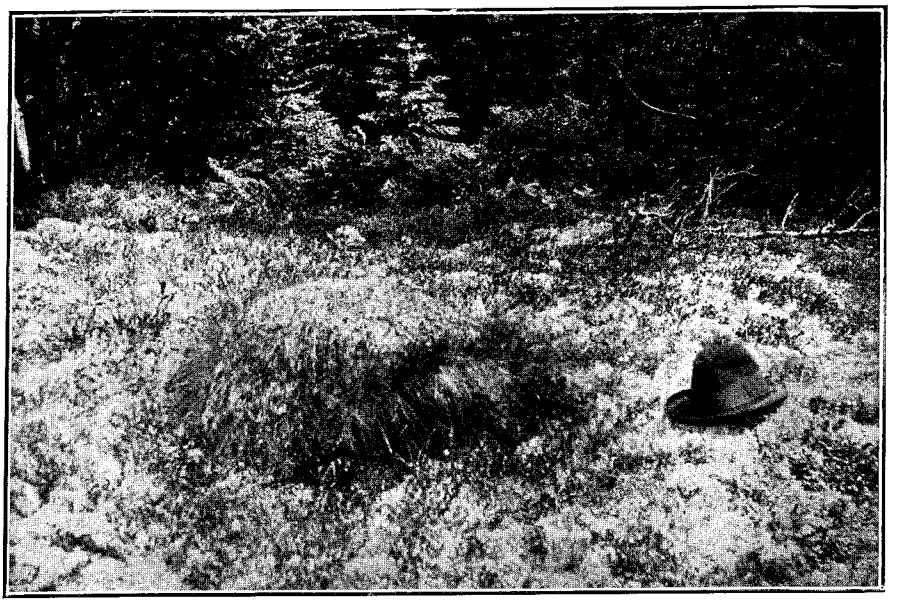

FIG. 28. ANT NEST IN THE OPENING AT THE SISKOWIT CAMP (V, 3).

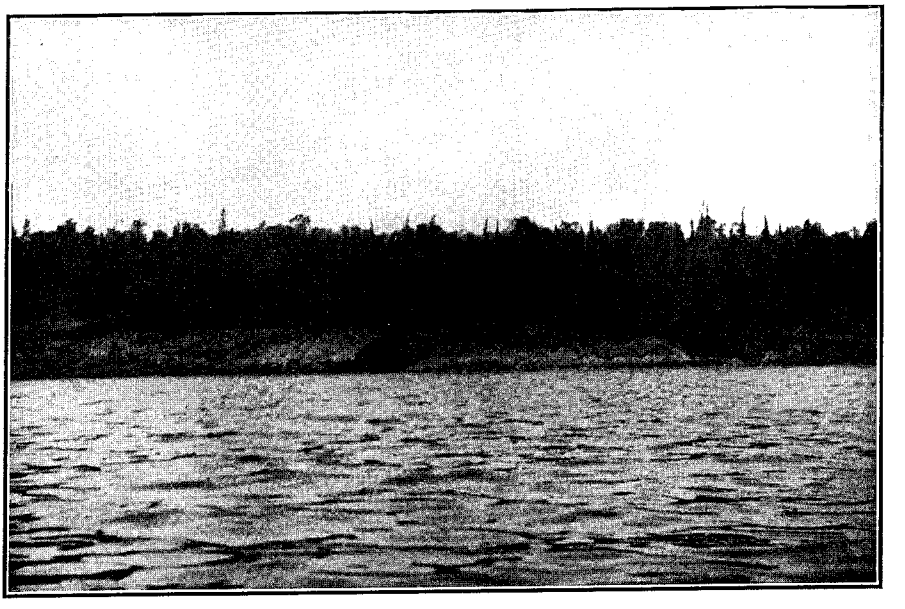

FIG. 29. GENERAL CHARACTER OF THE SOUTH SHORE, NEAR THE EASTERN ENTRANCE TO SISKOWIT BAY (V, 2).

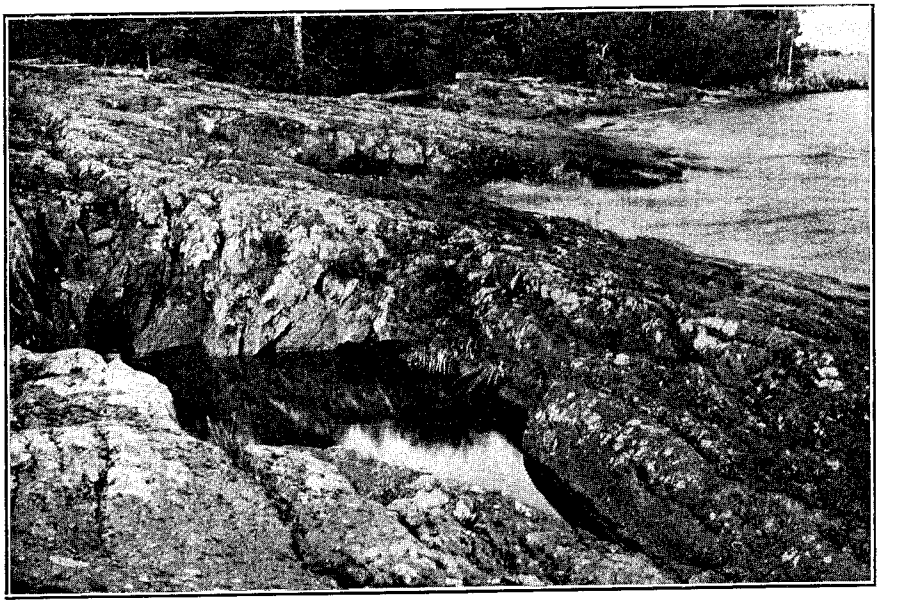

FIG. 30. ROCK POOL ON THE BEACH (V, 2), WHERE A VARIETY OF INVERTEBRATES WAS SECURED.

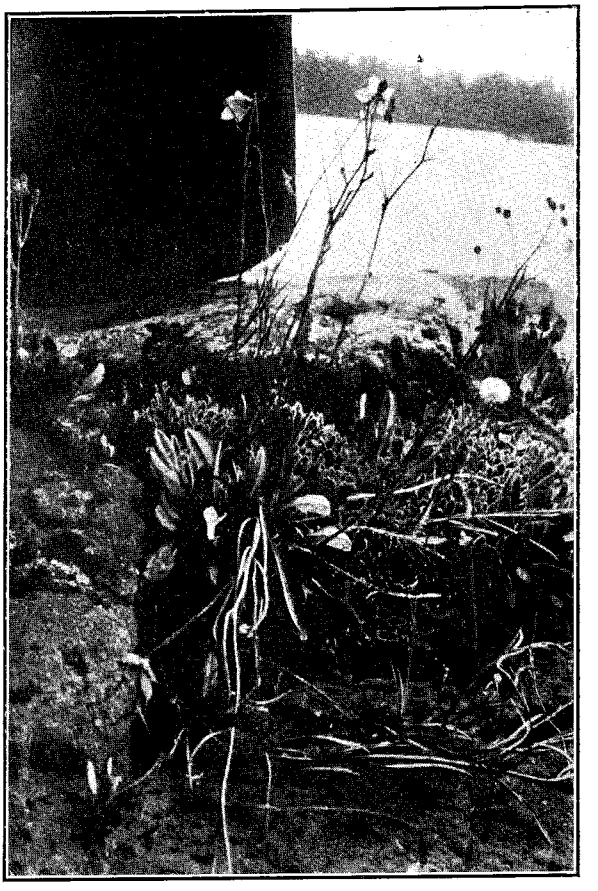

FIG. 31. SAXIFRAGA AIZOON ON BEACH (V, 2).

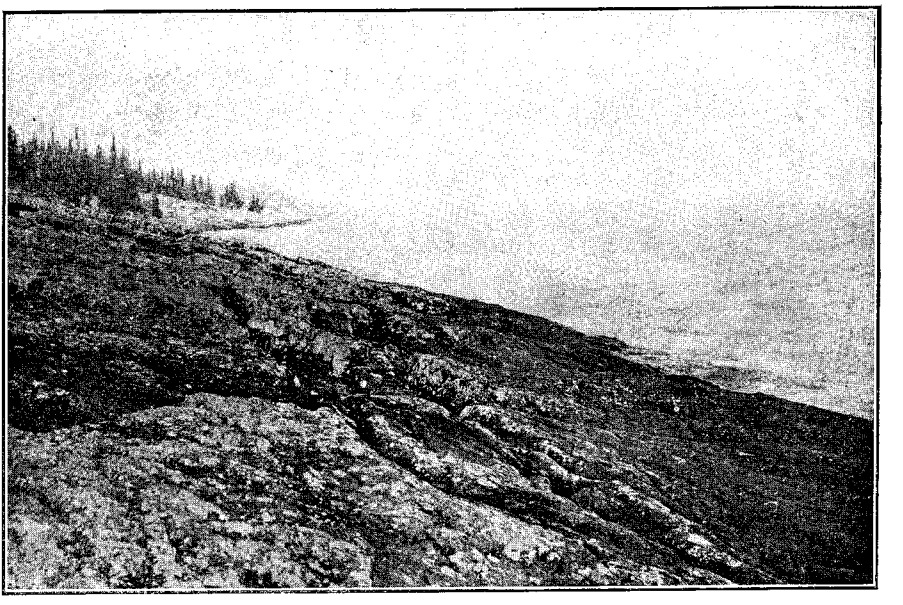

FIG. 32. GENERAL VIEW ALONG THE SHORE AT V, 2.

FIG. 33. FARTHER UP THE SAME SLOPE AS IN FIG. 32 AND ADJACENT TO IT.

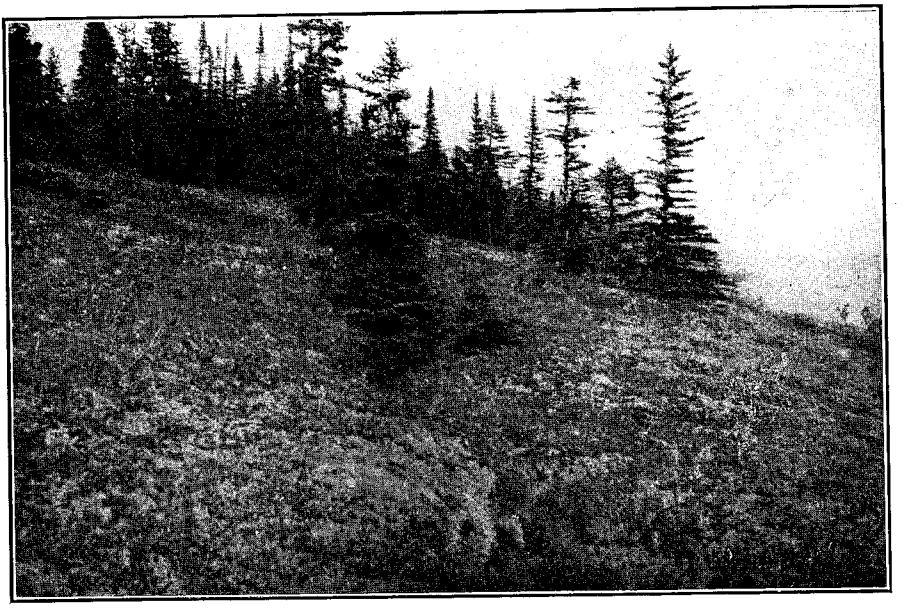

FIG. 34. STILL FARTHER UP THE SLOPE AND ADJACENT TO FIG. 33.

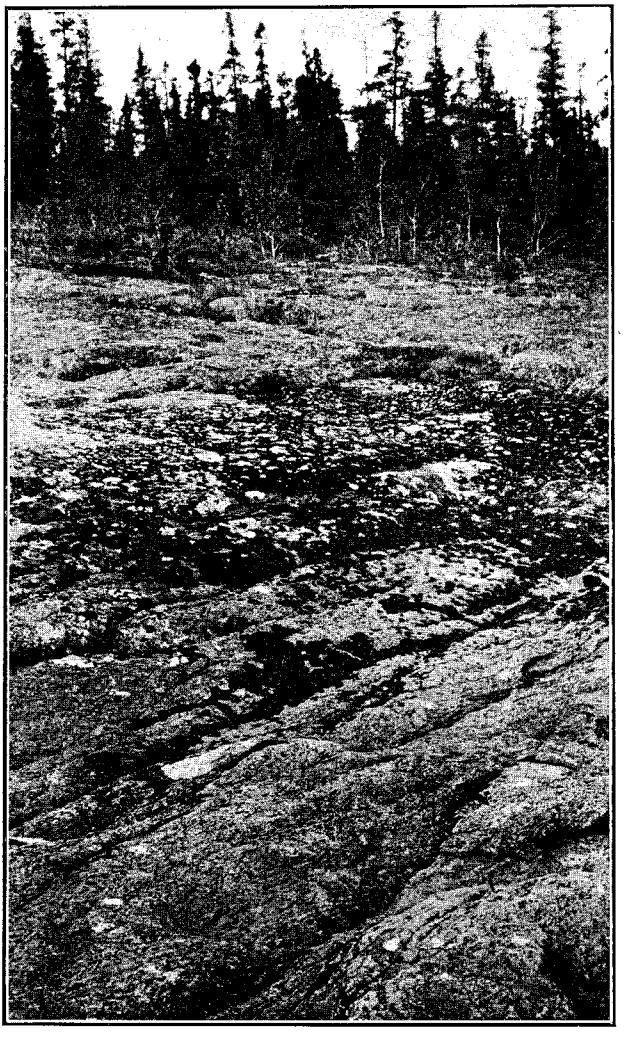

FIG. 35. LOOKING UP THE SLOPE ON THE WESTERN PORTION OF STATION V. 2.

FIG. 36. UPPER PORTION OF WESTERN PART OF STATION V, 2.

FIG. 37. DETAIL OF WESTERN PART OF STATION V, 2.

