THE PLANTS OF WESTERN LAKE ERIE, WITH OBSERVATIONS ON THEIR DISTRIBUTION.

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INTRODUCTORY.

In the spring of 1893 the writer accompanied a party sent out by the Michigan Fish Commission, under the direction of Prof. Jacob Reighard, to study the biology of the Great Lakes. The lake chosen for the study that year was St. Clair. This small lake presents in many respects ideal conditions for the study of lacustrine plant life. The extensive swamps and the gradually sloping mud bottom of its northwest side, which is also protected from the most violent winds, and therefore seldom experiences a heavy surf, provide an environment admirably suited to the growth of a variety of plants. The results of that year's work were published as the "Plants of Lake St. Clair,"[1] and is believed to be the first study of the kind undertaken in American lakes. It was therefore a pleasure to continue this line of work in Lake Erie. The United States Fish Commission, having entered upon a systematic investigation of the biology of the Great Lakes, placed the work under the direction of Professor Reighard, and the place chosen was Put-in Bay, Ohio. A United States fish-hatchery is located there, and the buildings and boats were placed at the disposal of the party.

The present paper covers the work on the Phanerogams, Characeæ, and Desmideæ. The work on the algæ, except Desmids, was in charge of Dr. Julia Snow, of Michigan University. The field work was done during the summer of 1898.

APPARATUS USED.

Much of the work was done from a row boat in Put-in Bay and in the swamps on the mainland, but the deeper parts of the lake were examined by means of an ocean dredge let out from the steamer *Shearwater*, while going at a low rate of speed.

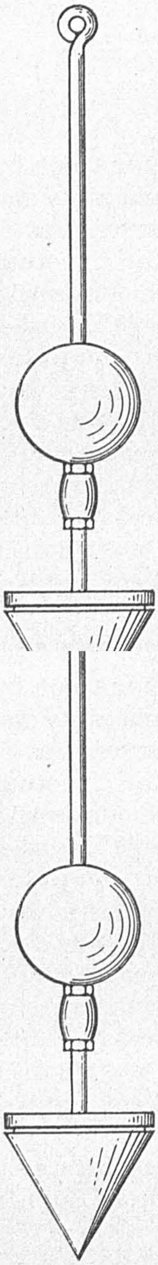
The plankton and tow nets used in collecting the microscopic organisms have been described by Reighard.[2] For collecting the larger plants growing in water more than a foot or two deep a grapple was used (fig. B, page 58). This was made by passing four or five bent steel wires through a piece of 1.5-inch pipe and bending back the free ends to make hooks. The pipe was filled with lead to make it heavier

[1] Bulletin of the Michigan Fish Commission No. 2, 1894.
[2] Reighard, J. E. A biological examination of Lake St. Clair. Bull. Michigan Fish Commission, No. 4, 1894.

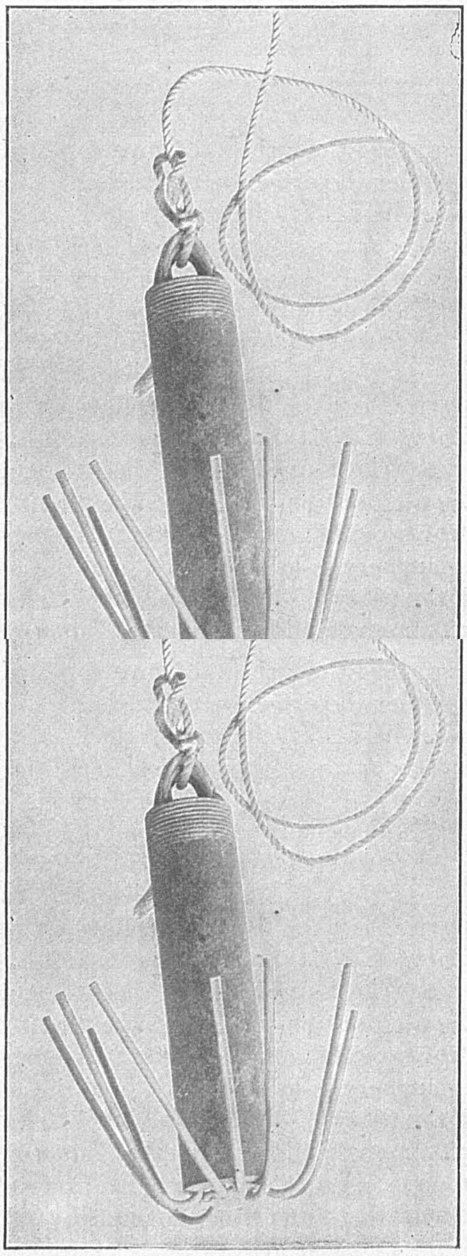
and a rope fastened through the loops of the wires. For taking soil samples an instrument was made after drawings in Delbecque, "Les Lacs Français" (fig. A). This gave satisfaction in soft bottom, but when the clay was stiff, or mixed with coarse sand or gravel, the point was unable to penetrate. These samples were sent to the Division of Soils, United States Department of Agriculture, for analysis.

DEPENDENCE OF FISHES UPON PLANT LIFE.

It is needless to go into the statistics of the value of the fish industry. The fresh-water fisheries alone amount to more than $4,000,000 annually, not to mention the capital invested in trout, bass, and other game fish. The importance of the subject from an economic point of view fully warrants an exhaustive study of the



A. Soil sampler, after Delbecque.



B. The grapple.

conditions of fish life and a thorough understanding of their food supply. As has in our lakes and streams. The vigorous growth and reproduction of plants furnishes a large food supply for the smaller animals, which in their turn can reproduce more abundantly and provide a greater amount of food for the fish.

Barring enemies and artificial hindrances to increase, such as overfishing, fish will multiply up to the limit of the food supply, but can never overstep that limit. If the food supply can be increased, an increase in the number of fish will naturally follow.

PROBLEMS OF AQUATIC PLANT LIFE.

To understand the factors controlling the primary source of food in the Great Lakes, we must study the plant life from every standpoint; we must learn the life history of each species, its physiology, distribution, and methods of reproduction. The important problems are, of course, physiological: The relations between the plant and the medium in which it lives; what it takes from the water and what it returns to it; the character of the bottom most favorable to certain species; the methods of passing the winter and of reproduction; the relations between the larger plants and the microscopic plant and animal forms that live on and among them, and the physical conditions of the lake--all these must be studied and, in great part, understood before we can determine what plants should be placed in a given lake and how we can best introduce them.

These are some of the problems that most plainly present themselves and to which a study of the species found, together with their distribution, may be regarded as preliminary. This "taking an inventory," as Zacharias aptly expresses it, is useful, but not final. We desire to know with what forms we have to deal, but the addition of a few more names to our list must not be thought of equal importance with a study of the life histories of these species.

MACROSCOPIC AND MICROSCOPIC PLANT LIFE.

The plant life of the Great Lakes may be roughly grouped into macroscopic and microscopic. It is exclusively the latter that enters into the plankton. These unicellular plants are the primary source of the food supply, their great reproductive power supplying a constant source of food for the plankton animals, which, in turn, feed the larger forms.

Although the higher plants are not known to enter to any large extent into the diet of mature food-fishes, yet their importance in the economy of aquatic life must be great because of the myriads of minute animal and plant forms that find shelter and subsistence among them. These forms—the insect larvæ, mollusca, crustacea, rotiferà, and others—are important as fish foods, and their absence must adversely affect the distribution of fish. The importance of shore and bottom vegetation was recognized by Ward (loc. cit.), who, in his report on the biology of the Traverse Bay region, makes constant reference to the scarcity of certain animal forms as due to the lack of plant life. The relative scarcity of hydra, worms, certain forms of rotifera, insect larvæ, and mollusca he attributes to the lack of bottom and shore vegetation, and says: "The barrenness of the littoral zone eliminates from the question of the food supply of this region one element which in Lake St. Clair was of extreme importance." This is recognized by Reighard (loc. cit.), who makes frequent reference to the abundance of certain animal forms in Lake St. Clair and connects it with the richness of the bottom flora.

TOPOGRAPHY.

The conditions in that portion of Lake Erie around Put-in Bay and Sandusky differ from those at St. Clair and at Traverse Bay. While the bottom and shore formations are not as abundant as in Lake St. Clair they are very much more abundant than at Charlevoix. The region about Put-in Bay and Sandusky is of limestone formation, Put-in Bay, or South Bass Island, East and West Harbor, belonging to the waterlime group, while about the mouth of the Portage River there is an outcrop of Salina shale. The channels between the islands have been scooped out of the limestone rock by glacial action, and the bottom is either of this rock or is covered with drift clay.[1] Much of the coast on the mainland is rocky and precipitous, but a great part of it is sandy beach (pl. 11, fig. 6), especially at East and West Harbors and at Port Clinton, while at Catawba Island and at Marblehead light the limestone rock juts out into the lake, breaking the continuity of the sand beach. The islands, of which there are on the American side six larger and as many smaller, usually present rocky shore lines to the waves (pl. 11, fig. 4), but there is one sand beach on South Bass Island and portions of the bay are less rocky than the west shore. The water is generally of considerable depth close to the rocks, and the bottom is covered with stone and gravel overlying a blue clay that comes to the surface in the deeper parts. In Put-in Bay the bottom is generally muddy close up to the shore, and in the western end, at Squaw Harbor, and also near the United States fish-hatchery, the bottom slopes gently, thus furnishing the conditions favorable to the growth of water plants. These parts of the harbor are, too, the most protected from the violence of the waves.

At four points on the mainland between Sandusky and Port Clinton there are extensive swamps, about upper Sandusky Bay, at East and at West Harbors, and along the Portage River at Port Clinton. These swamps are characterized by a great extent of low-lying muddy bottom, covered with varying depths of water and sloping back to low wet ground (pl. 11, fig. 1). They are intersected by many channels, some opening out to the lake or river, while others lose themselves in the body of the marsh. Pools of greater or less extent frequently occur. At Port Clinton and at Sandusky the swamps border the rivers and extend for miles up the stream, while at East and West Harbors they open directly into the lake by narrow channels, which are protected from wave action by sandbars.

DISTRIBUTION OF AQUATICS.

Phanerogamic water plants form a class distinguished from land plants by many differences of structure and form due to their peculiar habitat. The variety of form and the high development of land plants is wanting in aquatics, because a few types and relatively simple structure suffice to meet the nearly uniform conditions of their existence. Their distribution is almost world-wide, many of the species being found throughout the temperate zone and some even from the Arctic Ocean to the Equator. They grow in streams, pools, and lakes, in flowing and in still water; some species even flourish in stagnant water; and, together with marsh plants, they form the bulk of the vegetable matter in lakes and streams.

[1] Ohio Geological Survey, vol. II.

PLANT GROUPS.

The plants of this region may be roughly divided into swamp plants and water plants, the latter being such as are wholly submersed or have only their reproductive and small portions of their vegetative parts above water, or which float wholly or in part on the surface. The regions occupied by these forms can not be sharply delimited, because true water plants grow between the swamp plants throughout the greater part of the marsh. To these two groups must be added a few shore plants that affect, though perhaps to an insignificant degree, the vegetable matter in the lake. The shore line in this region is either sand or limestone, and the characteristic plants are such as are commonly found in similar locations. *Euphorbia polygonifolia*, *Triodia purpurea*, *Elymus canadensis*, *Cenchrus tribuloides*, *Salix longifolia* and *S. cordata*, *Cakile esculenta*, and *Polanisia graveolens* grow on the sandy beach (pl. 11, fig. 2). This vegetation has, however, no influence on the biology of the lake other than an occasional accidental one, such as the washing into the lake, by a storm, of parts of these plants. The same is true of the rock plants, although being almost constantly subject to wave action they are more frequently washed into the lake. Along a great deal of the shore of South Bass Island, as well as on the other islands of the group, the broken limestone rock is washed by the waves, and in the crevices of this rock a multitude of plants find a footing. The principal species in bloom during July and August were *Campanula rotundifolia*, *Steironema ciliata*, *Aster ericoides* and *A. polyphyllus*, *Carex eburnea*, and *Lobelia kalmii*. The rocks were nearly covered with lichens and a reddish alga. The unicellular algæ, which flourish in the many small pools among the rocks, are constantly washed out by the waves (pl. 12, fig. 1).

DESCRIPTION OF PRINCIPAL PLANT REGIONS.

Plants in Put-in Bay.—The plants in this bay were studied more thoroughly than elsewhere, owing to accessibility. Careful dredgings were made throughout the western part of the bay, including Squaw Harbor and the vicinity of the hatchery. Squaw Harbor is a shallow body of water averaging about 4 feet in depth and not exceeding 7 feet in the deepest part, with a rocky border which prevents a swamp formation of any extent (pl. 11, fig. 5). The mud bottom slopes gradually and is covered with a dense mass of vegetation. From the entrance of Squaw Harbor to the end of Gibraltar Island the water becomes gradually deeper, but does not exceed a depth of 15 feet, and reaches that depth only near the end of Gibraltar Island. The bottom changes as gradually from mud to clay, with some sand and gravel along the shore.

A bar separates Squaw Harbor from Hatchery Bay,[1] which is also shallow, nowhere over 11 feet deep and averaging perhaps 5 feet. The bottom of this bay varies much, being stony in some places and muddy in others. The water is turbid, and it is usually impossible to see plants more than 2 or 3 feet below the surface.

Plants in Squaw Harbor.—Squaw Harbor is bordered by a narrow strip of rush-like plants. These plants are limited abruptly on the land side by the rocks and on the other side by a depth of from 2 to 2.5 feet of water. Toward the east *Sagittaria rigida* forms a prominent group, extending about 30 feet from the shore and finding its limit of depth in about 2.5 feet of water. Looking over the plants

[1] For convenience I have applied this name to that part of Put-in Bay lying between Gibraltar Bar and the United States fish-hatchery. It opens by a ship channel directly into the lake.

from the water side, a gradual but striking change in the character of the leaves is evident. In the deeper water the petioles are rigid, sharply triangular, and tipped with a narrow blade sometimes scarcely distinguishable from the petiole. Nearer the land the blades are broader and the petioles shorter, and in the mud along the shore plants grow with broadly lance-shaped blades on petioles 8 to 10 inches long (pl. 15, fig. 1). Not infrequently blades are found with one or both sides lobed. This species also occurs on the other shore with *Scirpus lacustris*, but is not as abundant as on the east side. Wherever *Sagittaria rigida* and *Scirpus lacustris* occur together the former always occupies the deeper water. Near the shore *Typha latifolia*, *Carex pseudo-cyperus* var. *comosa*, and species of *Scirpus* form a background for the *Sagittaria*.

