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The aquatic botany of Cranberry Pond

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THE AQUATIC BOTANY OF CRANBERRY POND

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by

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INTRODUCTION:

In March of 1935, at the suggestion of Professor A. Vincent Osmun, Head of the Massachusetts State College Department of Botany, the writer undertook an introductory systematic and ecological survey of the aquatic plants of Cranberry Pond. This pond, a small, very shallow body of water, is situated on the Mt. Toby forest reservation of the Massachusetts State College in the eastern part of the town of Sunderland, Massachusetts. Cranberry pond itself lies approximately north of that portion of the mountain know as Ox Hill and is the northern drainage basin of the mountain.

The recent formation of an enlarged pond due to damming, with the accompanying addition of new food supplies for the aquatic life of the pond, suggested that this might well be used as a model pond for fish culture and in this connection a biological survey became of moment. That part of the survey pertaining to the plant life of the pond was entrusted to the Department of Botany. The completion of such a survey will require years of study and should embrace all seasons.

This paper, therefore, is essentially a preliminary listing of the aquatic plant forms supplemented by a brief ecological commentary on the nature of the existing plant relationships. As such it should be of importance in extending the knowledge of algal distribution, in pointing out the important and characteristic forms, in correlating these forms with the habitat, and in arranging the species involved in the relative order of abundance as dominant and subordinate forms. It is hoped that the included data may also help towards a knowledge of the management of the pond for fish culture.

REVIEW OF LITERATURE:

Investigations in aquatic botany are numerous but in the past have been more limited to taxonomy than to ecology. The taxonomy of the algae of New England has been very well cared for. F.S.Collins (2), besides having contributed a number of papers to such journals as Rhodora has also left his best work in:"The Green Algae of North America". Synopses of algal genera, particularly members of the desmids, have also appeared in Rhodora under the name of J.A.Cushman (6). More recent is C.J. Hylander's (14), "The Algae of Connecticut", which constitutes perhaps the best reference for Massachusetts algae. Sooner or later, in a study of an aquatic flora, reference must be made to one of the algal classics. "Die Süsswasser Flora Mitteleuropas", by A. Pascher (20) stands first on such a list with, "A Treatise on the British Fresh-Water Algae", by G.S.West and F.E.Fritsch (37) and also G.M.Smith's (29), "Fresh-water Algae of the United States", following closely.

In the field of ecology the work of the last named author (26)(28), on the plankton relationships of certain New York and Wisconsin lakes, is outstanding. Fritsch (11) and Hodgetts (13) in England and Moore (16) and Transeau (33) in this country have also contributed to the particular field with which this paper deals. A summary of most of this type of work done, particularly that which may be included in the field of limnology, may be found in the very recent reference text, "Limnology", by Paul S.Welch (36).

Algae may be separated conveniently into two main ecological groups, namely pelagic forms (organisms inhabiting the open waters) and littoral or benthic forms (organisms inhabiting the shores or bottom). The pelagic or, better, the plankton algae will be considered first.

Under the plankton algae are considered all normally free-floating species. Such floating algal plants, termed phytoplankton, make up, as Smith (28) says: " - a definite plant association and not an accidental heterogeneous collection of algae that grow in mid-lake. In a collection from mid-lake the greater part of the individuals are those to be found only in the plankton and not in the shore flora; there are, however, a small proportion of shore forms that have drifted out into the open lake. The former have been called the eulimnetic phytoplankton and the latter the tycholimnetic".

Here Smith has made definite reference to the plankton divisions of lakes as opposed to ponds. The question of physical distinction between lakes and ponds has not been considered. Such a distinction is usually made on the basis of size, depth, etc. Smith, however, believes that the latter should not be some arbitrary depth but rather one based on thermal stratification, - successive heat layers, as is characteristic in lakes of great depths. Depth of a body of water insufficient to produce thermal stratification would indicate that that body of water is of the pond category. All conceivable transitions between ponds and lakes exist, hence a hard and fast line should not be drawn.

According to Zacharias (1898)(Smith-28), certain small bodies of water have a rather constant eulimnetic flora whereas the same species are only of sporadic occurrence in large bodies of water. The presence of such constant eulimnetic species in the flora of small ponds suggested to him the term heleoplankton to describe the plankton community of a pond as differentiated from the limnoplankton of a lake. Such types can be readily singled out as true plankters. Their very structure, modified for the floating, suspended condition, identifies them as members of the open water community. Furthermore, eulimnetic phytoplankters readily reproduce in their floating environment. Casual visitors from the littoral or benthic zones are out of place and thus cannot multiply.

Since 1896 there have been several attempts to classify the plankton flora of any given pond or lake on the basis of the constituent organisms present. In that year Apstein (Smith-28) divided lakes into Chroococcus and Dinobryon types. The former is dominated by Chroococcacean forms, "with comparatively few Dinobryon colonies with a general quantitative richness of the phytoplankton; the latter have few Chroococcaceae, numerous Dinobryon colonies and clear waters, owing to the small bulk of plankton". Due to the fact that many lakes cannot be considered in such a classification criticism of it has been general. Agreeing that "distinction should be made between types of plankton flora, G.S.West (Smith 28) suggests that such should be based on a more far-reaching division.

W.J. and G.S.West first noted in Scotland (1903) lakes whose plankton was particularly rich in desmids. Since that time this fact has been accepted as world-wide with the result that lake phytoplankton is now divided into two types based on the richness of sterility of its desmid flora. Teiling (Smith-28) in 1916 called a desmid-rich plankton flora a Caledonian formation. This is in contrast to lakes which have few desmids which are then said to possess a Baltic plankton formation. These two types of formations in lake phytoplankton have been generally accepted and in this country have been shown to exist. Smith points them out in his studies of the phytoplankton as being typical for certain lakes in Ontario, Wisconsin and New York. Furthermore, he states that the Caledonian formation is characterised by a small proportion of the Myxophyceae, whereas the Baltic formation has a relatively large proportion of these algae.

Just what are the factors lying back of these two distinct formations has been the subject of much discussion but Smith holds to the opinion after investigation, that desmid distribution is governed "not by the antiquity of the lake but by the chemical nature of the water". The chemical nature would be directly affected by the geological source of all water entering a lake and so Smith is corroborating the view of the two Wests, that the prime factor controlling the distribution of the plankton desmids is the geological conditions. Not much is known about the effect of the specific compounds on a desmid flora, but it is interesting to note that rich desmid floras (Caledonian formations) are never found in limestone regions, but such regions invariably support the Baltic formation. That lime is either toxic or inhibitory to desmid growth would seem to be the logical conclusion.

Many lakes or ponds pass a period in the annual succession of their algal flora in which one or two plankton species multiply to such numbers that they give to the water the color characteristic of the individual cell. A pond or lake in such a condition is said to be in "bloom". For the most part algal blooms are disagreeable pond conditions for they pollute water supplies, inhibit the full recreational use of lakes and also upset the proper balance of an aquatic community. The most common blooms are found to be caused by plankton members of the Myxophyceae although members of the other great algal groups are not uncommon constituents of blooms.

As stated above, algal blooms are characteristic of a definite time in the seasonal cycle of certain lakes and ponds, at which time one species is usually found to be the causal agent. Investigators find that recently built artificial ponds bloom soon after their formation, whereas certain mature ponds have no blooming whatever. The ecological factors causing such happenings are not well understood, and will remain so only until a careful study has been made of the relationships of the various pond organisms.

Several things have been noted, however. In the first place, blooming of recently formed artificial lakes or ponds has been limited to those whose basins have not been well cleared before flooding (Smith). In other words, it would seem to suggest that the mass of uncleared and hence decaying organic matter is affecting the water in such a way as to produce conditions favorable for blooming. Such conditions are known to be favorable to certain plankton organisms - particularly the blue green algae which have been cited in numerous cases as increasing tremendously in waters overladen with organic or inorganic materials. The blue greens with their slime sheaths seem to be a group of algae which are well adapted to the unusual condition, and under such a condition, seem to thrive. They seem to thrive, not because of but rather in spite of conditions which are toxic to most algal types. One need only think of their unusual habitat - in hot springs, as epiphytes, etc., to realize that a hyperdose of the products of decay would hardly stifle their normal growth.

Even as the abundance of growth of land plants is dependent upon physical and chemical conditions, so are all aquatic plants dependent upon the same factors. Thus a given amount of water can only support a certain sized plant community that is dependent on available food materials, etc. According to Smith, light, chemical relations and temperature are the three factors most important in the consideration of an aquatic flora.

By means of light, aquatic plants, like land plants, are able to carry on photosynthesis and thus to manufacture their foods. Temperature, too, is a factor in the growth of algae. It is a familiar fact that algal communities are at ebb during periods of low temperature (i.e. winter), and that growth picks up with the raising of the temperature. An optimum seems to exist for various algal groups so that in any annual study of a pond or lake various heights will be found expressed in quantity. Thus diatoms are most prevalent in the spring and fall—blue-greens during mid-summer.