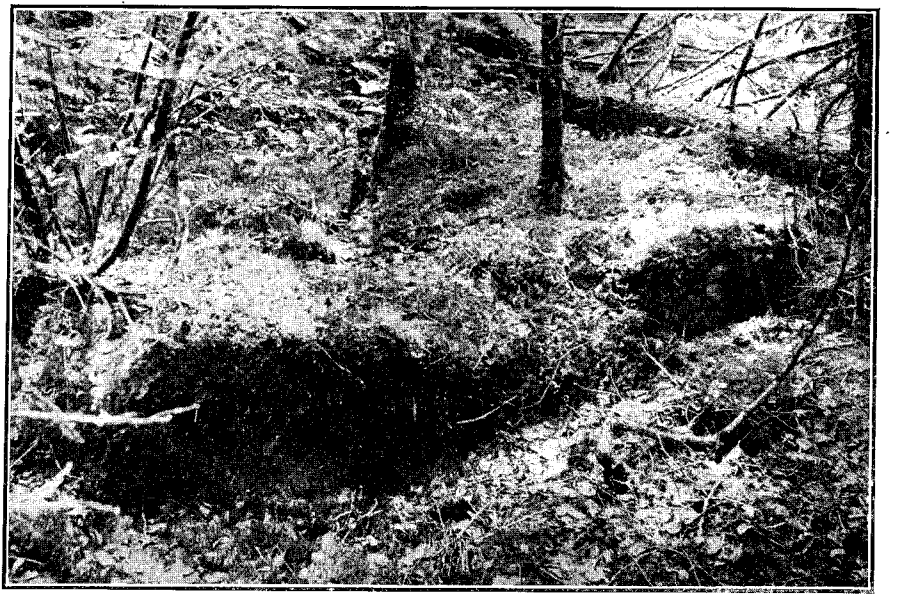

FIG. 38. CHARACTER OF GROUND COVER IN PARTS OF THE BALSAM-SPRUCE FOREST (V, 4).

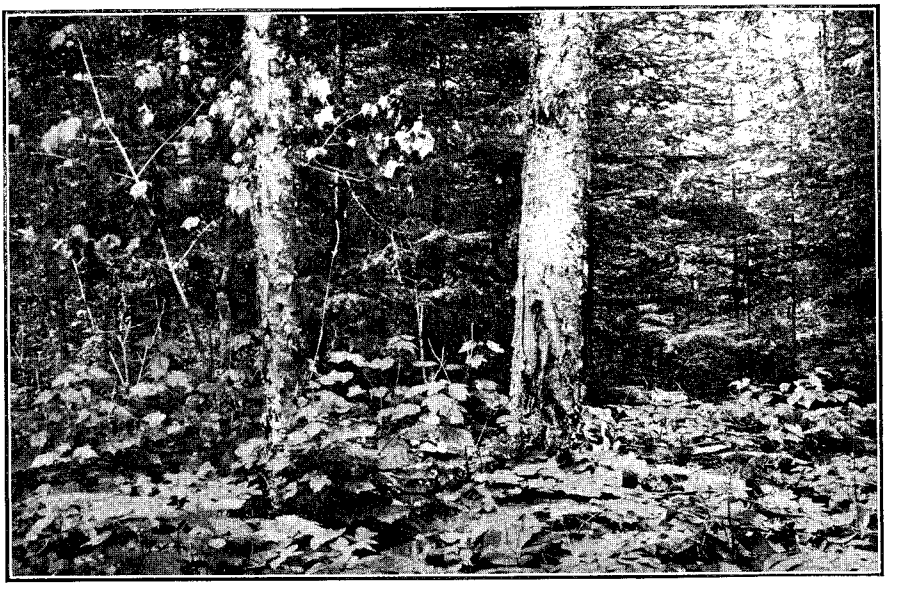

FIG. 39. OPEN SPACE IN THE BALSAM-BIRCH FOREST (V, 4).

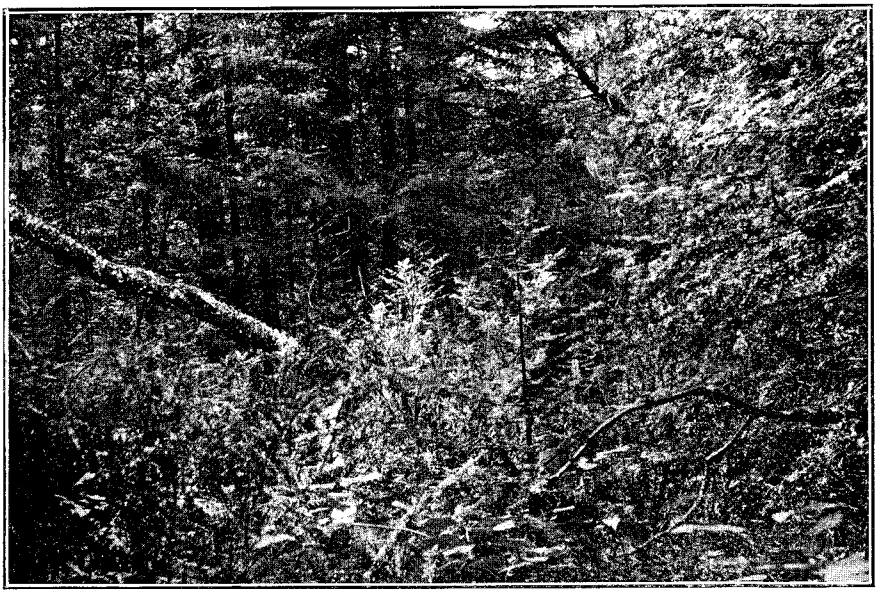

FIG. 40. OPEN SPACE IN THE BALSAM-BIRCH FOREST (V, 4).

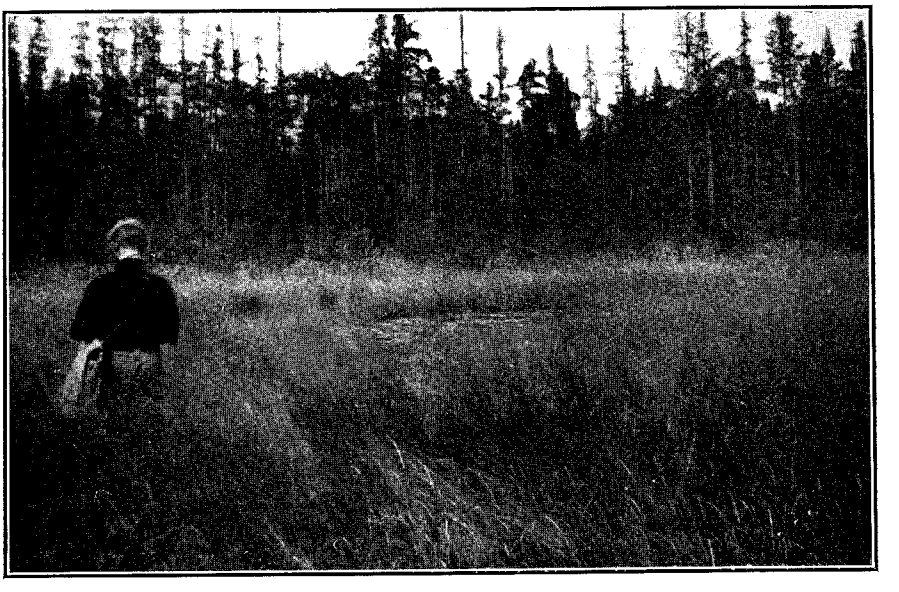

FIG. 41. TAMARACK SWAMP (V, 5).

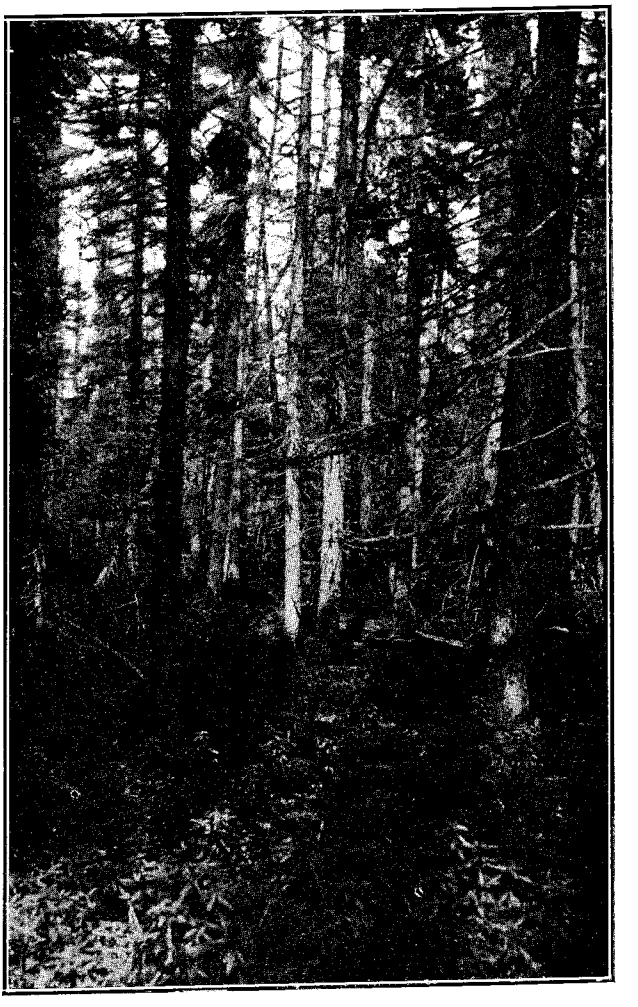

FIG. 42. SPRUCE MARGIN OF STATION V, 5.

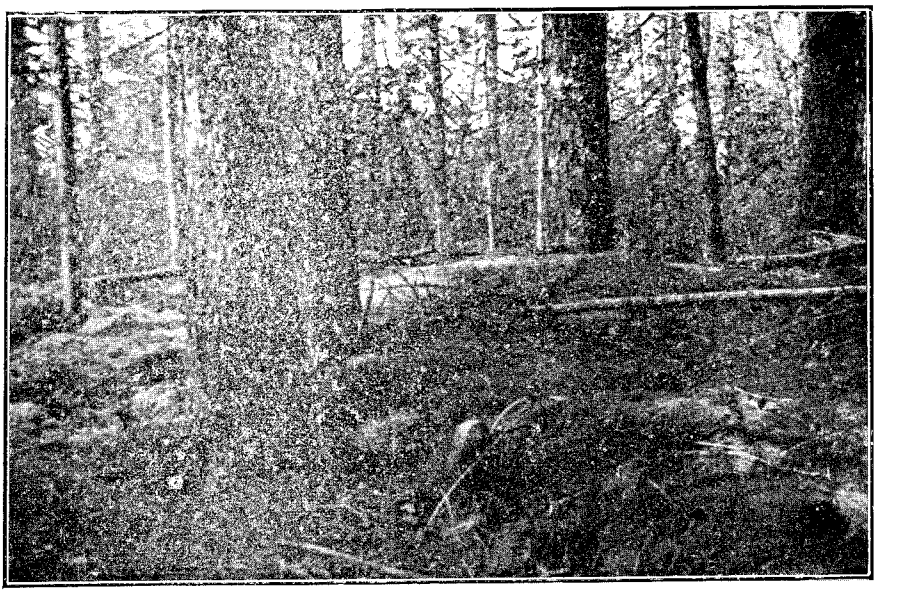

FIG. 43. BLACK SPRUCE MARGIN OF STATION V, 5.

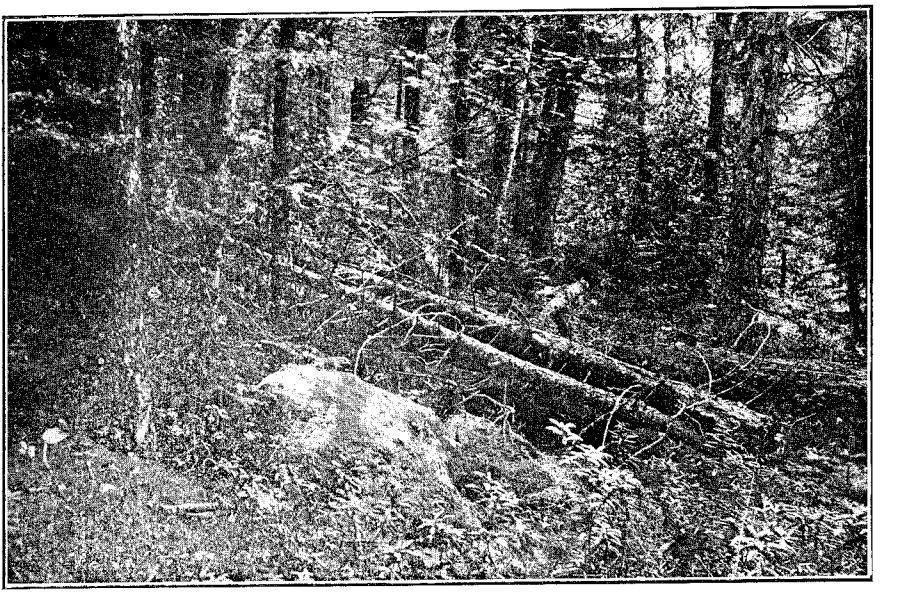

FIG. 44. BOG MARGIN OF STATION V, 5.

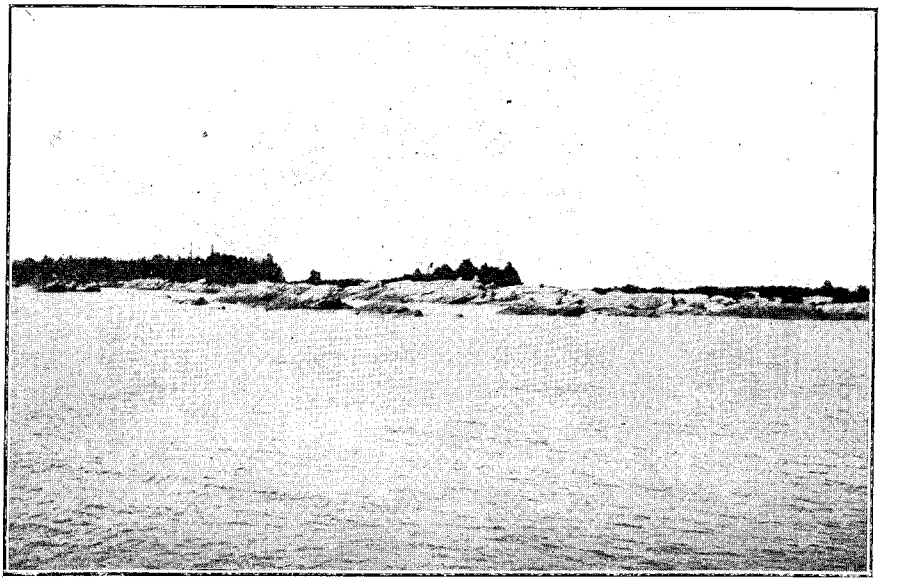

FIG. 45. LONG ISLAND GULL ROOKERY, (V, 10).