Scirpus lacustris is scattered along the east shore, but is not as abundant as on the other side, a few hundred feet away, where *Scirpus pungens* is the prevailing species. There are relatively few macroscopic forms in the water among the plants of *Sagittaria* and *Scirpus*, although various species of algæ are attached to the *Sagittaria* petioles. *Ceratophyllum* occurs, but not as abundantly as in the water between the two shore regions. Along the south shore there is a thick growth of *Dianthera americana*, and the shallow water of the harbor is filled with submersed forms, of which *Vallisneria spiralis*, *Myriophyllum spicatum*, *Naias flexilis*, *Cerato-phyllum demersum*, and the various species of *Potamogeton* are the principal ones. These all grow together freely, the *Naias* in company with *Chara*, mostly *Chara fragilis*, covering the bottom as clover covers a field, while the other species nearly all rise to the surface. In the early part of the season few or no plants can be seen, but after the middle of August the surface of the water is covered with their floating branches. A patch of *Nuphar advena* and one of *Nelumbium luteum*, the latter but recently established, occupy part of the head of the harbor. *Characeæ* are scarce in this harbor, excepting some *Chara fragilis* in the deeper parts and a few smaller species on the edges of a little clay bank near the south end. Here were found, in water from 2 to 10 inches deep, a number of species, some in vigorous condition, others barely holding their own. Here I also found *Zannichellia palustris*.

The growth of *Sagittaria rigida* along the east side of Squaw Harbor is doubtless due to the protection from wave action afforded by Gibraltar Island and Bar in the mouth of the main harbor. The west side is more exposed to waves than the east side, and while *Sagittaria* is not a plant that endures heavy wave action, *Scirpus pungens* grows equally well on a muddy flat or on a surf-beaten bar. In this place it runs out along the point toward Gibraltar Island as far as it can find footing among the rocks where the water is not too deep. The thick growth of filamentous algæ on the petioles of *Sagittaria rigida* and over the stones along the east shore must also be attributed, at least partly, to protection from wave action. *Œdogonium* and *Spirogyra* grow luxuriantly attached to *Sagittaria* petioles just beneath the surface of the water, and these masses swarm with minute forms of animal and plant life. *Pithophora* sp. covers the stems and petioles in shallow water as well as the mud and damp stones along the shore. The coarse filaments of this alga form a network whose meshes are filled with crustacea, insect larvæ, and unicellular algæ.

Plants near Gibraltar Island.—The same species that flourish in Squaw Harbor extend out into the main bay to a depth of 10 feet or a little more. Everywhere from Gibraltar Island to the shore of South Bass Island the bottom of the bay is covered, generally thickly, with plants of which *Naias flexilis* and var. *robusta*, *Vallisneria spiralis* and *Heteranthera graminea* are most abundant, but *Ceratophyllum demersum*, *Myriophyllum spicatum*, *Potamogeton zosteræfolius*, *P. perfoliatus*, *P. perfoliatus richardsonii*, *P. pectinatus*, and *Elodea canadensis* are also plentiful. In some spots an abundance of *Chara contraria* was found with a trace of *C. coronata* and *Tolypella intertexta*, but there are few *Characeæ* in Put-in Bay. In the deeper parts of Lake St. Clair *Tolypella intertexta* covers the bottom with a luxuriant growth, but in Put-in Bay this species is scarce and the plants are small.

The sandbar running from Gibraltar Island to South Bass Island separates to some extent this part of the bay from the part about the fish-hatchery. The bar is usually covered with water from 1 to 4 feet in depth, but at times a great part of it is above water. On the east side of the bar the slope is steep, while on the other side the bar slopes gradually into Hatchery Bay. In the deeper water just east of the bar the vegetation is most luxuriant, great quantities of *Naias* and of *Vallisneria*, with other species, being brought up at every cast of the grapple. The bar is covered with a layer of cobblestones and pebbles, overlying the blue clay which covers the bottom throughout this part of Lake Erie. Of all the plants found on the east side of the bar, but one grows on it; this is *Vallisneria*, which in many places forms dense patches. Besides the *Vallisneria* the principal plant on the bar is *Potamogeton heterophyllus*, and this I did not find elsewhere in the bay except in one wave-washed place on the south shore. This species flourishes all along the bar, but especially toward the Gibraltar end, where it is accompanied by a few plants of *Potamogeton filiformis* and a dwarf form of *Naias flexilis* with close, compact habit and strong root system (pl. 18, fig. 2). These plants root in the clay between the stones and flourish wherever the stones and pebbles are not too thick.

Plants in Hatchery Bay and in the open lake.—In Hatchery Bay the narrow-leaved *Potamogetons*, such as *P. pusillus*, *P. zosteræfolius*, and *P. pectinatus*, with *Heteranthera graminea* and *Naias flexilis*, are especially abundant, and in quiet places on muddy bottom *Ceratophyllum demersum*, *Myriophyllum spicatum*, and *Elodea canadensis* are common. A few species of *Characeæ* also occur in this part of the bay, but nowhere in great abundance. Beyond a depth of 10.5 feet no plants were found, except one small plant of *Vallisneria* in the channel at a depth of 13.5 feet. A depth of 10.5 feet corresponds roughly with a line drawn from the northern extremity of South Bass Island to Gibraltar Island. Beyond this is the lake, and although the bottom is free from stones and of a soft clay, not a plant was found growing in it. This was the case wherever the lake itself was examined. Dredging trips were made to various points and the bottom carefully dragged, but without finding as much as a *Chara*, except that on one occasion a small amount of *Lyngbya wollei* was brought up. This alga grows much more abundantly later in the season, often choking up the fishermen's nets with its coarse filaments. Close along the shore the stones are covered with *Cladophora glomerata*, to which many diatoms are attached, and among which many minute forms find a home.

East Harbor.—At East Harbor there is a wide stretch of swamp intersected by channels which open into the lake by one deep and narrow channel protected from severe wave action by a sandbar. The bed of the channel is entirely free from plants, but along each side is a border of *Vallisneria* and *Potamogeton*, the side toward the water being sharply defined by the current. On the west side there is a small bank of *Vallisneria* with some *Potamogetons* in the shallower water, while beyond these are

Scirpus pungens and *S. lacustris*, growing in wide stretches over the low sandbar and in the shallow lagoon behind the bar. The old rootstocks of these species of *Scirpus* can be seen everywhere in 6 to 9 inches of water, forming a network over the sand. In the lagoon, with *Scirpus pungens*, grows *Naias flexilis robusta*, long and slender, while in the shallow water on the exposed bar the dwarf form of *N. flexilis*, previously found in similar places in Put-in Bay, is not uncommon.

On the east side of the channel the number and kinds of plants is greater, in spite of the fact that the prevailing winds drive the waves against the shore. The probable reason is that these waves have washed a great deal of mud to that side, making more favorable soil for the growth of the plants. *Vallisneria* occupies the deeper parts on the east side of the channel as well as on the west, growing in 6 to 7 feet of water, but is present also among the other species in shallower places. Toward the land from the *Vallisneria* are the *Potamogetons*, *P. zosteræfolius*, *P. pectinatus*, *P. lonchites*, and *P. perfoliatus richardsonii*, with *Heteranthera graminea* occupying the ground in 3 to 5 feet of water and occasionally in the shallower places. In 1 to 2.5 feet of water, among the *Scirpus lacustris* and *S. pungens*, *Myriophyllum*, *Naias*, and *Elodea* are the principal species, but, as already remarked, the forms common in deeper water also frequently occupy this ground. In some places along this shore the *Scirpus* is mixed with *Zizania aquatica*, and on the sandy bank *Scirpus pungens* shares the ground with *Equisetum robustum*.

The sandbar which protects the channel entrance is large and is covered with water varying in depth from 6 inches to 2 or 3 feet. *Scirpus pungens* grows in many places on the most exposed situations in water up to a foot deep. Beyond the *Scirpus*, in places exposed to the heaviest surf during storms and where the water is 6 to 12 inches deep, I found scattered tufts of *Potamogeton heterophyllus*. The form is the same as that growing abundantly on the bar at Gibraltar Island, where it was found in fruit, but no fruiting specimens were found at East Harbor. In neither case did it have floating leaves, the plants growing in tufts with many branches coming out from near the base of the stem. This is the form which Dr. Morong named var. *longipedunculatus*.

Character of the vegetation up the channel.—A short distance from the entrance the channel divides, one branch going east, the other west; the latter again divides, one branch turning southwest, the other continuing in a westerly direction. With slight exceptions a description of the vegetation along the eastern branch will apply to this entire swamp region.

Just where the channel turns toward the east is a sandy beach covered with 2 feet or less of water, and here grow two forms of *Naias*, *N. flexilis robusta* and the dwarf form of *N. flexilis*, besides several species of *Characeæ*, which are more abundant here than elsewhere in the swamp. In an area not over 200 feet long by 10 wide I found four species of *Nitella* and four of *Chara*, all of low, compact habit, though in other locations plants of some of the same species grow long and of open habit. *Nitella subglomerata* and *Nitella polyglochin* grow in clusters a few inches across and as many high, while *N. tenuissima* and *N. batrachosperma* grow in about 1 foot of water with their branches spread out flat on the sand. *Chara fragilis* grows with close, compact habit; *Chara contraria* and its variety *subinermis* are here low, delicate plants, growing in the shallower places; *Chara coronata* has a habit different from that of the same species in the deep, quiet pools, being stocky, with short internodes and very compact. *Chara sejuncta* is the largest species here, and is notable for its long runners.

Here *Vaucheria tuberosa*, a plant usually found in deeper water, grows on the sand in thick, compact tufts, and looks almost black at the bottom of 2 feet of water. No Phanerogams, save a few plants of *Naias*, grow in this bed of *Characeæ*, but nearer the channel, in deeper water, is a bank of *Vallisneria* and *Potamogeton*. The current is slower here, and in many places the channel is entirely filled with vegetation consisting mostly of *Vallisneria*, *Heteranthera graminea*, *Potamogeton pectinatus*, *P. lonchites*, *P. lucens*, close along shore where the water is quiet, and *P. perfoliatus* with some *Nuphar* and *Nelumbium* in about 3 feet of water. Nearer shore the entire channel is lined with *Sagittaria rigida*, which nearly everywhere occupies the deepest water within the zone of submersed forms. In quiet places there are beds of *Elodea* with *Myriophyllum*, *Ceratophyllum*, and *Utricularia vulgaris*, while *Naias flexilis* and *Nitella polyglochin*, which here grow long and slender, with open spreading habit, are scattered everywhere between the stems of the larger plants in 1 to 2 feet of water. From the *Sagittaria rigida* zone, toward the land side, we come in succession to *Scirpus fluviatilis*, with a little *S. pungens* and *S. lacustris*, *Sparganium eurycarpum*, *Typha latifolia*, and *Sagittaria latifolia*. *Dianthera americana* begins in about 18 inches of water and continues to the muddy shore, mixing, in 6 to 10 inches, with *Scirpus atrovirens*, *Acorus calamus*, *Polygonum muhlenbergii*, and *Asclepias incarnata*, while on the muddy shore it accompanies *Phalaris arundinacea*, *Calamagrostis canadensis*, and *Convolvulus sepium*. Everywhere on the water, between the larger plants, are *Lemna minor* and *Lemna polyrhiza*.

A species of *Sagittaria* not in fruit, but probably *S. latifolia*, is mixed with the more landward specimens of *Sagittaria rigida* and continues toward the shore, its leaves becoming constantly broader as it approaches shallower water. On the wet bank groups of *Hibiscus moscheutos* make the swamp gay with their flowers.

The swamp on the south side of the channel.—On the south side of the channel the swamp covers many acres and is overgrown with rush-like plants. The species are always somewhat mixed, but in each association some one tall species is clearly predominant. Sometimes the boundaries are sharply limited and this in spite of the fact that no differences in soil or in depth of water can be detected. *Sagittaria rigida*, which is nearest the open channel, gradually gives place to *S. latifolia*, which is mixed with a little *Zizania aquatica* and *Sparganium*. Following this is a broad zone of *Scirpus lacustris* of nearly pure growth, then *Scirpus fluviatilis* mixed with a little *S. lacustris*, which soon increases to a second broad belt mixed this time with some *Sparganium*.

Throughout all these associations both *Sagittaria rigida* and *S. latifolia* occur, the latter being common. The water is about the same depth throughout this region, varying from 1 to 1.5 feet, and the bottom is a soft mud. The second zone of *Scirpus lacustris* encircles and sharply limits a large bed of *Sparganium eurycarpum*. The water here is a little deeper, being nowhere less than 1.5 feet, and the bottom seems softer, no other differences being noted. The *Sparganium* is sparingly mixed with *Pontederia cordata*, *Sagittaria rigida*, *S. latifolia*, and a few plants of *Scirpus lacustris* and some *Nelumbium*. Beyond the border of *Scirpus lacustris*, which encircles this bed of *Sparganium*, is a bed of *Typha latifolia* in the same depth of water as the *Scirpus*. *Naias flexilis* grows among the taller plants, and other low-growing aquatics are not uncommon. In shallower water *Dianthera* grows abundantly, and *Sium cicutæfolium* occurs in 6 inches of water with *Asclepias incarnata*. Beyond the *Typha* is a vast stretch of *Phragmites communis* occupying shallow water or exposed muddy places.

Such is the nature of the swamp and the arrangement of the species. A few may be called dominant species. These grow in groups from which the other dominant species are nearly or quite excluded, but the spaces between the larger plants are occupied by many small forms which occur throughout the swamp.