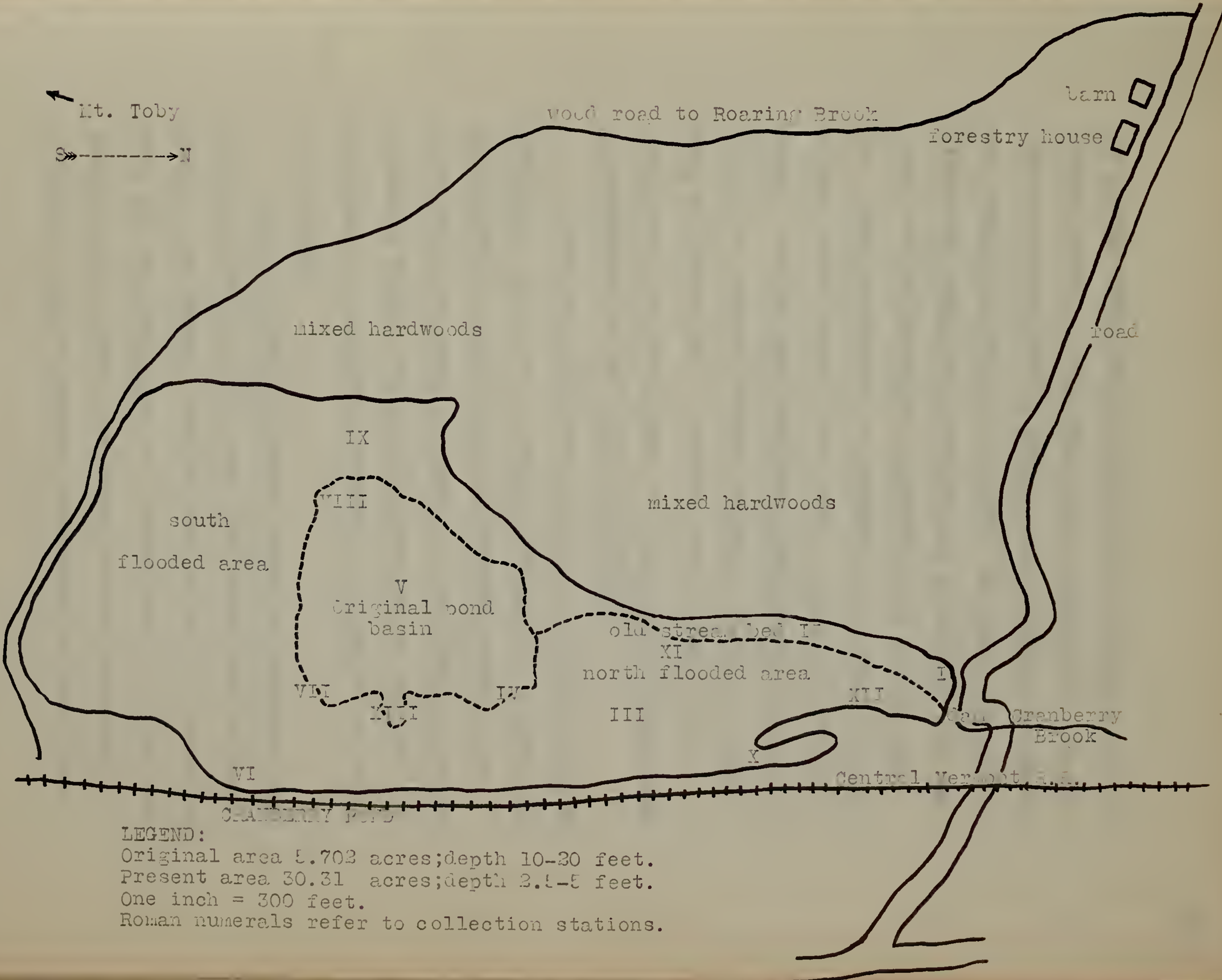
The chief factor governing the abundance of algae is the amount of available raw materials from which to make food. In the process of photosynthesis carbon dioxide is used for carbohydrate manufacture and so, according to Smith, the surest index of the amount of plankton algae to be found in a pond or lake is the available carbon dioxide present. Quoting from Smith:

"Carbon dioxid exists in lake water in a dissolved state, and when it has been withdrawn by the activity of the plant it must be replenished either from the air, by surface waters flowing into the lake, by respiration of living organisms within the lake, by decomposition of organic matter, or from the dissolved bicarbonates of calcium and magnesium. The first mentioned sources are of little importance, and the major portion of carbon dioxid comes from the last two sources mentioned."

HISTORY OF CRANBERRY POND:

Prior to 1933 the pond, surrounded by a swampy area of peaty nature, covered less than 5.702 acres, and was drained by a stream, Cranberry Brook, running northward through a similar swampy area hemmed in by ridges of glacial material. In the winter of 1933-1934 a small dam was constructed across Cranberry Brook about 1000 feet below its exit from the pond with the result that a new, greater Cranberry Pond was formed with an area of about 30.31 acres. The new pond has an average depth of 2½ - 5 feet as compared with the 10-20 feet average of the older basin. In some portions, however, the water has a depth of more than 25 feet.

Cranberry Pond lies in a pocket of land north of the portion of Mt. Toby known as Ox Hill. The northern part of the hill drops quite precipitously to the southern border of the water. The pond is sheltered from the west



LEGEND:
Original area 5.702 acres;depth 10-20 feet.
Present area 30.31 acres;depth 2.5-5 feet.
One inch = 300 feet.
Roman numerals refer to collection stations.

by a ridge which drops similarly into the water on the western border. This ridge bears a forest made up of mixed hardwoods with a ground cover of ferns, lycopods and straggling ericaceous types. The ridge extends a little way around the northern end of the pond, by the road, in the immediate neighborhood of the dam and for a distance around the southern end so that we find a good mixed forest on the north, south, and west portions. For the most part the eastern side, which parallels the Central Vermont railroad, is more or less open or shrubby due to cutting off. Several lots of young pines are found here, but this side is quite open in comparison to the other pond borders.

We find the pond to be, then, in a rather sheltered locality - set as it is behind a ridge that extends from Ox Hill on the south along the western border to the north where the ridge is pierced by the draining stream, Cranberry Brook. The pond is more open on the east but even here the land rises rapidly by ridges to the hills of the east.

Due to the well-sheltered nature of Cranberry Pond, as well as to its small size, its shores have not been open to wave action, with the result that its nature fulfils all the characters of a typical pond. Unlike most quiet ponds, however, its shores are not extensively occupied by higher aquatic plants with the result that there is no apparent zonation. This may be caused by the recent upset of water level due to damming with the result that any existing zonation has been destroyed. It seems probable, though, that there was no extensive zoning but rather a bog with creeping margins to form mats as described above.

Before its recent enlargement Cranberry Pond might well have been classified among those bodies of water known as bog lakes, for while it had some of the characters of a true pond, it had even more of the characters of a bog lake. In the first place Cranberry Pond has always been a permanent pond, a kettle-hole pond of glacial origin. As such it has not followed the cycle of many such permanent ponds which owe their origin to the slow filling in of lakes. As a bog lake it lacked the luxuriant swamp-plant growth of a pond and instead had an area of open water surrounded by true bog margins - a wide semi-floating mat which accompanied as an overgrowth, marginal peaty deposits. The mat was of the type known as a heath swamp being dominated by the ericaceous species of Vaccinium and Chamaedaphne. Around the periphery, no doubt, existed the same type of filamentous algae and floating plants (Utricularia) that are now found. The size of the marginal mat indicates that Cranberry Pond must have been a pond well on its way to maturity for eventually the overgrowth of such a margin would result in the final filling in of the open water. A quaking bog would be the result.

Figure 1

View of Cranberry Pond looking southwest from a point on the Central Vermont R.R.track. The main body of the pond lies beyond the cove in the foreground. The ring of mat islands can be seen at the center of the picture enclosing, on their farther side, the original pond basin. All the rest of the water that is visible constitutes recently flooded areas. In the background and to the right lies Mt. Toby; to the left lies Ox Hill.

Figure 2

View of Cranberry Pond looking south from its northern border. In the immediate foreground is the small,recently-formed dam. Water is flowing over it into Cranberry Brook. The mat islands are again visible far down the pond, the water lying between them and the dam constituting the northern flooded area. In the background rises Ox Hill.

Figure 3

View looking down on Cranberry Pond from the western ridge, The mat islands are here well visible enclosing the old pond basin,seen here in the middle of the picture. Dead maples,standing in the water on the eastern side, can be seen across the pond. Beyond them is the Central Vermont R.R. embankment.

Fig.1

Fig.2

Fig.3

The recent radical change due to damming has no doubt upset certain of the old pond conditions and from one standpoint is unfortunate, for the study of the conditions in such old bog lakes has been neglected in this country. It is hoped that the present aquatic forms are typical of the species existent in the old pond. If so, this paper should aid, in a small way, this field of limnology. The nature of the aquatic flora best relegates Cranberry Pond to the class of bog lakes but a description of this had best be left until the plankton forms are considered.

According to Doctor C.E.Gordon of the Massachusetts State College Department of Geology, Cranberry Pond is probably glacial in origin. The whole surrounding region is one covered with glacial till and one which possesses a number of glacial kettle-holes. Most of these not having their bottoms extending below the water table are dry but Cranberry Pond is formed by the basin of one kettle hole which extends below the water table. The pond basin stands lower than the stream bed of Cranberry Brook so probably Cranberry Pond just incidentally stood in the path of stream drainage from the mountain. Cranberry Pond Brook is the only stream draining the pond. Entering the pond from the south - from Ox Hill - are several temporary streams. One of these, lying just east of Ox Hill, has quite a large dry stream bed which, the writer has been informed, formerly carried considerable water into the pond when the ridges to the east of the pond were heavily forested.

Cranberry Pond is on the border of the Mt. Toby conglomerate and eastward-lying crystalline rocks. However, most of the underlying rocks of the Mt. Toby region consist of the Mt. Toby conglomerate or "pudding-stone". Outcrops of this rock may be found on the north face of Ox Hill and also on the slopes of the main part of the mountain. The presence of lime in this conglomerate has permitted a number of lime-loving plants to gain foothold in this region. The glacial till probably contains some percentage of lime also and the existence of such lime may cause it to find its way into the water of the pond. This is not known but if present it is evidently neutralized, for the pond water has a slightly acid nature.

