AN ECOLOGICAL SURVEY

OF

ISLE ROYALE, LAKE SUPERIOR

PREPARED UNDER THE DIRECTION OF

CHAS. C. ADAMS.

A Report from the University of Michigan Museum, published by the State Biological Survey, as a part of the Report of the Board of the Geological Survey for 1908.

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LETTER OF TRANSMITTAL.

To the Honorable the Board of Geological Survey of the State of Michigan:

Gov. Fred M. Warner, President.
Hon. D. M. Ferry, Jr., Vice-President.
Hon. L. L. Wright, Secretary.

Gentlemen:—I beg to present herewith for printing, a report by Dr. Chas. C. Adams on the ecology, that is the natural history, of Isle Royale. This comes to us with the approval of Dr. A. G. Ruthven, our Chief Field Naturalist, and our Board of Scientific Advisers, and is a continuation of the work published in our annual report for 1905.

This contribution to the Biological Survey of the State, which the legislature authorized me to supervise by Act No. 250 of the session of 1905, comes from the University Museum. The explorations were made without expense to the State Survey by means of contributions from friends of the Museum. As this work is in harmony with the aims of the Biological Survey we are fortunate in securing such co-operation. The reports on the Porcupine Mountains and Isle Royale at the north end of the state complement the work on Walnut Lake, Oakland county, and that in Huron and Tuscola counties.

I trust that the present report will be of service to the schools of the state.

Very respectfully,
ALFRED C. LANE,
State Geologist.

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INTRODUCTORY NOTE.

Through the generosity of Mr. Bryant Walker, of Detroit, Hon. Peter White* and Mr. H. M. Kaufman of Marquette, the University Museum of the University of Michigan was able, in the summer of 1904, to send a party to the Porcupine Mountains and to Isle Royale, Michigan. The aim of the party was to collect specimens for the museum and to make an ecological survey of the regions visited. The party was only able to spend a few weeks on Isle Royale at that time, but through the continued generosity of Mr. White and Mr. Walker, the survey was continued during the summer of 1905. The present volume on the natural history of the island has resulted from these surveys.

To Mr. White and Mr. Walker the Museum is under special obligations for their hearty and substantial support, not only in the funds provided, but also for their aid in securing the transportation of the party. Many other individuals also assisted in various ways. Those who aided the party in the matter of transportation were: Mr. Henry Russel, of the Michigan Central Railway; Mr. Geo. T. Arnold, of the Union Ticket Office and Dock of Mackinac Island; Mr. H. H. Brigham, of the U. S. and Dominion Transportation Company ("Booth Line"); Mr. Henry Meyering, of the Graham and Morton Line; Mr. M. Adson, of the Duluth, South Shore and Atlantic Railway. The survey is furthermore indebted to Section Director C. F. Schneider of the Michigan Section of the Climatological Service of the U. S. Weather Bureau, for the loan of meteorological instruments; to Major Lansing H. Beach, Detroit, of the Light House Establishment, for permission and suggestions as to camping in the abandoned Light-house at Rock Harbor; to Mr. Geo. C. Stone, Secretary of the Washington Club of Duluth, Minn., for the use of their grounds and many favors from their care-takers, Mr. Chas. Preulx and Mr. Michael Hollinger; to Mr. K. Neutson, of Park Place ("Neutson's Resort"), Rock Harbor, Isle Royale, for many favors during the stay upon the island; to Mr. J. H. Malone, Keeper of the Isle Royale Light, and to his sons, particularly to the Assistant Keeper, Mr. J. A. Malone, for many favors and for their hospitality. It is a pleasure to have this opportunity of thanking these persons for their cooperation.

On the return of the party from the field, work was at once begun upon the collections, and in this a large number of specialists have aided by the determination of the specimens. Acknowledgements are made to such persons throughout the report and will not be repeated here. Those who were not members of the party, but who have prepared papers are: Mr. Bryant Walker, of Detroit, Michigan, Dr. W. M. Wheeler, American Museum of Natural History; Mr. A. P. Morse, Research Assistant of the Carnegie Institution, and Wellesley College; Dr. Jas. G. Needham, Cor-

*Recently deceased.

nell University; Prof. J. S. Hine, Ohio State University; Prof. E. S. Titus, Utah Agricultural Experiment Station; Dr. A. G. Ruthven, University Museum, University of Michigan, and Mr. A. B. Wolcott, Field Museum of Natural History.

The volunteer members of the Museum party should be mentioned in this connection: Dr. R. A. Brown, Dr. H. A. Gleason, Mr. W. P. Holt, Mr. Max Minor Peet, Mr. Otto McCreary, and the writer. It will be evident that the volunteer work of this report comprises the major part of it.

Personally the writer wishes to express his appreciation of the assistance of Mr. Walker and Mr. White; of the cooperation of the members of the party and the many specialists who have examined the specimens; and of the valuable suggestions and assistance of: Mr. Norman B. Conger, Inspector U. S. Weather Bureau, Detroit; Dr. Glover M. Allen, Boston Society of Natural History; Mr. Frank Leverett and Mr. F. B. Taylor, of the U. S. Geological Survey; Prof. H. F. Wickham, State University of Iowa; and to Mr. A. B. Wolcott, of the Field Museum of Natural History. Also to Dr. A. C. Lane of the Michigan Geological Survey for many favors and courtesies, including the preparation of the topographic map, and to Dr. A. G. Ruthven, Chief Field Naturalist of the Survey, for assistance in the publication of the report.

The shortcomings of this report will be no more evident to any one than to the writer. If, however, with its defects, it preserves some "vanishing data," and presents suggestions for the improvement of such ecological surveys, it will have served the purpose for which it was intended.

CHAS. C. ADAMS.

July 23, 1908.
Hull Zoological Laboratory,
University of Chicago.

ERRATA ISLE ROYALE REPORT.

Page 2, line 29, for *and the* read *for the.*
Page 5, line 30, for *sources* read *resources.*
Page 11, line 43, for *larger* read *large.*
Page 13, line 11, for *White Spruce* read *Black Spruce.*
Page 14, line 7, for *has been* read *had been.*
Page 15, line 16, for *Cicada* read *Tibicem.*
Page 16, line 40, for *anti-lion* read *ant-lion.*
Page 19, line 28, for *hardwood* read *hardwoods.*
Page 21, line 24, for *Hibbiscus* read *Hippiscus* (and elsewhere in the report).
Page 21, line 25, for *versicolor* read *pickeringi.*
Page 21, line 48, for *Limnaea* read *Lymnaea* (and elsewhere in the report).
Page 22, line 26, for *2F* read *26.*
Page 22, line 43, for *Aechna* read *Aeschna.*
Page 26, line 21, for *Grophaena* read *Gyrophaena.*
Page 27, line 2, for *billow* read *billowy.*
Page 29, line 14, for *Fig. 45* read *Figs. 45 and 57.*
Page 46, line 21, for *the bearing of the latter* read *their.*
Page 47, line 46, for *e* read *4.*
Page 48, line 14, for *Fig. 53* read *Fig. 55.*
Page 50, line 33, for *f* read *5.*
Page 61, line 28, dele (*Fig. 29*).
Page 63, line 10, dele *Fig. 36.*
Page 63, line 16, for *Lake* read *Lakes.*
Page 64, line 3, for *Fig. 22* read *Fig. 56.*
Page 65, lines 48 and 49, for *Formica adamsii* read *Formica adamsi.*
Page 65, lines 50 and 51, dele *No. 114.*
Page 77, line 27, for *Grophoena* read *Gyrophaena.*
Page 93, line 25, for *XI* read *VI.*
Page 110, line 6, for *condition of weather* read *condition of sky.*
Page 135, line 31, for *fostered* read *forested.*
Page 152, line 29, for *Burns, F. Z.* read *Burns, F. L.*
Page 158, line 43, transpose *Buprestids* and *Trichias.*
Page 159, line 9, for *Grophoema* read *Gyrophaena.*
Page 161, line 44, for *Their* read *their.*
Page 188, line 28, dele *William.*
Page 205, line 46, for *Bolitobius* read *Boletobius.*
Page 205, line 46, for *Ney Jersey* read *New Jersey.*
Page 257, line 17, read *Salticidae=Attidae.*
Page 261, line 43, for *Jassidaeae* read *Jassidae.*
Page 284, line 28, for *61-62* read *Figs. 61-62.*
Page 306, line 26, dele *3.*
Page 306, line 28, add *3.*
Page 306, line 29, add *S. elongata.*
Page 342, line 25, for *Fig. 45* read *Fig. 57.*
Page 350, line 35, add *Fig. 60.*
Page 354, line 17, add *Fig. 17*; line 20, dele *Fig. 17.*
Page 393, line 15, for *influences* read *inferences.*
Page 397, line 7, for *Canton* read *Caton.*
Page 407, line 26, for *J. N. Malone* read *J. H. Malone.*
Page 419, line 14, for *Hoops* read *Hoopes.*

ISLE ROYALE AS A BIOTIC ENVIRONMENT.

BY DR. CHARLES C. ADAMS.

I. INTRODUCTION.

1. Itinerary and Personnel of the Party. The University Museum party left Ann Arbor, Michigan, June 29, and reached the abandoned light-house at Rock Harbor, Isle Royale, on the morning of July 5, 1905. The party was composed of the following: N. A. Wood, Dr. R. A. Brown, Dr. H. A. Gleason, W. P. Holt, Otto McCreary, a camp hand, B. F. Savery, and the writer. In general, the duties of the various members were as follows: Mr. Wood, the Museum taxidermist, looked after the trapping of mammals and the preparation of bird and mammal skins. He was assisted by Dr. Brown, who gave most of his attention to the study of the bird life, and who remained with the party until July 25. In the study of bird life, Dr. Brown, Mr. Wood and Mr. McCreary co-operated, the latter devoting his entire time to the ecological phase of the work. Dr. Gleason devoted his attention to the collection and ecological study of invertebrates, particularly molluscs and insects, and most of the photographs were taken by him. In collecting insects about the camps, he was assisted by B. F. Savery. Mr. Holt's time was devoted to the study of the vegetation. The writer, who was in charge of the expedition, gave special attention to the environmental dynamics, biotic succession, and the general correlation of the work of the various members of the party.

During the stay at Rock Harbor, *Fig. 1*, the following localities were examined: The shore, from the light-house south to the head of Conglomerate Bay; the region about the head of Rock Harbor and Summer lake; a line from the mouth of Benson brook to Sargent Lake and McCargoe Cove.; and the vicinity of Tobin Harbor; in other words, the localities included in Stations I-IV.

The party remained at Rock Harbor from July 5 to August 1, and then moved to Siskowit Bay. Here Mr. Max M. Peet joined the party on August 8, and devoted his attention to collecting birds and mammals. He also took a number of the photographs. While at the Siskowit Camp, the bay and lake of that name were examined, and also the Haytown trail and the islands near the Isle Royale Light. All of these localities are included in Station V.