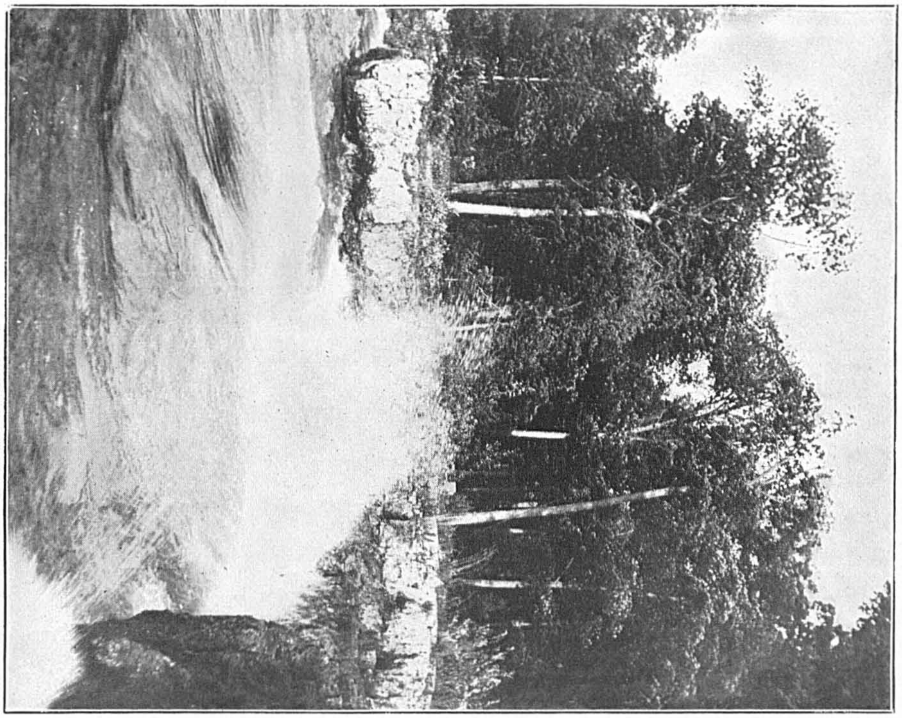
Plants growing about the head of the channel.—At the head of this branch of the channel is a quiet pool some 3 to 5 feet deep, where such forms as *Utricularia vulgaris*, *Myriophyllum*, *Ranunculus divaricatus*, *Bidens beckii*, and *Ceratophyllum* find a congenial home and fill the water. *Heteranthera graminea* and *Potamogetons* also find favorable conditions here; *P. natans*, *P. pectinatus*, *P. pusillus*, *P. zosteræfolius*, *P. robbinsii*, *P. lucens*, and *P. amplifolius* grow together in the clear, quiet water. *Nuphar advena* and *Nymphæa tuberosa* grow in places not occupied by *Utricularia* and *Ceratophyllum*, while the bottom is overgrown with *Elodea*, *Chara coronata*, and *C. gymnophila* var. *michauxii*. The average depth of water is 3 feet, with a soft mud bottom. On all sides this pond is surrounded by *Zizania aquatica*, which grows on a similar bottom and in the same depth of water as the *Scirpus* and *Typha* found down the channel.

Growth of Nelumbium luteum.—The conditions along other channels are very similar to those just described, except that along the west channel *Nelumbium luteum* flourishes. The immense yellow flowers rising just above the great dark-green standing leaves and the water covered with huge floating pads make this the most striking formation of the swamp (pl. 12, fig. 2). The *Nelumbium* grows in from 2 to 4 feet of water, or stray plants may be found in less than 2 feet. Many of the floating leaves were 20 to 24 inches across and the standing ones not much smaller. At Upper Sandusky Bay I found a floating leaf 26 inches in diameter and another with a petiole more than 5 feet in length. Both at Sandusky Bay and along the Portage River the acreage of *Nelumbium* was greater than at East Harbor, but nowhere did the plants present a more vigorous growth or so magnificent an appearance.

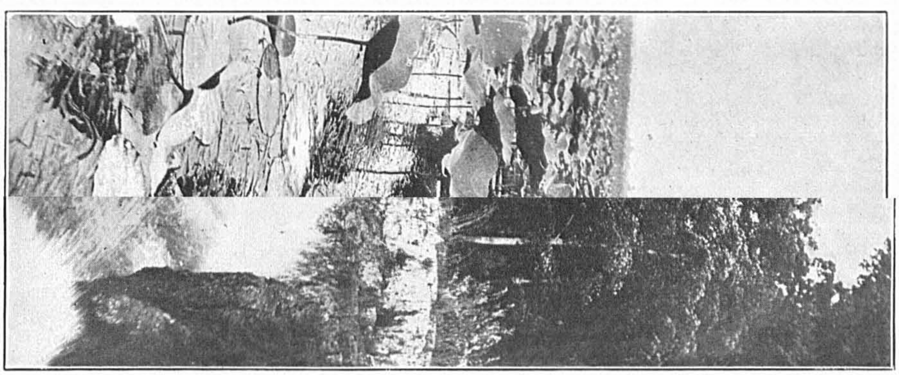
Portage River swamps.—The Portage River swamps differ somewhat from those just described, but not sufficiently to require a detailed description. A much greater area is covered, and the swamp extends for miles up the river; but in general the distribution of plants is the same—*Heteranthera*, *Vallisneria*, and *Potamogetons* along the stream, followed by *Sagittaria rigida* and the other marsh plants. The vast swamp is dotted here and there with pools in which *Utricularia* and similar plants flourish. Here also I found *Naias gracillima* and *Typha angustifolia*, the latter growing in a brownish clay differing from that common along this stream. In many places the bed of the river was entirely devoid of plants, although there was no perceptible current. On the muddy shore in a quiet place the bottom was covered with a thick growth of *Chara sejuncta*, accompanied by *Nitella subglomerata*, and in some pools *Nitella tenuissima* and *N. polyglochin* grew in 3 feet of water.

Swamps about Sandusky Bay.—At the head of Sandusky Bay the swamps are also very extensive, the general features being about the same as of those along the Portage River. Much of the water is from 3 to 6 feet deep and supports only

PLATE 12.



1. WAVES WASHING THE SHORE.



2. NELUMBIUM LUT

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2. NELUMBIUM LUTEUM, A FEW ACRE

The standing leaves are al

a moderate growth of *Vallisneria* and *Potamogeton*, mostly *P. perfoliatus* and *P. pectinatus*. The water is very muddy, and this may account for the scarcity of vegetation; for near the shore, where the water is clear, plants are more abundant, such bottom forms as *Chara*, *Nitella*, and *Naias*, as well as *Potamogetons*, being present.[1] In the clear water also were floating great masses of a species of *Mesocarpus* swarming with crustacea and other minute forms of animal life, while in some quiet places *Hydrodictyon* was found. Lower Sandusky Bay averages 10 to 12 feet deep, and no plants were found except scattered clumps of *Potamogeton pectinatus* and *P. perfoliatus*. The parts of the bay above and east of the city were but hastily examined. For the most part there is a scanty growth of *Potamogeton lonchites*, *P. perfoliatus*, *P. pectinatus*, *P. prælongus*, and *P. zizii*. In some places the water is clear, and one sees on the bottom, at a depth of 5 to 8 feet, *Potamogeton amplifolius* and *P. lucens* and the straight, slender shoots of *P. robbinsii*, as well as most of the other species native to these waters. Here *Eleocharis palustris vigens* grows just beyond *Scirpus pungens*, its stem below the water line covered with colonies of *Rivularia*.

ESTABLISHING ZONES.

It is clear that such a grouping of plants into zones as was established by Magnin[2] for the lakes of the Jura and by myself for Lake St. Clair is impossible for any region examined in 1898. Only two groups are possible—one including all submersed forms and those with floating leaves, the other all the remaining species with emersed leaves and growing with roots and parts of the stem in water. All the species of the three submersed and floating zones are either mixed together in a narrow border along the channels or cover the entire bottom of shallow harbors. Among the swamp plants it is sometimes possible to draw a more or less definite line between the landward forms and those growing in deeper water, but even this is so often vague and unsatisfactory that I do not consider it of any real value. The species intermingle so much on common ground that an attempt to separate them would only result in confusion.

INFLUENCE OF VARIATION OF DEPTH OF WATER ON PLANTS.

The influence of changes in the depth of water on the distribution of aquatics is important, but unfortunately we have little data on this subject. Through the kindness of Col. James Smith, of the engineer's office in Cleveland, Ohio, I secured a table showing the depths of water at Cleveland from 1859 to June, 1898. From the table it appears that since the records began the greatest difference in water level has been 2.86 feet between high water in 1859 and low water in 1895. In 1859 the water was nearly 1.5 feet higher than it was during the summer of 1898. This must have made a great increase in the extent of the swamp, especially of those portions in which the submersed forms could flourish. In 1895, however, the water suddenly fell from 0.4 foot below mean in 1894 to 1.39 feet below in 1895, causing a decrease in the submerged area and the destruction of a great deal of submersed vegetation. In the following year the water rose 0.64 foot and has continued to rise slowly

[1] This may also be connected with the character of the bottom. In the first locality the bottom contains a much larger percentage of clay than in the second.

[2] Magnin, M. Ant. Recherches sur la Végétation des Lacs du Jura. Revue Gén. de Bot., t. V (1893), p. 303.

since that time. Absence of data concerning the aquatic plants growing during those years makes it impossible to say what effect this change of level has had, but it is certain that data collected in any one year can-not be depended upon to give the normal depth at which certain plants flourish. Most species of aquatics being perennial, they may start during periods of low water in places that will be too deep for them during high water, but where they can struggle along for a season or two before perishing.

ECOLOGICAL GROUPS.

Many attempts have been made in recent years to arrange all plants into groups according to the conditions under which they flourish and the manner in which they adapt themselves to their environment. Warming, Drude, and others have adopted certain groupings, but as yet, save on the main divisions, there is no agreement among plant geographers. All classifications, however, include the hydrophites, or water plants, as one of the main divisions, and split this up into a number of smaller groups, each group including all those plants having more or less similar life habits, although perhaps belonging to widely separated families. Ecological groups, indeed, are not in the least based on taxonomic characters. Among the free-swimming, submersed forms are such widely different species as *Utricularia vulgaris*, *Lemna trisulca*, and species of *Mesocarpus*, *Spirogyra*, and *Lyngbya*, besides many others, both macroscopic and microscopic. The attached, low-growing, submersed forms include the *Naiadaceæ* and *Characeæ*, while species of *Potamogeton* and *Nymphæa* belong to the group with floating leaves. It would be possible to make a large number of groups, attempting to express in this manner all the ways in which water plants are influenced by currents, depth, light, and the other factors bearing upon an aquatic habitat, and in so far as such groups represent biological facts they have a value. It is doubtful, however, whether any but the broader divisions are sufficiently stable to be of use, the great adaptability, within certain limits, of the aquatic organism rendering the boundaries of the smaller groups too indistinct to be readily recognized. This is illustrated in *Vallisneria spiralis*, the long ribbon-like leaves of which are thought by some to be especially well fitted for floating downstream in a rapid current, but it grows equally well in almost stagnant water. *Potamogeton heterophyllus*, when growing in quiet pools, produces floating leaves, but when on a surf-beaten bar it branches freely from the base and the floating leaves are absent. I shall therefore divide the water plants of our region into only five groups, as follows:

1. Free-swimming, microscopic forms in the open lake: The Plankton.
2. All other unattached species, macroscopic and microscopic: *Utricularia vulgaris*, *Lemnæ*, *Ceratophyllum demersum*, and many algæ growing in quiet places.
3. Attached submersed plants: *Naias*, *Chara*, *Cladophora*, *Vallisneria*, *Potamogetons*.
4. Attached plants with floating leaves: *Nymphæaceæ*, *Potamogetons*.
5. Swamp plants.

The Plankton includes, of course, both animal and vegetable forms, among the latter being species of *Merismopedia*, *Pediastrum*, *Sphærozyga*, *Clathrocystis*, and many diatoms. Species of *Desmideæ* sometimes occur, but probably by accident. The species of the plant Plankton being mostly without voluntary motion, are subject to all the currents and movements of the water.

In the second group are many widely distant forms, all growing in quiet pools and sheltered places. Among the higher plants *Utricularia vulgaris*, *Ceratophyllum* *demersum*, *Lemna trisulca*, *L. minor*, *L. polyrhiza*, and *Wolffia columbiana* are free-swimming forms, either submersed or floating. With them are associated masses of *Mesocarpus*, *Spirogyra*, *Hydrodictyon*, and frequently quantities of *Oscillaria*, *Lyngbya*, and other related forms.

Microscopic algæ, especially *Desmideæ* and *Diatomaceæ*, occur in great numbers upon the larger plants in quiet water. They are especially numerous in the silt and dirt that collect upon narrow-leaved plants, as *Utricularia vulgaris* and *Bidens beckii*, but they are infrequent on *Ceratophyllum*, even when this grows near plants of *Utricularia* well supplied with microscopic life.

The plants of the third group occupy by far the largest place in aquatic vegetation. Though not always as conspicuous as the plants with floating leaves, they cover a much greater area and make up the mass of the vegetation. The *Characeæ* combine with *Naias* and *Elodea* to cover the bottom in water up to 10 or 12 feet in depth. *Heteranthera graminea*, *Vallisneria spiralis*, *Bidens beckii*, species of *Myriophyllum*, *Ranunculus*, and *Potamogeton* grow to near the surface of the water, and in favorable locations make a dense growth. *Bidens beckii* also has aerial leaves. In this group must be included the attached submersed algæ, as *Chætophora*, *Cladophora*, species of *Œdogonium* and the like.

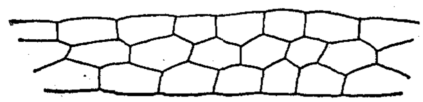


FIG. C.—*Potamogeton lonchites*, section through a portion of submersed leaf.

The *Potamogetons* and *Nymphæaceæ* of the fourth group are nearly all vigorous plants and form the most conspicuous feature of aquatic vegetation. In our waters the plants of this group are *Nymphæa tuberosa*, *Nuphar advena*, *Nelumbium luteum*, *Polygonum muhlenbergii*, and several species of *Potamogeton*. *Nelumbium luteum* has both floating and emersed leaves. The rootstocks of the *Nymphæaceæ* are thick and stout, while those of the Potamogetons are slender. The floating leaves are always thick and leathery.

To the swamp-plant group belong all of the species rooting in the mud and not truly aquatic, including such forms as *Sagittaria*, *Typha*, *Sparganium*, *Alisma*, *Acorus*, *Dianthera*, many *Cyperaceæ*, and some grasses. These all root in the mud in shallow water and have nearly their entire vegetative system exposed to the air. They are generally characterized by slender stems and long, narrow leaves. In *Sagittaria*, *Sparganium*, and *Typha* the lower portion of the stem is usually thick and spongy;

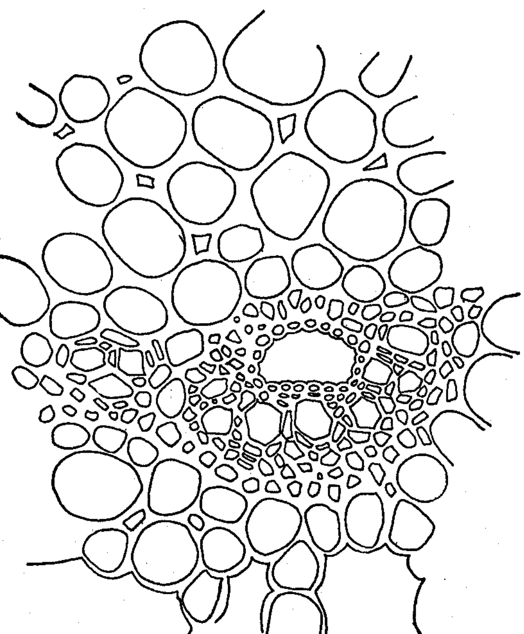


FIG. D.—*Potamogeton lonchites*, section through a bundle.

the stems are in all cases well supplied with air spaces. Rootstocks are common and the plants generally spread locally by this means.

ADAPTATION OF WATER PLANTS TO THEIR ENVIRONMENT.