PROCEDURE:

The actual collecting of specimens was begun in the spring of 1935 when weekly trips were made to the pond site. These collecting trips extended throughout the season up to the time of freezing over. Though planned weekly, that schedule could not always be carried out.

Through the courtesy of the State College Department of Forestry, a boat was placed at the writer's disposal and also the use of the Forestry field laboratory. The nearness of this building was of distinct advantage in permitting a quick surveillance of collections, especially since some of the forms are so short-lived when placed in collecting jars.

A standard net of fine bolting silk was used for obtaining plankton samples; various scoops, grapples and nets were used for deeper bottom samples; an iron pipe attached at one end to a rope served in collecting even deeper bottom samples in its core. In order to give a rough quantitative comparison of plankton at various stations in the pond, the net was towed for a definite length of time at each station. For the physical constants an ordinary laboratory thermometer was used. A thermometer for reading sub-surface temperatures was used for a time to get surface and bottom temperature but inaccuracies developed so its use was abandoned. The laboratory thermometer served very well, for in the shallow body of water it was soon found that surface and bottom temperatures were closely approximate. The pH was taken by the Winkler colorimetric method, and until the exhaustion of the oxygen content reagents, the percentage of that gas was taken. Determinations of this type were carefully checked by two observers.

With the aid of tho rowboat the pond was marked off into definite stations - those points being chosen which, through difference in exposure, situation (as to old or new pond), depth, percentage of vegetable matter - best offered or suggested variety in aquatic life, species and numbers. These stations, marked on the pond map, are found on page 17.

At the end of a few weeks collecting it was apparent which stations should be kept as being different, and which ones should be dropped due to close similarity with the flora or fauna of another station. At the beginning the temperature at the surface and at the bottom was taken, the percentage of oxygen in the water, a plankton sample, and a bottom sample. Plankton and bottom samples were carefully labelled as to station and then put into vials for later identification at the field house. Any unusual microscopic growth was recorded.

At the conclusion of a visit to all the stations enumerated the collections were taken immediately to the forestry house and would then be examined by means of compound and binocular microscopes, particular attention being paid to the species and also the relative numbers of individuals. Although no exact method of determining quantitative data was used, a fairly accurate account of the dominant plankton species was obtained by taking the consensus of opinion of three observers. Each looked at a given sample as it lay in a small stender dish or Syracuse watch glass with the aid of a binocular microscope. A list of the species noted was kept along with the other data obtained from the days' collecting. Whenever a questionable species was seen it was put into preservative and set aside to provide a source of material for identification during the winter. The preservative used was formol-alcohol because of its ease of use,for all that had to be done was to add enough of the preservative to a vial containing plant material, to fill it. Formol-

COLLECTION STATION LIST

Station Number	Depth of Water in ft.	Description of Station
I	3.5	-new-flooded area; center of cove in northwest corner of pond--just above dam; permanent station.
II	3.5	-new-flooded area; northwest shore of the old Cranberry Brook channel (About one half the distance from the dam to nearest mat islands); temporary station.
III	6.8	-new-flooded area; midway on a line drawn between stations #IV and #X; temporary station.
IV	6.0	-in center of channel on east side of old pond basin and joining it to the newly flooded area; permanent station.
V	20.5	-approximate center of the old pond basin; permanent station.
VI	3.0	-new-flooded area; middle of south cove next to R.R.; temporary station.
VII	11.0	-old pond basin; edge of island growth west of entrance to station #VI; temporary station.
VIII	7.0	-old pond basin; tiny cove in southwest corner, south of entrance to station #IX; permanent station.
IX	4.0	-new-flooded area; middle of southwest cove; permanent station.
X	3.0	-new-flooded area; middle of entrance to northeast cove; permanent station.
XI	7.0	-new-flooded area; midway between stations #II and III; temporary station.

COLLECTION STATION LIST (Cont.)

Station Number	Depth of Water in ft.	Description of Station
XII	6.0	-new-flooded area; a boat's length from shore and approximately 100 ft. south of dam on east side of pond; permanent station.
XIII	15-17	-old pond basin; center of south-east cove; temporary station.

alcohol is also a good killing agent to precede staining. In a few cases slides were later made of some of the more easily mounted species to make their study easier during the winter.

In an ecological discussion of a pond flora it is well to at least briefly survey the results of physical and chemical observations, those taken at Cranberry Pond being little more than indicators of existing conditions. During such a short period certain phases of this work had to be slighted. They happened to be these constants. Perhaps future work will find them justly treated.

Temperature recordings are the most complete of any of the constants taken. As has been mentioned previously they were taken with an ordinary laboratory thermometer but represent only surface temperatures. At first this type of temperature reading was taken at every station but it was soon learned that temperatures of this sort varied little all over the pond surface. Due to its shallowness Cranberry Pond has no true thermal stratification so one finds the few bottom temperatures taken approximate closely the corresponding surface temperatures at the same station. A table, representing one month (May) of 1935 shows the existing relations. The greater portion of the pond area is less than six feet deep. It is seen that at such a depth 5 degrees is the greatest difference between surface and bottom temperatures. As would be expected the greatest variation---

up to 20-25 degrees---is found at station V, which marks the center of the old pond and the deepest part (25 ft.) of that body of water. In midsummer such a difference in temperature at the old pond center is of distinct advantage to the cool-water loving trout population, for it offers a place of retreat during hot spells. The shallowness of Cranberry Pond not only insures general uniformity in temperature throughout its area but also makes for a fluctuation of that temperature to more or less equal the existing atmospheric temperature.

A study of the annual temperature curve of the pond best illustrates this latter statement. It will be seen that the temperature follows rather consistently that of the atmosphere at least during the period of open water which in 1935 existed from the middle of March to the first of December. Here the curve of water temperature parallels that of the atmosphere and reaches its peak in July and August with temperatures at the surface up to 85-90 degrees - then a gradual fall to freezing at the appearance of ice in the latter part of November. For a short time pH and oxygen content analyses were taken. Data gathered, though small in amount, will serve as an indication of conditions existing at the pond. These data have been included in the temperature table. From the pH column we see that the water of Cranberry Pond is about ten times more acid than pure water, averaging as it does around pH 6. We may say

CRANBERRY POND WATER

Results of the determination of Physical and Chemical Constants
May - June 1935

Station Number	Water Depth at Station (in feet)	Date of Determination	Water Temp. (in degrees Fahrenheit Top -Bottom	pH	Oxygen Content (Parts per million
I	3½	5/9	59	6.1	8.7
		5/16	59	6.2	8.3
		5/23	57 - 55	6.0	6.0
		5/29	65 - 65	6.0	(No reagent)
		6/6	65 - 65	5.9	(No reagent)
IV	6	5/9	51½	6.4	9.1
		5/16	58 - 57	6.0	7.9
		5/23	55½- 51½	5.85	6.7
		5/29	64 - 58	----	(No reagent)
		6/6	65 - 60	6.1	" "
V	20½	5/9	44	6.0	9.5
		5/16	57 - 45	6.0	7.9
		5/23	50 - 45	6.1	7.5
		5/29	64½- 45	6.0	(No reagent)
		6/6	65 - 45	6.0	" "
VIII	7	5/9	52	6.4	9.1
		5/16	57 - 57	6.0	8.3
		5/23	57 - 56	6.0	8.5
		5/29	65 - 59	---	(No reagent)
		6/6	65 - 60	6.0	" "
IX	4	5/9	60 - 57	6.4	6.7
		5/16	59 - 57	6.0	7.5
		5/23	55 - 51	---	6.4
		5/29	64 - 62	---	(No Reagent)
		6/6	64 - 60	6.4	" "
X	3	5/9	59 - 59	6.4	8.0
		5/16	61 - 59	6.0	7.9
		5/23	56 - 55	5.9	5.8
		5/29	65½- 65	6.0	(No reagent)
		6/6	65½- 61	6.0	" "
XII	6	5/9	59½- 59½	6.5	9.5
		5/16	59	6.2	8.3
		5/23	55 - 52	6.0	5.8
		5/29	65 - 64	6.0	(No reagent)
		6/6	65 - 61	5.8	" "

Table III - Cont.

Results of Physical Constant Determination

Station Number	Water Depth at Station (in feet)	Date of Determination	Water Temp. (in degrees Fahrenheit) Top- Bottom	pH	Oxygen Content (Parts per million)
XIII	17	5/9	47	6.4-6.0	9.5
		5/16	58 - 47	6.0	7.5
		5/23	52½- 46	6.0	7.5
		5/29	66 - 46	6.0	(No reagent)
		6/6	65½- 47	5.9	" "

then that the waters of Cranberry Pond are slightly acid. This fact would tend to disprove the statement that lime (an alkaline compound) leaching in from the Mt. Toby side, would have any direct effect on the pond life for it is evidently offset by the acid conditions of the water.

There is no shortage of light at Cranberry Pond. The water surface is, for all practical purposes, open to full sunlight throughout the day. Tho shallowness of the pond permits free access of light even to the bottom so that in a consideration of physical factors light penetration with lack caused by absorption by suspended particles need not be considered. There is sufficient light for any sized algal formation.