On August 17 the party moved to Washington Harbor, and was then partially disbanded. The members who remained made their headquarters on the grounds of the Washington Club, at the head of Washington Harbor. After September 5 Mr. Peet alone remained there until the 22nd, in order that he might continue the study of the fall migration

of the birds. He returned on the last boat of the season for Duluth, Minn.

During the previous (1904) season, the Museum party had made a general examination of the vicinity about Washington Harbor, so that it was now thought desirable to devote more time to other localities. With the exception of bird migration, no detailed work was done in this vicinity in 1905. In addition to the region about the head of the harbor, Lake Desor was also reached from this point by means of the road along the crest of the Greenstone Range.

2. *The Aim and Methods of Work.* The field work was conducted on the same general plan as that pursued during the previous season in the Porcupine Mountains and at Washington Harbor. Much more ground was covered, however, because it seemed improbable that a third trip could be made to the same region. It therefore seemed desirable to gain some idea of the biota of the island as a whole, because of its Canadian character. Even then, the survey was confined almost exclusively to the region south of the Greenstone Range.

As mentioned in the report for 1904 (Ruthven, '06, pp. 11-12), the aim of the work was not simply to collect specimens, but also to study the relations of the plant and animal life (the biota) to their surroundings. The environment as well as the biota was considered from a dynamic standpoint, and an effort was made to analyze the environment in order that the dominant conditions and processes of which it is composed might be recognized, and their laws of change be perceived and formulated. To resolve such a problem as this must of necessity require more time and detailed investigation than the possibilities of a few months work will permit, and yet it is equally evident that preliminary work should be carried on from a genetic standpoint, because such a method determines upon what facts emphasis should be placed, and the broader and more general relations, as well as the details, are equally subject to a genetic and dynamic treatment. In preliminary work of this character, it is considered of special importance to discover, if possible, the order of the major biotic successions, because these successions must be clearly perceived before their causes can undergo adequate analysis. Our knowledge of causes generally lags far behind our recognition of successions.

Thus throughout the study of the Isle Royale biota a special effort was made to investigate the genesis or successions of events. The environment has not been considered as limited to habitats alone, but also to include that greater unit, the geographic. To ignore this is to overlook the real background. It is believed that certain advantages are derived from this method of work, which, although they may be recognized from other points of view, are likely to be subordinated to other facts. It should not for a moment be thought that this method is considered as the only one of approach, but it appears to have certain advantages which seem to justify its adoption. Nor should it be inferred that the genesis of the biota and the habitat is all that should be included in an ecological survey. The problem of succession is only one of several which clearly show the intimate relations and responses between organisms and their environment; others that remain to be investigated involve physiological and structural changes, and various modifications of habit and behavior of both plants and animals.

The ecological relations in the north are so different, in some respects, from those farther south, that one may easily form an erroneous conception of the conditions under which such a preliminary investigation may be made. A very favorable condition for the work was the fact that practically all the time was devoted to it, instead of only occasional trips being made for the purpose, as is necessary with those busy with other duties. There are also certain advantages in being able to be in the field continuously, as a certain familiarity with conditions is acquired in the beginning, especially where the variety of forms is limited, which otherwise would involve time upon each visit. Although most of the members of our party were upon the island only during July and August, yet at this time those seasonal phenomena were concentrated which require much more, or several times that amount of time for their development farther south. The seasonal contrast is well illustrated when the summer season at the other extreme of the State of Michigan—500 miles away—is contrasted with that of Isle Royale. Such relations are further reinforced by the fact that the species and societies which are dominant in the various northern habitats are very much smaller in number than farther south. This necessarily simplifies the problem, and to a corresponding degree reduces the chances of error in anticipating biotic changes which are correlated with those of the environment. This is a relation of much importance in the study of succession. The writer was especially impressed with the *relative simplicity* of the problem of environmental relations and of the biotic succession upon Isle Royale, and has received further confirmation of the opinion that a tendency to exaggerate the complexity of the environment is prevalent.

An important aid in environmental analysis has been received from the effort to distinguish the major or geographic features of the gross environment from the minor habitat units which make up the mosaic or complex, although their mutual and genetic relations were not overlooked. Some of these relations have been well expressed by Montgomery in his comment on distribution ('06, p. 6) as follows: "And, as is always the case when the method has been consistent and scientific, the factors of distribution and the meaning of it will ultimately be stated in very simple form. These factors appear to us now to be enormously complex, but this is because we have hardly commenced to analyze them."

At this point it should be mentioned that there are certain difficulties which tend to confuse the field worker, which, if clearly understood, will often be of aid in ecological studies. In pursuing field studies, in addition to a knowledge of the species, one of the first essentials is a familiarity with the habits and habitat preferences of organisms; and further, there should be the ability to recognize how the dominance of one society is transformed into that of another. The lack of a sufficient power of constructive imagination makes the detection of such transformations very difficult, perhaps even impossible to some. This limitation almost completely restricts such a student to the purely descriptive phases of field ecology, because the explanatory phase lies beyond his grasp, although there remains for him a large

field for useful and valuable activity in the study of habitat preference, and the mutual relations of the associated species in given habitats. A familiarity with the forms studied, under diverse circumstances, develops a certain perspective which is a great help in preventing confusion caused by minor and relatively insignificant details.

The limited time spent in the present investigation did not permit detailed studies of the interrelations of the organisms within the habitat, either in their relation to the environment or to each other. In local studies attention is usually given to detailed life histories rather than to a deliberate study of their interrelations as members of a society. The emphasis which is sometimes placed upon individual life histories would lead one to expect that such histories could be assembled and would give us the same result as if they had been studied as a *society*. But the points of view are so different that such a result, although theoretically possible, is unlikely to be obtained. At this time we only wish to emphasize the fact that both methods should be used to secure the best results. For example, in applying these principles to the study of birds, the life histories of the *dominant* species of a society might first be given special attention. Then the relations of the *dominant* species to others of the association and to the environment may be determined and later on the subordinate kinds considered. This will involve prolonged study in the field (and laboratory) of the habits of nesting, feeding, rearing of young, etc., as influenced not only by other members of the same species, but also by other species in the same habitat. The same general method is applicable to other groups of organisms.

3. *Previous Biological Investigations upon Isle Royale.* Previous to the investigations by the Museum party in 1904, (Ruthven and others, '06) there seems to have been very little study of the Isle Royale biota. Several collections of plants and animals have been made, but very little has been published about them. In 1848 W. D. Whitney was "ornithologist and botanist" for the government geological survey parties, and he published a list of the plants found. (Foster and Whitney, '51, pp. 359-381). Incidental mention is also made in these geological reports of the collections of animals (Foster and Whitney, '50, pp. 17, 51, 201; Jackson, '49. pp. 423, 440, 441,); but, so far as known to the writer, no detailed reports were published.

So far as the vegetation is concerned, the most important source of information is the maps of the Ives Linear Survey. Here the general character of the forest, the extent of the swamps, and the underbrush are indicated. Mr. Henry Gilman ('73), of Detroit, made two visits to the island (one of which was in 1873), and his botanical and ethnological collections were presented to Columbia and Harvard Colleges. In 1890 Mr. F. E. Wood made a collection of plants from the vicinity of Rock Harbor and presented them to the herbarium of the Botanical Department of the University of Michigan; and in 1901 W. A. Wheeler ('01) published a short paper on some plants taken on the northeast end of the island.

The invertebrate fauna found in the deep water off Isle Royale was examined by Smith in 1871, and a list of Coleoptera from Isle Royale was published by Hubbard and Schwarz ('78). The writer has recently published a paper on certain phases of the problem of succession, as

illustrated by the birds upon Isle Royale. This paper, with some additions, is included in this volume. Detailed references to these papers will be found in the accompanying bibliographies.

From the above remarks, is it quite evident that very little attention has been given to the biological conditions of the island, and much remains to be done. In all probability other naturalists have visited the Isle, but I have not learned of their results.

4. *Historical Note.* The history of Isle Royale, since its cession by the Chippewa Indians in 1843, is, in brief, one of prospecting, mining explorations, fishing, summer resorts, and scientific surveys of the topography, hydrology, geology, and biology.

A general historical account is given in Lane's report ('98) on the geology of the island, and need be mentioned here only in outline. There is abundant evidence that in prehistoric times the Indians mined copper on the island. Within three or four years after the cession of the island to the United States, it was invaded by prospectors and explorers, so that by 1847, according to Lane, "the island presented perhaps as lively a scene as ever in its history." At this time the Linear Survey was made by William Ives. But this period of activity was only of short duration, for the decline was almost as rapid as had been the ascent, and by 1855 the "island was a desert once more, with no permanent inhabitants." (Lane). This passive condition of affairs lasted until the Lake Survey engineers arrived in 1867. This survey continued until 1871, during which interval explorations were somewhat revived, and continued for several years, only to be followed by another relapse and still another ascent in 1891, when a number of careful and detailed explorations were made for copper by means of the diamond drill. But this activity also ceased about 1892. A year later, and again in 1895, Dr. Lane visited the island for geological investigations.

The mineral sources are thus seen to have been the main attraction. The forest growth is too stunted and inaccessible to have merited the attention of lumbermen, although several timber prospectors were present during the summer of 1905. During more recent years the fishing and summer resort business have attracted some attention to the island, and have made it accessible during the summer through regular steamboat service. The climate, scenery and the fishing make the island very attractive as a summer resort, but it should be recognized that if the scenery is to be preserved the forests must be protected from fires, because reforestation is exceedingly slow on land with such a shallow soil. It is to be hoped that the geographic isolation may be a protection from such devastation, because the cool summer climate, the rocky coast, the forests, the picturesque scenery, and the surrounding Lake Superior, are natural features which should long remain attractive to summer visitors. If the interest in copper should revive permanently, the biota will become greatly modified, in which case some conception of the conditions upon the island in 1904 and 1905 will be preserved by these records.

[It may be of interest to note here that 86,000 acres of the island were for sale in the winter of 1908 for $150,000. Lane.]

5. *Available Maps of Isle Royale.* The available maps are not generally known to the public, and are therefore listed here, especially those which are of value from a biological standpoint.

1. The Ives Linear Survey Maps. Because of their large size (2 inches to the mile), and the details concerning the character of the swamps, the forest and the soil, this is the most useful map for the field. Photolithographic copies of the township maps, of which there are eighteen, may be secured for 25 cents each from the General Land Office at Washington, D. C.