FIG. 46. POND IN TAMARACK—BLACK SPRUCE SWAMP (V, 11).

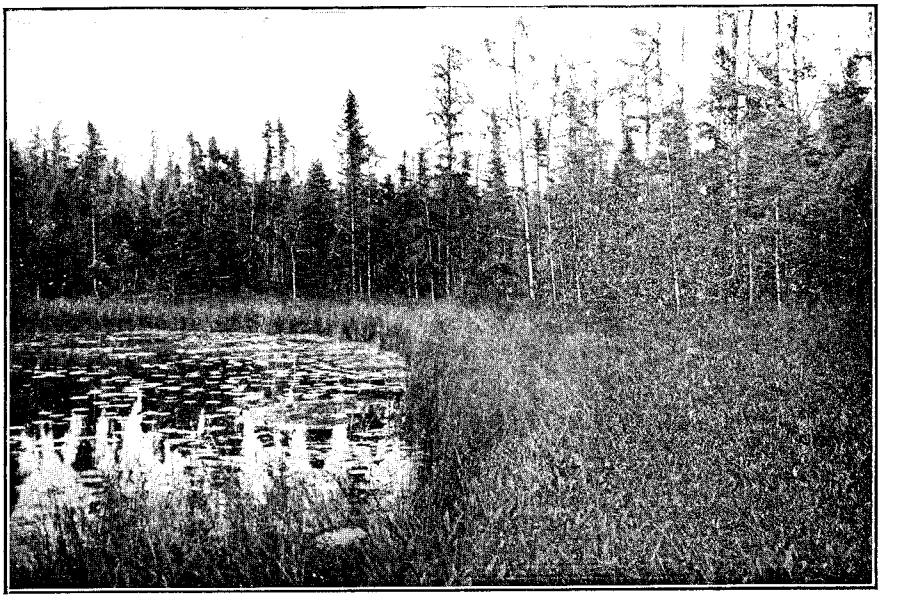

FIG. 47. MARGIN OF LILY POND (V, 11).

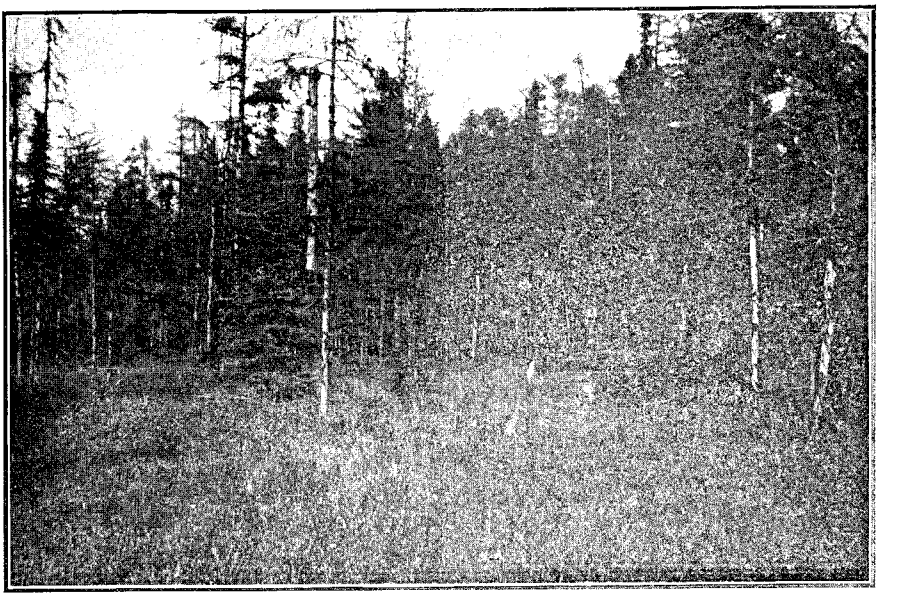

FIG. 48. BLACK SPRUCE IN CASSANDRA ZONE OF STATION (V, 11).

FIG. 49. MAPLE FOREST ON THE DESOR TRAIL (III, '04).

FIG. 50. FOREST ALONG WASHINGTON BROOK (IV, '04).

is rocky and steep, with Birches and other trees growing down to the water. The north shore has been largely burned over, and is being replaced by Birches and Small-toothed Aspens, which are now dominant; the undergrowth consists of alders and the abundant Large-leaved Aster. The water in the lake is brownish. At the western end there are White Waterlilies, near the shore Yellow Waterlilies, *Caltha palustris, Equisetum*, and farther back Cassandra and alders, Tamarack, Arbor Vitae, and Black Spruce.

On the north shore a rocky point projects into the water, and east of this along the shore is a floating sphagnum bog, ranging in width from about 40 to 100 feet and containing Pitcher Plants, Low Cranberry, Buckbean, scattered sedges and Blue Flags, and a shrub growth of Cassandra, Labrador Tea and Wild Rosemary. Scattered trees of Tamaracks, Arbor Vitae, and Black Spruce grow to the edge of the water. Water stands in the small depressions over this bog.

The fauna was not studied in detail, but the forms collected were as follows: The spider, *Pardosa glacialis*, with egg masses, was found running about over the wet sphagnum; a dragonfly, *Aeschna*, was seen on wing; two species of grasshoppers were found in the wet Sphagnum; *Melanoplus extremus* and, in the wetter places, nymphs of *Mecostethus lineatus* were quite abundant. There were also great numbers of mosquitoes and Black Flies. Upon some driftwood near the end of the lake was found *Physa gyrina* (No. 71 A.). Yellow Perch were so abundant in this lake that locally it is called Perch Lake. A Canada Jay was seen in the top of a tree.

Station III. Western End of Rock Harbor. This station was intended to include those localities near the western end of Rock Harbor.

Station III, Substation 1 and 2. Small Island. The general character of this island is shown in *Fig. 15*. This is a small, rocky, wooded island, the trees consisting of one large White Pine, about 14 inches in diameter, Arbor Vitae, Birch, Balsam, and White Spruce, the dominant ones being the Balsam, Arbor Vitae and Birch, with a shrub growth of Mt. Alder, Willow, Nine-bark, Mountain Ash, *Amelanchier alnifolia*. Upon the rock occurred *Cladonia*, Bearberry, and Low Juniper, and toward the western end of the island, where the trees shade the ground, grew *Lycopodium complanatum*, mosses and *Clintonia borealis*.

Of the fauna, the bird life only was examined; Cedar Birds and a Song sparrow nested here, the former being quite abundant.

The submerged western end of this island formed Station III, 2. The bottom was composed of sand and angular rocks. In the shallower water *Anodonta grandis footiana* valves were found, and live animals in water about 18 inches deep. These rocks also furnished a number of *Limnaea stagnalis*, and a dead specimen of *Planorbis bicarinatus*. A few scattered rushes (*Scirpus*) grew at this place.

Station III. Substation 3 and 6. Head of Rock Harbor. These stations include the delta at the mouth of the largest stream flowing into the Harbor, Station 3, and the sandy and rocky shallow water zone extending from III, 2 around the head of the Harbor, Station 6.

The general character of the delta, III, 3, region is shown in *Fig. 16*. This small delta had been formed by a small sluggish brown-stained brook, 15 or 20 feet wide, which enters the Harbor at this point. The

channel contained a growth of *Vallisneria spiralis, Potamogeton crispis,* and the banks supported a growth of sedges, *Lycopodium complanatum, Clintonia borealis,* alders and Mountain Ash. The surface of the delta is strewn with driftwood and other plant remains, upon a clean sandy bottom. Nearer the shore, upon a muddy bottom, were found an abundance of Amphipod crustaceans, *Hyalella knickerbockeri, Gammerus limnaeus,* and the small bivalve molluscs, *Pisidium.* The fresh water sponge, *Spongilla lacustris,* was found here, and water striders, *Gerris remigis,* were found on the surface. Individuals were abundant, so that the fauna is relatively varied.

Substation 6 included the southwestern coves of the Harbor. The bottom was rocky, and covered in places with much sand; the water was shallow and contained, near the shore, many patches of rushes, *Scirpus* and *Equisetum. Anodonta grandis footiana, Limnaea stagnalis* and *Pisidium* were the characteristic molluscs, and a few fish were found.

The protected character of the shore is noteworthy, as no beach is developed, because the coves are protected from the heavy lake waves. Another characteristic feature is the sand bottom. This sand is carried toward the head of the Harbor by the currents. Even at higher Lake levels, this Harbor was sandy, as is shown by the sand banks on the north shore, and these are being re-worked by currents and waves and carried up the Harbor. The spit developing from the south shore, *Fig. 17,* illustrates this.

Station III, Substations 4 and 5. Sumner Lake and Trail. The trail to Sumner Lake (III, 4), begins on the south shore of Rock Harbor and extends south about one-half mile to Sumner Lake. It passes through a second growth of Birch and Aspen (which has followed a burn), a small Arbor Vitae swamp, over a rock ridge to the north shore of the lake, where there are a few large Norway Pines, from 12 to 15 inches in diameter, and a few White Pines. But little attention was given to the life along the trail, although a few observations on the bird life were made, and some mammals were trapped. However, Sumner Lake proved to be such an interesting locality that attention was given to it more especially than to the trail. This lake has many of the characteristics of a large lily pond, because the White Waterlilies and Potamogetons form such a wide belt around the lake. *Figs. 18-23.* In passing from the interior of the lake toward the shore, the following zones of vegetation are found: The bulrush zone, which is well developed, with its denser growth about the eastern end; then the Yellow Waterlilies, followed by the dense sedge zone which produces a substratum. In the eastern and western ends of the lake the water gradually shallows; but on the sides the change is more abrupt, thus interrupting the shallow water zone of sedges, as shown on the north shore, *Fig. 23.* This encroachment of vegetation upon each end of the lake is very marked, and is much more extensive at the eastern end, where the lake is drained into the head of Conglomerate Bay by a small brook. The encroachment at the western end of the lake is well shown in *Fig. 19.* A partial view of the eastern end of the lake is given in *Fig. 18.* The sedge zone contains a variety of plants, including several orchids, Iris, Pitcher Plants, Buckbean, scattered Eriophorum and Sphagnum, Cassandra and Andromeda. The substratum is quaking and sinks

several inches below the water level with the weight of one's body; occasionally small but deep holes are found through this substratum, and care must be taken to avoid them. This zone is very broad and contains an abundance of life. Outside the sedge zone occur alders and Tamaracks, which border the forests at the base of the slopes.

The fauna of the open Waterlily, Bulrush and Potamogeton zone consists of insects flying over the water, such as the dragonfly, *Aeschna* and the leaf beetles *Donacia,* which abound, especially about the Yellow Waterlilies. On the surface film were water striders, *Gerris marginatus*, and whirligig beetles, Gyrinidae. Sticklebacks were abundant, and are quite characteristic of such waters, as is another small fish. Loons were frequently seen here, and also a Hooded Merganser. Toward the outer margin of this zone where the lilies are often closely matted on the surface, the insect life and the surface film fauna are the most abundant. A live mussel, *Anodonta grandis footiana,* was found on the bottom; and the snails, *Planorbis campanulatus* and *parvus*, were found in small pools in this sedge zone. The bottom in this vicinity, and that bordering the water margin of the ridges, is covered with a mass of partly floating debris, the appearance of which suggested to Wood, who first observed it, that something had exploded and scattered the strands of debris about the surface. It is not improbable that the formation of marsh gases will adequately explain this phenomenon, (Cf. Penhallow, Science Vol. 22, 1905, pp. 794-796).

The dragonflies were *Enallagma hageni, Aeschna, Somatochlora shurtleffi*, and *Lucorhina proxima*, the last being very abundant.

Where the sedge zone was absent, as at our raft landing at the end of the trail, an abundance of needles, leaves and twigs from the overhanging conifers and hardwoood had accumulated at the shore, and were stained almost black. The water of the lake is brownish. At this point a number of invertebrates were taken, including shells, leeches, insects, etc.

Station IV. Tobin Harbor and Vicinity. As very little time was spent at this station, the description will be correspondingly brief. Tobin Harbor is a deep, narrow, protected bay, similar to that at the head of Rock Harbor, but narrower. The adjacent hills are forest covered, largely with Aspen and White Birch. In the vicinity of Neutson's Resort there is a large, cleared area. Mattson's resort is located on an island in this Harbor. The most marked scenic feature of the Island, Monument Rock, is on the north side of Tobin Harbor.

It is a noticeable fact that many of the low islands in Tobin Harbor, and especially those near its eastern end, are clothed with vegetation close to the edge of the water. They are thus in marked contrast with the islands along the southern shore, and to the various points of rocks which project into the water.

Upon a small island, Number 14 on the Land Office map, were found small rock beach pools, just above or near the height of the usual quiet weather waves. The water in one was about a foot in depth and contained a very small amount of algal growth. In this pool were found water striders, *Gerris remigis,* a few other insects (No. 30), and small tadpoles. In another small pool about 10 inches above lake level, and with a temperature of 77° (the Harbor water having a temperature at the

time of 50° F.), were many species of *Limnaea catascopium* and a few adult *Physa*. Algae were only seen in the crevices.

Station IV, Substations 1 and 2. Rock Pools and Scovill Point. Scovill Point is an almost bare, glacially planed, narrow and low rock ridge, projecting out into the lake. Numerous small faults occur on the sloping southern side, and these, supplemented by the waves, etc., have produced rock pools. In one case a long row of pools occurred along the line of the fault. The presence of tadpoles about an inch long would suggest that these pools have some duration. The higher summer waves might also reach many of these pools. Water striders, *Gerris*, are abundant upon the surface, and a large deep ravine, near the lake level, contained Sticklebacks, but no shells were observed in any of these pools.