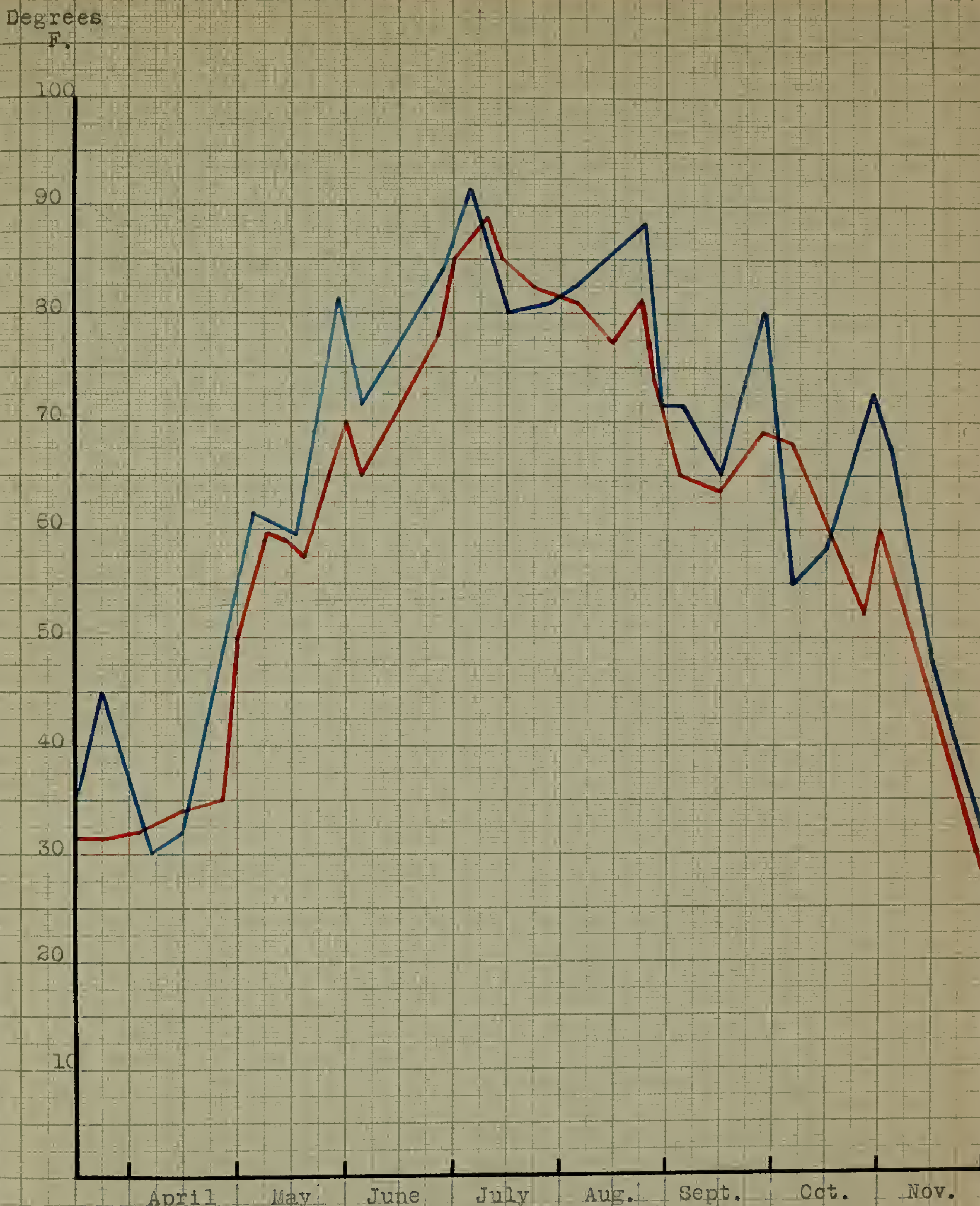
DISCUSSION: THE FLORA OF CRANBERRY POND

1. Plants other than the Algae

From the accompanying map it may be seen that Cranberry Pond may be divided into two parts. One part, the original pond (5.702 acres) exists more or less in the center of the new flooded area, which constitutes the second part.

The original pond possesses a marly basin (10-20 feet deep) which appears quite free of any larger submerged aquatic vegetation. A water moss, *Fontinalis antipyretica* var. *gigantea* Sull., covers the bottoms of several of the smaller coves, notably the southeastern cove where springs are known to exist, but for the most part the bottom of this area is free of higher rooted plants. The marly basin is well marked by a ring of quaking and partially floating vegetation forming small mat-islands which represent the bog plant encroachments surrounding the old pond. These floating islands have been built up by a cover dominated by the low evergreen shrub, Chamaedaphne calyculata (L) Moench. This shrub seems to be the initial pioneer in mat formation, growing out into the open part of the pond in a loose, tangled form which floats on the surface of the water. The gradual filling in of the tangle with debris along with the creeping out of the Carex stricta Lam. and several Sphagnum species extends the island border. A number of other forms are found growing in association with the Chamaedaphne on the Sphagnum base, notably Cephalanthus occidentalis L., Rhus Vernix L., Ilex verticillata (L) Gray., and Alnus incana (L) Moench., all interspersed with Carex stricta. A few low forms---Vaccinium macrocarpon Ait., Eriocaulon articulatum (Huds.) Morong., Drosera longifolia L., and D. rotundifolia L., are also typical of the Sphagnum cover.

In addition are found certain forms less common but scattered here and there---probably remnants of groups slowly killed by a change in water conditions or level. Thus we have a few representatives of Pontederia cordata L. growing near the old outlet of Cranberry Brook near the



GRAPH SHOWING COMPARATIVE SEASONAL TEMPERATURES OF THE WATER AND AIR AT CRANBERRY POND

Blue line = atmospheric temperature
Red line = surface temperature of water

mat islands. Near station VIII is also a sizeable colony of Typha latifolia L.

The rise in the water level will no doubt inhibit the growth of the Chamaedaphne mat for now it has no base on which to progressively build. For a period now there will not be much noticeable replacement of the margins of the pond with zonation aquatics. When these marginal forms do take root their growth will be rapid due to the shallowness of the water. Probably the first area to have any active filling-in will be the south-east part of the pond near the R.R. tracks where quantities of Carex stricta hummocks exist in very shallow water. Unless removed as formed, vegetation will soon encroach to capture, for the land, areas now chiefly of open water.

The recently flooded area constituting the new Cranberry Pond may in turn be divided into two parts. One part, that seen extending from the dam at the north, south to the northern extremities of the old pond is an open body (with the few mat islands) of shallow water in which most of the trees caught by flooding have been removed. This area is made up of the old winding bed of Cranberry Brook which follows, roughly, the western side of the pond and makes an exit at the dam. The path of the submerged stream bed may be determined by the floating aquatic Nymphaea odorata (Ait.) Woodville and Wood, which, existing before the dam construction, still marks its channel. This channel portion is the deepest part (5-6 feet) of this portion of the flooded area and supports the two floating aquatics - Nymphozanthus variegatus (Engelm.) Fernald and Nymphaea odorata.

Such a well-established stream bed differs somewhat from the immediate surrounding pond bed which has an average depth of 2½-3 feet and which, unlike the former, is not well established, but consists of the flooded grasses, sedges, and other vegetation of the swamp which prior to the damming followed the exit stream. At the present time the newly flooded bottom is in a state of active decay, thus making available large amounts of inorganic substances for aquatic plant and animal forms and making the study of such most interesting. Some higher plants, of course, have already migrated into this food-laden area, so it is not surprising to find masses of Utricularia vulgaris L. in these shallows. The presence of so much decaying bottom matter at Cranberry Pond must mean an abundant supply of carbon dioxide for photosynthesis. Algae should be correspondingly abundant.

The remaining flooded part has not been cleared of its former cover so that its area appears much smaller than it really is. Here the dominant swamp maples are intermixed with numerous alders, birches etc. - all drowned due to the flooded conditions. Such an area would serve admirably for wild life, sheltering aquatic birds, etc. This portion of Cranberry Pond is untouched in this paper due chiefly to the inability to navigate around the trees and brush tangles, but its floristic nature is undoubtedly similar to that which is to be discussed.

Pond floras may be roughly divided into lower and higher plant forms, Thallophyta and Embryophyta. In any body of water the thallophytes greatly outnumber the vascular forms both in species and in quantity. The thallophytes of Cranberry Pond are no exception.

Embryophytes, omitting the swamp forms which have already been mentioned as dominant members of the pond "islands" and shores, are limited to a few species - notably the members of the genera Utricularia, Nymphaea, Nymphozanthus, Lemna, Vallisneria and Ludwigia. The only other higher plant of note is one of the fountain mosses, Fontinalis gigantea, which is well established on the pond floor at Station XIII. With this brief mention of the higher forms we may pass to the thallophyte group which is dominated by the algae.

2. The Algal Plants

a. Phytoplankton

The results of water temperature recordings at Cranberry Pond show that no true stratification exists throughout its area and so, following the divisions of Smith, it may be classed as a typical pond. In such a small body of shallow water one would think that there would be ample chance of invasion of the plankton realm by plant members of the bottom and shore. From an examination of the list of plankton species it will be seen that a great number of these (i.e. Spirogyra, Mougeotia, Hyalotheca, etc.) are casual migrants from the benthic region. The presence of such forms was inevitable in all collections taken, with the possible exception of net collections from the basin of the original pond, for the plankton net was in most cases but a few feet from the bottom and frequently lodged against the submerged branches which are quite common in the recently flooded basin. Since these migrants were found in plankton collections, they have been included in this list. In addition to such migrants we find, even in such a homogeneous body of water as that of Cranberry Pond, a small number of true (eulimnetic) plankton forms such as Dinobryon, Uroglenopsis etc. - forms which only reach their best and greatest development in their planktonic optimum. These contribute to the eulimnetic flora of Zacharias.

An examination of a plankton sample from Cranberry Pond reveals a phytoplankton flora poor in species but seasonally rich in individuals. The dominant form is the dendroid colony of Dinobryon sertularia Ehr. which can be found in water taken from any portion of the pond. Fluctuating in quantity present, it is at certain periods represented in a water mount by but a few individuals but at other periods is so numerous as to coat the plankton net with a mass of brownish slime. Although distributed throughout the pond, it yet is most abundant, as would be expected, in the open deep water of the old pond basin. At all times during this survey Dinobryon has been dominant in the plankton, even at times surpassing the animal forms in numbers. Winter and spring are its low seasons. From then on the growth is such as to have an almost constantly increasing quantity - with no sign of diminishing - throughout the later spring, summer and fall periods.