2. The U. S. Lake Survey Chart of Isle Royale, (Catalog No. Sh.). This is very useful because it indicates the topography, in part by hachures, and gives the details of the coast, including soundings and the character of the bottom. A large tract of the interior, between lakes Desor and Chickenbone, is unmapped. This map may be secured for 25 cents from the Lake Survey Offices at Detroit and Duluth. An excellent chart of the entire Lake Superior basin may be secured from the same source.

3. Lane's Geological Map. Published by the Michigan State Geological Survey. It accompanies Lane's report ('98) on the geology of the island, and is on a scale of 5/8 of an inch to the mile.

4. Passage Island Topographic Sheet. This is the only sheet published by the U. S. Geological Survey which includes any part of Isle Royale, and it covers only the extreme northeastern end of the island. This may be secured from the Survey for 5 cents. The contour interval is 20 feet, and the scale one inch to the mile.

5. An English land company is said to own much of the island, and has published a map on a scale of 7/8 of an inch to the mile. The agent for this company is R. R. Goodell, Houghton, Michigan.

II. THE BIOTA CONSIDERED BY STATIONS.

1. *The Location of Field Stations in 1905.* As a detailed survey of the entire island was impossible, it was necessary to select representative localities and conditions, or habitats, and to devote to these all available time for study and collecting. In order to make sure that these conditions were representative, considerable care was necessary in locating these stations. In general a Station, in the strict sense, stands for a region, while a Substation refers to a particular habitat, usually of relatively limited extent. The character and extent of a Substation, (or, as it is generally called, for the sake of brevity, a "station,") was determined primarily by the relatively homogeneous character of the conditions. Thus a "station," as the Balsam-Spruce forest (V, 4) for example, varied somewhat in its extent with different groups of organisms. In the case of birds it included a greater area than was necessary for many invertebrates, such as land snails, but in every case such a "station" is intended to enable one to determine what organisms were dominant and characteristic of such a sample situation.

Some such system of sampling is generally advantageous or necessary, and this is particularly essential in the case of a surveying party, in order to give definiteness and co-ordinated activity to their work, particularly if the results are to be made at all comparable. Of course some individual judgment is necessary in applying such a plan to different groups, but no more perhaps than is necessary to carry out any other comprehensive plan.

1. Location of Field Stations, 1905.

Station I. Light-house Peninsula, between Rock Harbor and the head of Conglomerate Bay, Sec. 26 and N. E. ¼ Sec. 34, T. 66 N., R. 34 W.

Sub. 1. Lake and Bay Beaches.
Sub. 2. Natural Rock Clearings, N. E. ¼ Sec. 26.
Sub. 3. Balsam-Spruce Forest, N. E. ¼ Sec. 26.
Sub. 4. Tamarack, and Arbor Vitae Swamps, Sec. 26.
Sub. 5. Jack Pine Ridge, S. W. ¼ Sec. 26 and S. E. ¼ Sec. 27.
Sub. 6. Sphagnum-Spruce Bog, S. W. ¼ Sec. 26 and S. E. ¼ Sec. 27.
Sub. 7. Light-house Clearing, N. W. ¼ Sec. 26.

Station II. Rock Harbor and McCargoe Cove Trail, Sec. 27, 22, 21, 20, 29, 30, T. 66 N., R. 34 W., and Sec. 25 and 26, R. 35 W., T. 66 N.

Sub. 1. Benson Brook and Ransom Clearing (outlet of Benson Lake), N. E. ¼ Sec. 27 and S. E. ¼ Sec. 22, T. 66 N., R. 34 W.
Sub. 2. Tamarack Swamp, S. W. ¼ Sec. 22 and S. E. ¼ Sec. 21, T. 66 N., R. 34 W.
Sub. 3. Rock Ridge Clearings (burned over), Sec. 21 and 20, T. 66 N., R. 34 W.
Sub. 4. McCargoe Cove, at end of Trail, N. E. ¼ Sec. 26, T. 66 N., R. 35 W.
Sub. 5. Forbes Lake, N. E. ¼ Sec. 28, T. 66 N., R. 34 W.

Station III. Western End of Rock Harbor, Sec. 28, 33 and 32, T. 66 N., R. 34 W., and Sec. 5 and 4, T. 65 N., R. 34 W.

Sub. 1. Small Island, S. E. ¼ Sec. 32.
Sub. 2. In Harbor at West end of Island, Sub. 1.
Sub. 3. Bulrush Zone and Delta, Sec. 32, T. 66 N., R. 34 W.
Sub. 4. Trail to Sumner Lake, Sec. 33, T. 66 N., R. 34 W.
Sub. 5. Sumner Lake, Sec. 33 and 34, T. 66 N., R. 34 W.
Sub. 6. Southwest Coves of Rock Harbor, Sec. 5 and 4, T. 65 N., R. 34 W.

Station IV. Tobin Harbor and Vicinity, T. 66 and 67 N., R. 33 W.

Sub. 1. Scovill Point, Sec. 26 and 35, T. 67 N., R. 33 W.
Sub. 2. Island No. 14, Sec. 26, T. 67 N., R. 33 W.
Sub. 3. Bayou, North of Monument Rock Trail, N. W. ¼ Sec. 34, T. 67 N., R. 33 W.
Sub. 4. Trail to Monument Rock, N. W. ¼ Sec. 34, T. 67 N., R. 33 W.
Sub. 5. Clearing at Neutson's Resort (Park Place), Sec. 4, T. 66 N., R. 33 W.
Sub. 6. Small island in Tobin Harbor, Sec. 5, T. 66 N., R. 33 W.
Sub. 7. Head of Tobin Harbor, Sec. 7, T. 66 N., R. 33 W.
Sub. 8. Trail to Greenstone Range, Sec. 7, T. 66 N., R. 33 W., and Sec. 12, T. 66 N., R. 34 W.
Sub. 9. Mountain Top, Sec. 12, T. 66 N., R. 34 W.

Station V. Siskowit Bay, Lake and Vicinity.

Sub. 1. The Beach, (at camp), Sec. 32, T. 65 N., R. 35 W.
Sub. 2. Heath Zone and Beach, Sec. 33, T. 65 N., R. 35 W.
Sub. 3. Rock Clearing (at camp), Sec. 32, T. 65 N., R. 35 W.

Sub. 4. Trail through Balsam-Birch Forest, Sec. 32 and 31, T. 65 N., R. 35 W.

Sub. 5. Tamarack Swamp, N. W. ¼ Sec. 32, T. 65 N., R. 35 W.

Sub. 6. South Shore of Siskowit Lake, Sec. 31 and 32, T. 65 N., R. 35 W.

Sub. 7. Haytown Trail, from Siskowit Lake, West Line of Sec. 24, across Sec. 13, T. 65 N., R. 36 W., cf. Lane, '98, pl. XI.

Sub. 8. Arbor Vitae Swamp, at end of Haytown Trail, N. W. ¼ Sec. 13, T. 65 N., R. 36 W.

Sub. 9. Outlet of Siskowit Lake, N. W. ¼ Sec. 36, T. 65 N., R. 36 W., and Sec. 31, T. 65 N., R. 35 W.

Sub. 10. Long Island Gull Rookery and Menagerie Island, T. 64 N., R. 35 W.

Sub. 11. Tamarack-Spruce Swamp, Sec. 33, T. 65 N., R. 35 W.

The following stations were examined by the Museum party during the season of 1904. Part of these Stations were re-examined and will be referred to by Station number and date, thus: Sta. I, '04.

Station I, '04. Clearing on the Shore of Washington Harbor, Sec. 29, T. 64 N., R. 38 W.

Station II, '04. Washington Creek, Sec. 29, T. 64 N., R. 38 W.

Station III, '04. Trail along the top of Greenstone Range (Desor Trail). T. 64 N., R. 37, 38 W.

Station IV, '04. Washington Brook, Secs. 28 and 32, T. 64 N., R. 38 W.

Station V, '04. Tamarack Swamp, Sec. 20, T. 64 N., R. 38 W.

Station VI, '04. South of Greenstone Range, Sec. 32, T. 64 N., R. 38 W.

Station VII, '04. Lake Desor, T. 64 N., R. 32 W.

Station VIII, '04. Western end of Siskowit Bay, Secs. 27 and 28, T. 64 N., R. 37 W.

Station IX, '04. Southwestern end of Minong Trap Range, Sec. 30, T. 64 N., R. 39 W.

Station X, '04. Washington Harbor, T. 64 N., R. 38 W.

2. *General Characteristics of the Stations.* In this section, I do not aim to give a completely correlated account of the biota of each station, but to present a general idea of the main characteristics of the various situations examined, and some of their common and representative plants and animals. Photographs illustrating the characteristics of the various "stations" will accompany this section, and should be consulted in connection with the text.

Station I, Substation 1. The Lake and Bay Beaches. This "station" includes the shore line from Rock Harbor, near the light-house, *Fig. 1*, to the head of Conglomerate Bay. The entire shore was not studied in detail, as most of the time was devoted to the beaches which are being formed at the heads of the coves and bays. Quite a variety of conditions are represented along this shore, due not only to the degree of exposure to the waves of Lake Superior, but also to the character of the rocky coast itself. All degrees of shore and beach are developed, from overhanging and vertical cliffs, *Fig. 2*, with bases strewn with large blocks lowered by sapping, to a shore line with a low angle strewn with shingle and gravel, and a sandy beach, as found at the head of Conglomerate Bay. In harmony with the dip of the rocks and the effect of the

glacial ice movement upon the valley slopes, which tend to be gentle on the southeastern side, the corresponding shores of the bays and coves are usually at a low angle, except possibly where faulting has taken place, or a wave cut terrace has been developed. The northern sides of the bays are comparatively abrupt, and there is thus a tendency for the cliffs to occur mainly upon the northern slopes and shores. The larger bays are the submerged portions of the valleys, mark the location of the less resistant rocks, and are inherited topographic features; but many of the minor coves and the rocky headlands have been carved by the activity of the present lake. The beaches are only developed at the heads of the coves and bays, and are very largely composed of shingle and gravel. The only extensive sand beach seen was at the head of Conglomerate Bay. The character of the material composing these beaches clearly shows its local origin, and emphasizes the isolation which prevents long shore transportation of such material. Thus only floating material is liable to extensive long shore dispersal, a significant fact that bears upon the dispersal of the snail life along the shore.

During severe storms, the wave action upon this coast is quite intense and even the waves of the summer storms are quite active, as may be seen by referring to *Fig. 3*. The blue deep lake water comes close up to the shore, so that generally no breaker line is developed off shore. In several places there are numerous reefs or islands (usually the isolated continuations of the rock ridges), which tend to break the force of the waves rolling in from the open lake.

No effort was made to study the life of the open lake, only the shallow water of the bays and coves being examined. The major environmental features of the coast are the Lower, Middle and Upper Beaches; but these are only differentiated clearly at the heads of the coves and harbors. The Lower and Middle Beaches are only seasonal expressions of the same phenomena, but ecologically they are fairly distinct.