Station IV, Substation 3. Bayou East of the Monument Rock Trail. This is a very small pond which is connected with the Harbor by a small stream just large enough to admit a row boat. It illustrates the last stage of separation of the valleys from the Harbor, as only a very slight fall of the lake level would completely isolate it. In this particular case the outlet is on the south side, and not at one end as is usually the case. The central part of the pond is open water and is surrounded by an almost complete zone of Yellow Waterlilies, and a sedge zone containing several low shrubs. The Waterlilies were badly infested by a small leaf beetle, *Galerucella nymphaea;* larvae, pupae, and freshly emerged beetles were taken. A few dead shells of *Anodonta marginata* and one of *Limnaea megasoma* (the only specimen taken upon the island) were secured here. An extensive suspended flocculent mud covered the bottom, so that molluscs could not obtain a foothold. At the western end of this pond innumerable small tadpoles formed an almost compact pavement upon the bottom at the edge of the water. A few dragonflies were seen, but were not captured.

Station IV, Substation 4, 8 and 9. Forest on the Greenstone Range. These three stations are combined because they are related to the forest occupying the Greenstone range. The trail to Monument Rock (IV, 4) begins on the north shore of Tobin Harbor and extends northwest about one-half mile to Monument Rock. The forest is dense and is apparently a second growth of Balsam, White Spruce, Birch and Aspen, with underbrush of Mountain Alder, Mountain Ash, Ground Hemlock, and a ground cover of Few-flowered Cranberry, *Clintonia borealis*, *Linnea borealis,* and Wild Sarsaparilla. In the moist places was found Ground Cornel, *Aster macrophyllus*, an *Equisetum*, *Lycopodium*, and, in wet places of the swamp traversed, the Buckbean and Skunk Cabbage. For some distance on the slope down from the base of Monument Rock occur large blocks which are covered by a dense mat of mosses, and the ground is covered with a thick layer of humus, so that the general appearance of the vegetation is that of a mesophytic forest.

The trail up the Greenstone (IV, 8), begins at the mouth of a small brook at the head of Tobin Harbor, and follows the crest of an open burned over ridge southeast for about half a mile. This ridge contains a scanty growth of *Amelanchier oligocarpa* and *alnifolia, Prunus pennsylvanica,* Jack Pine, wild rose, *Solidago,* Bearberry and Yarrow. From the end of this ridge a valley crosses to the north and contains large

Aspens, Tamarack, Norway and White Pine, and an underbrush of Speckled Alder and Ground Hemlock. After crossing this depression, the trail ascends the slope and crosses the burned ridges where there is a growth of Birch and Aspen. The slope increases more abruptly as the crest of the Greenstone is approached. This is the vicinity of an old signal station and has an elevation of about 460 feet, according to the Lake Survey. This forest along the crest comprised Station IV, 9. The large trees stand above the surrounding second growth, on the burned area, and can be seen for some distance. The Balsam, Birch and Quaking Aspen are the dominant trees, the Balsams reaching a diameter of about 10 to 12 inches, and the Birches and Aspens about 12 to 15 inches. The shrub growth is composed of Mountain Maple, Ground Hemlock, and the Few flowered Cranberry, the ground cover of *Diervilla diervilla,* Large-flowering Raspberry, *Aster macrophyllus, Clintonia borealis, Linnea borealis, Lycopodium,* Wild Sarsaparilla and Brake Fern; the White and Black Spruces being only occasionally seen. This forest produced dense shade. Fallen timber is abundant in places, but no signs of fire were observed. This ridge was bounded on the north by a cliff of perhaps 20 to 30 feet, below which was a long talus slope covered with Birch, Aspen and Balsam. From the top of this ridge there is a splendid view to the north. The crest was followed west to a small open burned area where *Diervilla diervilla* and Large-flowering Raspberry were abundant. The leaves of the latter were badly perforated by the abundant grasshoppers, *Hibbiscus tuberculatus* and *Melanoplus alaskanus.* In the deep wood a Tree Toad, *Hyla versicolor,* was found, and Varying Hares and Red Squirrels were seen.

Station IV, Substation 5. Clearing, and Vicinity of Neutson's Resort (Park Place). There is a rather extensive clearing at Neutson's Resort, so that very little collecting was done in this vicinity. A collection of grasshoppers was made here by Brown and Wood, and the following list of plants was made by the former from the same vicinity: White Spruce, Birch, Aspen, Mountain Alder, *Juniperus nana,* Wild Red or Pennsylvania Cherry, Red and White Clover, Bush Honeysuckle, *Fragaria vesca,* Cow Parsnip, and *Lycopodium complanatum.*

The grasshoppers were: *Chloealtis abdominalis, Camnula pellucida, Hippiscus tuberculatus, Circotettix verruculatus, Melanoplus alaskanus,* and *huroni.* Two butterflies, *Argynnis atlantis* and *Pyrameis cardui,* and the dragonfly *Lestes unguiculatus* were also taken here. In Rock Harbor, at Neutson's, leech egg capsules of *Nephalopsis obscura,* and *Physa* were taken. On a small island across the Harbor to the south, in a Sphagnum, Pitcher Plant and Tamarack swamp, a number of Wood Frogs, (*Rana cantabrigensis*) were taken.

A Red-bellied Snake (*Storeria occipitomaculata*) was reported to have been killed in the clearing, during July.

Station IV, Substation 6. Small Island in Tobin Harbor. This station includes the sedges and shallow water at the west end of a small island in Tobin Harbor. The bottom was covered with sand and large angular blocks of rock. *Limnaea stagnalis* was very abundant and occurred in water with a depth of about three feet. The shells are very fragile. Upon the rocks *Physa* occurred in limited numbers and was widely scattered, but they were abundant on the stems of the sedges not far

below the surface. The young of *L. stagnalis* occurred with the *Physa.* A specimen of *Gordius aquaticus* was secured here.

Station IV, Substation 7. Head of Tobin Harbor. A small brook empties into the head of the Harbor, and its brown water brings into the bay quantities of vegetable remains and flocculent debris. These cover the bottom near the mouth of the stream, and although carefully examined, were found to be singularly free of animals. Upon patches of *Potamogeton perfoliatum* occurred a few *Physa,* and in the shallow water a few fish were found. (No. 35.)

Station V. Siskowit Bay, Lake, and Vicinity. This station includes all the localities in the vicinity of Siskowit Bay and Siskowit Lake, except that of VIII, '04, which is at the head of Siskowit Bay.

Station V, Substation 1 and 3. The Bay Beach at Camp, and the Rock Clearing. The beach (V, 1), is protected from the waves of the open lake and bay by large off-shore islands. The rock composing it is vesicular lava, and slopes to the water at an angle of about 10 degrees.

The Rock Clearing about Camp (V, 3), begins at the beach and extends up the slope backward to the Balsam, Spruce and Birch forest as a park-like opening. The soil, mainly of residual and humic origin, is very shallow and completely lacking in places. The surface of the rock is rough, showing that it has been eroded since glaciation. In places the rocks are more or less covered by crustaceous and foliaceous lichens, or, where there is more humus or soil, by *Cladonia, Fig.* 24. Where the soil is deeper is found Bearberry, Narrow-leaved Cow-wheat, *Solidago,* grasses and moss. A scattered shrub growth is composed of *Juniperus nana* and *Amelanchier, Fig. 25 and 26,* and the bordering tree growth consists of Balsam, Black and White Spruce, Birch and Arbor Vitae. In the shade of these bordering trees, *Aster macrophyllus* develops in abundance. The above description also outlines the probable succession of plant societies upon this surface, all stages of which are now to be found within this area. Many smaller patches of this open condition are found scattered through the forest and are becoming shaded and converted into the forest as a soil develops, *Fig. 27.*

The fauna of the openings is rather characteristic and abundant. Of course many species range over a variety of plant societies and only recognize a clearing or forest society, and not their varieties. Yet others are much more sensitive to smaller environmental units. This is well shown by certain ants. Ant nests of *Formica fusca* as illustrated by *Fig. 28,* and certain spiders, as *Pardosa,* are quite characteristic of the *Cladonia-Bearberry* plant society. The opening, as contrasted with the forest, is frequented by grasshoppers, such as *Melanoplus fasciatus;* butterflies, as *Argynnis* and *Basilarchia arthemis;* and the dragonflies, *Sympetrum,* which were very abundant and characteristic (*Aeshna* patrols the margins of such openings). The robber fly, *Asilus annulatus,* frequents such open sunny areas where animal food abounds.

The vertebrate frequenters of the open were the Flickers, which were observed by McCreary to destroy ant nests. Several of such demolished nests were seen. Toward night a nocturnal association frequented the open; the bats on wing; and the hares came from the forest to feed, having been in hiding during the day.

No doubt the presence of this opening, in part, determined the location

of the log cabin used by our party. The logs were thoroughly infested by beetle larvae, and attracted vast numbers of parasitic Hymenoptera. For this reason, insect collecting about the cabin was of an exceptional character, and included a considerable variety of species. From the adjacent forest a number of trees had been cut, but this did not materially influence this locality, except near the shore.

Station V, Substation 2. Heath Zone and Beach. This locality includes a strip of rocky coast on the south shore of the island, a short distance east of the entrance of Siskowit Bay, *Fig. 29,* and extends from the edge of the water back to the forest. This is an exposed section of the coast and is unprotected by offshore islands, so that easterly storms from the open lake have full sweep on this shore. The slope is a fairly uniform rock surface, with an upward slant of about 10 degrees, and is composed of amygdaloidal lava. Crevices of various dimensions, from a mere crack to a deep rock ravine, extend obliquely up the slope. One of these ravines, the only large one, divides this station into two sections east and west. The eastern section of the slope is covered by a *Cladonia-Juniperus procumbens* society, while the western section is occupied by a *Cladonia-Juniperus nana*-Huckleberry society. Thus there are three fairly well defined natural divisions of this part of the coast, the beach, the *procumbens,* and the *nana* societies.

1. *The Beach.* The low angle of the slope, and the exposed situation and deep offshore water all combine to make the beach zones quite wide (four or five paces) upon this slope. No collections were made upon the submerged beach and only a few specimens were taken upon the lower. The characteristic species, however, were a small hemipterous shore insect, *Salda ligata,* a caddis fly, and ants. Above the lower beach is a wide upper one, characterized by a dark green moss (*Grimmia*) and crustaceous lichens.

A number of rock pools occupy the oblique crevices which extend up the beach. The largest of these is shown in *Fig. 30.* This is a pool about 4 x 8 feet in diameter and contains about 15 to 18 inches of water. On the surface of the water were fragments of insects, water striders, *Gerris remigis,* and on the bottom, dragonfly nymphs (No. 14), while caddis fly larvae crawled upon the sides and bottom. No algal growth was visible. The character of this insect life suggests a pool of some duration, but the absence of shells suggests a lack of permanent water. Numerous basin-like depressions, a few inches in depth, occur on the lower beach and on the foliaceous lichen-covered portions of the middle beach. The sharp angles of some of the pools show that these are occasionally produced by the removal of small blocks of rock. Most of the pools, however, occur in crevices. From one of the large pools a frog, *Rana clamitans* (No. 120), was taken, clearly showing how tadpoles may reach such pools.

In the crevices and behind angular rock projections occur Hare-bells, Yarrow, Ninebark, and an interesting succulent Saxifrage, *Saxifraga aizoon, Fig. 31,* and some grasses. In the crustaceous lichen zone is a greenish moss, *Grimmia,* and in the crevices are Bearberry, *Juniperus procumbens,* and Arbor Vitae.

2. *The Cladonia-Juniperus procumbens Society of the Eastern Section.* About ten paces farther up the slope, *Fig. 32,* this crevice society spreads

out, and, with the addition of *Cladonia* and some *Juniperus nana*, forms interrupted patches or streaks, *Fig. 33*, which farther up the slope fuse and form a solid mat, completely covering the surface of the rock, *Figs. 33 and 34*. The dominant forms are *Juniperus procumbens* and certain species of *Cladonia*. This was the only place where *J. procumbens* was found growing on such an extensive scale, or associated in abundance with *Cladonia*. This formed a novel and beautiful sight, the light-colored patches of the Reindeer-lichens in places intermingled with the bright green of the *procumbens* to form a variegated mat. The beauty of color and pattern is lost in a general view, as in *Fig. 34*. The White Spruce invades the slope in crevices, just in advance of the solid mat formation, but the soil is so shallow that it may be blown over, as is shown in *Fig. 33*. *Procumbens* grows so densely and close to the ground that it greatly favors the formation and retention of the soil, and it apparently precedes, on this slope, the *Cladonia*. In the large crevices within this zone grow patches of White Pine, Balsam, Mountain Alder, Spruce, Birch and Arbor Vitæ. The general relations of this slope can easily be seen by a comparison of *Figs. 32, 33 and 34*, in which is shown the transition from the bare wave washed beach, the flat growing lichens, the pioneers of the mat formation invading the crevices, and the dominance of the *J. procumbens-Cladonia* society with its scattered trees, up the slope into the Balsam-Spruce forest. This same order probably also expresses the succession of plant societies at this place. As previously mentioned, the fauna of the lower beach is quite limited, the greater variety occurring in the pools; but farther up the slope appear various forms which frequent the open. On the scattered part of the *Cladonia-procumbens* zone occurred the spiders, *Pardosa glacialis* and *sternalis*, the grasshoppers, *Circotettix verruculatus*, *Melanoplus alaskanus* and *fasciatus*. A ground beetle, *Pterostichus femoralis* was found under *Cladonia*, and under similar conditions were found an abundance of shells, *Acanthinula harpa, Strobilops virgo, Vertigo tridentata, Vitrina limpida, binneyana, Euconulus fulvus, Euconulus chersinus polygyratus, Zonitoides arborea milium, Agriolimax campestris, Pyramidula cronkheitei anthonyi, Helicodicus parallelus,* and *Cochlicopa lubrica*. The number of these shells which have a distinctly boreal range is particularly noteworthy, suggesting that such a habitat has some of the characteristics of a "boreal island."

