK; Conifer-Hardwood/*Osmunda-Onoclea*

PHYSIOGRAPHY AND SOIL

Characteristic of broad, poorly defined drainages with low slopes (0-1%) and slow water movement, often on the border of other wetlands and lakes. Microtopography is characterized by shallow depressions surrounded by mounds around tree bases.

Microtopography of mounds creates two contrasting surface-soil types: extremely acid fibric organic matter on mounds and medium acid to neutral muck in the depressions. Mounds poorly decomposed (fibric) in the upper 5 cm. Moderately decomposed and well decomposed (hemic and sapric) below. Depressions have hemic and sapric material at the surface. Very poorly drained depressions, and poorly drained hummocks. Extremely acid on sphagnum hummocks. Medium acid to neutral in depressions. Microsite variation in acidity, fertility, moisture, and aeration is great. Lateral water movement is slow but not trapped.

Most similar to ecosystem 46 and distinguished from it by the common muck depressions. Distinguished from ecosystems 48 and 49 by the presence of extremely acid mounds around the tree bases.

VEGETATION: Conifer-hardwood/*Osmunda-Onoclea*

The overstory is composed of a mixture of conifer and hardwood species. Northern white-cedar is usually dominant, with lesser amounts of balsam fir, yellow birch, hemlock, red maple, and black ash. Germination and establishment on logs is a common means of reproduction for northern white-cedar, hemlock, and yellow birch. The understory is composed of a mixture of these same species plus occasional stems of mountain maple. Coverage in the herbaceous layer is moderate. Species richness is high due to high microsite diversity. *Osmunda*, *Onoclea*, *Chamaedaphne*, and *Coptis* species groups indicate fertile to infertile (on mounds), very poorly drained, moderately shaded conditions.

ECOSYSTEM TYPE 48: FERTILE UPLAND MUCK DEPRESSION; Hardwood-Conifer/*Onoclea-Ilex*

PHYSIOGRAPHY AND SOIL

Characteristic of small depressions in flats and foot-slope areas. Shallow pit and mound microtopography common. Slopes level to 2%.

Thin peat and muck accumulations over mineral soil. Poorly decomposed (fibric) at the surface. Moderately to well decomposed (hemic and saprie) horizon occurs above the mineral substratum. Poorly drained. The mineral soil horizons (sandy loam and sandy clay loam texture) are mottled throughout. Medium to slightly acid throughout.

Lateral water movement is very slow due to the low surface gradient (0-1%), fine textured soil, and lack of a surface outlet for drainage of excess water following snow melt in the spring or after heavy rains. May be adjacent to ecosystem 35 in a footslope position or contained within other level to gently sloping ecosystems.

Distinguished from other wetland ecosystems by the presence of sandy loam to sandy clay loam, mottled mineral soil within 25 cm of the surface.

VEGETATION: Hardwood-Conifer/*Onoclea-Ilex*

The overstory is composed of red maple, yellow birch, balsam fir, hemlock, northern white-cedar, and white spruce. Hemlock, northern white-cedar, balsam fir, and white spruce are common in the understory. The canopy is moderate in closure, and coverage in the herbaceous layer is moderate. Species richness is moderate to high. *Onoclea*, *Ilex*, and *Corylus* species groups indicate fertile, poorly drained, moderately open conditions.

ECOSYSTEM TYPE 49: VERY FERTILE DECIDUOUS SWAMP ON MUCK OR ORGANIC-RICH MINERAL SOIL; Black Ash/*Onoclea-Osmunda*

PHYSIOGRAPHY AND SOIL

Characteristic of lowland and depressional areas usually near lakes or other wetlands. Ground water and surface water moves slowly through this ecosystem into wetlands or lakes. Slopes level to 2%.

Two types of soil are common: (1) Soil with thick organic accumulations in which a thin fibric horizon overlies thick sapric muck. Organic material usually medium acid to neutral. Mineral substratum neutral. Poorly to very poorly drained. (2) Soil with organic-rich mineral surface. Sandy loam to silt loam texture common. Neutral pH. Poorly drained.

Lateral water movement is slow but drainage is not trapped. Colluvial and alluvial additions of fine soil material to the surface may occur in the spring following snow melt and after heavy rains.

Similar to ecosystem 50 and distinguished from it by less frequent flooding, producing less variation in water table depth and rate of lateral water movement. Distinguished from ecosystem 48 by the greater depth to the water table, and usually a higher pH. Distinguished from ecosystem 47 by the absence of sphagnum mounds around the tree bases. Distinguished from other wetland ecosystems by the higher pH and more fertile soil.

VEGETATION: Black Ash/*Onoclea-Osmunda*

The overstory is dominated by black ash with lesser amounts of northern white-cedar. Figure 14 pictures the lush undergrowth typical of this ecosystem. American elm was once important but is absent now due to Dutch elm disease and phloem necrosis. The understory is usually absent, but alder, black ash, and northern white-cedar may be present. Coverage and species richness in the herbaceous layer is very high. *Onoclea*, *Osmunda*, *Carex*, *Arisaema*, and *Botrychium* species groups indicate very fertile, poorly to very poorly drained, moderately open conditions.

ECOSYSTEM TYPE 50: FERTILE SHRUB SWAMP ON MUCK; Alder/*Osmunda-Onoclea*

PHYSIOGRAPHY AND SOIL

Characteristic of streamsides in areas of low stream gradient, stream deltas, and lake sides. Frequently along streams adjacent to lakes. Slopes level to 1%.

Thick organic muck over sand. Well decomposed (sapric) horizon overlies mineral substratum. Thin, poorly decomposed (fibric) horizon often at surface. In frequently flooded environments the profile may comprise many lenses of muck, sand, and sandy loam high in organic matter. Mineral A horizons may occur. Very poorly drained. Medium acid to neutral throughout.

Seasonal flooding may be very important in the accumulation of soil material and the input of nutrients attached to organic and mineral colloids. Moderate to

Fig. 14. Ecosystem 49. The wet, fertile soil and open tree canopy of black ash swamps support a rich groundflora, here dominated by ostrich fern, *Matteuccia struthiopteris*. Western shore of Pine Lake (NE 1/4 Sec 29 T52N R28W).

rapid lateral movement of water through the sand substratum along the gradient of the stream. Very closely related to ecosystem 18 and often adjacent to it downstream. Water table higher than in ecosystem 18, and the stream gradient and rate of flow are less.

Distinguished from ecosystems 47 and 49 by the seasonally flooded stream-side, stream-delta, and lake-side positions where the supply of well oxygenated groundwater is high. Distinguished from ecosystem 42 by the absence of sphagnum peat at the surface.

VEGETATION: Alder/*Osmunda-Onoclea*

The canopy is very open. Low densities of northern white-cedar and black ash are common. American elm was once common but is now absent due to Dutch elm disease and phloem necrosis. The understory and shrub layers are composed of very dense alder stems. Coverage in the herbaceous layer is moderate to high and species richness is high. *Osmunda*, *Onoclea*, *Myrica*, and *Carex* species groups indicate very fertile, very poorly drained, open conditions.

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