The Lower Beach. This beach extends from the shallow water to the upper limit of the summer waves. The submerged portion is not sharply defined above on account of the changes in level of the water surface, due to waves, the periodical and seasonal fluctuations, and the atmospheric pressure (seiches). In time there has been a downward migration of the entire beach zone, a tendency which is in part counteracted by the northward elevation of the land. This is the zone dominated by water, ice, and wave action. It is certainly a sharply defined tension line upon an exposed coast, which clearly suggests that it is not probable that many forms of animals have made the transition from fresh water to the land under such conditions. If we consider the shore habitats as including all stages from a rock cliff to the sand beach, the lower beach and the protected shores are the most favorable aquatic habitats upon such shores.

Upon the sloping rock, shingle, gravel and sand beaches is found a varied fauna. In winter, when the bays are frozen over, a calm is produced which must be favorable to the preservation of the aquatic life upon this stormy coast.

The general character of the sandy beach at the head of Conglomerate Bay is shown in *Fig. 4*. The life of the submerged portion of the shore is quite limited, except on the beaches and protected portions. The vege-

tation consists of algae, which grows in moderate abundance, though not luxuriantly, as found about the Gull Rookery (V, 10), or at the fishermen's camp at Rock Harbor, a fact which suggests that the abundance of suitable nitrogenous material is much greater in such places than in the open lake water. With the development of the fall storms, Mr. J. A. Malone states that these rocks (V. 10) are washed free of the algae, thus evidently necessitating a repopulation of these surfaces each season.

The characteristic fauna secured in the shallow water shore margins were the snails, *Limnaea stagnalis, L. emarginata*, and *Physa sayii*. A small fish, the Miller's Thumb, *Uranidea franklini*, is also fairly abundant and characteristic of this shore.

Upon low rocky shores beach pools, *Fig. 5*, are occasionally found which, when favorably located, are supplied with water by the ordinary summer waves, otherwise by storm waves and rains. The precarious existence of life in such places is indicated by the general type of the fauna, which shows exceptional power of locomotion, usually coupled with a short life cycle. The immature stages of insects are rather characteristic, as shown by nymphs of the water boatmen, *Corixa*, dragonflies and Caddis fly larvae. Water beetles were represented by *Rhantus binotatus*, and the snails by *Limnaea emarginata* and *Planorbis parvus*. The Gulls and Spotted Sandpipers should be mentioned as birds which frequent these conditions.

The Middle Beach. This beach occupies the strip of shore over which the winter waves retreat as they fall to the upper summer storm limit. It is thus seen that the Middle Beach is only a temporary or summer abandonment of part of the upper shore, which is repeatedly claimed by the winter waves. In summer this strip is exposed to denudation; in the fall and early winter, to the fury of the waves, and, later, it is covered with ice. Driftwood and debris tend to lodge here and to accumulate. It is an important region of biotic invasion for land forms. Beach pools are also developed in this area, upon the abandoned wave cut terraces of earlier lake levels. Upon the cliff faces, sloping rock shores and shingle beaches, little is found that is favorable to life, but upon the protected sand of the Middle Beach, relatively favorable conditions for many organisms are found during its period of exposure. The character of the substratum of the Middle Beach varies from rock to shingle, gravel and sand.

The characteristic features of the vegetation, where the wave action is not too severe, are the fruits which are washed ashore by the waves, together with certain annuals and lichens. The fauna varies with the character of the conditions. The open character of this beach and the relative abundance of animal food makes such situations favorable for spiders of the genus *Pardosa*. The same open character makes the shores a favorable patrol for certain butterflies, particularly *Basilarchia arthemis*. Insects and snails washed ashore by the waves also characterize this habitat.

The Upper Beach. This part of the beach is beyond the reach of the waves, and forms the transition between the open beach area and the inland forests. The width of this belt varies greatly with the gradient of the shore. Where the beach is continuous with a more or less bare rock

ridge, this habitat may be rather extensive and ill defined, as at the ridge south of the light-house (I, 2), but when it borders a depression, as at the head of the rockbound coves, or where a beach is well developed, this transitional zone is more clearly defined and limited. When this beach is wide and grades into the rock openings, as in *Figures 6 and 7*, the crustaceous and foliaceous lichens grow upon the rocks; but if soil accumulates, as is shown in *Fig. 6*, the *Cladonia*—Bearberry society becomes established, and includes some annuals, such as *Solidago*. A limited variety of insects, especially ants, characterize such conditions. When adjacent to the forests, in depressions, this beach is generally bordered by alders, some aspens and young trees.

The fauna consists largely of insects, such as butterflies, certain dragonflies and Hymenoptera, which frequent the open places on wing.

Station I, Substation 2. Natural Rock Clearings. This Station consists of two small rock openings, one just north of the light-house, and the other south of it, on the north side of the entrance to Tonkin Bay, only a short distance from the light-house. They were both park-like avenues extending along the ridges, largely bordered by the Balsam-Spruce forest.

The north ridge will first be considered. The general character of the opening is well shown in *Fig. 8*. The White Spruce, Balsam, Paper Birch and Arbor Vitae bound the ridge on either side, within which there is a distinct heath zone of Bearberry and patches of *Cladonia*, while along the central aisle there is a shallow residual and humic soil on the almost bare rock. The south slope is rather gradual, but the north slope and the end of the ridge at the shore form a cliff.

The fauna of this location was limited. Snails were found among the *Cladonia*, such as *Vertigo, Zonitoides arborea* and *Pyramidula cronkheitei anthonyi*. This was also a runway for Hares.

The south opening or clearing is situated on a low sandstone ridge which slopes down to the beach, and is thus in marked contrast to the north clearing, which ended in a cliff. This gradual slope beautifully illustrates the transition from the bare rock beach, through the moss and lichen zone, to the *Cladonia*, Bearberry and *Solidago* flora, (*Figs. 6 and 7*), and on to the crest of the ridge, *Fig. 9*, with its dominance of *Cladonia* and Bearberry. The severity of the conditions is furthered by the weathering of the sandstone into thin scale like layers, about ¼ of an inch thick, which become loosened and slide down the slope. Thus a vegetation may become fixed to the rock surface, but not permanently to the slope. These scale like fragments are shown in *Fig. 6*. That a greater amount of vegetation would grow here, if the soil were allowed to accumulate, is shown in Fig. 6, where such conditions have been produced by the presence of a larger boulder. The *Cladonia*-Bearberry avenue extends along the crest of the ridge, *Fig. 9*. This is bounded by large Jack Pines near the beach, and farther from the shore by the Balsam-Birch forest.

The zonal distribution on the ridges is quite marked; the central strip is composed of *Cladonia*, Bearberry, *Solidago*, and *Linnea borealis;* while this is bordered by a shrub zone composed of *Juniperus nana*, alder, Arbor Vitae and young Balsams, and a bordering tree zone is composed primarily of Balsam. When once the shade of the forest, es-

specially that of the Balsams, encroaches upon the *Cladonia* society, the Bearberry first becomes reduced in number, and is then replaced by *Aster macrophyllus*, and a moss from the forest floor. The former is perhaps the most striking and characteristic shade plant upon Isle Royale. The succession, or order of invasion on the ridge, from the *Cladonia* to the Juniper and into the Balsam forest, is thus briefly shown in the transverse section from the central ridge to its margin. This zonal phenomenon, as will be seen later, is only an expression of the relative rates of invasion, and is not a phenomenon separate from the normal succession.

The soil upon the top of the ridge is about two inches deep. It is residual, supplemented by the humus from a now extinct crustaceous lichen society (that of the *Cladonia*-Bearberry), and at its margins by the Juniper, Balsam, Birch and Jack Pine leaves and debris and further, to an important degree, by the excrement of the numerous Varying Hares which frequent the rock ridges.

In the case of rock ridges which entend down to the beach and are thus in direct communication with the shore drift, conditions exist which show how such ridges may have been invaded by lichens from two sources—the shore drift and the exposed beach itself—because of the continuity of the rock habitat. Of course possibly another origin is to be found in the fact that this ridge was itself once a beach. Ants, grasshoppers and a few other insects characterize this fauna, which is limited in variety, but fairly abundant in individuals. The Hares are abundant and form distinct paths or runways, as shown in *Fig. 9.*

Station I, Substation 3. Balsam-White Spruce Forest. This station included the forest traversed by a blazed trail from near the southeastern part of Sta. I, 2, and extended northward to the clearing about the light-house (I, 7), and beyond it to the north rock clearing (I, 2). Most of the region occupied by the forest is of low relief, with an occasional low rock ridge or hill. The dominant tree was the Balsam Fir, with much Paper Birch and White Spruce. Where the forest was very dense, especially if due to the number of Balsams, the ground was densely shaded and there was almost no herbaceous ground cover; but wherever there was a small opening, due to a fallen tree, or where one had been cut down, there was an abundant growth of Large-leaved Aster and White-flowering Raspberry; and it was in the midst of such conditions that young Balsams abounded. These were very characteristic plants in such conditions. In most cases a thick layer of humus covered the ground, but the tree growth was of small size. The common size of the Balsam was about 4 inches, the larger ones reaching 8 to 10 inches. The Birches averaged larger, usually about 6 inches. No evidence of burns were seen, but probably many trees have been cut from this vicinity, because of its proximity to the light-house, and the former Indian campground now occupied by the fishermen. The Balsam appeared to become dominant at this place, as more young trees of this species were seen than of any other.

The fauna found in this forest was rather limited, and doubtless great numbers of the insects which were taken in the clearing about the light-house (I, 7), bred in the adjacent forests. This is particularly true of the Cerambycids and other wood infesting beetles, the wood-boring

Hymenoptera (*Urocerus*), and their parasites. In addition to such species as feed upon Balsam, White Spruce and Paper Birch and their associated vegetation, there were those animals which are dependent upon the shade, moisture, soil, decaying logs and other features associated with forests. To this class belong certain insects which frequent decaying timber or the fungi growing upon them, and the earthworms of the soil, the ground beetles or Carabids, and the ground-inhabiting spiders, Lycosids. Some of the birds found were: Chickadee, Red-breasted Nuthatch, Golden-crowned Kinglet, Whitewinged Crossbill and Purple Finch.