3. *The Cladonia-Juniperus nana Society of the Western Section.* Here, as at the eastern section of this slope, the bare lake beach bounds this area shoreward. A general view up this slope is shown in *Fig. 35*. The bare wave-washed lower beach is in the foreground, and the green moss and light colored lichen zone is a broad belt above it, followed in turn by foliaceous lichens, and in the crevices by Aspen. The rock surface is considerably rougher than that of the east beach. In general appearance this beach is much more like that about the camp at Siskowit Bay (V, 3) than the *Cladonia-procumbens* section, and contains more of the Low Juniper rather than the Procumbent Juniper. There is also much more exposed rock, and a much more diversified flora. In places the Low Huckleberries are very abundant, while they are not at all conspicuous on the eastern section. To get an idea of the general appearances *Figures 34 and 36* should be compared.

Figure 34 shows the marked dominance of *procumbens,* which was not abundant on the west slope. The plant life is more varied, with the foliaceous lichens and bunches of coral-like *Cladonia,* ferns, grasses, *Solidago,* and the willows and aspens in the crevices, *Fig. 37.* These forms give a very different aspect to the pioneer society from that of one composed of a *Cladonia-procumbens* mat. The open or patch like character of this society suggests that the retarded development of the vegetational cover may be related in some way to the scarcity of *J. procumbens,* which is such an excellent agent in soil formation. But why this shrub should not thrive here is not known.

Associated with these conditions were the snail *Polygyra albolabris,* and the grasshopper *Melanoplus fasciatus.* The absence of the dense mat, and less soil, greatly reduced the variety of animals frequenting such conditions.

Taking the station as a whole (V, 2), it is one of the most interesting places seen on the island. The beauty of the variegated Cladonia mat, the extensive area of the open habitat, the boreal character of the lichens, the Saxifrage and many of the shells, the apparent completeness of the preservation of the stages in the transformation from the lower beach back to the forest, all combine to make this situation one of the most interesting and important of those examined.*

Station V, Substation 4. Trail through Balsam-Spruce Forest. This station begins at the opening about camp (V, 3) and extends northwest to the south shore of Siskowit Lake, opposite the eastern end of an elongated island. The topography of the region traversed is one of low relief, with only occasional low rocks, hills, or ridges, 15 to 20 feet in height, and a few shallow and moist ravines. A thick layer of humus covers the surface, except on the ridges. The trail first passes through a forest of White Spruce, Balsam, Birch and scattered Tamaracks. Among these trees are many fresh windfalls, due to the winds and the shallow soil. In the more shaded portions the ground cover consists of a dense growth of mosses, liverworts, *Fig. 38,* with *Aster macrophyllus* in the less shaded portions. There are open patches 10 to 15 feet in diameter scattered about through the forest, especially on low rock ridges, which contain a growth of Cladonia, and illustrate the last stages of the decline of the openings.

In the moist depressions was found an abundance of Round-leaved Cornel, alder, and also Ground Hemlock, Mountain Ash, Balsam, White Spruce, and the Ground Pine (abundant.) There were many fallen and decayed logs. In and characterizing the more open places, such as were associated with large Birches, are the Large-flowering Rasp-

* This slope is very favorable for the study of the ecological distribution of lichens, and at this point attention is directed to some papers on lichen societies by Professor Bruce Fink, of Miami College. These are the most important papers on this subject.

1902. Ecological Distribution an Incentive to the Study of Lichens. Bryologist, 5, pp. 39-40.
1903. Some Common Types of Lichen formations. Bull. Torrey Bot. Club., 30, pp. 412-418.
1903. Some Talus Cladonia Formations. Bot. Gaz., 35, pp. 195-208.
1904. A Lichen Society of Sandstone Riprap. Bot. Gaz., 38, pp. 265-284.

Contributions to the Study of Lichens of Minnesota:

I. Lichens of the Lake of the Woods. Minn. Bot. Stud., 1, 1896, pp. 693-701.
II. Lichens of Minneapolis and Vicinity. Minn. Bot. Stud., 1, 1896, pp. 703-725.
III. The Rock Lichens of Taylors Falls. Minn. Bot. Stud., 2, 1898, pp. 1-18.
IV. Lichens of the Lake Superior Region. Minn. Bot. Stud., 2, 1899, pp. 215-276.
V. Lichens of the Minnesota Valley and Southwestern Minnesota. Minn. Bot. Stud., 2, 1899, pp. 277-329.
VI. Lichens of Northwestern Minnesota. Minn. Bot. Stud., 2, 1901, pp. 657-709.
VII. Lichens of the Northern Boundary. Minn. Bot. Stud., 2, 1903, pp. 167-236.

berry, Sarsaparilla (dominant), and *Clintonia borealis*, but *Aster macrophyllus* was not as abundant here as elsewhere. The larger Birches averaged about 12 to 15 inches in diameter. The general appearance of the conditions is shown in *Fig. 39.* This patch of birches was near the swamp (V, 5). From this Birch colony, on to the end of the trail to Siskowit Lake, the forest was dominated by large Birch, with a few quaking Aspen, Balsam and White Spruce, while in the damper places Ground Hemlock and Dogwood were abundant. On the ridges there are small "islands" of Cladonia, mosses, Bearberry and a ground pine. The general appearance of this forest, in an open place, is shown in *Fig. 40.*

While there are thus minor differences which prevent absolute homogeneity in the general conditions of the forest, yet these differences do not seem to particularly influence the environment as a whole. The general transition from the openings, as found on rock ridges like those about camp (V, 3), to the Balsam-Spruce forest may be seen by a comparison of *Figures 25, 26, 27 and 38.*

The fauna of the forest (V, 4) is rather varied. The shells are represented by *Acanthinula harpa, Zonitoides arborea,* and *Pyramidula cronkheitei anthonyi;* the beetles by the carabid, *Calathus,* the fungus-inhabiting beetles, *Boletobius, Tritoma* and *Grophaena,* and doubtless many of the other species which were taken about the flowers and the camp. The wood-boring Hymenoptera, as *Urocerus,* are also characteristic of this kind of forest. Hares remained concealed in the forests during the day, but at dusk they came in large numbers into the clearings to feed. The birds had begun to migrate when this location was examined, so that little attention was given to their habitat preferences.

Station V, Substation 5. Tamarack Swamp. This swamp lies between Siskowit Lake and the western end of the trail through the Balsam-Spruce forest (V, 4). This is a valley swamp bordering a small stream which flows through the swamp. The central open part of the swamp is occupied by a small pool or pond, *Fig. 41,* which is invaded by Yellow Waterlilies. Surrounding this is a zone of Buckbean and sedge, the overgrowing sedge being more conspicuous. This sedge zone is quite wet and quaking. The current of the stream passed through this zone and parted the sedges in a wet line two or three inches wide. At its outer border, the zone becomes invaded by small Tamaracks, 4 to 5 feet high, alders, willow, scattered Cassandra and Pitcher Plants, and Wild Rosemary (common). *Eriophorum,* the Blue Flag and the Purple Cinquefoil occur in some of the depressions. A very few small Arbor Vitae also occur here. A strip of trees bordered the stream, while farther south occurred the Cassandra and Sphagnum zone proper. The latter contained scattered Blue Flags, and upon dry hummocks, colonies of *Cladonia,* which seemed rather out of place. The margin of this area was invaded by the Tamarack, Black Spruce and Labrador Tea. The general appearance of this forest is shown in *Figs. 42-43.* Near the margin of the swamp, where the spruces are quite large and the ground well shaded, the growth of Labrador Tea and Sphagnum was very luxuriant. The growth of Sphagnum at this place was by far the most luxuriant seen upon the island. It grew in hillocks over fallen trees and stumps, and stood considerably above the general level of the swamp.

This ground cover was not limited to the swamp, but invaded the Balsam-Spruce forest in large billow growths, such as is shown in *Fig. 44*. In other places the undergrowth and ground cover of the Balsam-Spruce forest apparently invaded the swamp, as was seen by the intermingling of the two plant societies. Here there is a mat of the Sphagnum and Labrador Tea intermingled with Ground Cornel, *Clintonia borealis* and young Balsams. As in *Fig. 44*, this might also be interpreted to mean an invasion of the Balsam-Spruce forest by the swamp; but the vigor and dominance of the Balsam society favors the interpretation that this is an invasion of the swamp by the Balsam society. It is not surprising that along such a tension line either society may dominate at times.

The fauna of this bog consisted of a Garter Snake (*T. sirtalis*), found near the small brook flowing into the western or upper end of the bog. Here also was found *Hyla pickeringii, Rana clamitans,* and *R. cantabrigensis,* and a water strider, *Gerris,* running on the surface. In the Cassandra and Sphagnum hummock zone were found the grasshoppers, *Mecostethus lineatus, Melanoplus extremus,* and *Stenobothrus curtipennis.* Nearer the central lilypond, among the sedges and Cassandra, were found the dragon flies, *Tetregoneuria spinigera, Aeschna, Leucorhinia hudsonica* and *Sympetrum obtrusum,* and the spider *Epeira patagiata.* Through the central area of the bog the stream was only indicated by the parting of the sedges, but at the lower or eastern end it again became well defined, and contained the small Stickleback, *Eucalia inconstans.* Beetles taken from this bog were *Haliplus ruficollis, Hydroporus tristis* and *Agabus congener.* The molluscs were represented by the small bivalves, *Pisidium.*

Station V, Substation 6. South Shore of Siskowit Lake. This situation is simply the end of the trail through the forest, and marks the location of some collecting in the lake. The shore is rocky, with rather low and overgrown banks.

Station V, Substation 7. The Haytown Trail. This trail begins almost directly opposite the outlet of Siskowit lake, where a large White Pine has been marked "36 W. 65 N., 19 E." This area has been burned over, but farther inland the blaze on the older trees enables one to follow the trail. The course is shown by Lane, ('98, Pl. XI), but we examined it only to about the point where it is crossed by the outlet of Hatchet lake, at which place there was a Tamarack swamp with very large trees (V, 8). After crossing the burned area near Siskowit lake, this trail passed through dense Arbor Vitae bogs and a large area of Balsam-Birch forest. In general the area traversed was rather deeply covered with soil and contained very few rock exposures, those observed probably being due to fires.

The general character of the upland forest, of mixed conifer and hardwood, is indicated by the following list: Balsams, Birch and Aspens (all about 10 inches in diameter), scattered Arbor Vitae (10 to 15 inches), a few scattered White Pines (about 3 feet in diameter), and a few Hard Maples (some 8 inches). It is thus seen that the largest abundant trees are the White Pine, Arbor Vitae, Birch, Hard Maple and

Aspen. The large amount of hardwood present was an unexpected feature. This forest may be considered transitional between the Balsam, White Spruce forest, and the Hard Maple, Yellow Birch, Balsam and Arbor Vitæ forest as found on the Desor Trail (III, '04).

The undergrowth consisted of Ground Hemlock in abundance, Mountain Maple, Beaked Hazel, young Balsams and Birches. The ground cover was composed of *Clintonia borealis, Lycopodium lecidulum, Clabonia* on dry rotten wood, *Aster macrophyllus,* Large-flowering Raspberry and Wild Sarsaparilla.

Mountain Maples and young Balsams showed a marked tendency to take possession of the trail. The lack of an undergrowth in the dense swamps was particularly noticeable, and the clearly defined old trail through such places indicated relatively stable conditions.

A very marked characteristic of this trail was its limited fauna. Very few birds were seen, and Red Squirrels were not at all abundant. Several times we saw the remains of Balsam cones where a Red Squirrel had taken a meal. Almost no effort was made to collect invertebrates.

Station V, Substation 8. Arbor Vitæ Swamp. This swamp marked the end of our Haytown Trail, and bordered on a small stream. The dark colored soil contained much humus and was soft and spongy. The vegetation bordering this stream was composed of Speckled Alder, Skunk Cabbage, Marsh Marigold, *Clintonia borealis,* scattered Blue Flags, and Ground Cornel; in the moderate shade, *Coptis trifolia,* Mountain Ash, young Arbor Vitæ and Balsams, Twayblade, and, in the damp places, away from the stream, *Mitella nuda.*

In the dense and apparently well drained swamp there was a firm humic soil covered by a thick layer of leaves, conifer needles and twigs. The ground cover was composed of Ground Cornel, *Clintonia borealis* and Wild Sarsaparilla, with an undergrowth of Mountain Maple, Ciliated Honeysuckle, numerous young Balsams, young Arbor Vitæ, Ground Hemlock, Mountain Ash, and Beaked Hazel. The large Tamaracks were about 3 feet in diameter, and the Arbor Vitæ about 2 feet, others about 20 inches in diameter were abundant. It is thus seen that this was an old and mature swamp with some very large trees, under which the ground was quite open. With better drainage, the young or suppressed undergrowth would succeed the Tamarack society.

The old trail through this swamp was remarkably well preserved and distinct because the dominance of the large shade-producing trees prevented the development of an undergrowth. No animals were collected.

Station V, Substation 9. Outlet of Siskowit Lake. A trail or path ran from the head of the outlet of Siskowit Lake south to the Siskowit Bay beach, a distance less than a quarter of a mile. The area traversed had been burned, and second growth had developed, the best of which was in the depressions where the soil is deeper. The open ridges near Siskowit Lake, where the soil is thin, have an open growth near the head of the trail and support *Prunus pennsylvanica,* Birch, *Dierville dierville,* Mountain Ash, Mountain Maple, *Amelanchier oligocarpa,* Ground Cornel, Everlasting, Wild Rose, White Clover, Fire Weed and mosses. In the depressions among the underbrush in the deeper soil and in shade

is found *Diervilla diervilla*, Fire Weed, *Prunus pennsylvanica*, Mountain Maple, Mountain Ash, Birch, Mountain Alder, Willow, Sarsaparilla, Wood *Equisetum*, Oak and Ladies' Fern, Large-flowering Raspberry, *Cornus stolonifera* and *Clintonia borealis*.