It is not the purpose of the writer to enter into the details of the structure of water plants, but a few general remarks indicating the relation between the structure of leaf and stem and the medium in which these plants grow will not be out of place.

Aquatic plants show in form and structure special adaptations to their environment. Their development is affected by dim light, the motion of the water, absence of transpiration, difficulty in obtaining oxygen, and the necessity of taking the mineral substances needed through the entire plant system instead of by means of roots.

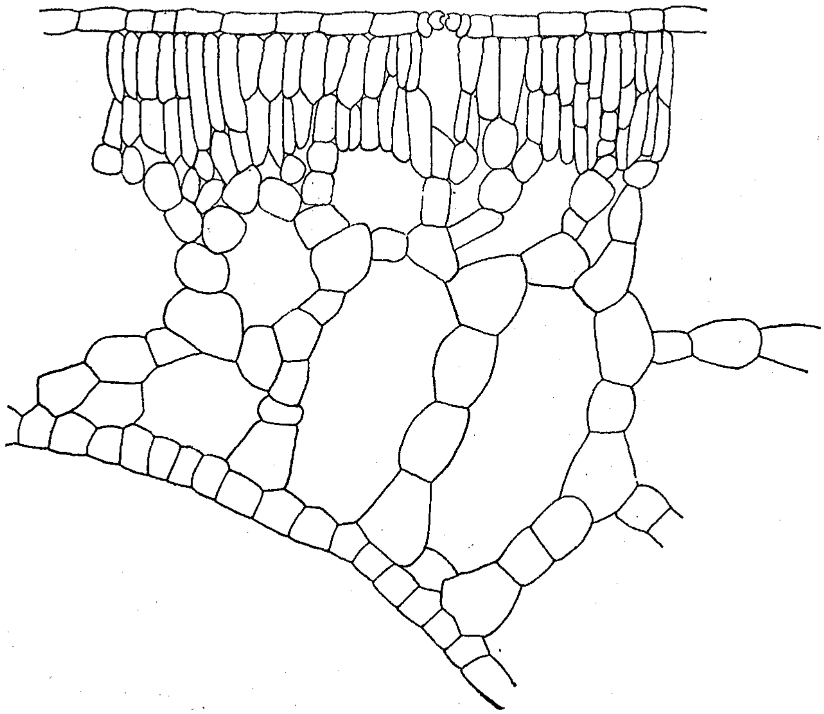


FIG. E.—*Potamogeton lonchites*, section through floating leaf.

Even in clear water there is some loss of light by filtration and by reflexion, and in the muddy water common in the Put-in Bay region this loss must be considerable. Other things being equal, plants would be limited in their growth by the depth of the water. That the plants within our region do not occupy all the places where depth of water would allow will be shown later on to be perhaps due to the character of the bottom. To make the most of the dim light that reaches them at the bottom of several feet of water, such plants as *Naias* and the *Characeæ* have numerous narrow leaves, always ascending and of the same structure on both sides (fig. H). The stem also is green and assists in the work of assimilation. A narrow or finely divided leaf is common among water plants. In *Utricularia*, *Ceratophyllum*, *Bidens beckii*, and *Ranunculus* the leaf is split into many narrow divisions; in *Elodea*, *Naias*, and in the fine-leafed *Potamogetons* the leaves are linear or narrowly lanceolate, sometimes almost capillary, while *Vallisneria* has long ribbon-like leaves that frequently attain a length of 6 feet. The broad submersed leaves of such species as *Potamogeton perfoliatus*, *P. amplifolius*, *P. lonchites*, and *P. lucens* are very thin and consist in great part of but three cell layers, an upper and lower epidermis and a median layer, all of the cells having essentially the same character.

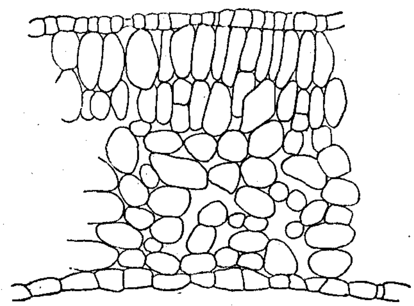


FIG. F.—*Bidens beckii*, section through portion of aerial leaf.

This broad, thin leaf is an ideal one for making the most of the dim light, but it is not so well adapted to withstanding the motion of the water. To offset this, these broad leaves have ribs that are wanting in other submersed leaves, and in these ribs bast fibers are found which, according to Schenck,[1] are absent in all other submersed leaves. In *Naias flexilis* the leaf is but two cell layers in thickness except at the midrib, and in *Elodea* an upper and a lower epidermis alone make up the thickness of the leaf.

A palisade parenchyma, so universal in the leaves of land plants, is entirely wanting in submersed leaves, the chlorophyll being arranged in the epidermal cells and on the tangential as well as the radial walls (see figs. F and G, portions of aerial and submersed leaves of *Bidens beckii*). The absence of stomata from most submersed leaves and the thinness of the epidermal cell walls are to be expected in a medium where adaptations for controlling transpiration are unnecessary.

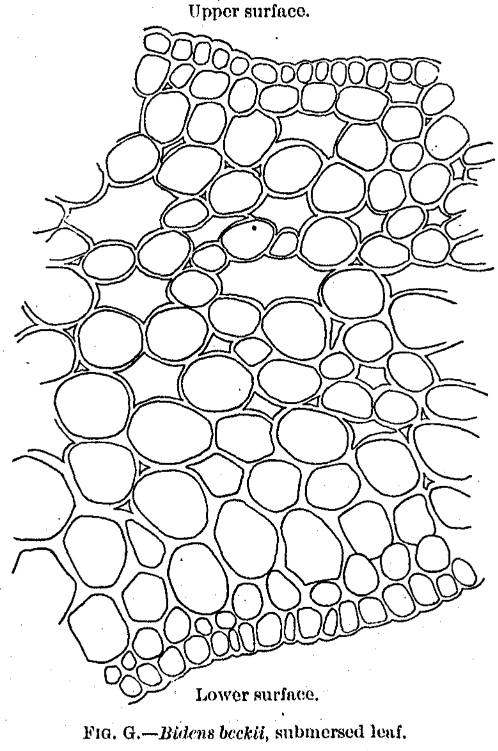


FIG. G.—*Bidens beckii*, submersed leaf.

The stem of the submersed aquatic with its central cylinder and reduced mechanical elements is well adapted to the movements of the medium, while the numerous and often large cavities supply an abundance of air to all parts of the plant. The reduction of the vascular bundles is one of the most striking features. In some aquatics, as *Naias*, no vascular bundles remain, their place being taken by a central canal (fig. K). This canal is also present in the *Potamogetons* and in some dicotyledons, as *Ceratophyllum* (pl. 13, fig. 5), and represents the wood portion of the bundle, an occasional ring or spiral indicating the former

[1] Schenck, H. Vergleichende Anatomie der Submersen Gewachse. Bibliotheca botanica, Heft 1, 67 pp., 1886.

presence of vessels. In *Bidens beckii* the dicotyledonous type of bundle is found, but the bundles are small and far apart. Between the bundles and the epidermis there are numerous cavities separated from each other by layers of tissue one cell in thickness (pl. 13, fig. 1). In *Ceratophyllum* the dicotyledonous type of stem has been obliterated and the entire stem is composed of parenchymatous cells, those of the

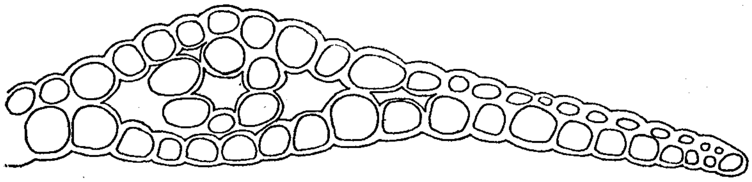


FIG. H.—*Naias flexilis*, section of part of a leaf.

central cylinder being only slightly differentiated. The stem is strengthened by collenchymatous thickening of the angles of the cell walls (pl. 13, fig. 6).

The *Potamogetons* having the monocotyledonous type of bundle differ from *Bidens beckii* in the central cylinder, but outside of this central cylinder the two forms have a similar structure. A sheath of thick-walled cells surrounds the central cylinder, and such cells are also frequently clustered about the inner side of each bundle. In some flat-stemmed *Potamogetons*, as *P. zostereæfolius*, groups of thick-walled cells are placed at irregular intervals just beneath the epidermis (pl. 13, fig. 4).

The structure of the floating leaf shows many striking differences from the submersed leaf, due to the difference in environment. The cells of the upper epidermis of the floating leaf are smaller than in the submersed leaf, with thicker outer walls, and frequently of more irregular outline. Stomata are confined to the upper epidermis. Below the epidermis are one or two layers of palisade tissue with the chlorophyll arranged on the radial walls. Between the palisade tissue and the lower epidermis there are large cavities separated by partitions one cell-layer thick (figs. C, E).

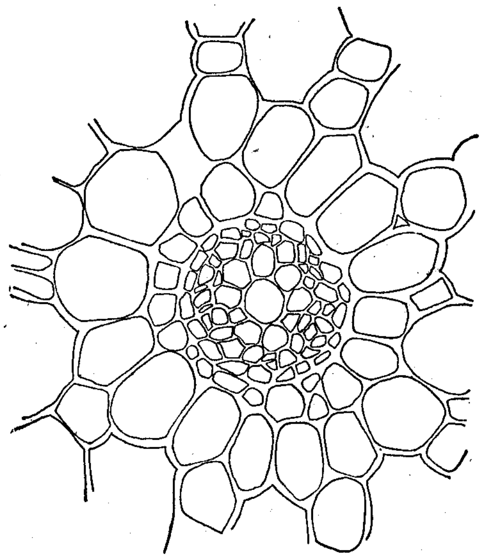
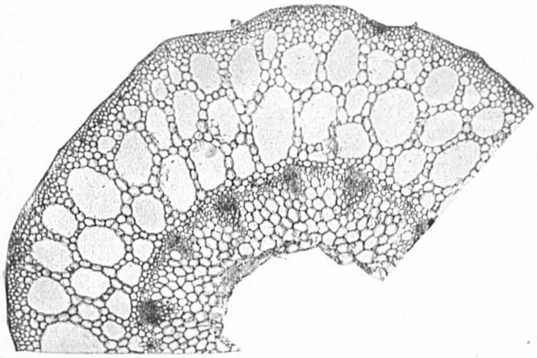


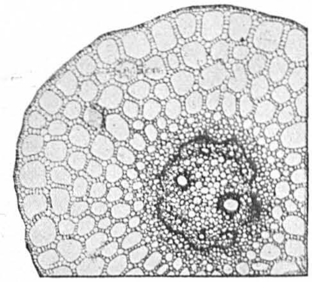
FIG. K.—*Naias flexilis*, cross section of central cylinder.

The lower epidermis is composed of larger, thinner-walled cells than the upper epidermis, and is devoid of stomata. Floating leaves are of firmer texture than submersed ones and have some protection against injury by water. This protection in most aquatics is a waxy covering (Schenck), but in *Nelumbium luteum* it consists of countless papillæ, each arising from an epidermal cell. A layer of air is always held by these projections, so that water falling on the leaf stands in great drops, as if on an oiled surface, until it can run off.

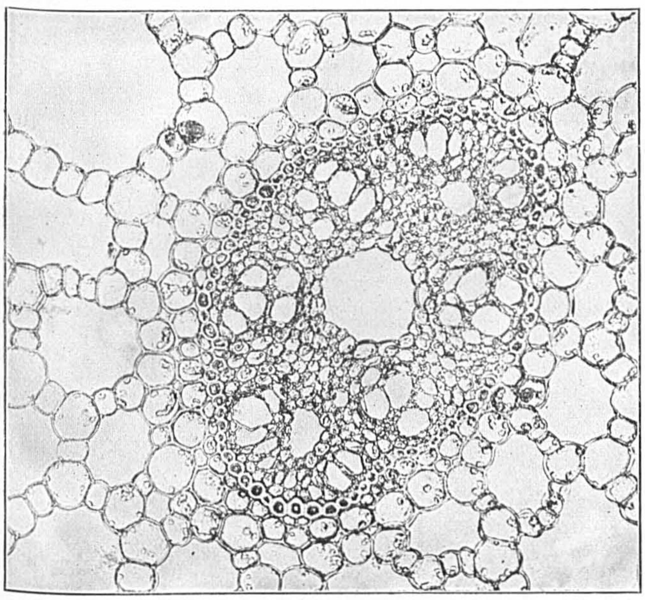
Nelumbium luteum has both floating and emersed leaves. There is no essential



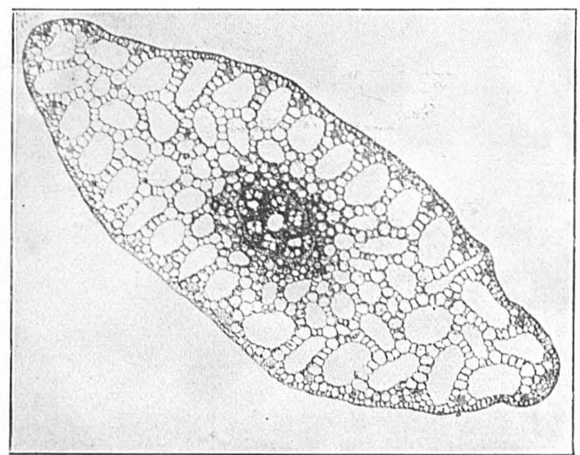
1. BIDENS BECKII, CROSS SECTION OF A PORTION OF A STEM.



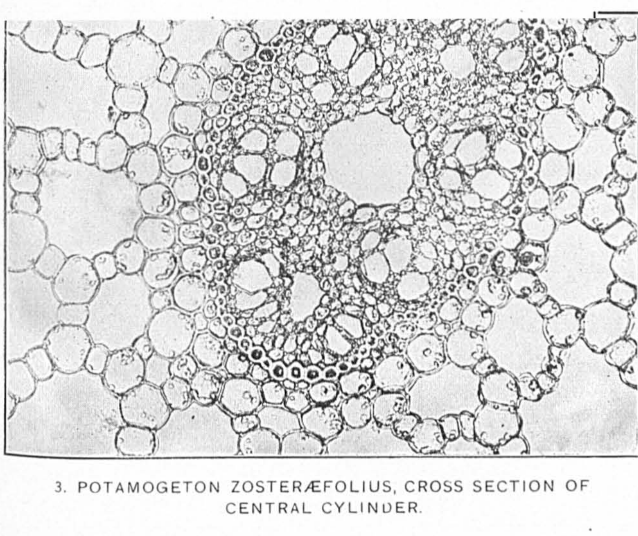
2. POTAMOGETON LONCHITES, CROSS SECTION OF A PORTION OF THE STEM.