Station I, 4. Tamarack and Arbor Vitae or White Spruce Swamps. This swamp is located in one of the valleys near the head of Tonkin Bay, and extends back from the bay about one-fourth of a mile. It begins just back of the beach and is bordered by a strip of Alders, Paper Birch, Mountain Ash, young Balsams and White Spruces. The rock walls of this valley are about 75 or 100 feet apart and are well shaded and covered by lichens and mosses, the south surface largely by lichens alone. Back of the marginal beach strip above mentioned, comes the dense growth of very large Arbor Vitae trees, intermingled with numerous large fallen trunks, partially decayed and covered with a dense growth of mosses. In the dryer places the ground is covered with a dense litter, and a thick damp or wet mass of mosses, but no pools of water. The undergrowth is composed of young Balsams, Birch and Ground Hemlock, *Fig. 10.*

Proceeding farther up the valley, the Arbor Vitae is replaced by Balsams and Paper Birch; the forest is more open, and the amount of moss on the ground is greatly reduced, and is replaced by a growth of Large-leaved Aster and large quantities of Ground Hemlock—all of this vegetation being indicative of mesophytic conditions. In this region there are scattered pockets or small pools of water containing dogwoods. Still farther up the valley the Balsams and Arbor Vitae continue and Tamaracks are added, but no standing water was found. The valley turns, and returns to the bay on the north side of the ridge which bounds the Arbor Vitae swamp on the north; the entire basin is thus somewhat horseshoe shaped. The returning section becomes almost pure Tamarack and contains numerous small pools of water. The conspicuous feature of this environment is its jungle-like character, the rapid accumulation of litter and humus, and the damp substratum.

The fauna of such a bog is surprisingly limited in variety and amount. A few shells were found, as *Pyramidula cronkheitei anthonyi* and, in the small pools, *Pisidium*. The large numbers of Mosquitoes and Black Flies made up for all deficiencies, and were almost intolerable. The birds frequenting this forest were the Red-breasted Nuthatch, Black-throated Green Warbler and Chickadee.

Station I, 5. The Jack Pine Ridge. This ridge is located near the mouth of Conglomerate Bay, on the north shore. Some general idea of the location is given in *Fig. 11*, which is a view looking toward the head of Conglomerate Bay. Just back of the beach, on an outcrop of conglomerate, was a small rock clearing, with *Cladonia*, *Juniperus nana*, and a wild rose. From here the trail extended through a narrow strip of forest, composed of Balsams, White Spruce and Arbor Vitae, with an

undergrowth of Balsam, Mountain Alder, and a ground cover of Large-leaved Aster, and passed on through a belt of young growth of Birch, with the usual White-flowering Raspberry and Large-leaved Aster, *Fig. 12*, and up the face of an escarpment to the crest of the ridge, which had a height of about 100 feet above the lake level. From the abundance and characteristic growth of Jack Pines on this ridge, the station takes its name. Part of the ridge has been burned over, as was shown by the burned and fallen timber, but the part to which our attention was given was apparently an original growth. The Jack Pine was scattered, and largely occupied the depressions and the larger crevices. The ridge is fairly flat topped, but is occasionally broken by transverse gullies, which contain Aspens, Birches, etc. The surface of the lava has weathered but little in some places, the original *roche moutonées* surface being very clearly preserved, and the planed glacial surface but little eroded. Near the escarpment, however, disintegration and decomposition have been much more active, probably influenced in part by lake waves at former levels, thereby developing a talus slope, composed of angular blocks, and in some places forming a stony soil. All intermediate stages are found between these two extremes. In addition to the large amount of bare rock surface, and that covered by only a thin layer of soil and vegetation, the shallowness of the soil is further evidenced by overturned trees, *Fig. 13*. This soil is of residual and organic origin, the crustaceous lichens and the Cladonia-Bearberry society, and later the Jack Pines, having contributed much to its formation. The excrement of the Hares has also been an important factor in soil formation, and that of the Lynx also, though to a much less degree.

The process of weathering must be relatively rapid on this ridge, because it is exposed to the winds at all seasons of the year, and to the marked seasonal and daily changes of temperature. The heat of the noonday sun is excessive, and the radiation from the nearly bare rock must be rapid, as it also is at night, so that the various influences consequent to temperature changes are allowed full play. Weathering is further favored by the irregularities of the surface, and the crevices, which allow the accumulation and downward conduction of this moisture, thus permitting the prying action of ice.

In general, the succession of plant societies on this ridge appears to be about as follows: Lichens are the pioneers on the rock surface, and these may be of several species, *Umbilicaria*, and the crustaceous and foliaceous forms. As a soil develops in the crevices or on the surfaces, these are followed by *Cladonia*, Bearberry, *Sibbaldiopsis tridentata*, *Solidago*, *Diervilla diervilla* (Bush Honeysuckle); and later, when the soil becomes deeper, by *Amelanchier*, *Prunus pennsylvanica* (probably dispersed to these ridges by birds) and *Juniperus nana*. The presence of the Small-toothed Aspen, willow and an occasional Birch probably indicates the next society. In the shade of the Birches and Jack Pines *Solidago* and *Aster macrophyllus* occur, if sufficient soil is developed. From the character of the vegetation in the ravines which traversed the ridge, and upon the talus slope toward the bay, it is apparent that the next society tends to be that of Birch and Aspen with some Balsam, Pennsylvania Cherry, Mt. Alder; and a ground cover of Large-leaved Aster, Large-flowering Raspberry, Ground Cornel and *Lycopodium*. It

is clearly seen that among these there are several elements of the Balsam, White Spruce and Birch forest society, which tends to ultimately possess the ridge.

The fauna of the ridge is quite diversified, and there is a general faunal correlation corresponding with these successions of the vegetation. Thus during the Lichen-Heath stage, ants and spiders, certain shells, and grasshoppers are abundant. As the soil becomes thicker or the crevices deepen, a subterranean fauna, consisting of myriapods, earthworms, etc., develops. As shrubs and trees encroach in patches, the animals frequenting the open tend to perpetuate themselves mainly at the open margins. From this condition on, so far as the fauna is concerned, it is largely a question of an "opening" or a forest environment. So long as this habitat remains open, the grasshoppers, ants, spiders, butterflies, flies, and certain Hymenoptera, Hares and Bats are characteristic, and this condition tends to continue as long as the trees are scattered. The *Cicada* is very characteristic of the Jack Pine stage, and although it occurs elsewhere in young Birches it is not so characteristic as on these hot ridges. With the advent of the Balsam-Birch society, which is slowly encroaching upon the ridges, the forms frequenting the open will disappear, or linger in the open spots where local conditions have retarded the advance of the forest. Only a few birds were seen here, but Hares had been numerous, as was shown by the large amount of excrement, and there was similar evidence of the occurrence of the Lynx. A bat was flushed from under a stone at the edge of the escarpment.

Station I, 6. Tamarack-Spruce Bog. This is a very small bog located at the base of the north slope of the Jack Pine Ridge (I, 5), and roughly estimated as about 250 by 300 feet in extent. The central part is covered with sphagnum, Cassandra, and a scattered growth of Labrador Tea. Widely scattered throughout the bog occur Tamaracks and Black Spruces, small Birches, Dwarf Cranberry, Cotton Grass and alders. No standing open water was found in this area, nor was the bottom quaking. Bordering the sphagnum zone is one of alders, willows, and a tall grass which merged into a zone of Tamaracks, willows, alders, Cassandra and Balsam, *Fig. 14*. Along the western end a narrow strip of water, a few inches deep, was found, which flowed through a ravine across the ridge. Along this outlet the deeper soil and moisture has permitted the development of Balsam, Birch, Small-toothed Aspen, Mt. Maple, Ground Hemlock, Ground Cornel, Large-leaved Aster, and a few Black Ash trees.

The fauna, like the vegetation, was not studied in detail, but the following general relations were observed. In the open central Sphagnum-Cassandra society were numerous large ant nests. A Toad was observed here; and the following birds: Golden-crowned Kinglet, White-throated Sparrow, Cedar Waxwing, and Black-throated Green Warbler.

Station I, 7. Light-house Clearing. This was a small clearing which has been made about the Light-house: it connects by a path to the fishing camp on Rock Harbor. It covers about half an acre, and was originally, in all probability, a Balsam and Spruce forest like the surrounding forest. A sod covered much of the ground, and there were numerous

weeds, of which the Cow Parsnip umbels furnished excellent places for collecting Syrphid flies, Cerambycid beetles and Hymenoptera.

The fauna of this clearing consisted largely of insects which frequent flowers, and butterflies which fly in open places; but a few animals were found about the Light-house itself. The Chipping Sparrow bred in this clearing. *Fig. 1.*

Station II. This station included the clearing at the mouth of the stream which drained Lake Benson, and which we called Benson Brook, and followed the blazed trail to Sargent Lake, and on to McCargoe Cove. The clearing at the beginning of the trail at Rock Harbor marks the site of the former settlement called Ransom on the old maps.

Station II, Substation 1. Ransom Clearing and Benson Brook. The clearing was occupied by scattered Small-toothed Aspens and Birches, and was well sodded with grass and Red Clover. Our attention was called to this locality because of the great number of Garter Snakes (*Thamnophis sirtalis*) which were found there. These snakes were very abundant in a small area east of the mouth of the brook, in a rank growth of grass and among some rails.

The brook contained but little life, although it was carefully examined near its mouth and farther back where the trail crosses the brook. Only a few dead *Physa* were found, and a young fish, at the mouth of the brook.

Station II, Substation 2. Tamarack Swamp. This is a long swamp which is crossed by the trail, and which contains a scattered tree growth of Tamaracks, Black Spruces and Arbor Vitae, a dense shrub growth of Cassandra and Labrador Tea, and a ground cover of Sphagnum and Pitcher Plants. While no water was seen on the surface, it was a wet swamp.

This locality was only examined for birds and mammals.

Station II, Substation 3. Rock Ridges. This station number is given to the open rock ridges which were crossed by the trail between II, 2 and Sargent Lake. These ridges have been burned over and are largely destitute of soil and the *Cladonia* growth usually found on other rock ridges. Small-toothed Aspens generally border these ridges which have a northeasterly southwesterly direction. The heat during the middle of the day is excessive. The scant vegetation which grows in some crevices and depressions in the rock leaves an open area which is decidedly favorable for grasshoppers. In some places they were exceedingly abundant and many ridges were examined almost solely for their grasshopper fauna. In the dry soil on one ridge an ant-lion larva was found in the dust at the base of its funnel, and a large Garter Snake was taken on another. The grasshoppers found here were *Chlocaltis conspersa* and *abdominalis*, *Circotettix verruculatus*, *Melanoplus alaskanus* and *fasciatus*.

Station II, Substation 4. McCargoe Cove. This station simply marks the location of the end of the trail, and the cove where a few molluscs were found. There were dead shells of *Anodonta grandis footiana*, which were abundant at the edge of the water. Here upon the low rocky shore were also found specimens of *Limnaea stagnalis*.