The open arid character of much of this station is reflected in the grasshopper fauna, as follows: *Hibbiscus tuberculatus*, *Melanoplus alaskanus, fasciatus* and *Circotettix verruculatus*. The butterfly, *Basilarchia arthemis* was also taken here. The rare dragonfly, *Ophiogomphus columbrinus* was also taken at this station, probably because of the proximity of the rapid flowing outlet, which forms a trout stream.

Station V, Substation 10. Long Island Gull Rookery and Menagerie Island. This station was examined solely for its bird life, which will be discussed elsewhere in this report. This large Gull rookery is on Long Island, *Fig. 45*, which lies about one mile west of Menagerie Island where Isle Royale Light is located. This bird clearly breeds upon the middle and upper beaches. Long Island is formed by the upturned edges of red sandstone and is exposed to the full sweep of the lake waves, as is clearly evidenced by the bare rocks. The vegetation on the island was not examined, as the time that could be devoted to the examination of the rookery was limited. But mention should be made of the abundance of algae in the lake bordering the rookery, and of their abundance in the rock pools on the beach.

Station V, Substation 11. Tamarack-Spruce Swamp. This station includes a waterlily pond surrounded by zones of sedge, heath shrubs, Tamarack and Black Spruce. A general view of the pond is shown in *Fig. 46*. It was located almost due west of the western end of Station V, 2, and only a short distance northwest of the boat landing.

In the pond, submerged, was Utricularia, Yellow Waterlily, *Potamogeton*, and *Brasenia* (Water Shield); practically all the open water was occupied by the Yellow Water Lily. At the edge of the water grow the sedges, *Fig. 47*, which form a distinct zone, and the Buckbean. The sedge zone also includes the *Equisetum*, Purple Cinquefoil, *Comarum palustre*, a willow, *Hypericum*, Water Hemlock (*Cicuta bulbifera*), and the White Bog Orchid. Beyond the sedge zone comes *Sphagnum, Andromeda polifolia*, Cassandra, patches of Labrador Tea, *Oxycoccus oxycoccus* (Small Cranberry, abundant), Alder, *Chiogenes hispidula* (Creeping Snowberry), Bunch Berry or Dwarf Cornel (*Cornus canadensis*), *Kalmia glauca*, Pitcher Plants, *Drosera intermedia*. The trees do not extend to the inner limit of the Cassandra zone. Cladonia grew upon dry hummocks in this zone. In a few places, in depressions in the tree zone, Eriophorum was found. The trees are Tamarack, Black Spruce, and small Arbor Vitae. The general appearance of the Cassandra and tree zones are shown in *Fig. 48*.

The invertebrate fauna of this station was abundant and varied, but the vertebrates were more limited. In the Water Lily and Potamogeton zone the Stickleback, *Eucalia inconstans*, was taken, and at the sedge margin, *Rana clamitans*. Water bugs are represented by *Belostoma* and *Corixa* nymphs, and on the surface by the Water Strider, *Gerris rufoscutellatus*. A small shell, *Physa aplectoides*, was found in

small foot-print like pools in the outer part of the Buckbean and sedge zone. In the Cassandra zone were taken the dragonflies *Enallagma hageni, Aeschna, Leucorhinia proxima,* the grasshopper *Melanoplus alaskanus,* and the butterfly *Pyrameis cardui.* From this bog were also taken the Arachnids, *Lacinius ohioense, Drassus neglectus* and *Pardosa glacialis.*

The stations at Washington Harbor were not examined in 1905 in as much detail as were other localities, and the descriptions will therefore be correspondingly brief, and will be supplementary to a similar account by Ruthven, '06, pp. 48-52.

Station I, '04. Clearing at the Head of Washington Harbor. This clearing is the property owned by the Washington Club of Duluth, Minn. Much of it is sodded, pastured and under some form of cultivation. These conditions were particularly favorable for grasshoppers, which occur in great numbers. The following species were taken: *Stenobothrus curtipennis, Chloealtis abdominalis, C. conspersa, Mecostethus lineatus, Camnula pellucida,* and *Melanoplus alaskanus.* This area appeared to be a favorable resort for migrating birds, as shown in the accompanying report by Peet.

Station II, '04. Washington Creek. This is the small trout stream which flows into the head of Washington Harbor.

Station III, '04. Trail along the Top of the Greenstone Range, the "Desor Trail." This trail follows the road which has been opened from the Club House (I, '04) to Lake Desor (VII, '04). At the western end this road traverses a forest which varies considerably in its composition. In places it is dense and apparently original, but at one place it has been burned and replaced by an abundant growth of Birch. The original forest is dense and composed of large trees, and the proportion of hardwoods is surprising, since the Balsam-Spruce forest is so prevalent elsewhere upon the island. The hardwoods are really dominant. The forest *Fig. 49,* is composed of Yellow Birch, Balsam, Arbor Vitae, and a few Sugar Maples, and the undergrowth of Mountain Maple and Ground Hemlock. Farther out on the trail, toward Lake Desor, the Maple becomes dominant and forms an almost pure stand, so dense that in places there is almost no undergrowth, and the forest appears quite open with a scattered ground cover. A loose thick layer of leaves and twigs covers the forest floor. In the more open places the ground cover is composed of Large-flowering Raspberry, Wild Sarsaparilla, *Clintonia borealis, Lycopodium,* mosses, Ground Cornel, and the shrubs, Mountain Maple, Beaked Hazel, Round-leaved Cornel, Mountain Ash and Red Cherry. The Yellow Birch is a large tree, with a diameter of about 2 feet; White Pine is very rare, but the trees are large, even about 3 feet in diameter; Arbor Vitae reaches about 2 feet. A few Large-toothed Aspens, Black Oak and Black Ash were seen, the Aspens about 20 inches in diameter and the Maples 10 to 15 inches.

Red Squirrels were seen in the forest, the body of a Lynx was found hanging on a tree where it had been left by a trapper, and several Toads were seen. Invertebrate life was abundant. In an Arbor Vitae stump, galleries of an ant, *Camponotus herculeanus whymperi* (140 A), were

found in both the seasoned and the decayed wood. A few beetles were taken along the trail; *Quedius fulgides, Tachinus memnomius* and *Geotrupes blackburnii.* Shells were abundant: *Strobilops virgo, Vitrea binneyana, Euconulus chersinus polygyratus, Zonitoides arborea, Z. exigua. Pallifera dorsalis, Pyramidula alternata and P. cronkheitei anthonyi.*

Station IV, '04. Washington Brook. Cf. Ruthven, '06, p. 50. This station was examined on the slope back of the Club-house. It is a swamp forest along the border of a very small stream, *Fig. 50.* Part of the forest is being cleared.

Station V, '04. Tamarack Swamp. This swamp was not visited in 1905. Cf. Ruthven, '06, p. 50.

Station VI, '04. North Slope of Greenstone Range. Cf. Ruthven, '06, p. 49.

Station VII, '04. Lake Desor. Cf. Ruthven, '06, p. 51. A few additional records are: The dragonfly, *Enallagma exsulans,* the water strider, *Gerris remigis,* the fish, *Coregonus artedi.* At the end of the trail (III, '04) at Desor, the beetle, *Melanotus paradoxus,* and the spider *Dolomedes idoneus,* were taken.

Station VIII, '04. Western End of Siskowit Bay. The large clearing and burned area at the head of Siskowit Bay marks the site of a former town, the county seat. A well-defined graded road leads from near the north shore of the Bay westward and north to an old mining camp, This road is being invaded in places by Birches and Aspens. This extensive clearing was overgrown with many introduced plants and was given only a cursory examination. The following vertebrates were observed: Sharp-tailed Grouse, (of which several were seen), the Hare, Toad and Garter Snake. The snails, *Polygyra albolabris* and *Pyramidula alternata,* and the grasshopper *Stenobothrus curtipennis* were found here. The limits of this station were changed somewhat from those given in 1904.

Station IX, '04. Southwestern End of Minong Trap Range. Cf. Ruthven, '06, p. 51-52. No additional collections were made here in 1905.

Station X, '04. Washington Harbor. Cf. Ruthven, '06, p. 52. No additional collections were made at this station in 1905.

III. THE EVOLUTION OF THE GROSS ENVIRONMENT.

1. *Geological Succession.* In his report on the Porcupine Mountains. Ruthven ('06) has summarily outlined the general geological history of the Lake Superior region. It is only necessary, therefore, for our purpose, to repeat some of this history and to enlarge upon those phases peculiar to Isle Royale. The structural geology of Isle Royale has been studied in detail by Lane ('98) and is relatively simple. The different rock formations are in narrow strips nearly parallel with the long axis of the island, while the dip of the rocks is toward the basin of Lake Superior. The rocks north of Siskowit Bay consist of the truncated beds of ancient lava flows, interrupted by a small amount of interbedded sedimentary rocks. Although these tilted and truncated beds are

inclined at a high angle, this was not their original position; in all probability they were formed in a nearly horizontal position by fissure eruptions under the sea, because the lavas are interbedded with shales, sandstones and conglomerates. In thickness these lava beds vary from a few inches to hundreds of feet. The narrow beds often show upper and lower surfaces filled with small cavities (amygdules) in contrast with the denser central part. These cavities were formed by gas or vapor while the lava was hot, and leave such a rock porous and less resistant to disintegrating agencies and to erosion. The same principles also hold for the thicker beds of lava; the outer parts are more porous and softer than the central part. This structural difference is clearly shown in the topography of the island; the ridges mark the central or more resistant parts of the truncated lava beds, while the valleys, in general, have been worn into the softer outer parts of the lava and into the interbedded sedimentary rocks. These beds are of Keweenawan or pre-Cambrian age; their formation ceased with an elevation of the land from the sea and their destruction was begun by the agents of subaerial erosion. These processes continued until the titled strata were truncated and reduced to a base level. Again the region was depressed and upon this eroded surface were deposited unconformably those red sandstones and conglomerates which now characterize the Siskowit Bay region and to the southward, and are of Cambrian age. Once more the region was elevated, titled and subjected to prolonged erosion and the strata truncated as had been done with the Keweenawan. Similar processes continued until the marked elevation of the land, which took place at the close of the Tertiary, and which initiated the repeated glaciations of the Ice Age.

With the extension of the last or Wisconsin ice sheet in the Superior basin, Isle Royale was completely overridden by the movement of an ice sheet from the northeast that moved almost parallel to the ridges, but was somewhat more inclined from the east (Lane '98, p. 183). For this reason there was a tendency to plane down the southeastern slopes and to preserve the steeper ones which had been formed on the northwestern side (Foster & Whitney, '50, p. 202). As the island has a topography which indicates subaerial rather than marine erosion, it must have had at one time a residual soil, which, unless it had been swept away by a former ice invasion or the waves of some body of water, was probably removed at this time with the minor inequalities of the surface. In this manner the Superior lobe buried the island under several thousand feet of ice and continued its movement far to the southward, leaving a glacial desert in its wake. This condition of affairs lasted until the return movement broke up the great ice sheet into lake basin lobes and brought the receding ice front into the Superior basin. As soon, however, as this lobe wasted away from the margin of this basin, the water from the melting ice accumulated before it and formed a lake which, overflowing the rim, found its way through the St. Croix valley to the Mississippi river, as indicated in *Fig. 51*. But, as the ice

wall continued to retreat toward the northeast, these ponded waters increased in area and formed the highest beach lines now preserved on the north shore of Lake Superior. The evidence for this is found on Mt. Josephine, located on this shore just north of the southwestern end of Isle Royale, which reaches an elevation of about 800 feet above the Lake. Far up on its slopes, according to Lawson ('93, p. 253), evidence of beach lines are found, about which he says: "These two terraces at 585 and 607 feet are remarkable for being the highest strand lines which

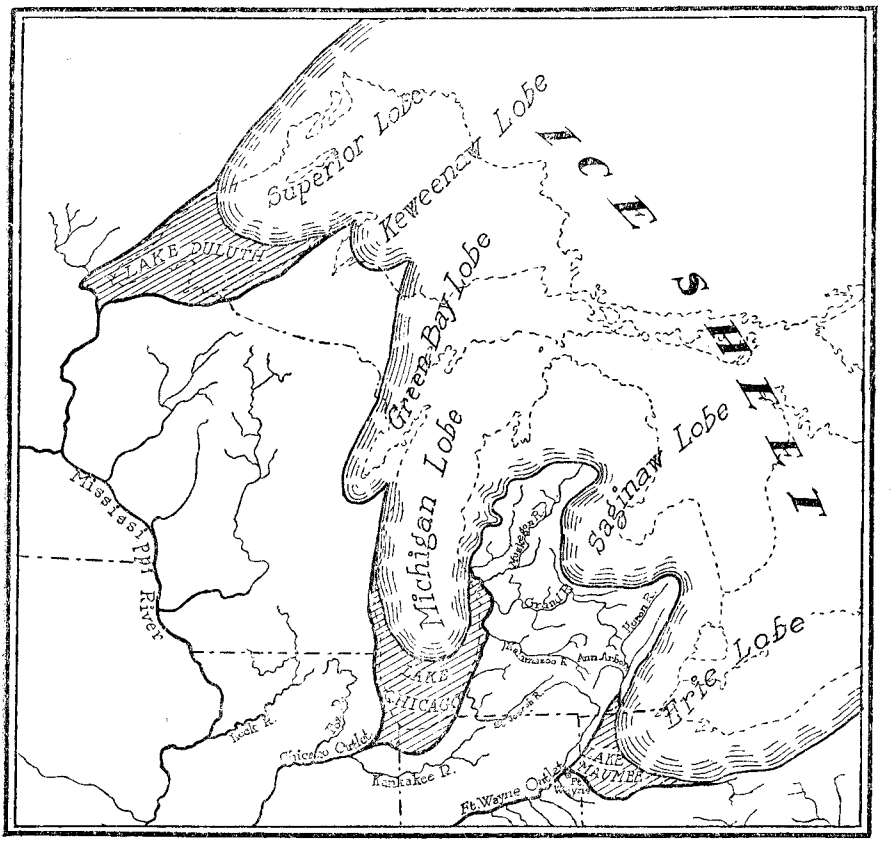

FIG. 51. Showing origin of the Glacial Lakes, their relation to the ice sheet and their Mississippi drainage.

have thus far been observed on the coast of Lake Superior." Under such conditions it seems that Isle Royale would undoubtedly have been submerged. The ice retreat continued and finally Isle Royale, freed from the ice and in part from the lake waters, emerged as a narrow rocky ridge—the crest of the Greenstone Range which today rises, at the northeastern end of the island, to a maximum elevation of about 550 feet. As the ice wall retreated the Michigan and Huron basins became confluent, and an outlet to the east (Trent valley, Ontario) at first, later the Port Huron and possibly the Chicago outlet (Goldthwait, '09, p. 65) became available, *Fig. 52*, and at about this time the Glacial Great

Lakes became isolated from the Mississippi drainage. The lake level was lowered, and it was perhaps at this level that the beach lines were formed on the north side of Lake Superior, which are now 400-500 feet above the present lake level (Taylor, '97, p. 126). Similar evidences of ancient beaches have been recognized by Lane ('98, pp. 188-191) upon Isle Royale, but he is inclined to place the level of this Glacial Lake Algonquin at about 485 feet. It is probable that more field work will be necessary before adequate correlations of these beaches can be made.