More variable in numbers are the spherical colonies of Synura uvella Ehr. and Uroglenopsis americana (Calkins) Lemm. These species, with the possible exceptions of Tabellaria fenestrata Kutz. and Ceratium hirundinella (O.F.M.) Schrank are the only forms which approach the dominancy of Dinobryon. Synura, Uroglenopsis and the diatom Tabellaria might well be called sub-dominants in as much as they are, like Dinobryon, regular members of the plankton, though not as common. For a time, particularly in the late spring (May, June) Synura became the dominant species but not for long. Uroglenopsis, too, seemed to have its period of prevalence in May or June. These two Chrysophycean forms might well be called late spring annuals for that season represents the period of their greatest numbers. Dinobryon and Tabellaria, on the other hand, are more nearly perennials; the former with numbers increasing to an early fall height; the latter always present, but with a spring and fall maximum. Ceratium might be called ephemeral for it reached tremendous numbers at several stations but only for a very short time - hardly more than a week at the beginning of June. On the list of plankton algae are found but six genera of desmids, possibly representative of a dozen species. The majority of the species listed are probable migrants from the littoral zone for only in that area were the desmid species of the pond anywhere near what might be called numerous.

Thus we see that three Chrysophycean species and a species of the Bacillarieae existing together constitute the dominant members of the phytoplankton of Cranberry Pond. All other species listed are usually represented, in a plankton sample, by but very few individuals.

If the phytoplankton of Cranberry Pond is to be classified on the basis of its constituent organisms, it will be seen to fall most easily into the proposed classification of Apstein (1896)(Smith-28) who, as mentioned previously, separates ponds or lakes into the Chroococcus and Dinobryon types. Dinobryon sertularia was always represented in plankton samples and for most of the samples it was the dominant phytoplankton species and frequently the dominant plankton species. Furthermore the plankton flora of the pond had few if any Chroococcacean species, the only two forms recorded being a species of Chroococcus and Microcystis incerta Lemm. The latter was the more prevalent of the two but was never common. In all respects then, namely, in the numerous Dinobryon colonies, in the absence of Chroococcacean forms, and in the small bulk of plankton, Cranberry Pond fills to the letter the Dinobryon type of Apstein's classification.

Unlike the majority of phytoplankton formations of this country the formation at Cranberry pond cannot be relegated to either of the formations of the Wests - it seems to be neither Caledonian nor Baltic. Teiling's Caledonian is supposed to have a rich desmid plankton flora with a noticeable lack of Myxophyceae. The phytoplankton of Cranberry Pond is seen to lack both of these types, and whereas, in so doing, it follows the desmid paucity characteristic of the Baltic it yet has not the latter's large proportion of Myxophyceae. It will be recalled that in many cases the absence of a rich desmid flora has been caused by the presence of lime leached from underlying limestone (Smith). It would seem, then, that the absence of lime may be a factor which permits desmid development. The absence of desmids at Cranberry Pond may have its explanation in the geology of the Mt. Toby region. It is probable that the conglomerate which is found in outcrops on Toby underlies the Cranberry Pond basin. Certain it is that lime exists in sufficient amounts in the Toby conglomerate to support such lime-loving plants as Cystopteris bulbifera (L.) Bernh. and Pellaea atropurpurea (L.) Link. It is possible that the glacial till out of which Cranberry Pond has been gouged contains some percentage of lime. Whether such lime is leached into the basin of the pond is a question that can only be answered by calcium determinations. The acid condition of the pond waters seems to indicate that any lime finding its way into the pond is neutralized. A lack of plankton Myxophyceae is also significant.

In its present condition, Cranberry Pond exists in a rejuvenated state. Before the recent damming, its flora was probably well balanced and old. Recent flooding has created a new area. Here we have a rebirth which is being accompanied by organic decay and by a leaching of the submerged soil of its inorganic compounds. In this respect Cranberry Pond may be compared to certain types of newly made reservoirs. A change in the chemical constituency of the pond must have been effected or is being effected by such flooding - and as such, has probably been changing the nature of the old aquatic community. Unfortunately there was no pre-damming biological survey of the pond so it is difficult to say just what is characteristic of the aquatic flora of the old pond, or what new things have been added. The writer has no knowledge of any annual blooming in the old basin, a condition which would generally be the case in an old pond where an aquatic balance is the rule.

During the period covered by this study the closest approach to an algal bloom in Cranberry Pond was caused by the previously mentioned Dinobryon and Uroglenopsis, which at the height of their occurrence existed in great numbers in practically all parts of the pond. Their presence was at all times apparent, due to an unmistakable fishy odor which they added to the water. It would be interesting to know whether their period of dominance has been an annual event during the life of the pond, or whether the change in the condition of the water due to flooding has called forth such a Chrysophycean flora.

It might well be that such a bloom has for years characterized Cranberry Pond. Such a bloom is of necessity dependent for its abundance and size upon the amount of organic or inorganic compounds available in the water. "For all practical purposes the formation of new plants is correlated with the formation of food materials"(Smith-28). That such ultimate food sources find their way into a pond from the surrounding drainage area and particularly from the immediate pond surroundings has been pointed out by Smith. It has been seen that ponds which are bounded by marshy or swampy areas are more frequent supporters of annual blooms, and naturally, for the surrounding swamp is a constant natural source of raw food materials - coming as they do chiefly from the decaying plant materials. On the other hand the present number of Chrysophycean types at Cranberry Pond may be the direct result of the flooding; but if their numbers have remained the same since the dam was built it would be logical to expect an increase in their ranks or in the ranks of some other plankton form which gains by such organic content increase of water. Such an increase in algal blooming forms or the appearance in several years of new "algal bloomers" is something to be looked forward to as highly probable. Unless new plankton migrants to Cranberry Pond appear it is only reasonable to look to the other local plankton forms as possible nuclei for future blooms. Smith has compiled a list of algae by families which have been seen at some time, in some place in the world as bloom producers. From his list the following genera are found to be present, though very sparingly, in Cranberry Pond plankton samples: - Microcystis, Anabaena, Gleotrichia, Eudorina, Protococcus, Scenedesmus and Tabellaria. Of this list the first three are Myxôphycean genera and as such their presence is significant, for the Myxophyceae are noted as bloom formers, particularly in ponds the percentage of whose organic water content has been appreciably raised. Such is the case at Cranberry Pond, so it is something of a surprise not to find a plankton dominated by Myxophycean genera. It may well be that not enough time has elapsed for such a flora to appear - unless other unknown factors are at work. The paucity of a phytoplankton rich in species and made up of only a few similar dominants that occur in rich numbers suggests that there may be certain physical or chemical properties of the water which do not permit a more varied flora to exist. It is also peculiar that the Chrysophycean genera can reach such numbers. They may be forms particularly suited to the chemical content of that type of pond.

The type of phytoplankton just described is one reason for classifying Cranberry Pond as a bog lake. Investigations of European bog lakes show them to have similar characteristics. As in the case of Cranberry Pond, this is based more on a survey of the net plankton cath, rather than on the nannoplankton, so the statement that the pond is very poor in plankton may not be entirely correct. However, like bog lakes in general, Cranberry Pond is slightly acid, it has a restricted number of plankton species, a diversity of algal genera as compared with the number of species, a good representation of dinoflagellates, and a great number of planktonic rotifers. Unlike bog lakes the Chlorophyceae do not dominate the phytoplankton; the Myxophyceae are not common; there is no preponderance of desmids; fish, sponges, nematodes and flatworms are present. From this and what has been said before, it will be seen that Cranberry Pond possesses, about equally, characters which are like and unlike those of a bog lake. The best that can be said is that the mixed characters of the pond indicate that processes of change are going on in its waters - processes which, due to pond enlargement, will possibly bring it closer to the lines of a true pond from a probable bog lake ancestry.

Before consideration of the other main ecological algal division - the species of the benthos - it might be well to briefly mention the animal relationships of the phytoplankton - or at least to see with what animal types they were associated in a plankton sample.

All but the dominant zooplankters have been omitted. It will be seen from the lists of dominant species in plankton catches throughout the year just which animal forms were most numerous. Generally speaking, the plant and animal plankton were about equally divided as to number of species as well as to quantity. A list of the ten plankton members most commonly found from May to December (1935) follows, each being placed in order of comparative abundance: -

1. Cladocera (several species)
2. Synura uvella
   Dinobryon sertularia
3. Copepoda (Cyclops sp.)
4. Notholca longispina
5. Nauplii
6. Synchaeta stylata
7. Uroglenopsis americana
8. Stentor pyriformis
9. Ceratium hirundinella
10. Tabellaria fenestrata

This list was compiled from the tables giving the plankton members in the order of their abundance at each of the various stations, and on each of the days on which samples were taken. A list in order of dominance was made for each collection day and then an average of all the days resulted in the above list.

As can be seen, cladocerans dominated the plankton with Dinobryon and Synura closely following and about equally distributed for second place. Copepods, represented by the genus Cyclops, takes third place with their larval Nauplius form following as fifth in the scale.