Station II, Substation 5. Forbes Lake. The examination of this small lake was mainly confined to the north shore, as the south shore

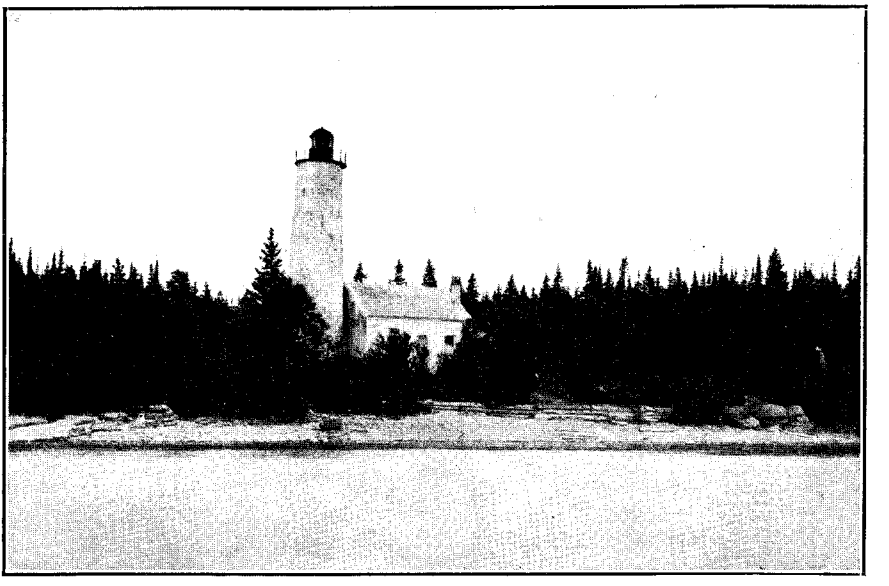

FIG. 1. THE LIGHT-HOUSE AT ROCK HARBOR, ISLE ROYALE.

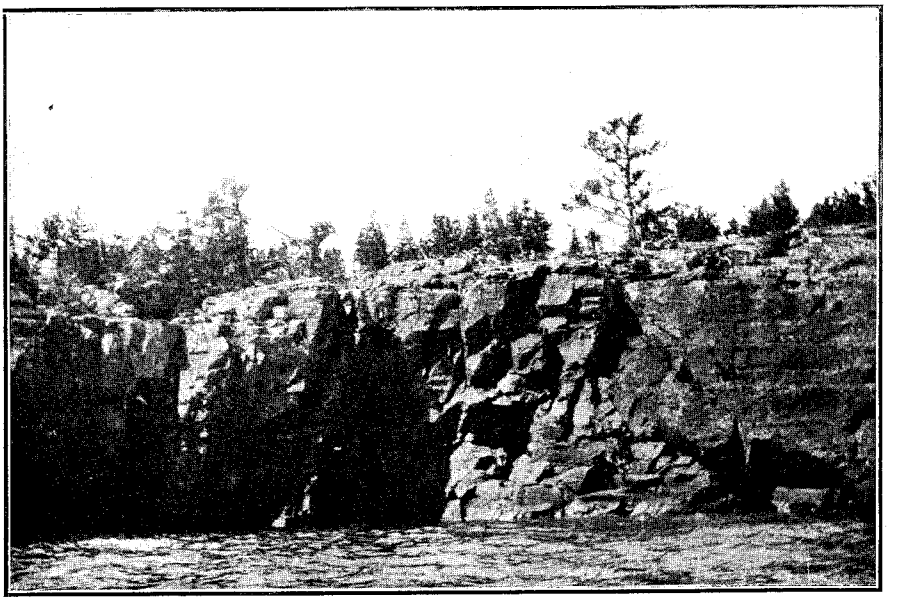

FIG. 2. CLIFFS BETWEEN TONKIN AND CONGLOMERATE BAYS.

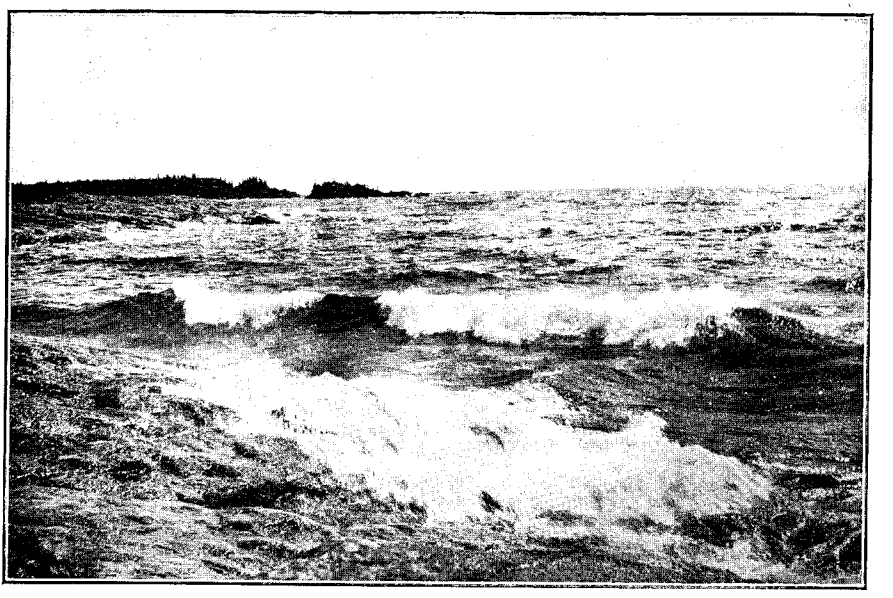

FIG. 3. SUMMER STORM WAVES UPON THE BEACH (I, 1) AT THE HEAD OF TONKIN BAY, SOUTH OF THE LIGHT-HOUSE.

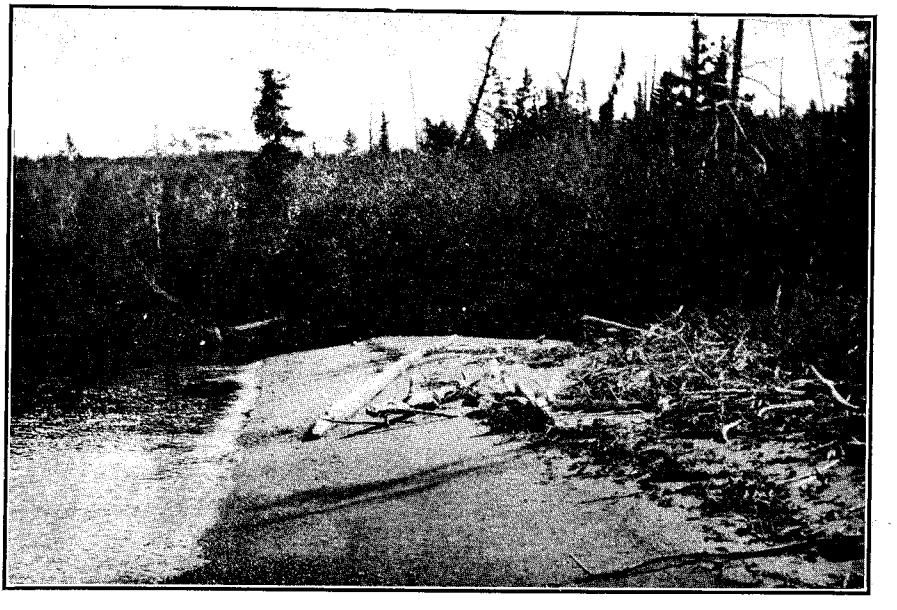

FIG. 4. SAND BEACH AT THE HEAD OF CONGLOMERATE BAY (I, 1).

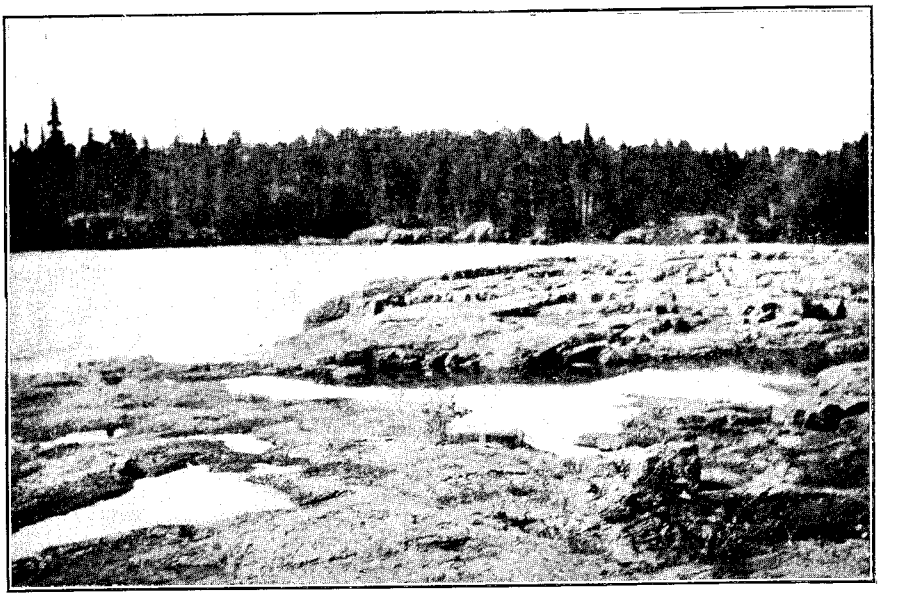

FIG. 5. BEACH POOL (I, 1) NEAR TONKIN BAY.

FIG. 6. TRANSITION FROM THE BEACH (I, 1) TO ROCK CLEARING (I, 2), SOUTH OF THE LIGHT-HOUSE.

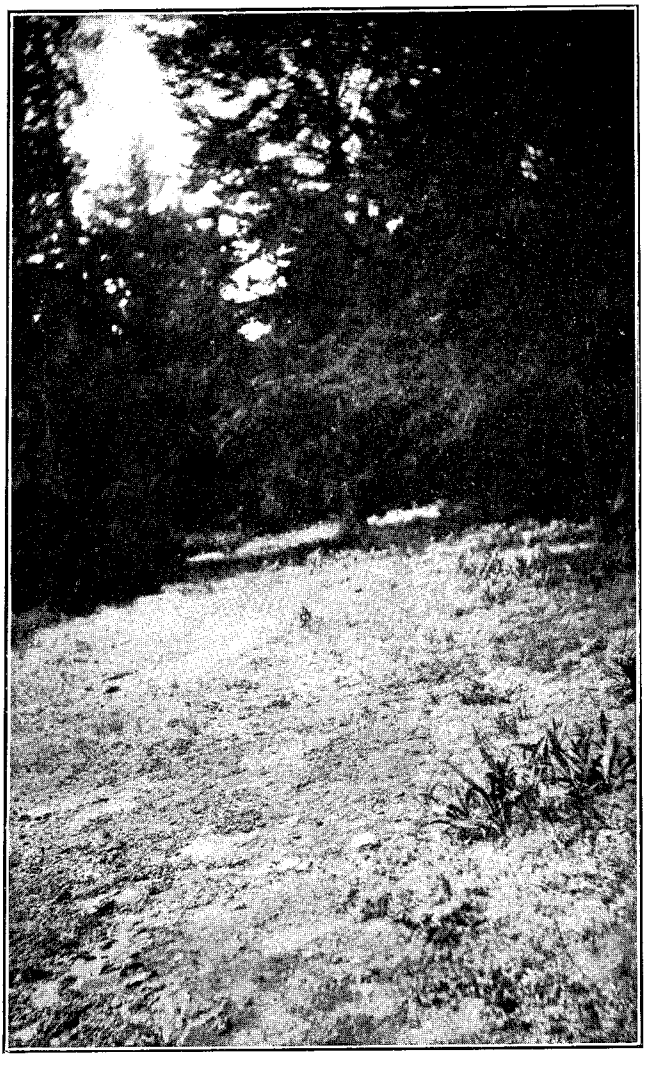

FIG. 7. NATURAL ROCK OPENING (I, 2) OR AVENUE, FARTHER UP THE SLOPE THAN IN FIG. 6.