Some general idea of the extent of the island at this stage may be gained by reference to the 460 foot contour on the accompanying map,

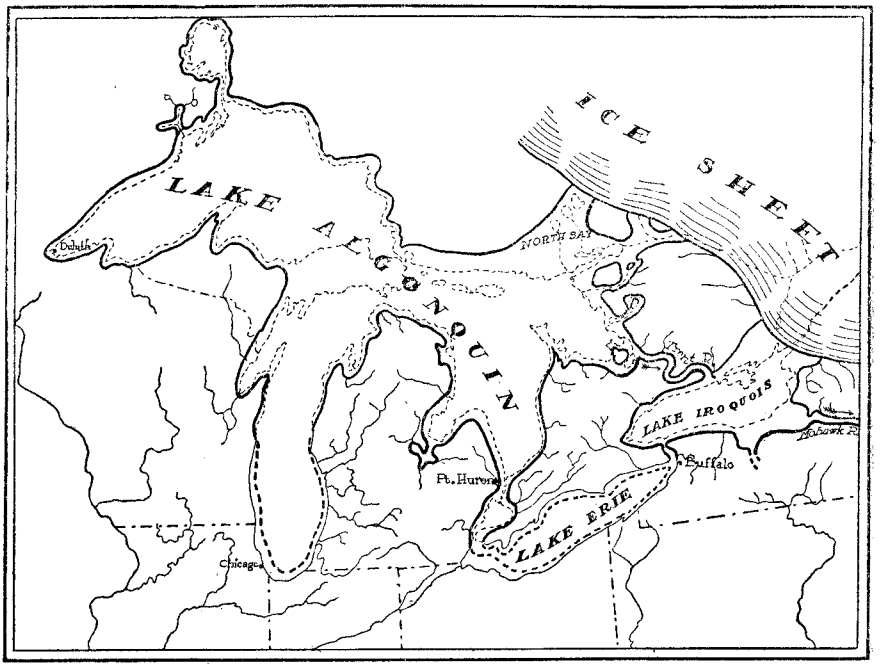

FIG. 52.—Showing the Algonquin stage of the Great Lakes. A water barrier to northward dispersal of the land biota.

Fig. 53. At this time, *Fig. 52*, the ice sheets had retreated far enough to the northeast that the climate of the Superior basin must have been so greatly ameliorated that animal life could have lived in its water. This inference seems probable because fossil shells have been found in the beach lines of the same lake farther to the south by Lane and Walker (Lane '00, pp. 248-252), and at Port Huron, Michigan by the writer in company with Dr. J. W. Goldthwait and Dr. A. G. Ruthven (Goldthwait, '07, p. 118). Here were found an abundance of *Goniobasis livescens*, occasional valves of *Sphaerium striatinum* Lam. and Unionid fragments, a fauna like that of the present beaches. It is therefore not improbable that this fauna invaded the Great Lakes drainage from the Mississippi during the early stages of the great glacial lakes, when they still overflowed into the Mississippi drainage.

The time of invasion and the sources of the Glacial and post-Glacial supply of life which invaded the northern land and waters presents several interesting problems. At this point the origin of the aquatic biota is of special interest. From what is known of the fresh-water aquatic biota of the far north, it is very probable that the Glacial Great Lakes, at least in their later stages, were not utterly devoid of animal life. So it seems reasonable to infer that such forms as lived during Glacial times near the ice margin were among the first to succeed the retreating ice sheet.

As the lake fauna is one of the most characteristic features of the life of northeastern North America, the question naturally arises as to where this fauna was preserved during the Ice Age. Today there is no extensive development of lake fauna south of the glaciated region. Where then was such a fauna preserved? On the west were the arid plains, and to the south an old land area of mature drainage and very few lakes. Such relations as these suggest that this fauna must have occupied the lakes formed on the rejuvenated glacial topography or in the adjacent streams. Had there been extensive lake areas to the south to act as regions of preservation, it seems probable that the present fauna of the Great Lakes would have been much richer. Undoubtedly the most important fresh-water preserve was the Mississippi system, on account of its direct communication with the glacial drainage, thus allowing a southward escape into more favorable climatic conditions. This was also a water communication of considerable duration, lasting even into early post-Glacial times, and one which has greatly influenced the origin of the present fauna of the Great Lakes. In all probability it was this Glacial and post-Glacial water connection and barrier that retarded the northern extension of so many land species, and at the same time favored the extension of certain aquatic animals. The later development of the eastern outlets did not open up such a favorable source of supply as occurred farther west.

So much for this phase of the problem. Now let us continue with the history of the Superior basin since Algonquin times. The fall in the lake level did not take place suddenly, since a series of beach lines are preserved which show that it halted for some time at different levels, but none were of any remarkable duration until it reached a level marked by a very extensive series of beach lines now preserved at about 60 feet above the level of Lake Superior. This well defined beach represents the shore of the Nipissing Great Lakes, post-Glacial lakes whose general outline was much like that of the present lakes in the same basins, as is indicated in *Fig. 54*. The low outlet of this lake was to the east through the Ottawa valley into the Champlain Sea, and is of special interest in that it is suggestive of how certain Great Lake animals of marine affinities (*Mysis, Pontoporcia, Triglopsis*) might have invaded the upper lakes in post-Glacial times. At one time it was thought that there had been a Glacial salt water communication between Lake Superior and the Hudson Bay region, but this view has been abandoned (cf. Taylor, '97, pp. 127-128; '96, pp. 255-256, and Coleman, '06, pp. 193, 198-199). It is definitely known that the land was depressed to the north of Lake Superior, but this period of depression was at a time when it was covered by the ice sheet,

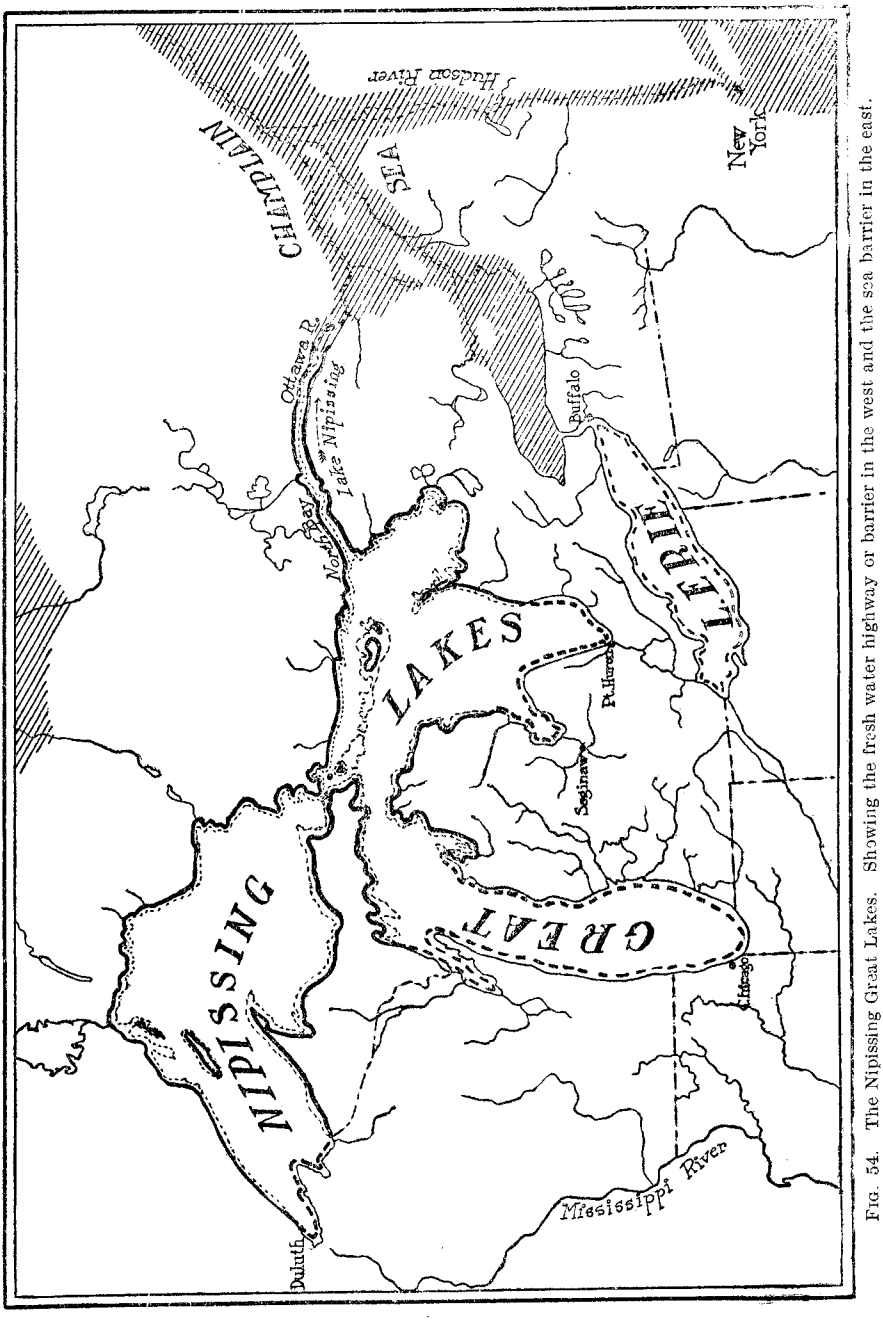

FIG. 54. The Nipissing Great Lakes. Showing the fresh water highway or barrier in the west and the sea barrier in the east.

and thus the salt water was excluded. An alternative hypothesis is that these animals are adapted to a constant and low temperature rather than to fresh or salt water, and that during Glacial times they were dispersed far to the south in fresh water and have only been preserved in restricted favorable localities. The low temperature of Glacial times would be a period especially favorable for the acclimatization of marine forms to fresh water on account of the favorable conditions which accompany the slow rate of changes at low temperatures.

The long duration of the Nipissing Great Lakes is well attested by the character of the beach. As Taylor ('96, p. 398) remarks: "It is altogether the most remarkable littoral feature of the Great Lake region. It is a shore line well advanced towards old age. All other beaches of the lakes are youthful in comparison ..... Instead of the slender spits and barrier bars of the Algonquin and other beaches, the Nipissing beach has what may be called barrier plains, made up of many, sometimes forty or fifty, massive beach ridges laid one against the other. Many bays were entirely filled by these beach plains and others were cut off, so as to form small littoral lakes. Some of these plains are a mile to a mile and a half wide. In some instances the old deltas of other beaches are large and conspicuous, but the constructive products of wave action have no comparison to those of the Nipissing beach." From a biological standpoint these facts are of special significance. The maturity of the beach line is a condition decidedly favorable to the development of a littoral biota. The sandy shore, spits, bars, beach pools, cut-off ponds and lakes furnish a variety of favorable habitats in marked contrast with the poverty stricken character of life frequenting an exposed and topographically youthful lake shore. Such an old beach is both qualitatively and quantitatively favorable to the biota, and not only favors an abundant supply but also its dispersion along shore and by currents throughout such a body of water. The long duration of such conditions is of evident advantage to an extensive dispersal of such life.

As the basin of the Nipissing Great Lakes in the Superior basin was so much like that of Lake Superior, it is not improbable that the lake currents were much the same in both lakes, so that our knowledge of the present lake currents should aid in the interpretation of those of the Nipissing Great Lakes. Such relations as these suggest that at the Nipissing stage, and perhaps even earlier, the lake currents tended to people Isle Royale with north shore drift. By this time the island was quite large, though smaller than the present island by the subtraction of the area below the 60-foot contour. At this time the climate of the region must have become greatly ameliorated so that the north shore of Lake Superior was perhaps repopulated from the south, largely around the western end of the lake. With the advent of an abundance and diversity of plant and animal life, a new element enters the environment, whose influence is far reaching. The vegetation tends to blanket the surface with a humus layer and thus to bind the soil so that it retards erosion and becomes a geological agent. The influence of animal life is also far reaching and may be conspicuous if beavers are abundant. But these influences will only be mentioned here.

The development of the Nipissing beach upon Isle Royale has not

been so clearly recognized as elsewhere. Thus Lane ('98, p. 187) considers the present beach as the most distinct of any found upon the island. In a way this is not surprising when we recall the fact that at former lake levels the small area of the island did not permit of an extensive stream development, hence the limited quantities of sand, gravel and boulders. Thus the overriding of the ice, the isolation of the island in deep water, and the steep shores of resistent rocks are conditions unfavorable for supplying tools with which the waves could work. All of these conditions would tend to preserve the youthful topographic features and exaggerate the apparent relative rate at which the island emerged from the waves and the small time during which the waves beat at any particular level. The materials available to the present waves have therefore been cumulative. Lane ('98, pp. 188-189) has recognized several evidences of a 60 foot level.