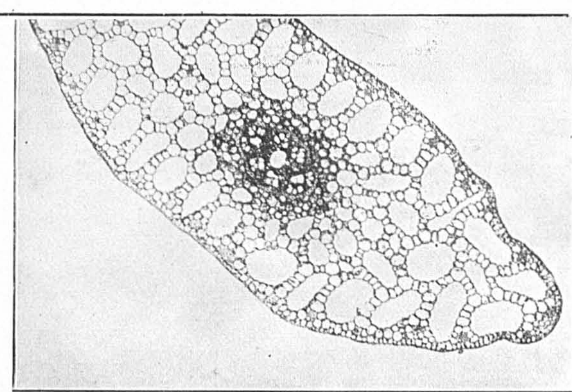
3. POTAMOGETON ZOSTERÆFOLIUS, CROSS SECTION OF CENTRAL CYLINDER.



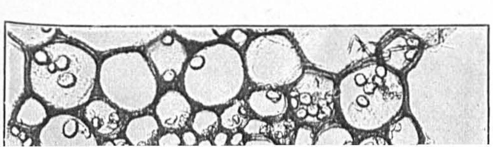
4. POTAMOGETON ZOSTERÆFOLIUS, CROSS SECTION OF A STEM.

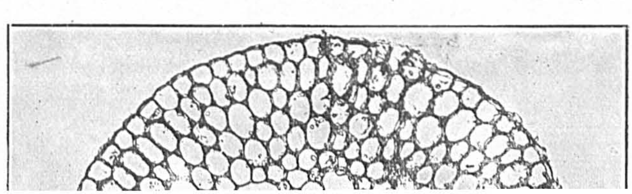


3. POTAMOGETON ZOSTERÆFOLIUS, CROSS SECTION OF CENTRAL CYLINDER.



4. POTAMOGETON ZOSTERÆFOLIUS, CROSS SECTION OF A STEM.





difference in the structure of these two, except that the emersed leaf is much better provided with ribs, which, besides being more numerous, are stronger than those in the floating leaf.

ROOTS AND RHIZOMES.

Some aquatic phanerogams have so completely adapted themselves to a watery medium that they have dispensed with roots except in the germinating seedling, and in *Ceratophyllum* even these are almost wholly suppressed. With the exception of *Utricularia*, *Ceratophyllum*, and *Wolffia*, all phanerogams in our waters produce some roots. In *Lemnaceæ* these are slender organs serving to keep the plant in position on the surface. The rooting aquatics, as the *Potamogetons* and *Myriophyllum*, are provided with roots that, according to Schenck,[1] have no purpose save to anchor the plant. Hochreutiner[2] has endeavored to show that the roots of *Potamogeton* have another function. In experiments tried by him at Geneva, it appeared that eosine solution was absorbed by the roots and passed up the stem much more readily than it passed through the leaves. If this function of the roots of aquatics can be proven, it will help to explain some observations referred to under the discussion of the soil samples.[3]

ROOTSTOCKS.

Most aquatics and swamp plants have rhizomes or running rootstocks by which the species often spreads over considerable areas. On Gibraltar Bar the runners of *Potamogeton heterophyllus* ramify in all directions, and specimens of *Potamogeton lonchites* were collected at Sandusky showing extensive runners bearing buds at their ends. *Heteranthera graminea* has long black rootstocks. The thick rootstocks of the *Nymphæaceæ* buried in the mud give rise year after year to leaves and flowers and produce an abundance of strong fibrous roots. *Sparganium eurycarpum*, *Sagittaria latifolia*, *Typha latifolia*, *Juncus torreyi*, *Scirpus pungens*, and *S. lacustris*, among swamp plants, were specially examined for root systems. All are well supplied with running rootstocks, those of the species of *Typha* and *Scirpus* being particularly strong and widely spreading. Probably many square feet in an association of *Scirpus* and *Typha* are occupied by the plants of one system, each plant connected with all others of its species by the thick rhizomes. (See pl. 14, figs. 1–4; pl. 16, fig. 1; pl. 17, figs. 4, 5. *Typha*, *Nuphar*, *Potamogeton*, *Juncus*, *Scirpus*, *Sparganium*.)

REPRODUCTION, PROPAGATION, AND WINTERING.

In most aquatics the reproductive organs show the influence of the medium less than any other part of the plant. Such typical aquatics as *Utricularia* produce showy flowers and the seeds ripen above water. Most aquatics, however, ripen their

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[1] Schenck, H. Die Biologie der Wassergewächse, Bonn, 1886.

[2] Hochreutiner, Georges. Études sur les phanerogames aquatiques du Rhône et du port Genève. (Revue gén. de Bot., t. VIII, p. 158.)

[3] Since writing the above, Mr. R. H. Pond, while a special assistant to the United States Fish Commission, has investigated the relation of water plants to the solid substratum. A summary of results has been published in Science, vol. XIII, No. 320, February 15, 1901, and is in part as follows:

"1. Plants rooted in soil exceed in vegetation and dry weight plants rooted in sand or merely suspended.

"2. Plants rooted in sand or merely suspended contain starch, calcium, and magnesium in excess, while they are lacking in nitrogen, potash, and phosphoric acid.

"3. *Lithium nitrate* is absorbed by the roots and conducted to the upper portions of the plant, where it may be detected with the spectroscope."

These results confirm the work of Hochreutiner and justify the views expressed on page 76 as to the importance of the soil for the growth of aquatics.

seeds below the surface, although the flowers are borne on emersed peduncles and have no adaptation for water fertilization. In the well-known case of *Vallisneria spiralis* the water assists in fertilization. The male flowers are borne on scapes at the base of the plant. When the inclosing spathe ruptures, the flowers rise to the surface and float about until they come in contact with the stigma of the female flower, to which some of the pollen adheres. After fertilization, the female flower is drawn below the surface, where the seeds ripen.

Our knowledge of the germination of the seeds of aquatic plants is still very fragmentary. The seedlings of rootless aquatics show the greatest departure from land forms. In *Ceratophyllum* a short radicle is developed, but it never grows out into a primary root, nor are other roots formed. In the *Potamogetons* and other rooting species the special adaptations for an aquatic existence in the seedling are not so marked. A primary root is developed, which later perishes and gives place to adventive roots.

Kolpin Ravn[1] has studied the power of seeds of aquatic and marsh plants to float and he finds that most seeds are heavier than water and thus can not float unless adhering in masses; or they may not be easily wet, when they will float in spite of their weight. Some float but a few days and their distribution is local. Many seeds, however, are doubtless carried by currents and water fowl, although the seeds of true aquatics are not well adapted to spread by animal agency, and it is probable that waves, floods, and water currents are more important in this respect than animals.

The active vegetative propagation and the perennial character of water plants have tended to reduce the importance of seed production. Many aquatics produce seed much less freely than land plants and in some seed production occurs but seldom or has never been recorded. *Ceratophyllum*, *Elodea*, and *Lemnaceæ* may grow for years in one locality and never produce seed. *Potamogeton robbinsii* is not known to seed. In the Put-in Bay region I was unable to find *Potamogeton amplifolius* in fruit, and fruits were scarce on *P. zosteræfolius*, *P. pusillus*, and *P. freisii*. The last three propagate by winter buds, and are perhaps losing the power to produce seed.

BUDS AND OFFSETS.

Besides rhizomes water plants propagate vegetatively by simple offsets and pass the winter by various means. Almost any fragment of a plant of *Elodea* when in water may continue to grow and produce a new plant. The same is true of *Ceratophyllum*, *Utricularia*, many *Potamogetons*, *Myriophyllums*, etc.

Some species pass the winter unchanged at the bottom of the water. Of these are *Zannichellia palustris*, *Ceratophyllum*, *Vallisneria*, and some species of *Potamogeton*. Among *Potamogetons*, *P. pectinatus* is remarkable for wintering by means of tubers produced at the ends of special roots. *Vallisneria* also produces a pseudo tuber, which is really a bud at the end of a rootstock. This tuber is eagerly sought after by water fowl. A third method of wintering is by means of hibernacula. *Utricularia* is the best example of this. Toward the fall the tips of the branches, instead of elongating, cease growth, and the leaves are crowded into large, compact buds. When the plant dies on the advent of cold weather, these buds sink to the bottom, where they remain until spring. The winter buds of certain *Potamogetons*

[1] Kolpin Ravn, F. Om Flydeevnen hos Froene af vore Vand og Supplanter. Bot. Tidsskrift, vol. 19, pp. 143-177, 76 fig.

are of this nature, and *Myriophyllum* also passes the winter in this way. Winter buds were common on three species of narrow-leaved *Potamogetons*, *P. zosteræfolius*, *P. pusillus*, and *P. freisii* (pl. 15, fig. 2). *Potamogeton lonchites* sometimes propagates by means of short branches, which produce buds at their ends. Roots and leaves grow out from these buds, and the result is a small plant, ready to root and grow whenever it is detached from the parent plant.

ANALYSIS OF SOIL SAMPLES.

The samples of soil collected at Put-in Bay, East Harbor, and Sandusky Bay were analyzed by the Division of Soils, U. S. Department of Agriculture. The results of the analyses are given in Table I. The number of samples is not sufficient to make general deductions possible, and therefore I shall merely indicate the direction in which the results seem to point, leaving it to future work to establish the relation, if any exists, between the texture of the soil and the plants growing upon it.

By reference to Table I, it will be seen that, as a rule, the soils on which plants occurred in abundance were composed largely of fine sand and very fine sand, and contained relatively little silt, fine silt, and clay, while the soils on which few or no plants occurred, although the depth of water and other physical conditions were favorable, were composed largely of silt, fine silt, and clay, and were poor in fine sand and very fine sand. The other items are of no practical importance, the amounts of gravel, coarse sand, and medium sand being very small, while the amount of organic matter is not at all regular, being relatively large in all samples from places where no plants grew and irregular in the other samples. Of all the samples taken, six must be excluded from the comparisons on account of other factors coming prominently into play. Sample 1, from Gibraltar Bar, is not comparable with the others, both on account of its mixed character and the exposed position of the bar, and the three samples from the open lake, Nos. 3, 4, and 7, were taken at a depth of 33 to 36 feet, and hence can not be compared with samples taken at depths not exceeding 7 feet. The two samples, 11 and 12, collected on the lake shore, were taken to determine the cause of the presence or absence of *Scirpus*. All the other samples, ten in number, were taken from places where the depth of water ranged from 6 inches to 7 feet, and where all the other physical conditions were nearly similar. I have, therefore, divided these ten samples into two sets, six in one and four in the other, and have added together for each sample the percentages of fine sand and very fine sand to make the first column of Table II, and the percentages of silt, fine silt, and clay to make the second column. The six samples of the first set represent localities well stocked with plants, while the four samples of the second set were taken from bottoms either bare or on which but a few plants were growing.

The agricultural value of soils is largely determined by their power to retain water—sandy, dry soils being good for early truck crops, but almost useless for the heavier late crops, as wheat or corn; while soils containing much clay retain water better and are consequently later and colder but more valuable for wheat and grass crops. As shown in pl. 2, Bulletin No. 5, Division of Agricultural Soils, a typical truck land contains 79.69 per cent of medium, fine, and very fine sand and 14.36 per cent of silt, fine silt, and clay. It is somewhat similar, therefore, to the sample of the first group on which the heaviest growth was found (No. 2), the greatest difference being in the fact that in truck lands the percentage of medium sand is large while in our sample it is insignificant. The samples on which practically no plants were found are more uniform in texture than those of the first group and very much resemble the typical wheat lands, as given in plate 3, Bulletin 5, in which the percentage of fine sand and very fine sand is 36.90 and that of silt, fine silt, and clay 55.91.

The water in sandy soils is undoubtedly better aerated than that in clay soils, though both are under water, because in the former case the water passes through the soil more rapidly than it does in the latter, and it would seem that even the roots of aquatics are unable to thrive in a soil so poor in oxygen as the saturated heavy clays.

It will be necessary in future work to take many samples of the bottom under all conditions of vegetation and to take the temperatures not alone of the water but of the soil in which the plants are growing. A large series of such samples would make possible general conclusions that might be of practical value.

TABLE I.—*Mechanical analyses of soil samples taken from bottom of Put-in Bay and vicinity.*

Division No.	Locality.	Collection No.	Vegetation.	Moisture in air-dry sample.	Organic matter.	Gravel (2-1 mm.).	Coarse sand (1-0.5 mm.).	Medium sand (0.5-0.25 mm.).	Fine sand (0.25-0.1 mm.).	Very fine sand (0.1-0.05 mm.).	Silt (0.05-0.01 mm.).	Fine silt (0.01-0.005 mm.).	Clay (0.005-0.0001 mm.).
				P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
3852	Near West Harbor	11	Scirpus pungens.	0.14	0.88	0.20	0.22	0.78	83.70	12.80	0.35	0.07	0.65
3853	....do	12	....do	0.21	1.99	1.40	1.59	3.82	67.11	23.82	0.38	0.12	0.75
3847	Mouth of East Harbor	5	Good	0.88	3.68	0.00	0.00	0.38	74.15	18.65	1.04	0.31	1.86
3858	Edge of water near swamp	17	Fair	0.40	1.15	0.00	0.02	0.09	11.42	82.50	1.72	0.67	2.55
3857	Upper Sandusky Bay	16	Very good	0.74	2.02	0.00	0.05	0.12	20.66	63.56	5.64	1.52	5.85
3844	Southeast of Gibraltar Bar	2	Excellent	0.26	4.52	0.67	1.64	6.36	38.45	35.90	3.36	2.35	8.10
3851	Portage River	10	Good	2.54	7.07	0.00	0.00	0.68	4.70	62.00	9.51	2.92	12.55
3848	East Harbor	6	....do	2.80	7.79	0.00	Trace.	0.48	21.58	38.65	7.53	4.68	17.13
3843	On Gibraltar Bar	1	Scant	1.56	6.26	7.73	7.13	14.20	12.15	8.59	16.58	6.09	21.60
3850	Portage River, broad part	9	Nothing	3.13	8.19	0.00	0.00	Trace.	1.86	27.46	24.37	7.63	27.39
3854	Upper Sandusky Bay	13	....do	2.47	7.76	0.35	0.00	0.12	2.13	35.73	16.85	6.68	28.11
3855	1,000 feet from swamp	14	Very scant	2.34	6.45	0.00	0.29	Trace.	2.40	29.60	21.75	7.95	28.23
3856	Near Winona Point Clubhouse, Sandusky Bay.	15	....do	3.62	7.23	0.00	0.00	Trace.	1.10	30.43	19.76	7.99	28.46
3845	Near fish hatchery in open lake.	3	Nothing	2.88	5.76	0.19	0.48	1.35	19.15	15.78	19.54	7.62	29.00
3846	In open lake	4	....do	2.26	5.65	0.05	0.17	0.37	1.65	20.61	29.21	9.20	32.50
3849	East point of Middle Bass Island, open lake.	7	....do	1.63	7.46	0.21	0.41	0.86	2.77	16.77	26.06	9.33	36.10