Fourth and sixth places were filled by two free-swimming rotifers, Notholca longispina Kellicott and Synchaeta stylata Wierzejski. These first six and the tenth, Tabellaria, could be found almost anytime in a plankton sample. The four remaining were not as numerous but rather fluctuated between periods of scarcity and periods of tremendous numbers. Stentor might be called an exception to this, for it was at all times apparent in the pond, even to the unaided eye. It had, however, the habit of being more often benthic than planktonic, being found around the pond margins attached to submerged leaves, coloring them a vivid green, or else attaching itself to growing Utricularia and was even seen covering entirely a twelve inch pickerel suspended motionless in the shallows.

b. Benthos

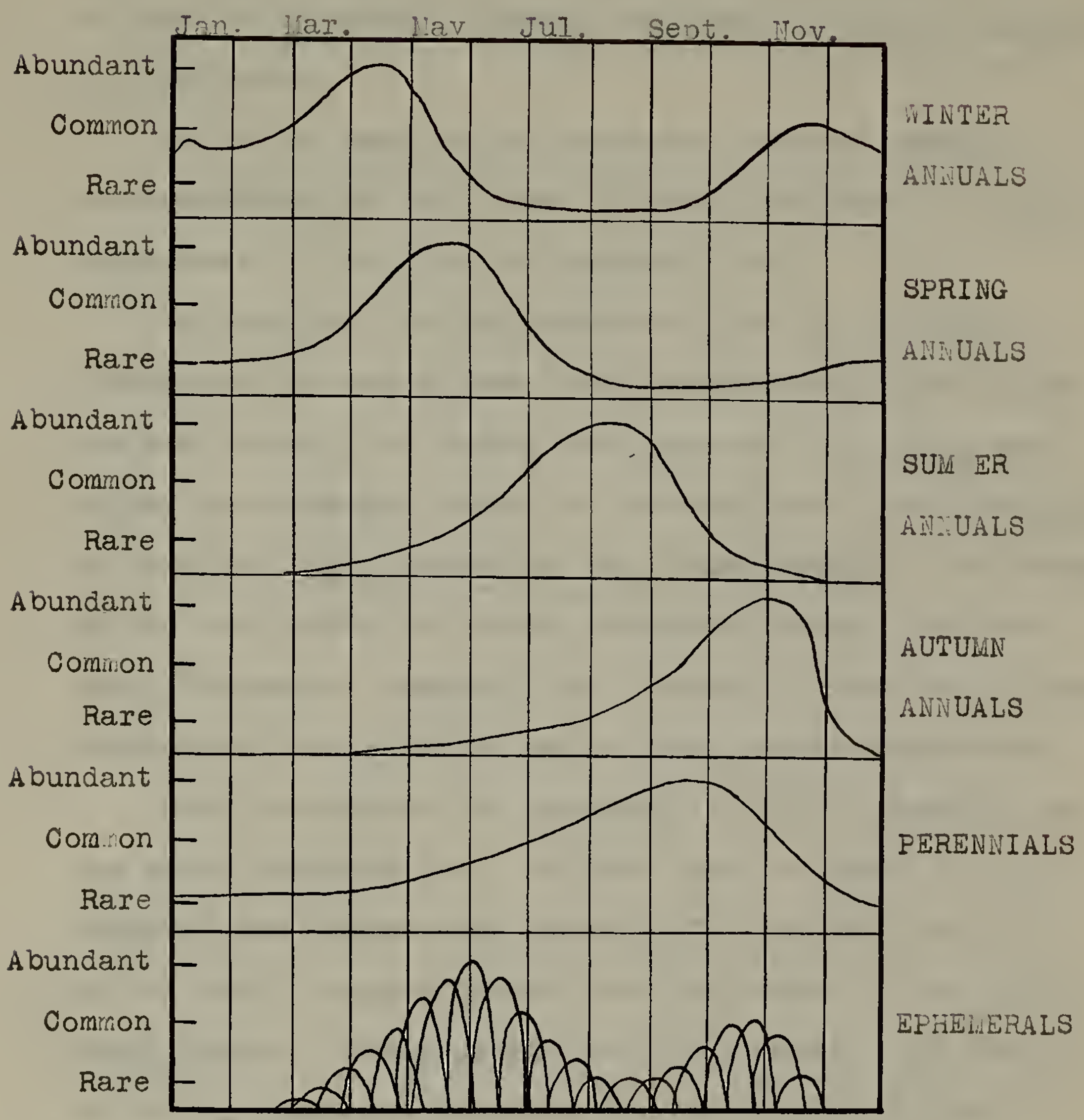
On page 5 it is stated that there are two main ecological groups of algal plants. So far only those forms included in the plankton or free floating community have been considered. We now turn to a survey of the algal plants which are not typical of the plankton flora in other than the category of a casual migrant. These represent the benthos. Undoubtedly a good number of the forms listed from the plankton are but transient members from the benthos; they could never reproduce in the free-floating life. In other words they are true benthic types.

These forms, the benthos, represent the greater number of algal species of Cranberry Pond. They are largely restricted to the shores - the littoral regions, and in as much as Cranberry Pond is so shallow throughout its area we find that these littoral forms are pretty well universally scattered close to the pond bottom. The old pond basin is the sole portion that does not support such forms in any great numbers excepting around its borders. Such littoral algae are very diverse in character. They represent all the main groups of algae. In addition they inhabit all types of situations being found on most any submerged object. The filamentous types in particular are found coating twigs, rocks, higher plants, etc., with their streamer formations, and frequently become so tangled that mat formations come into being. These large forms in turn support hosts of smaller attached forms so that stalked epiphytic diatoms, desmids, etc., are found.

Close study of the pond throughout the year would doubtless show that most of the algal species have definite cycles represented by normal growth curves with opening periods of scarcity, periods of growth resulting in abundance, and final periods of decadence bringing again paucity of numbers. Individual species of algae have curves of growth which mature at different times throughout the year. Thus, according to Transeau (33), we may speak of Spring, Summer, Autumn, and Winter annuals. Each

CURVES OF FREQUENCY OF THE SIX ECOLOGICAL GROUPS OF ALGAE

(After Transeau)



of these groups is typified by a curve which rises as is shown by the chart of Transeau. Since a good many of the algae listed in this paper may be placed in one or more of Transeau's groups, his chart has been included in this paper.

As in the case of the plankton, benthic species are considered in the order of their dominance and hence importance to the life of Cranberry Pond.

In quantity, the filamentous types are dominant. Throughout the whole year they represent the types which can most readily be noted, tangling and attaching themselves to submerged debris in the shallows - and floating as derelict algal masses in the flooded areas. The middle of the pond basin is rarely visited by other than lone torn filaments. However, the floating islands are usually surrounded by tangles of one or more filamentous forms.

Best represented in quantity, if not in species, is the order Zygnematales. In this order we shall list as dominant the filamentous genera Spirogyra and Mougeotia of the family Zygnemataceae, and Hyalotheca of the family Desmidiaceae. These genera are the principal mat formers of the pond margins, existing as floating or slightly submerged twining masses which form one of the characteristic groupings of the pond - a grouping which may be known as the filamentous alga group or as the Spirogyra-Mougeotia association. Sporulation of Spirogyra and Mougeotia was not observed and hence the species remain undetermined. The genus Spirogyra, however, is represented by probably three or four species, most of them growing intermingled with one another and with the unidentified species of Mougeotia in a characteristic mat formation.

Hyalotheca dissiliens (Smith) Breb. is the commonest of the desmids and as a slimy-sheathed, filamentous type, drapes itself upon the submerged twigs and roots, which constitute the submerged border of the floating islands. From here it migrates by fragments to place representatives in the phytoplankton. Unlike Spirogyra and Mougeotia, which were abundant through the year, Hyalotheca did not make its appearance in abundance until the season was well advanced. Its yellowish-green filaments were first noted at mid-summer and it reached its peak in the early fall.

Not as common, but occupying a similar habitat - on submerged peaty outliers of the floating island ring and upon rootlets and branches, was the genus Tolypothrix, represented by the species T. lanata (Desv.) Wartm. and T. tenuis Kutz. This genus was not prevalent until the beginning of the summer when its masses were first noted on those twigs later to be covered by Hyalotheca. Its growth, unlike that of Hyalotheca, was low, creeping, and closely applied to the substratum. Later on, in the early fall, Tolypothrix took on a reddish to red-orange tinge as its filaments began to give back to the waters .

by its disintegration the materials it had taken. Filamentous algae other than the species of Spirogyra, Mougeotia, Hyalotheca and Tolypothrix were not common and so will be merely annotated on the Cranberry Pond list.

As has been mentioned, algal mass groupings such as are formed by the filamentous types, offer places of harborage for the aquatic plant and animal forms. Among the plants are represented particularly those unicellular types which are not found as free floating plankton. Diatoms, desmids, chlorococcacean forms, etc. are particularly prominent in such a situation. Their presence is probably due to the similar nature of this habitat - close to the surface - to their natural habitat in the shallows of the pond's edge. The latter situation is where such forms reach their greatest numbers - floating in, and around, and attached to the barely submerged Utricularia whorls, or on the detritus-sticks and dead leaves - which are found everywhere washed close to the shore. The desmids, with the exception of Hyalotheca, here have their most frequent occurrence; they are nevertheless sparce in number. Species of Closterium dominate but Xanthidium, Staurastrum, Micrasterias, Docidium, Gonatozygon, Spirotaenia, Pleurotaenium, Euastrum, Cosmarium, Desmidium, and Gymnozyga are also represented.

In just such locations are found the members of the diatom groups. By far the most common is the genus Tabellaria, represented by the two species _T. fenestrata_ and _T. flocculosa_ (Roth) Kutz. The former is the more prevalent, and in fact is well nigh universal in distribution in the pond, for not only is it found in tremendous numbers attached to the detritus of the littoral zone, but its chains are even found in goodly numbers in plankton samples from among filamentous algal mats, etc. T. flocculosa is rare in comparison. Not nearly as common as Tabellaria fenestrata, but surpassing in numbers T. flocculosa, is the wedge-shaped, stalked form Gomphonema acuminatum Ehr. var. coronata (Ehr.) W. Smith. Littoral samples which do not contain a few examples of this stalked epiphyte can hardly be found. Other more common diatom genera are Brebissonia, Navicula (numerous unidentified species), Synedra, Pinnularia and Melosira. The latter is the only Centricean form thus far found at the pond. In among such a varied grouping of plants was occasionally collected an elongated form of Synura uvella which was most peculiar in structure, being more or less sausage-shaped with the diameter of an ordinary normal colony. Whether these individuals were due to a non-fragmentation of a growing colony is not known. No reference to such a form has been found in the literature.