FIG. 8. NATURAL ROCK CLEARING OR OPENING (I, 2) NORTH OF THE LIGHT-HOUSE AT ROCK HARBOR.

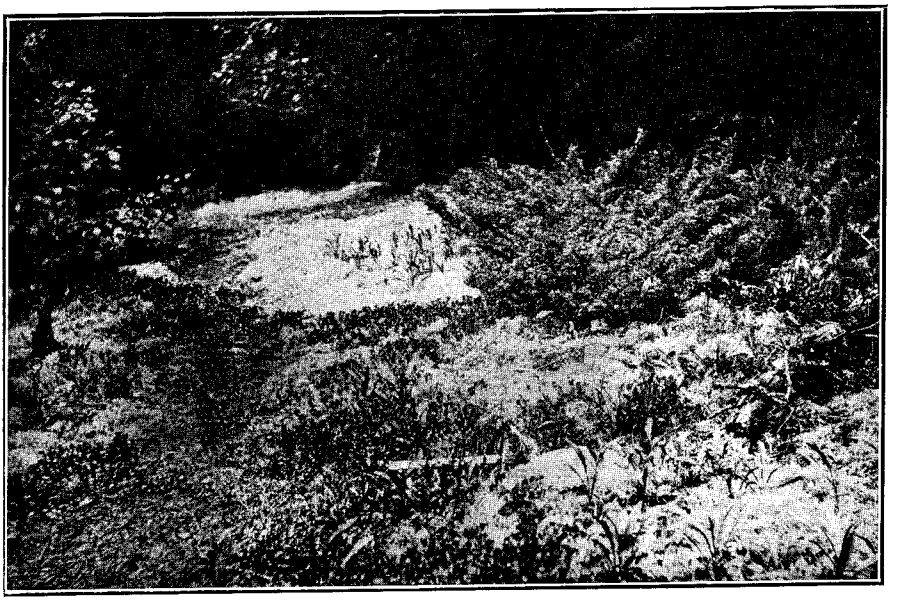

FIG. 9. NATURAL ROCK CLEARING (I, 2) SOUTH OF THE LIGHT-HOUSE, ADJACENT TO FIG. 7.

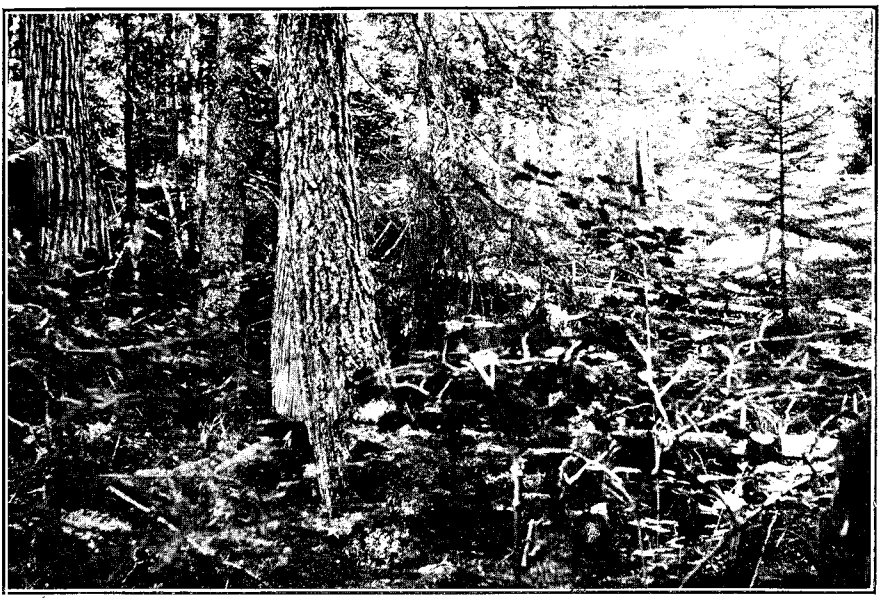

FIG. 10. ARBOR VITAE BOG (I, 4) NEAR TONKIN BAY.

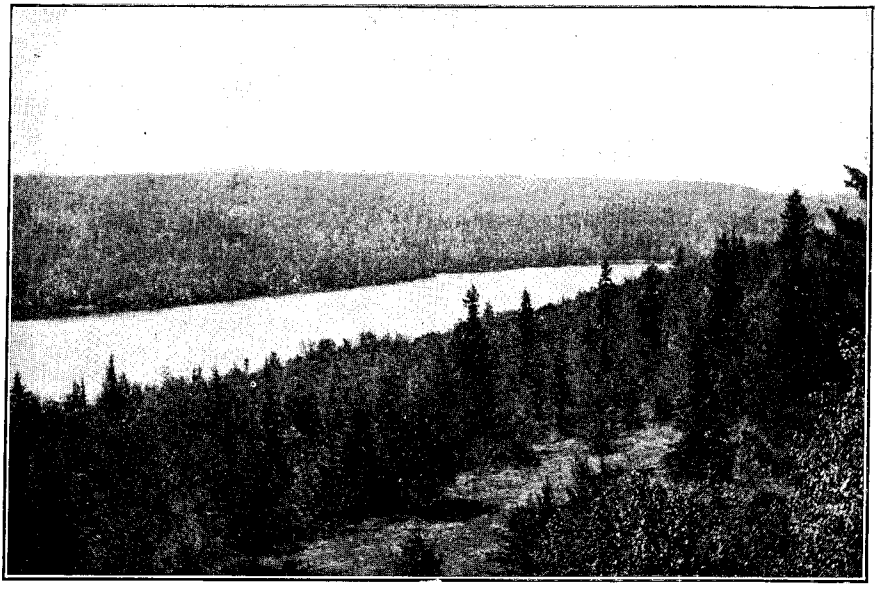

FIG. 11. VIEW FROM THE JACK PINE RIDGE (I, 5), LOOKING TOWARD THE HEAD OF CONGLOMERATE BAY.

FIG. 12. SECOND GROWTH OF WHITE BIRCH ON THE TRAIL TO THE JACK PINE RIDGE (I, 5) CONGLOMERATE BAY.

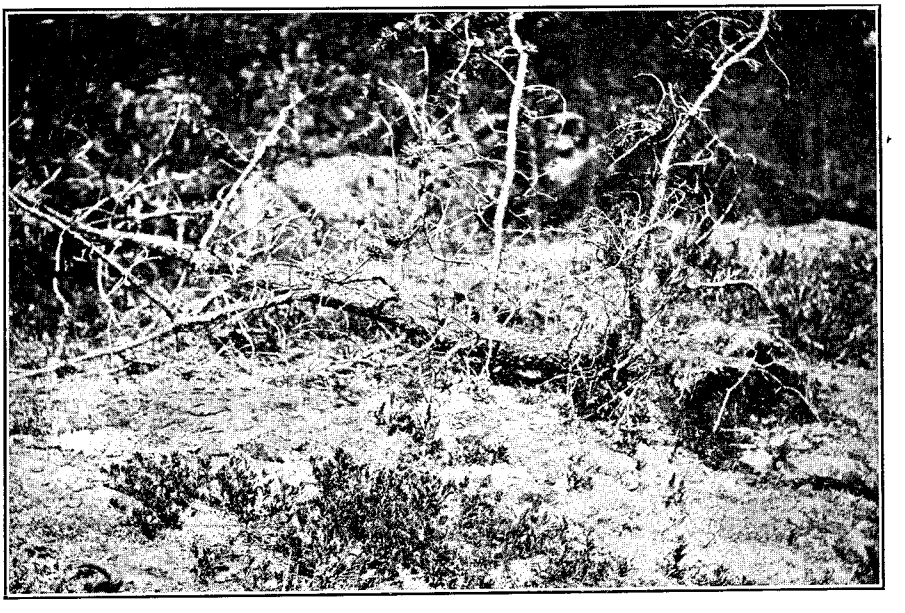

FIG. 13. JACK PINE RIDGE (I, 5) CONGLOMERATE BAY.

FIG. 14. SPHAGNUM-BLACK SPRUCE BOG (I, 6) NEAR THE JACK PINE RIDGE.

FIG. 15. SMALL ISLANDS NEAR THE HEAD OF ROCK HARBOR (III, 1).

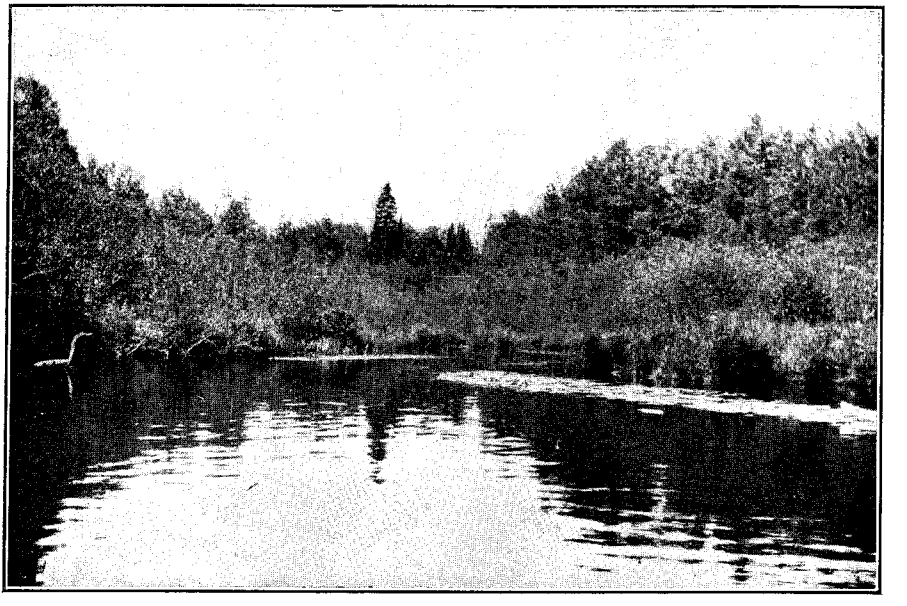

FIG. 16. BULRUSH ZONE AND DELTA AT THE HEAD OF ROCK HARBOR (III, 3).