TABLE II.—*Comparison of samples collected at Put-in Bay and vicinity, with typical truck and wheat soils.*

Division No.	Collection No.	Depth in feet.	Condition of vegetation.	Per cent of medium sand, fine sand, and very fine sand.	Per cent of silt, fine silt, and clay.	
3847	5	1 to 2	Good	93.18	3.21	Set I.
3858	17	.5 to 1	Fair	94.01	4.94	
3857	16	3.5	Very good	84.34	12.99	
3844	2	7	Excellent	80.71	13.81	
3851	10	3	Good	67.38	25.08	
3848	6	3 to 4	....do	60.71	29.34	
Early truck soil. Plate 2, Bull. 5, Division of Agricultural Soils				79.69	14.37	
3850	9	6	Nothing	29.39	59.39	Set II.
3854	13	6	....do	37.98	51.64	
3855	14	5	Very scanty	32	57.93	
3856	15	6	....do	31.53	56.21	
Wheat soil. Plate 3, Bull. 5, Division of Agricultural Soils				38.07	55.91	

Alphabetical list of plants occurring in Lake Erie and in swamps in the vicinity of Put-in Bay, Sandusky, East Harbor, and Portage River, Ohio.[1]

PHANEROGAMS.[2]

Acorus calamus L. East Harbor.
* *Alisma plantago* L. Portage River.
Apocynum cannabinum L. With *Scirpus pungens* in shallow water, West Harbor.
Asclepias incarnata L. Everywhere in very shallow water or on exposed muddy banks.
Bidens beckii Torr. Pond in East Harbor and in Squaw Harbor.
Boltonia asteroides L'Her. With *Scirpus pungens* in shallow water near West Harbor.
* *Brasenia schreberi* J. F. Gmel. Cedar Point.
* *Carex aquatilis* Wahl. Cedar Point, Sandusky.
Carex pseudo-cyperus var. *comosa* Boott. Squaw Harbor. Seen only in one place.
Carex stricta Lam. Pond on South Bass Island near hatchery.
* *Carex torta* Boott. Cedar Point, Sandusky.
Ceratophyllum demersum L. Everywhere.
Cyperus erythrorhizos Muhl. Muddy shores, Upper Sandusky.
Cyperus strigosus L. Upper Sandusky Bay.
Deyeuxia canadensis Munro. Muddy banks, East Harbor.
Dianthera americana L. Squaw Harbor, Put-in Bay, and East Harbor.
* *Eleocharis acicularis* R. Br. Cedar Point.
Eleocharis intermedia Schultes. Cedar Point.
Elodea canadensis Michx. Common.
Eupatorium perfoliatum L. With *Scirpus pungens* in shallow water, Squaw Harbor.
* *Fimbristylis autumnalis* R. S. Cedar Point.
Heteranthera graminea Vahl. Everywhere. One of the most common submersed aquatics. Found on mud flat at Portage River.
Hibiscus moscheutos L. East Harbor on muddy banks.
Ilysanthus riparia Rafin. Upper Sandusky Bay.
* *Juncus balticus* Willd. Cedar Point, Sandusky.
* *Juncus brachycephalus* (Engelm.) Buch. West Harbor.
Juncus torreyi Coville. Squaw Harbor in shallow water and on mud banks.
Leerzia oryzoides Sw. With *Scirpus pungens*, West Harbor.
Lemna minor L. In ponds on South Bass Island and at East Harbor.
Lemna polyrhiza L. Common.
Lemna trisulca L. Pond on South Bass Island.
Lippia lanceolata Michx. Upper Sandusky Bay.
Mentha canadensis L. Muddy banks, Upper Sandusky Bay.
Myriophyllum spicatum L. Everywhere in quiet water, 2 to 4 feet deep.
Naias flexilis Rost. & Schmidt. Common.
Naias flexilis robusta Morong. More common than the species.
Naias gracillima Morong. Pond in Portage River swamp near Port Clinton.
Nasturtium palustre D. C. Muddy banks, Upper Sandusky Bay.
Nelumbium luteum Willd. Abundant at East Harbor, Portage River, and head of Sandusky Bay. Introduced into Squaw Harbor and near fish-hatchery.
Nuphar advena Ait. Common.
Nymphæa tuberosa Paine. East Harbor in 3 or 4 feet of water.
Phalaris arundinacea L. East Harbor, on mud banks.
Phragmites communis Trin. East Harbor. Forms extensive associations.
Physostegia virginiana Benth. Muddy bank, in Upper Sandusky Bay.
Polygonum muhlenbergii S. Wats. East Harbor and Sandusky Bay.
Polygonum acre H. B. & K. Muddy shores, Upper Sandusky Bay.
Populus monilifera Ait. Beach at East Harbor.
Potamogeton amplifolius Tuckerman. Near fish-hatchery and in Sandusky Bay. Not found with floating leaves.
Potamogeton foliosus Raf. Put-in Bay.
Potamogeton freisii Ruprecht. Put-in Bay. Not abundant.
Potamogeton heterophyllus Schreb. Gibraltar Bar, East Harbor, and Sandusky Bay. Floating leaves on specimens from Sandusky Bay.
* *Potamogeton hillii* Morong. East Harbor.
* *Potamogeton interruptus* Kitaibel. Sandusky Bay.
Potamoge'on lonchites Tuckerman. Put-in Bay, East Harbor, Sandusky Bay. One of the commonest species.
Potamogeton lucens L. East Harbor and Sandusky Bay.
Potamogeton filiformis Pers. Gibraltar Bar.
Potamogeton natans L. Put-in Bay, East Harbor.
Potamogeton pectinatus L. Everywhere. Extremely variable in size and habit.
Potamogeton perfoliatus L. Everywhere.
Potamogeton perfoliatus richardsonii A. Bennett, Put-in Bay.
Potamogeton prælongus Wulf. Portage River.
Potamogeton pusillus L. Put-in Bay, East Harbor.
Potamogeton robbinsii Oakes. East Harbor, Sandusky Bay.
Potamogeton zizii Roth. Sandusky Bay.
Potamogeton zosteræfolius Schum. Everywhere.
Ranunculus divaricatus Schrank. Sandusky Bay.
Rumex verticillatus L. Pool on South Bass Island.
Sagittaria arifolia Nutt. Muddy shore, Upper Sandusky Bay.
Sagittaria graminea Michx. Muddy shore, Upper Sandusky Bay.
Sagittaria latifolia Wild. Squaw Harbor, East Harbor.
Sagittaria rigida Pursh. Everywhere.
Salix longifolia Muhl. East Harbor. Frequently in several inches of water on the beach.
Salix nigra Marsh. East Harbor, on sand bar in 4 to 10 inches of water.

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[1] Species marked with an asterisk were found in the herbarium of E. L. Mosely, of Sandusky, Ohio, and were not observed by me.

[2] Nomenclature generally according to Index Kewensis.

Alphabetical list of plants occuring in Lake Erie and in swamps in the vicinity of Put-in Bay, Sandusky, East Harbor, and Portage River, Ohio—Continued.

PHANEROGAMS—Continued.

Salix wardii Muhl. East Harbor. Sometimes in shallow water.
Scirpus atrovirens Muhl. Muddy banks, East Harbor.
Scirpus pungens Vahl. Everywhere.
Scirpus eriophorum Michx. Shallow water, Upper Sandusky Bay.
* *Scirpus erectus* Poir. East Harbor.
Scirpus fluviatilis A. Gray. Everywhere.
Scirpus lacustris L. Everywhere.
Scirpus sylvaticus L. Shore of pool on South Bass Island.
* *Scirpus torreyi* Olney. East Harbor.
Scutellaria galericulata L. East Harbor swamps.
Sium cicutæfolium Gmel. East Harbor swamps.
Sparganium eurycarpum Engelm. Everywhere.
Spartina cynosuroides Willd. Upper Sandusky Bay.
Stachys aspera Michx. Borders of pool on South Bass Island.
Typha angustifolia L. Rare, along Portage River and Upper Sandusky Bay.
Typha latifolia L. Everywhere.
* *Utricularia gibba* L. Cedar Point, Sandusky Bay.
Utricularia vulgaris L. East Harbor, Portage River.
Vallisneria spiralis L. Everywhere.
Wolffia columbiana Karst. Abundant in pool on South Bass Island.
Zannichellia palustris L. Squaw Harbor.
Zizania aquatica L. East Harbor, Portage River, Upper Sandusky Bay.

CHARACEÆ.[1]

Chara contraria A. Br., forma *gymnotiles* (No. 2). Abundant in Hatchery Bay, the common species.
Chara contraria A. Br., forma *paragymnophylla* (No. 17). This was identified with a doubt by Dr. Norstedt. The form is rare in Put-in Bay, growing in only one spot near Gibraltar Island, in 7.5 feet of water. It is so peculiar that a brief description will be given. Fruiting plants 5 to 10 cm. high; mostly with incomplete cortication, one plant of the collection being fully corticated, some not corticated at all, others with one or two joints of the leaves corticated; in these cases the second and third leaf joints are corticated with eight cells. Stipular whorl inconspicuous but double. Stipules short, less than one-half to one-third length of carpogone. End segment of leaf either obtuse and 1-celled or acute and 2-celled.
Chara contraria A. Br., forma (28). On sandy beach at East Harbor, Ohio. (Pl. 17, fig. 2.)
Chara contraria A. Br. (29). A low-growing delicate form found with 28, but having longer stipules and dwarfer habit.
Chara contraria A. Br. forma *subinermis* (30). Found with 28 and 29. Very dwarf habit; leaves much longer than the internodes and cortication imperfect; identified by Dr. Norstedt. No. 66, identified by Dr. Allen as belonging to this species and form, was collected on a clay bank in Squaw Harbor; water 6 to 12 inches deep. (Pl. 17, fig. 1.)
Chara contraria A. Br. (62). Very small specimens with extremely long leaves; collected in Lake Erie a mile outside of Sandusky Bay and in 6 to 8 feet of water.
Chara contraria A. Br. (68, 69, 70). In Put-in Bay.
Chara contraria A. Br. forma *elongata, macroptila, macrotiles, gymnotiles* (72). Put-in Bay.
Chara coronata Ziz. forma *microptila, incrustata* (23). Dr. Allen says this is a very unusual form with very short bracts. (Pl. 20, fig. 5.)
Chara coronata Ziz. (41, 42). East Swamp and East Harbor. (Pl. 20, figs. 1, 2.)
Chara coronata Ziz., forma *meiocarpa, meioptila* (32). On sandy beach, East Harbor. (Pl. 20, fig. 4.)
Chara coronata Ziz., forma *incrustata* (74). Clay bank in shallow water, Squaw Harbor. (Pl. 20, fig. 3.)
Chara sejuncta A. Br. (31). On Sandy beach, East Harbor.
Chara gymnopus var. *michauxii* A. Br. (53). On mud bottom in shallow water, Portage River. (Pl. 19, fig. 1.)
Chara fragilis Desv., forma *brevibracteata* (33). East Harbor, Ohio. (Pl. 16, fig. 2.)
Chara fragilis Desv., forma *subinermis* (36). Put-in Bay.
Chara hydropitys Reichenbach, forma *compacta* (65). On clay bank in very shallow water, Squaw Harbor. (Pl. 17, fig. 3.)
Chara aspera (Dethard) Willd. (67). On clay bank in very shallow water, Squaw Harbor. This species was not found in fruit.
Chara intermedia A. Br. (71 probably) (73). Both in Put-in Bay.
Nitella subglomerata A. Br. On sandy beach at East Harbor (75). (Pl. 18, fig. 3.) In mud with *Chara gymnopus michauxii*, Portage River. (55). (Pl. 18, fig. 1.)
Nitella polyglochin A. Br. (26). With other Characeæ on sandy beach at East Harbor. (55). (Pl. 19, fig. 2.)
Nitella batrachasperma (Reichenbach) A. Br. (27). On sandy beach East Harbor and on mud bottom in Portage River.
Nitella tenuissima Desv. (27½). Two specimens of 27 were sent to Dr. Allen, and they were thought to belong to the same species. It appears, however, that one was *N. batrachasperma* and the other, which Dr. Allen numbered 27½, was *N. tenuissima*. The one sent to Dr. Nordstedt as 27 was *N. tenuissima*.
Nitella gracilis Ag. vel sp. *affinis* (64). Upper Sandusky Bay, in quiet water. Immature.
Tolypella intertexta Allen (No. 1). Occurs in Hatchery Bay, but the plants are nowhere thrifty. July.

[1] The Characeæ were kindly determined by Dr. T. F. Allen and Dr. Otto Nordstedt.

Alphabetical list of plants occurring in Lake Erie and in swamps in the vicinity of Put-in Bay, Sandusky, East Harbor, and Portage River, Ohio—Continued.

DESMIDEÆ.

Closterium ehrenbergii Menegh. In tow, Put-in Bay.

Closterium leibleinii Kuetz. In washings from *Bidens beckii* and *Utricularia vulgaris.*

Closterium parvulum Naeg. In washings from *Bidens beckii* and *Utricularia vulgaris.*

Closterium venus Kuetz. In tow, Put-in Bay; in *Utricularia* washings and in pool on Starve Island.

Closterium dianæ Ehrenb. In washings from *Sagittaria rigida*, Squaw Harbor.

Cosmarium angulare Johnson. In *Utricularia* washings. Mr. Johnson described this species from material collected by myself at Lake St. Clair in 1893. It will probably be found at other points along the lakes.

Cosmarium botrytis Menegh. In tow, Put-in Bay, and nearly all plant washings.

Cosmarium brebissonii Menegh. Starve Island.

Cosmarium depressum Lund. Put-in Bay.

Cosmarium granatum Breb. In *Utricularia* washings.

Cosmarium læve Rabenh. In washings from *Enyconema* and *Sagittaria.*

Cosmarium margaritiferum Menegh. In *Utricularia* washings.

Cosmarium meneghinii Breb. In *Utricularia* washings.

Cosmarium moniliforme Ralfs. In *Bidens beckii* washings.

Cosmarium nitidulum De Not. In washings from *Enyconema* and *Sagittaria.*

Cosmarium ornatum Ralfs. In *Bidens beckii* washings.

Cosmarium portianum Archer. In *Utricularia* washings,

Cosmarium punctulatum Breb. In tow and in washings from various plants.

Cosmarium reniforme Archer. In tow and in washings from various plants.

Cosmarium reniforme var. *compressum* Nordst. Put-in Bay.

Desmidium swartzii Breb. Put-in Bay.

Disphinctium connatum (Breb.) De Bary. Put-in Bay.

Euastrum elegans Kuetz. In *Bidens beckii* washings.