Finally in this discussion of the more common habitat types may be cited the nodular types of algae. These forms, typically benthic, are found existing as radiating, sometimes branching, masses embedded in a firm gelatinous matrix which affixes them firmly to the substratum, usually found to consist of submerged leaves, twigs, branches, grass stalks, Typha bases, and trunks of trees. The

Myxophyceae are represented in this class by several species of the genera Rivularia and Gleotrichia while the Chlorophyceae have as their one example the genus Chaetophora with species C. incrassata (Hudg.) Hazen and C. elegans (Roth) Ag. The former, though surrounded by a gelatinous matrix is not globose in colony habitat, but rather exists in elongated, irregularly-lobed colonies.

c. Special forms

In this listing of both planktonic and benthic algae one habitat type of alga has been until now purposely omitted. This type includes the symbiotic forms and although represented so far by but one genus, they are yet so numerous quantitatively that they are one of the more noticeable members of the pond life.

On the list of the dominant plankton forms it will be seen that Stentor pyriformis Johnson stands at eighth place. This ciliate protozoan, due to its large size, was at all times microscopically visible during the year and because of this, might easily have been listed as first in numbers amongst the plankton. Its presence could be noted everywhere, particularly resting on the numberless submerged leaves and debris which characterized the submerged pond margin. It also was quite well represented in open water and on the submerged and floating aquatics. The animal's vivid green color is due to the presence of numerous spherical algal cells contained within the ciliate, and which probably live in a symbiotic relationship with the animal. In return for its "travels" it undoubtedly gives to the Stentor cell some of the products of its photosynthesis. The species contained in Stentor is Chlorella conductrix Brandt. Another species, Chlorella parasitica Brandt., is common in the tissues of the fresh water member of the Spongillidae represented by the species, Heteromeyenia ryderi Potts. Heteromeyenia finds easy sustenance at Cranberry Pond and is found wherever submerged branches offer harborage. The nature of the Heteromeyenia -Chlorella relationship is similar to that of Stentor-Chlorella.

3. Relation of Flora to Pond Fish

Since the establishment of the new enlarged Cranberry Pond, trout have been introduced into its waters with the idea of forming a balanced and controlled aquatic area for pond fish. After a year's freedom in the pond, interrupted by several open periods for fishing during the 1935 season, the trout seem to be doing well, finding the waters suitable to their growth despite the recent upset of the old pond conditions. Due to this upset and the probable increase in inorganic basic plant food substances it was believed ultimate food for fish would be greatly increased.

The work here reported was first suggested, as has been previously stated, with the idea that an introductory survey be made of the aquatic plant life of the pond, and if possible to correlate it with the life of the introduced fish.

Trout are typically carnivorous in food habit and those of Cranberry Pond are no exception. During the period in which fishing was permitted at the pond all stomachs of fish taken were preserved for their stomach contents, these contents being sent to the Massachusetts State College Department of Zoology for analysis. As would be expected, insect forms made up the bulk of the stomach contents, forms represented being for the most part the larvae of mosquitos, dragon flies, chironomids, etc. In addition, fingerling pickerel were frequently found. There is, then, no general direct use of plant forms for food.

Indirectly, however, algal forms of Cranberry Pond are probably of the utmost importance in completing the food cycle of trout. Much work could be done along this line in establishing food chains by serial stomach analyses of certain invertebrates, and also of fry and fingerlings of the pond fish.

That the source of all available energy of animals is the green plant in whose cells complex foods are built up from inorganic compounds in sunlight by the aid of chlorophyll and with carbon dioxide is an established fact. More and more recent investigations show that the algal flora of a pond has its place in the biologic cycle and that without its presence animal life could not go on.

Certain fundamental facts bear out the above statement. Welch (1935) has expressed them thusly: -

1. The ultimate, basic substances are (a) inorganic nutritive materials dissolved in the water and (b) certain energies and gases from the atmosphere.

2. Only the chlorophyll-bearing plankters, the chlorophyll-bearing littoral flora, and certain bacteria can utilize directly these ultimate basic materials in constructing living matter.

3. All other organisms, plant or animal, rest as a dependent superstructure upon those mentioned in item 2.

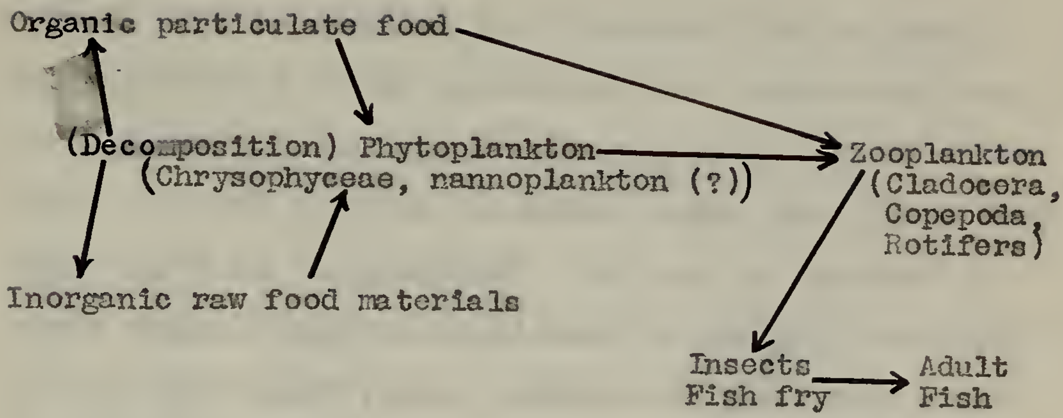
4. Every organism of a lake population may, (a) by death and disintegration, contribute directly to the dissolved materials and detritus, or (b) be consumed as food by other organisms.

In the open regions of Cranberry Pond the inorganic materials in the water must be taken in by plankton forms. Those species which have been listed as most abundant, and which as plants contain chlorophyll or allied substances, are represented by Synura, Dinobryon, and Uroglenopsis. These, then, must represent the majority of the all-important basic food synthesizers of the open water. As such, they are found to be prevalent in goodly numbers for the greater part of the year. They are minute forms and are found associated in their open water habitat with about equal numbers of the Cladocera and Copepoda. The only other important (in numbers) members of the plankton were the two rotifers Synchaeta and Notholca. It should be noted that throughout the whole collecting season large numbers of zooplankton went hand in hand with large numbers of phytoplankton, indicating that there may be a close dependence of the animal upon the plant form, a dependence that can only be proven by sufficient stomach analyses. It would not be too extreme to suggest, however, that the zooplankton for the most part feed upon the phytoplankton. The theoretical must, however, be backed with evidence.

Naumann (1921) (Welch-36), in studies on the food of Cladocera and Copepoda, found that practically all particulate matter - inorganic debris, organic debris, living organisms - is filtered from the water as it comes, without selection, and is passed into the digestive tract of the animal. In the case of the Cladocera, algae were present among the granular stomach contents - algal forms evidently varying as to the size of the particular Cladoceran species. The Copepoda, too, were found to have minute algae present at all times in their digestive tracts. It would seem, then, that in part at least, Crustacea feed upon phytoplankton forms.

The same author, in a survey of the stomach contents of various rotifers, among them Synchaeta and Notholca, reported the presence of numerous minute algae. In the case of these two, the algae would necessarily have to be smaller than the colonial forms mentioned, probably consisting of members of the not-too-well known (from Cranberry Pond) nannoplankton.

The probable food cycle that exists among the plankton is graphically shown in the following diagram:



Here it is seen that a strong link in the food chain is being taken by the phytoplankton which form most of the available food of the zooplankton. The members of this group, in turn, are the basic animal food forms of the higher aquatic forms for the insects and the vertebrate fish. The link with adult fish is apparent.

Of all the benthic algae the filamentous types are probably the only forms which have any real importance in pond control work.

According to Josephine Tilden (1935)(31) there are at least two important reasons why the growth of filamentous green algae in fish ponds should be encouraged. According to this investigator they are: -

"1. Algae, when in thriving condition, keep the water supersaturated with oxygen. Fish can not live in water in which there is a deficiency of oxygen.

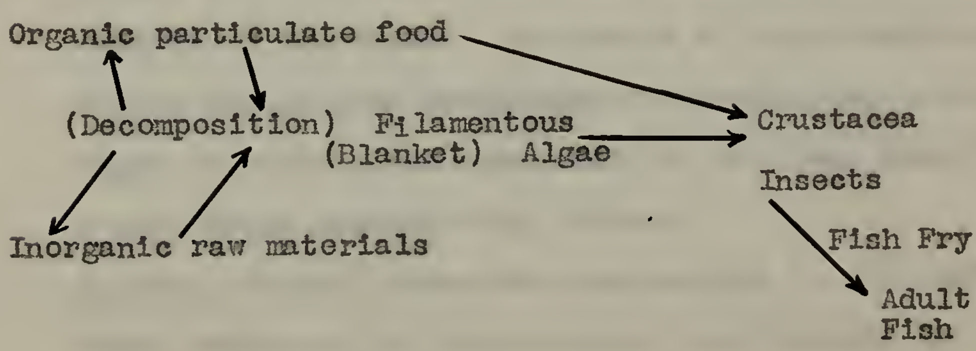
2. Masses of floating filamentous algae, sometimes termed "blanket algae" form the natural home of the minute animals upon which some fish species, or developmental stages of others, live. These minute organisms feed on and are protected by the algae so that they are able to reproduce abundantly and thus maintain the animal food supply".