After the formation of the Nipissing beach there was an uplift toward the north, as shown by Taylor's ('97, p. 127) study of this beach on the Canadian shore north of Isle Royale. In the vicinity of Port Arthur this beach is at 60 feet; at Nipigon 90 feet, and 110 to 115 at Peninsula Harbor. Such an assumed variation or tilting near Isle Royale suggests the necessity of great caution in attempting to correlate the various beaches and emphasizes the desirability of further field work upon this subject. Lane ('98, p. 192) suggests that this northward tilting has tended to pond the northeastward flowing streams and to drain the ones flowing in the opposite direction. Such tilting as this would have considerable influence upon the biota. Even in an uplift of a few feet per mile, in the case of Isle Royale 45 miles long, would be sufficient to have a marked influence upon the swamp environment, which is one of the most characteristic features of the island. In this manner a swamp and its biota might migrate several miles, become a pond or lake or even become drained, and other fates are suggested for ponds, lakes and other environments when such a distinct trend or dynamic tendency is present in a given region.

The change from the Nipissing to the present lake level was not a sudden one, as Lane ('98, p. 191) has recognized beaches at various levels showing its gradual character; the 30 and 15 foot levels are, however, the most distinct. A few observations were made upon two of these abandoned beaches, but their height was not determined. One was located just south of the mouth of Conglomerate Bay in a small cove about 60 or 70 feet wide. There was an abundance of fresh drift wood a few feet from the edge of the water, back of this a zone of weathered and decayed drift, and beyond this a high boulder beach containing disintegrated boulders with foliaceous lichens, while back of the lichen zone came Wild Cherry, Paper Birch, Bear-berry, Wild Rose, Jack Pine, Alders and Columbine. The back slope then declined into a Jack Pine growth. This beach is interesting because it illustrates the various stages from wave-washed, clean sand and gravel back into the forest growth. Lane ('98, p. 185) refers to a lichen covered beach on Sec. 10, T. 65, R. 34. The second of the beaches mentioned is located on the south shore near the eastern end of Siskowit Bay (Sec. 26, T. 65 N., R. 35 W.). The present beach is locally known as the "Greenstone beach" and forms a good boat landing.

2. *The Topography and its Origin.* The most conspicuous and characteristic topographic features of the island are its parallel flat-topped rock ridges with the intervening valleys and numerous swamps. These ridges project far out from the main body of the island and form the narrow rock ridges bounding the harbors, and forming a vast number of small islands and low rocky reefs. The tilting, faulting and truncation of these narrow beds clearly shows that the dependence of the topography upon rock structure is one of the most characteristic features of the island.

The main ridge, the Greenstone Range, is a divide which extends the entire length of the island, and is from about 400 to 500 feet high, with a maximum height of about 550 feet at the northeastern end of the island. At only one place does a drainage line cross the Greenstone. This is a small stream heading in Sec. 17, T. 64 N., R. 37 W. and a tributary to Washington River. This ridge is a truncated lava bed whose outer softer part has been eroded, thus throwing into prominence the compact resistant central core. Thus erosion, faulting and the dip of the rocks have combined to produce a northwestward facing escarpment nearly throughout its extent. The fairly flat topped truncated ridges of the island clearly show that their origin must be due to a period of baseleveling and is no doubt related to those extensive processes which have produced the Laurentian peneplain (cf. Ruthven, '06, p. 45) of the Superior region. The ridge of second importance is the Minong Trap Range, which lies parallel with the Greenstone, about a mile to the northwest, and reaches a height of about 400 feet. Between these ranges lies a valley containing five fairly large lakes, all of which drain across this range to the northward, and the probable faults indicated by Lane ('98, pl. 1) at Todd Harbor and McCargoe Cove are suggestive as to how the ridge has been broken through. Faults seem to have influenced the location of several lakes, such as Angleworm, Lesage, Livermore, Chickenbone, Feldtmann and also the outlet of Lake Richie into Chippewa Harbor. In addition to these main ranges there are great numbers of lower ones whose heights range from 100 to about 300 feet. East of Lake Feldtmann there is a bold escarpment 130 feet high, which was said by McIntyre (Foster, '50, p. 506) to afford the "finest view that I have seen on the island."

The drainage of the island presents some interesting features. At each end of the island the drainage is mainly along the valleys into the harbors at their ends. Between these two extremes, roughly marked by the area between lakes Desor and Sargent, the drainage, although it may follow the valleys for some distance, is yet to a marked degree across the strata or ridges. Taken as a whole the drainage is very imperfectly developed. Although the island is not extensive, it contains numerous small independent streams which drain into the lakes or directly into Lake Superior, but it has no master stream. It seems probable that this is also related to faulting, as also in the case of the stream, which may be called Malone Creek, that flows into the head of Siskowit Bay. The probable influence of faulting upon the location of lakes has previously been mentioned, and combined with its influence upon streams reinforces the idea of the dominance of structure upon the topography and consequently upon the drainage. But when in the

field the most conspicuous features of this imperfect drainage are the vast strips of swamp land found in the valleys and bordering the lakes and streams. The rock bound character of the basins and the southward tilting of the surface must greatly influence the form and extent of these strips. The stream channels have not cut deeply but are largely bordered by swamps, and the divides between many of them are very low or may even be swamps, so that the drainage from either end of a swamp may be into a different drainage line. Such imperfection of the drainage means that evaporation rather than run off is the pronounced feature, and this condition, combined with the insular location, must greatly influence the relative humidity of the atmosphere. The brownish waters of even the largest lake upon the island, Siskowit, 54 feet above Lake Superior, clearly shows the influence of the imperfect drainage and the extensive swamps of its drainage basin.

The general character of the soil was indicated by Ives on the Linear Survey map. This is as a rule shallow, the deeper being at the southwestern end (T. 64 N., R. 38 W.) and is characterized as "sandy loam and stony, second rate sufficiently deep for cultivation." At the head of Siskowit Bay (T. 63 N., R. 37 W.) he records soil "stony, 2nd and 3rd rate land. Soil varies from a few inches to 3 or 4 feet in depth." And near McCargoe Cove (T. 66 N., R. 35 W.) the soil is from 1 to 10 feet deep. The soil then in general may be said to be shallow, second and third rate stony, sandy loam. In the swamps and valleys there is a large amount of vegetable debris, although it is probable that this is generally not deep. No bog lime or marl has been observed. Large strips of the ridges are destitute of soil, especially those which have been burned. No morainic materials were recognized, although the ice overrode the island, and glacial boulders are abundant in places, as about the head of Washington Harbor. Dr. Lane writes me that there is some till, "especially on the lee end near Washington Harbor."

The origin of these soils appears to be relatively clear as there are only a few possibilities available. Some of the pre-Glacial residual soil may have been preserved but it has not been recognized. As above mentioned there are some Glacial boulders and till. The post-Glacial disintegration and decay of the rocks has been the most important source, supplemented by organic remains, from the vegetation in particular. A fourth source is the lake deposits of sand and clay as the waves have worked over the entire surface. These are best preserved in what were once harbors or places protected from the waves. In many localities the origin of the soil is diverse, several different processes having contributed a part.

From the above topographic relations it is seen that the flat-topped ridges and depressions are due to the structure of the rock, the influence of base leveling processes and probably also to faulting. The present drainage is not sufficient to explain the primary ridges and valleys; these must therefore have been inherited from past conditions. The present drainage is therefore consequent and in its infancy, hence its imperfection. From a biological standpoint these facts are significant because such conditions favor isolation of small streams, swamp and lake habitats affect the relative humidity and produce a prominent zonal and linear arrangement of the habitats along the ridges and

valleys. The absence, residual, or organic character of the soil is also an important factor of the environment.

3. *The Atmospheric Influences and their Evolution.* a. *Climate.* Unfortunately there has been no continuous series of climatological records made on Isle Royale. A few records were made by our party with instruments loaned by Mr. C. F. Schneider of the Michigan Weather Service, that, while very imperfect, are suggestive. The mean temperature for 26 days in July is 58° F., the minimum record is 46°, and the maximum 79°. From August 2 to 17 the mean is 59°; the mean maximum is 71° and the mean minimum is 47°. For the same period the maximum is 80° and the minimum 36°. There was but little rain although it rained all day on July 15.

Very fortunately, however, these meager records may be supplemented by those from Port Arthur, about 25 miles distant on the Canadian shore.[1] This data has been kindly furnished by Mr. B. C. Webber of the Canadian Meteorological Service. The records cover the decade of 1896 to 1905, and show the mean monthly and annual temperatures, maximum and minimum temperatures, and the precipitation for the same period.

The table of temperature, Table 1, shows that the decade average of the mean monthly temperatures for February is 7.65° F., with a maximum during July of 62.24° and an average annual of 36.07°. The monthly averages of the maximum temperatures for January is 38.1° and for July 85.8°, with an average annual of 36.7°. The lowest average monthly temperature for the same period is—27.5° for January, and for July 42.0°. The average minimum temperature for this ten years is—30.8°. The monthly averages for 5 months are below zero.

TABLE NO. 1.—MEAN, MONTHLY AND ANNUAL TEMPERATURES AND AVERAGES FOR 10 YEARS. PORT ARTHUR, 1896–1905.

Mean Temperatures in °F.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Ann'l mean.
1896	9.3	12.4	15.9	35.5	51.6	59.8	63.5	60.2	51.0	38.5	19.7	16.0	36.1
1897	6.9	13.2	19.5	36.1	46.5	53.7	64.0	59.6	57.0	44.4	23.1	11.3	36.3
1898	10.4	10.6	24.2	35.5	47.9	54.5	60.4	59.6	55.9	41.7	28.1	12.2	36.1
1899	3.2	1.4	9.9	36.3	46.6	55.9	61.8	60.8	48.8	44.3	36.7	14.3	35.0
1900	14.8	1.5	16.6	40.6	50.8	57.9	61.9	63.5	54.7	49.3	25.1	17.2	37.8
1901	7.6	5.6	17.8	38.3	49.2	56.8	64.0	62.1	52.6	42.3	24.7	12.1	36.1
1902	10.9	15.0	27.5	35.8	46.7	52.6	63.2	58.9	50.2	40.6	30.7	11.7	37.0
1903	7.8	7.9	24.0	35.2	46.4	56.9	61.8	57.3	50.0	43.4	26.0	7.5	35.4
1904	4.4	0.5	18.4	33.3	47.4	55.5	60.4	58.4	50.2	41.0	30.9	10.1	34.2
1905	4.4	8.4	21.6	35.3	45.8	54.6	61.4	61.4	54.6	40.3	26.9	18.7	36.1
Average	7.97	7.65	19.54	36.19	47.89	55.82	*62.24*	60.18	52.5	42.58	27.19	13.11	*36.01*
S. E. Michigan (Mean)	24.1	22.2	30.8	46.9	56.7	67.1	*71.9*	69.1	62.6	50.6	36.5	27.0	*47.2*

[1] For a general account of the Canadian climate see Stupart '98 and '05.

Highest Temperatures in °F.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Ann'l min'm
1896	36.0	47.0	47.0	59.0	89.0	88.0	91.0	87.0	77.0	66.0	46.0	47.0	91.0
1897	42.0	33.0	45.0	67.0	73.0	86.0	84.0	83.0	88.0	74.0	47.0	38.0	88.0
1898	35.0	38.0	43.0	60.0	76.0	80.0	85.0	82.0	78.0	64.0	61.0	43.0	85.0
1899	38.0	42.0	32.0	74.0	78.0	81.0	86.0	82.0	78.0	67.0	60.0	43.0	86.0
1900	46.0	32.0	54.0	66.0	84.0	83.0	86.0	82.0	78.0	68.0	57.0	40.0	86.0
1901	36.0	38.0	44.0	67.0	77.0	85.0	90.0	85.0	82.0	70.0	48.0	37.0	90.0
1902	35.0	41.0	49.0	69.0	81.0	76.0	83.0	80.0	71.0	64.0	53.0	34.0	83.0
1903	34.0	43.0	48.0	61.0	71.0	85.0	87.0	82.0	76.0	63.0	69.0	34.0	87.0
1904	37.0	33.0	41.0	66.0	81.0	80.0	84.0	81.0	70.0	65.0	48.0	44.0	84.0
1905	42.0	41.0	54.0	67.0	77.0	77.0	82.0	79.0	73.0	77.0	52.0	39.0	82.0
Average	*38.1*	38.8	45.7	65.6	78.7	82.1	*85.8*	82.3	77.1	67.8	54.1	39.9	*86.2*

Lowest Temperatures in °F.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Ann'l ma'xm
1896	-33.0	-26.0	-18.0	6.0	31.0	38.0	41.0	34.0	23.0	14.0	-21.0	-24.0	-33.0
1897	-30.0	-26.0	-15.0	2.0	26.0	28.0	50.0	37.0	25.0	20.0	-11.0	-21.0	-30.0
1898	-19.0	-26.0	-3.0	1.0	30.0	36.0	37.0	40.0	30.0	14.0	-11.0	-30.0	-30.0
1899	-37.0	-37.0	-17.0	8.0	27.0	37.0	43.0	41.0	20.0	24.0	-14.0	-22.0	-37.0
1900	-24.0	-30.0	-16.0	18.0	25.0	34.0	41.0	44.0	31.0	28.0	-4.0	-25.0	-30.0
1901	-25.0	-20.0	-26.0	16.0	29.0	32.0	42.0	40.0	28.0	20.0	0.0	-29.0	-29.0
1902	-30.0	-18.0	-11.0	5.0	23.0	34.0	44.0	39.0	25.0	21.0	-6.0	-20.0	-30.0
1903	-22.0	-31.0	-10.0	2.0	16.0	34.0	40.0	37.0	29.0	21.0	-8.0	-26.0	-31.0
1904	-34.0	-26.0	-13.0	12.0	25.0	37.0	40.0	35.0	30.0	20.0	-1.0	-23.0	-34.0
1905	-21.0	-24.0	-16.0	16.0	24.0	35.0	42.0	33.0	28.0	10.0	-12.0	-11.0	-24.0
Average	*-27.5*	-26.4	-14.5	8.6	25.6	34.5	*42.0*	38.0	26.9	19.2	-8.8	-23.1	-30.8

The precipitation during the same period is shown in Table 2. The minimum average monthly rainfall for the period is .002 inches for February, with a maximum of 4.25 inches in July, and an annual total of 21.73 inches, more than half of which fell during the growing season for the vegetation—June, July and August. The snowfall averaged a maximum for January with 4.59 inches and an annual total of 25.44 inches. The deep snows of this region are thus seen not to be due so much to the abundant precipitation as to its preservation by the low temperature.