FIG. 17. EXPOSED SECTION OF SPIT FORMED AS THE WATER LEVEL HAS LOWERED IN ROCK HARBOR, NEAR THE BEGINNING OF THE TRAIL TO SUMNER LAKE (III, 4).

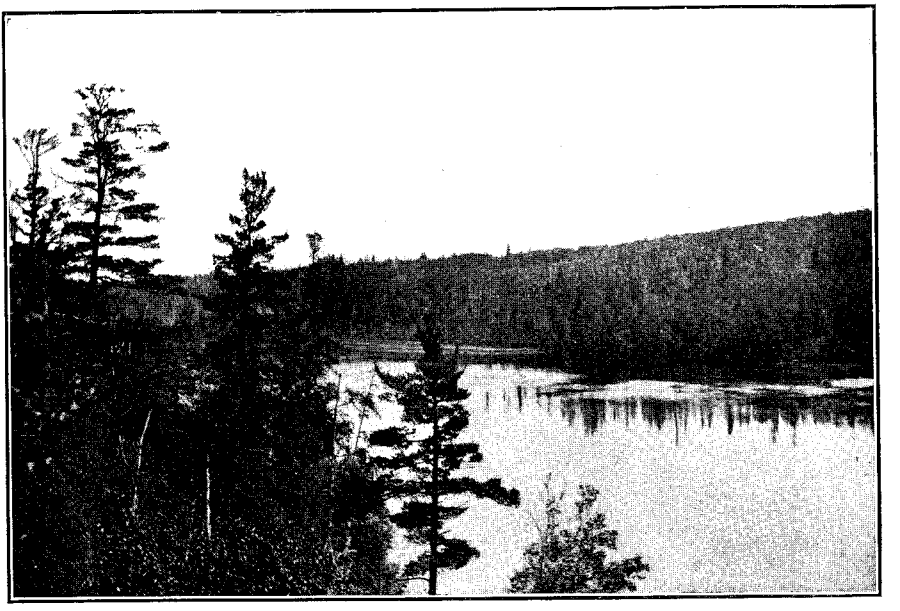

FIG. 18. SUMNER LAKE (III, 5), EASTERN END.

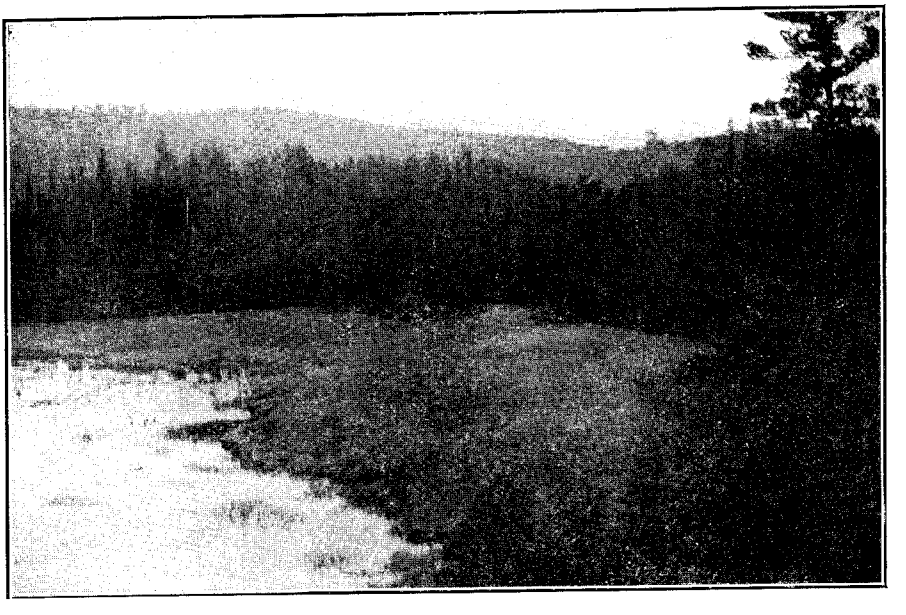

FIG. 19. WESTERN END OF SUMNER LAKE (III, 5).

FIG. 20. NORTHEASTERN MARGIN OF SUMNER LAKE (III, 5).

FIG. 21. SOUTHEASTERN CORNER OF SUMNER LAKE (III, 5).

FIG. 22. WESTERN END OF SUMNER LAKE (III, 5).

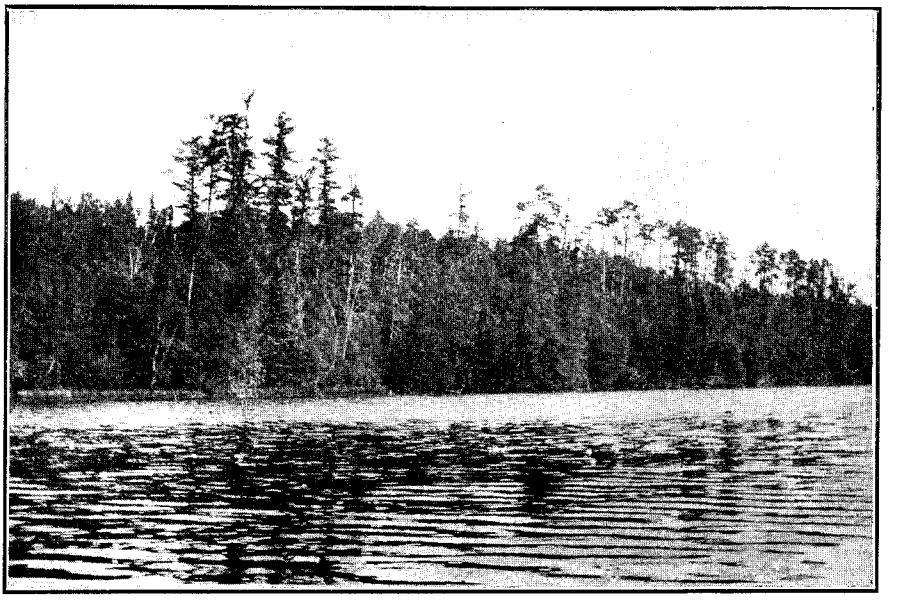

FIG. 23. NORTHERN SHORE OF SUMNER LAKE (III, 5).

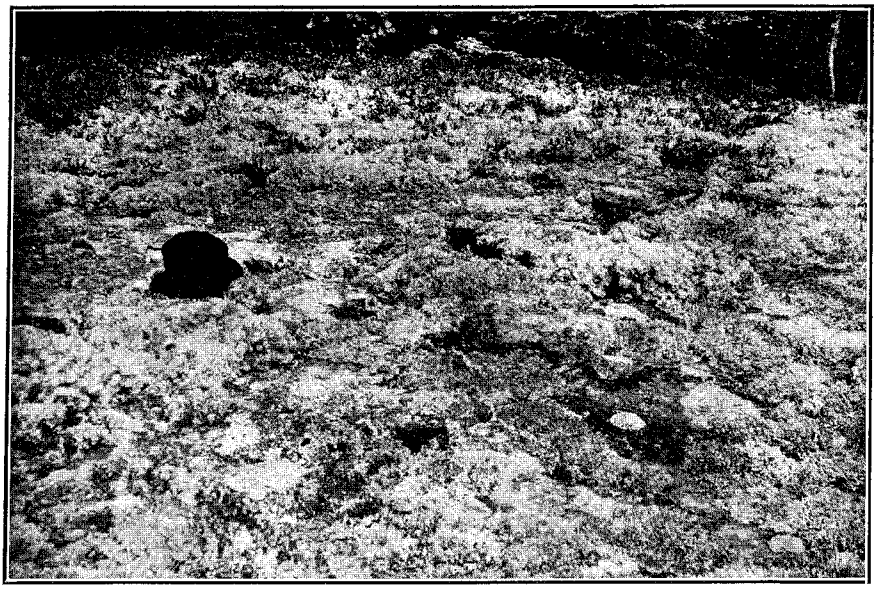

FIG. 24. ROCK OPENING ABOUT CAMP ON SISKOWIT BAY (V, 3).

FIG. 25. ROCK OPENING AT SISKŌWIT CAMP (V, 3).

FIG. 26. ROCK OPENING ON SISKOWIT BAY (V, 3).

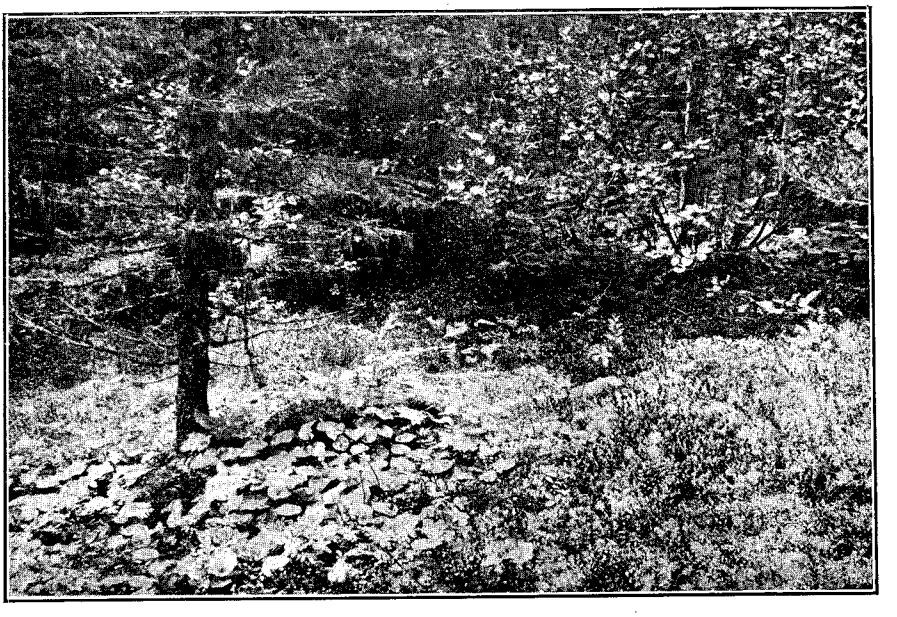

FIG. 27. BORDER OF THE OPENING ABOUT THE SISKOWIT CAMP (V, 3), NEAR THE BEGINNING OF THE TRAIL TO SISKOWIT LAKE (V, 4).