Euastrum binale Ralfs. In washings from *Bidens beckii* and *Utricularia vulgaris.*

Euastrum elegans var? In *Utricularia* washings.

Gonatozygon kinahani (Archer) Rabenh. In *Bidens beckii* washings.

Gonatozygon ralfsii De Bary. In *Bidens beckii* washings.

Hyalotheca dissiliens Breb. In *Utricularia* washings.

Hyalotheca mucosa Ehrenb. In *Bidens beckii* washings.

Pleurotæniopsis ralfsii (Breb.) Lund. In *Utricularia* washings.

Pleurotænium trabecula (Ehrenb.) Naeg. In *Utricularia* washings.

Staurastrum avicula Breb. In *Utricularia* washings.

Staurastrum brebissoni Archer. In *Utricularia* washings.

Staurastrum crenulatum (Naeg.) Delponte. In *Utricularia* washings.

Staurastrum dejectum Breb. In tow, Put-in Bay.

Staurastrum dilatatum Ehrenb. In *Utricularia* washings.

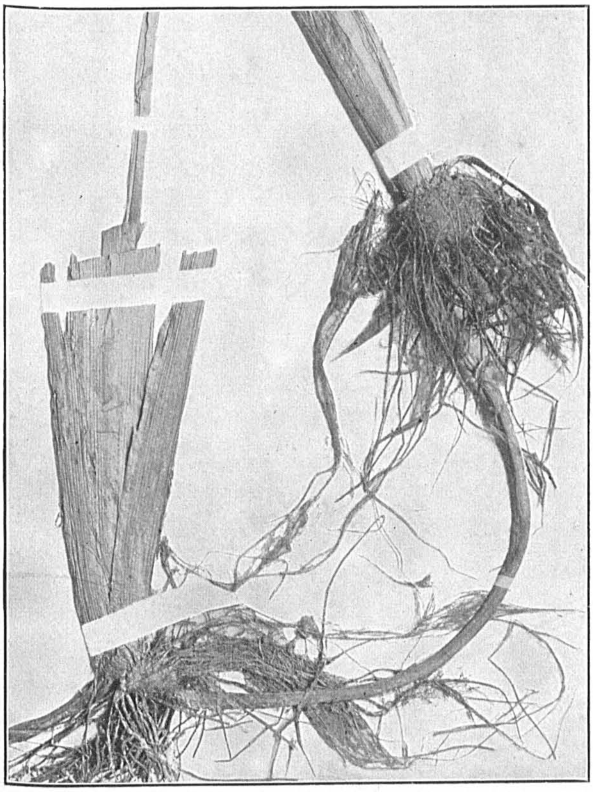
Staurastrum furcigerum Breb. In *Utricularia* washings.

Staurastrum punctulatum Breb. In tow, Put-in Bay.

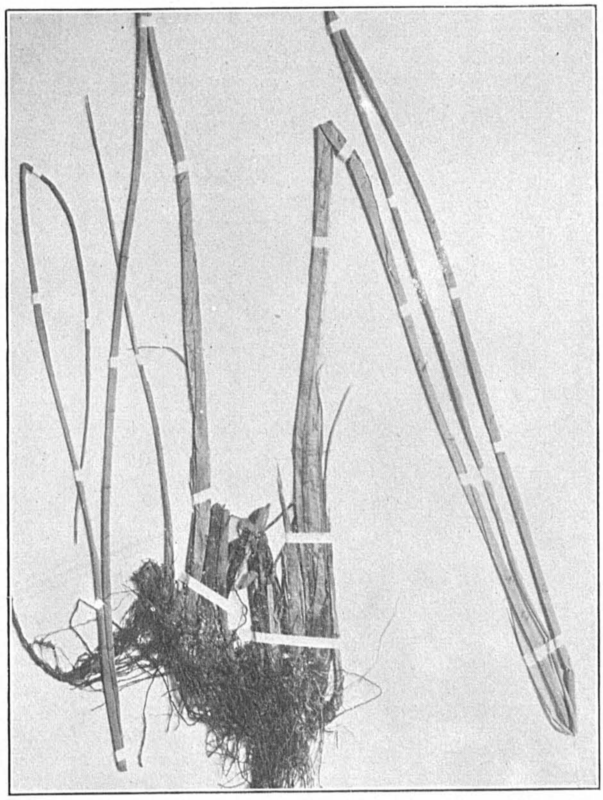
Staurastrum striolatum Archer. In *Sagittaria* washings.

Staurastrum tetracerum (Kuetz.) Ralfs. In *Bidens beckii* washings.

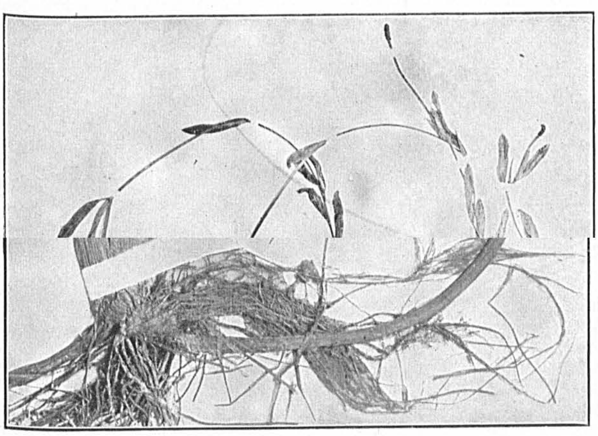
Xanthidium antilopæum Kutz. In *Utricularia* washings.



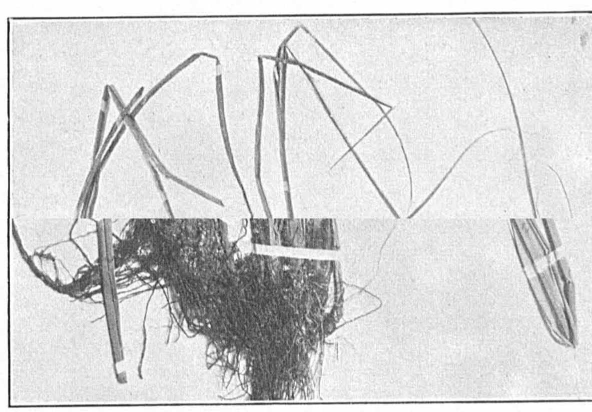
1. SPARGANIUM EURYCARPUM, ROOTSTOCK.



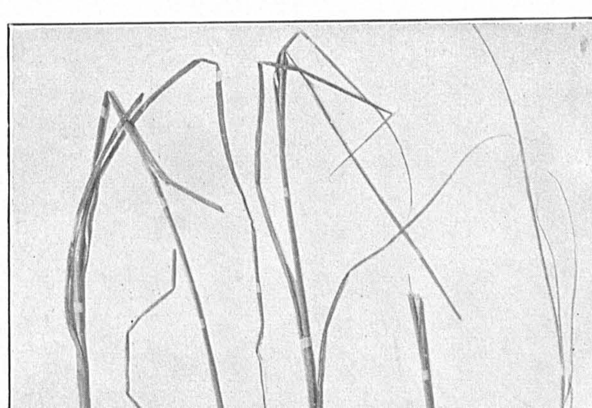
2. SCIRPUS LACUSTRIS, ROOTSTOCK.

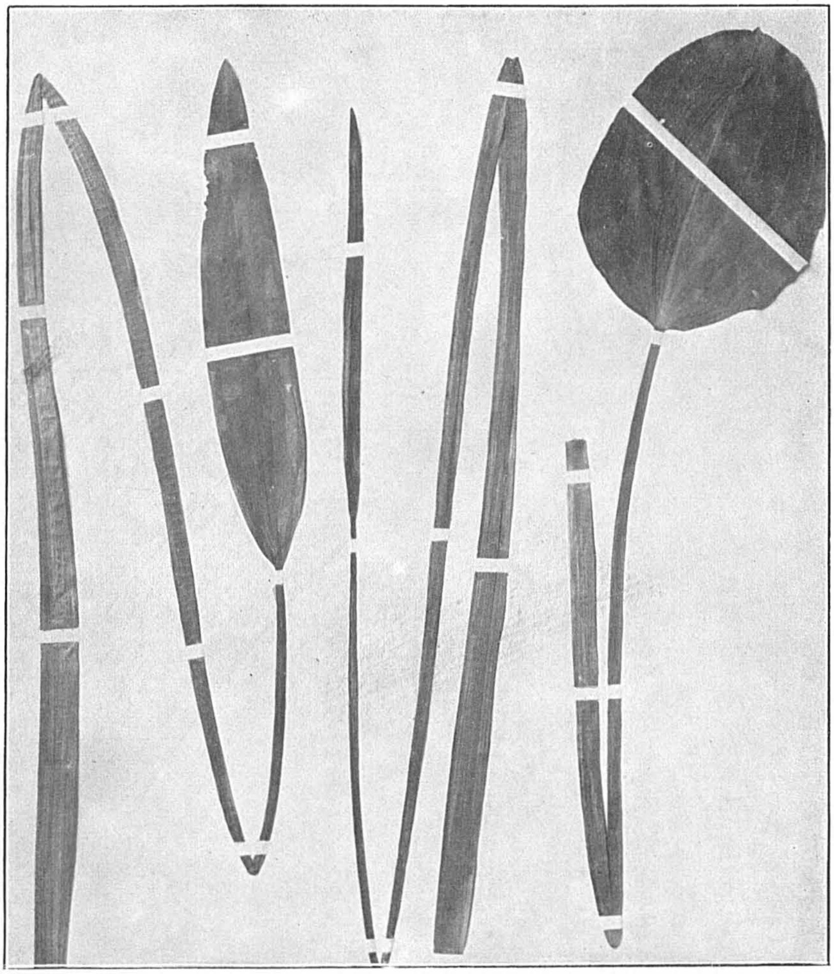


1. SPARGANIUM EURYCARPUM, ROOTSTOCK.



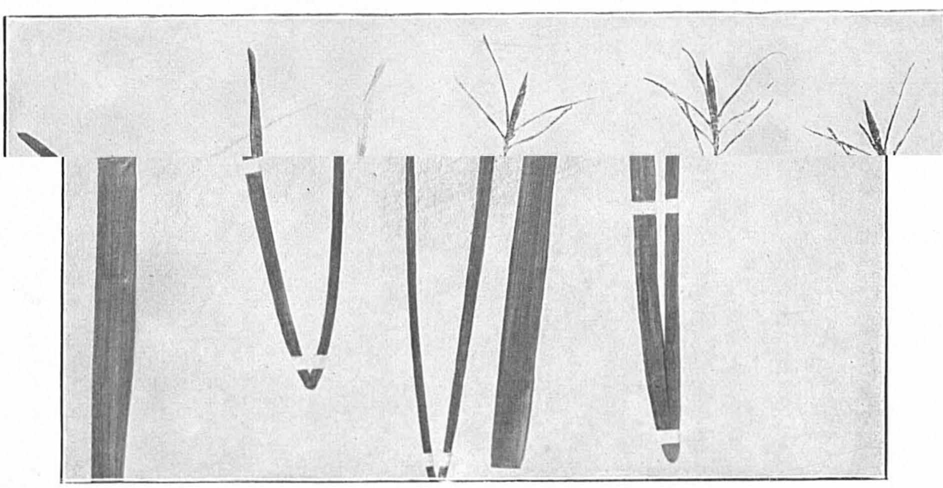
2. SCIRPUS LACUSTRIS, ROOTSTOCK.





1. SAGITTARIA RIGIDA.

The leaf in the center is from deep water; that at the right from shallow water near the shore.



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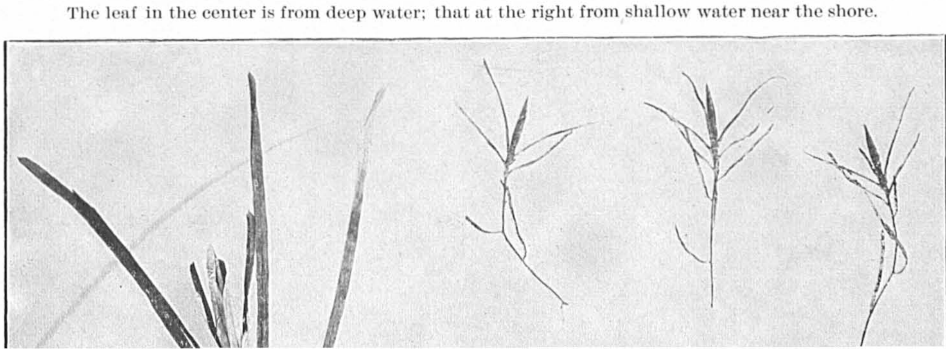
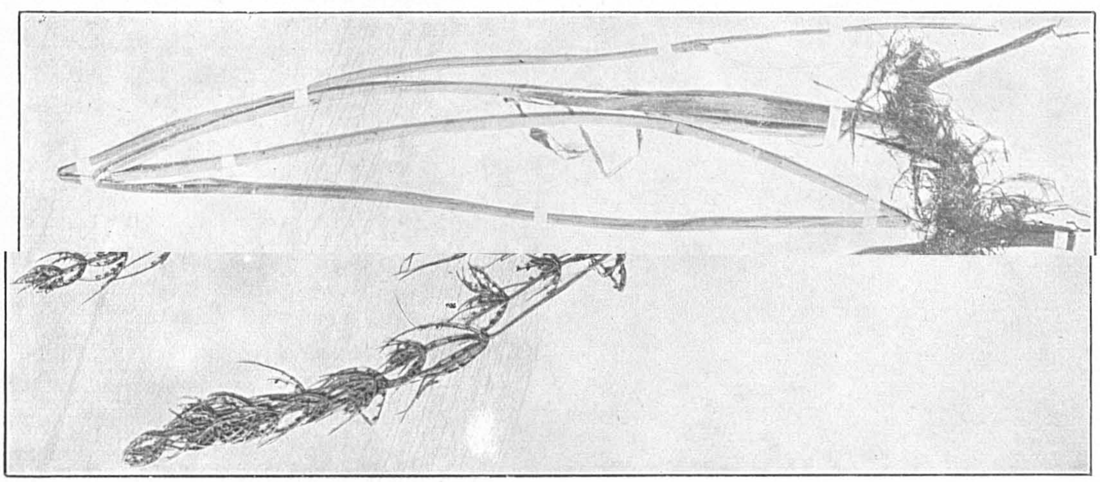
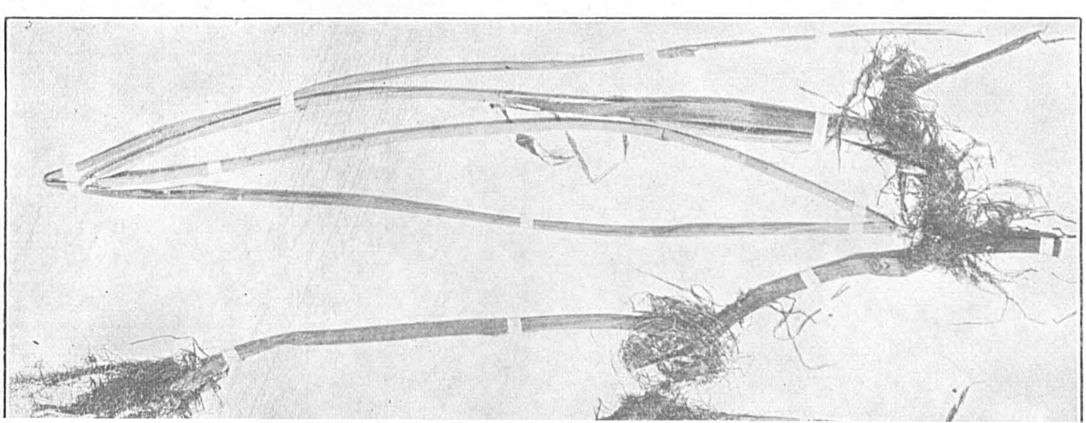


PLATE 16.

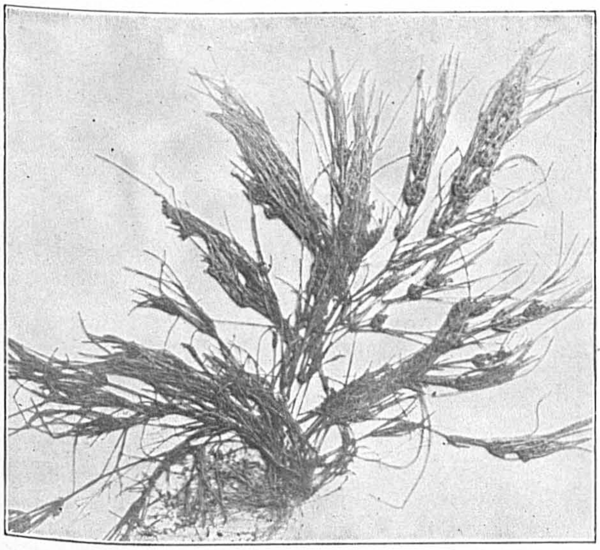
2. CHARA FRAGILIS FORMA BREVIBRACTEATA.



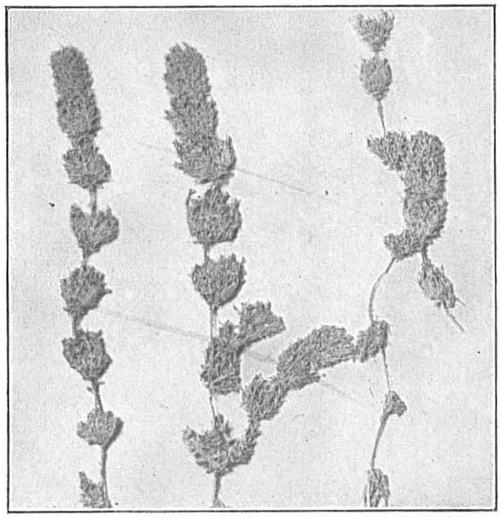
2. CHCK.



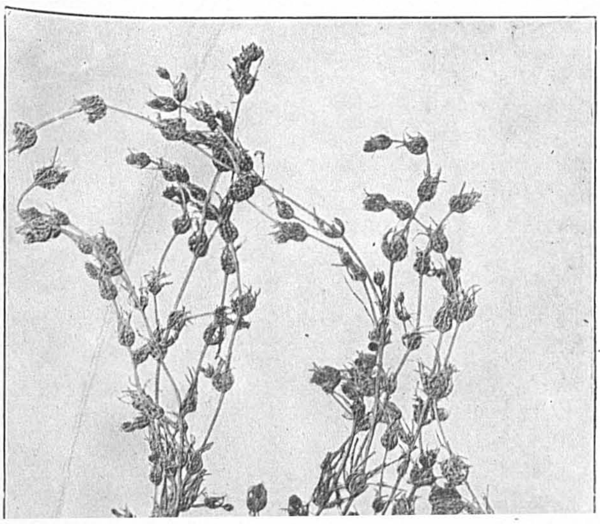
NGENS, ROOTSTOCK.

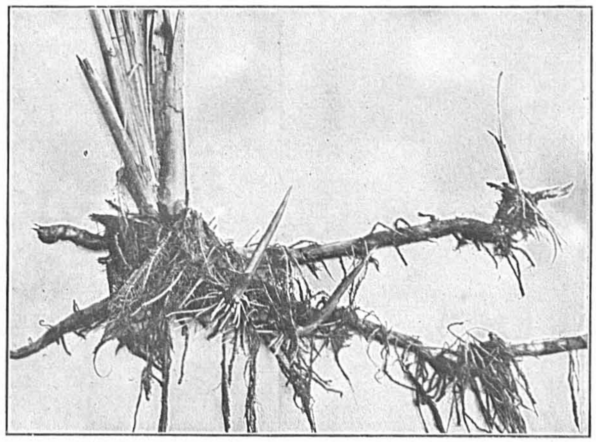


1. CHARA CONTRARIA FORMA SUBINERMIS.

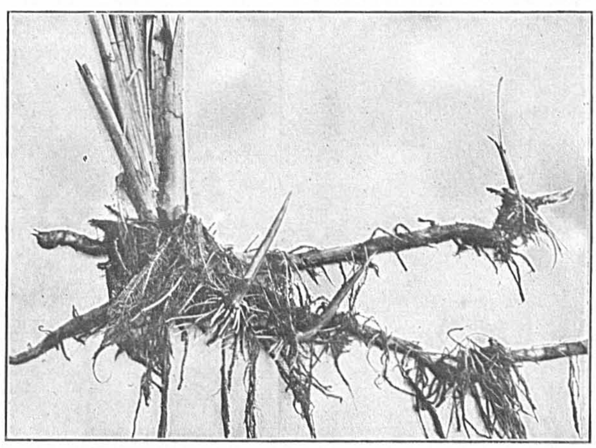


3. CHARA HYDROPITYS.

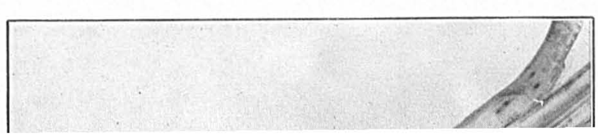




4. TYPHA LATIFOLIA, ROOTSTOCKS.



4. TYPHA LATIFOLIA, ROOTSTOCKS.



1. NITELLA SUBGLOMERATA, MUD BOTTOM.

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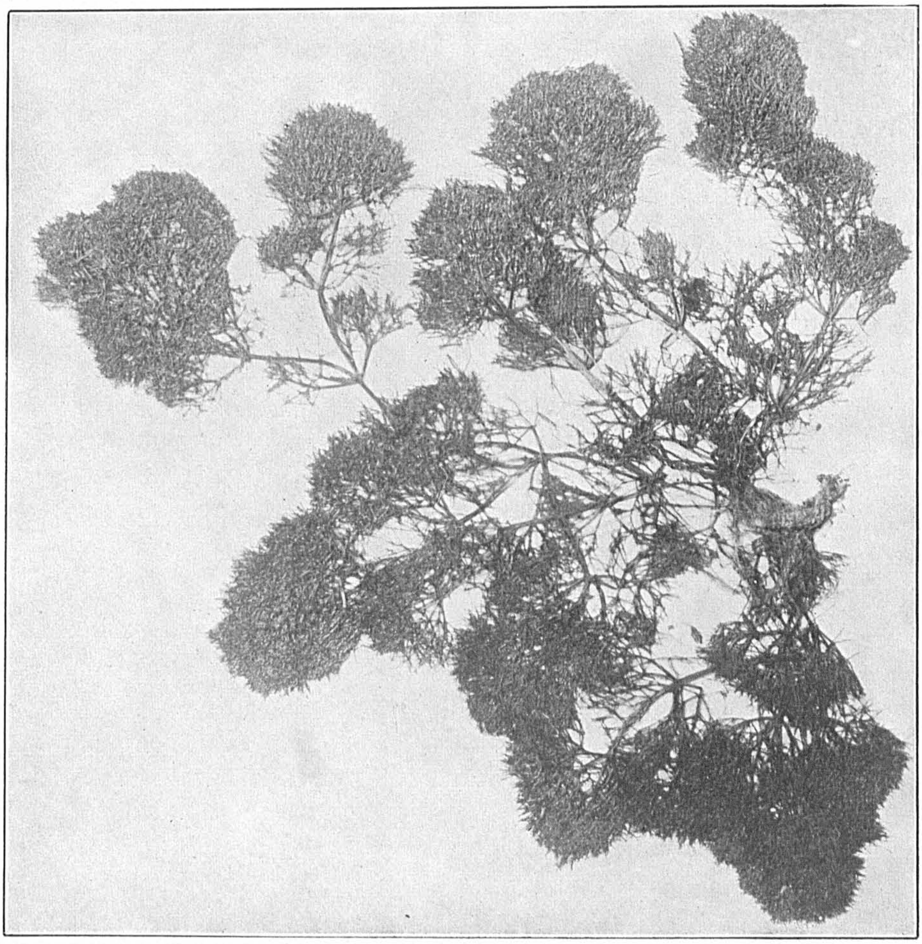
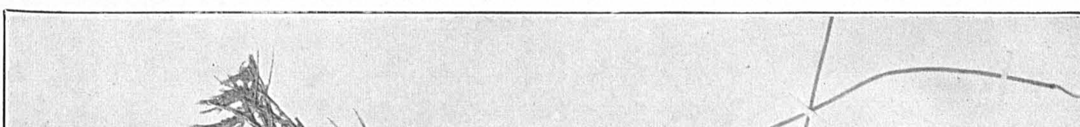
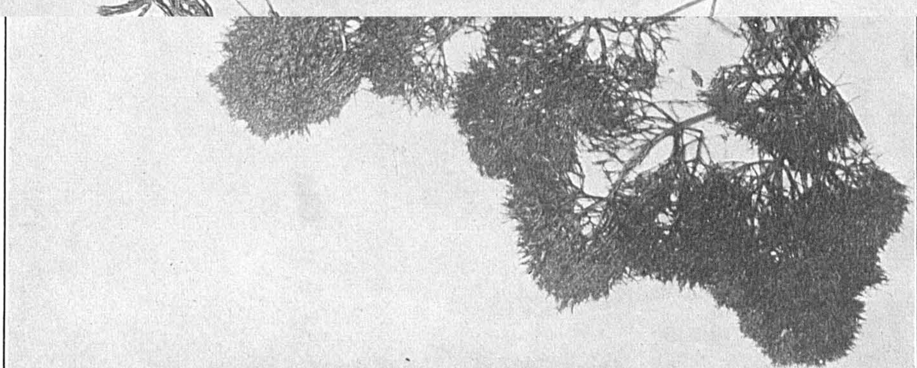


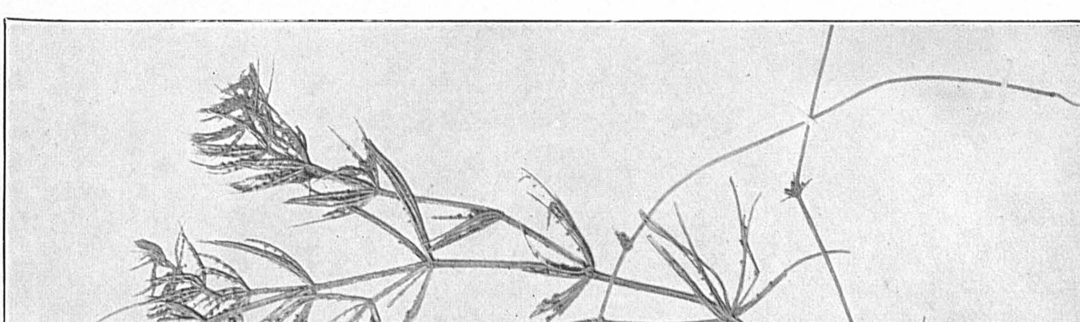
2. NITELLA POLYGLOCHIN.



RS.



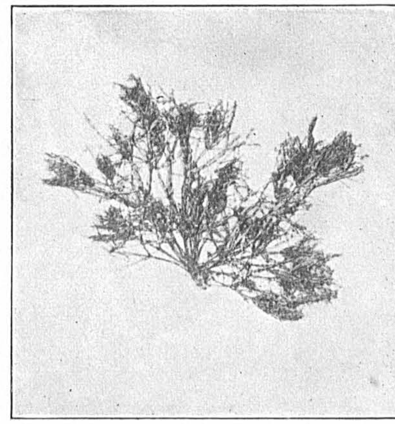
2.



SHOWING RUNNERS.

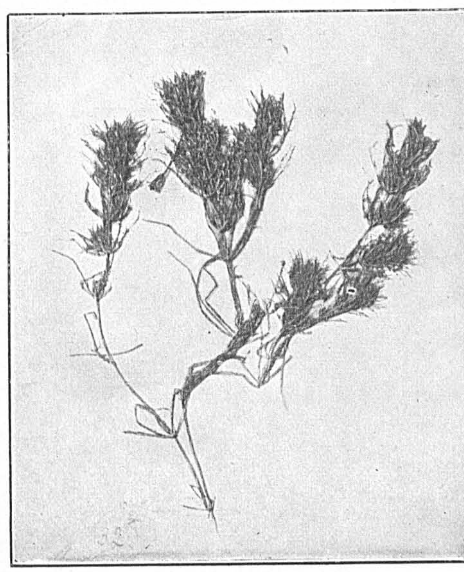
1. CHARA CORONATA.

On mud bottom in shallow water.



3. CHARA CORONATA.

From shallow water in Squaw Harbor.

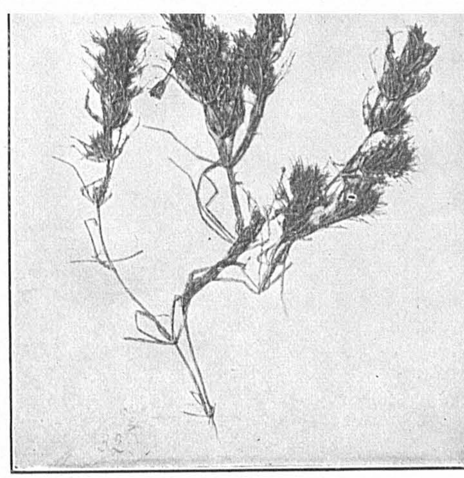


4. CHARA CORONATA.

In shallow water on sandy beach.

1. CHARA CORONATA.

On mud bottom in shallow water.



4. CHARA CORONATA.

In shallow water on sandy beach.