It will be recalled that Cranberry Pond is small and sheltered from the prevailing winds which might tend to keep, by wave action, a well oxygenated body of water. There are also very few submerged higher plant forms which might serve as "oxygenators". The bulk of the work of plant oxygen formation would seem, therefore, to be left to the lower plant forms, particularly the fairly abundant filamentous algae.

It has been the custom in the past in the control of fish ponds to remove so called "mat-algae" or "blanket-algae", because of the idea that such types were useless and in fact obnoxious to the well being of the fish. That such practices are incorrect has been definitely shown by various algologists. In fact, such practices may even be harmful to the best fish productivity of a pond by upsetting the natural pond balance. Such "blanket algae" serve very definitely the functions stated under #2 above. Certainly anyone who has examined at all the filamentous algal forms of a pond will marvel at the amount of life teeming in its filaments. Such masses are natural breeding centers for many forms of crustaceans and insects, which ultimately become fish food. They also serve to protect fry from the ravages of their adult enemies. Undoubtedly the green algae are as much used as food by water insects as are our higher plants by terrestrial insects, so again we find algal species forming a valuable link in the food chain of fresh water pond life.

Miss Moore (1920)(16) in a study of some plants of importance in pond fish (bass) culture, indicates that algal mats of the Spirogyra or Mougeotia type are of utmost importance to close the link in the food cycle of fish. She points out that in order to insure an abundant and continuous supply of natural forage in ponds they must be correctly rationed - and such rationing can only be accomplished by a more precise knowledge of animal and plant associations. Her studies on the food demands of bass indicate the type of work that needs to be done. She finds that in the case of carnivorous young bass chironomid larvae are one of the most important single items of their dietary. Furthermore, the genus Mougeotia seems to be the staple food of the chironomids. This completes a Mougeotia - chironomid - bass food cycle. In Cranberry Pond waters chironomids abound - indeed at certain times so plentiful are they that the water surface is covered with the shed pupal skins of the emerged adult. The presence of Mougeotia has already been noted. A similar relationship of food may well exist at Cranberry Pond. Miss Moore has indicated that such relationships as have been set down by her are undoubtedly widespread in occurrence. Stomach analyses of Cranberry Pond trout show that they, like bass, feed on chironomid larvae.

Moreover, another animal food form is present in great numbers at Cranberry Pond, a member of the plankton, - cladocerans, representing several genera. Such forms have been long known to be the fresh water equivalents of the plankton crustacea of the sea, which form the strong link in the chain of foods of the marine fishes. Fry of all sorts of fresh water fishes feed on cladocerans, which in turn also feed upon algal fragments - particularly those forms that mat into "floating blankets". Cladocerans were at all times numerous in among masses of floating algae. Analyses of their stomachs should show fragments of filamentous forms, while the stomach contents of Cranberry Pond fry and fingerlings should consist largely of cladocera and chironomids. The members of such a plausible food chain are present and in sufficient abundance to balance good pond-fish numbers. This food cycle is the same except in the replacement of plankton algae by littoral forms: -



From the preceeding survey the writer hopes the importance of the relationship of the algal members of the pond with reference to the fish may be emphasized.

SUMMARY:

1. Recently enlarged Cranberry Pond exists as a body of water of questionable classification.
2. In its slightly acid nature, in its restricted number of plankton species, in its diversity of algal genera as compared with the number of species, in its representative dinoflagellates, and in its large proportion of planktonic rotifers, Cranberry Pond fits into the category of a bog lake.
3. Unlike bog lakes the Chlorophyceae do not dominate the phytoplankton; the Myxophyceae are not common; there is no preponderance of desmids; fish, sponges, nematodes and flatworms are present.
4. Its mixed condition indicates that an old bog lake is evidently being changed into a true pond.
5. Flooding, with subsequent progressive decay of submerged terrestrial plants, has increased the organic content of the water. The result of such increase is either the present dominance of Chrysophycean plankton algae or will be the appearance in the near future of a more truly typical algal bloom.
6. Marginal higher plants are represented by few species. Plant overgrowth of the original pond margins has been

raised by flooding to form floating mat islands formed chiefly by the two species, Chamaedaphne calyculata and Carex stricta. These two forms will undoubtedly be important as agents in any future filling in of the pond basin by plant growth.

7. The algal flora of the pond is not a rich one. The phytoplankton is dominated by great numbers of individuals representing few species, namely Dinobryon sertularia, Synura uvella, and Uroglenopsis americana. Thus the plankton flora can be classified as the Dinobryon type of Apstein. The benthos contains a number of species, but is not great quantitatively. Mougeotia, Spirogyra, and Hyalotheca are representative of the dominant filamentous type.
8. As direct and indirect sources of food, as "oxygenators" of a water lacking in higher submerged vascular plants, and as sources of harborage for fish fry, the algal plants are of utmost importance in the life of the fish of Cranberry Pond.

LIST OF ALGAL SPECIES FROM CRANBERRY POND
(With Ecological Notations)

Note: 1. All listed have been found as benthonic forms. The letter P after the name indicates that the particular species has been also collected from the plankton.

2. Relative abundance of a species is indicated by the following symbols in the progression from plants seldom found to those often found:
   - A - rare
   - A1 - scarce
   - A2 - Common
   - A3 - abundant
   - A4 - very abundant

3. This list follows the classification as given in Gilbert M.Smith's "THE FRESHWATER ALGAE OF THE UNITED STATES" (29)

CLASS MYXOPHYCEAE

ORDER CHROOCOCCALES

Chroococcus sp. A1, P
-mixed with other blue-greens in littoral debris.

Gleocapsa sp. A1
-in littoral debris

Microcystis incerta Lemm. A2, P
-free floating in littoral zone.

Merismopedia glauca (Ehr.) Näg. A1
-with desmids amongst other algae and debris.

Oscillatoria sp. (at least two species) A2, P
-forming felt-like mats on bottom at pond margins; also covering stones and submerged branches.

Lyngbya sp. A1, P
-forming stratum in littoral zone.

Anabaena sp. A1, P
-single filaments mixed in Chaetophora nodules, also in littoral debris.

Tolypothrix tenuis Kutz. A3
-envelops submerged Chamaedaphne twigs of mat islands; also forms stratum over submerged peaty masses.

Tolypothrix lanata (Desv.) Wartm. A3
-accompanies preceding species in mat formation.

Stigonema ocellatum (Dillw.) Thur. A1
-found amongst littoral algal mats and upon submerged twigs -etc.

LIST OF ALGAL SPECIES (Cont.)
-2-

Hapalosiphon hibernicus W. & G.S.West A1
-in littoral region; -often upon old Utricularia stems.

Rivularia dura Roth. A3, P
-found everywhere in littoral zone in gelatinous nodules upon submerged stones, stems, twigs, leaves, and stumps; associated with Chaetophora and Gleotrichia

Gleotrichia Pisum (Ag.) Thur. A3
-thalli firmly gelatinous and growing in similar locations with Chaetophora and Rivularia.

CLASS RHODOPHYCEAE

ORDER NEMALIONALES

Batrachospermum moniliforme Roth. A1
-found in close proximity to springs at station XIII (bottom) (collected by Miss C.E.Anderson '34)

CLASS CHRYSOPHYCEAE

ORDER CHRYSOMONADALES

Mallomonas sp. A, P
-found but once in a plankton haul from station VIII.

Synura uvella Ehr. A4, P
-with Dinobryon, most abundant plankton species at the pond - everywhere; a peculiar sausage-shaped form collected several times from littoral zone - from amongst dead leaves.

Uroglenopsis americana (Calkins) Lemm. A3, P
-essentially planktonic.

Donobryon sertularia Ehr. A4, P
-with Synura, the most abundant plankton species in the pond waters.

CLASS BACILLARIEAE

ORDER CENTRALES

Melosira undulata (Ehr.) Kutz. A1
-in littoral region of pond amidst filamentous algae.

LIST OF ALGAL SPECIES (Cont.)
-3-

ORDER PENNALES

Tabellaria flocculosa (Roth) Kutz. A1, P
-mixed with T.fenestrata; most prevalent from scrapings from Utricularia stems.

Tabellaria fenestrata (Lyngb.) Kutz. A3, P
-the most common diatom in the plankton and benthos; particularly prevalent as an epiphyte.

Tabellaria fenestrata (Lyngb.) Kutz. var. asterionelloides Grun. A, P
-several times recorded from both plankton and benthos.

Diatoma sp. A1, P
-intermixed with Tabellaria in similar situations.

Fragilaria virescens Ralfs. A2, P
-present especially amongst littoral detritus.

Fragilaria sp. A2, P
-different from last species but found in similar situations.

Synedra ulna (Nitzsch.) Ehr. A2, P
-another common genus universally distributed throughout pond.

Synedra ulna (Nitzsh.) Ehr. var. biceps (Kutz.) A2, P
-as with type species.

Synedra acus Kutz var. angustissima Grun. A1, P
-similar to above two species in distribution.

Asterionella formosa Hass. A, P
-a few specimens in plankton samples along with Tabellaria

Navicula sp. A2, P
-one of most common genera and probaably represented in the pond by a half dozen unidentified species.

Pinnularia nobilis Ehrb. A2
-amongst shore detritus

Pinnularia Maior Kutz. A2
-amongst shore detritus.

Stauroneis sp. A1 P
-amongst shore detritus

Brebissonia Palmeri Boyer A2, P
-amongst shore detritus.

Gomphonema acuminatum Ehr. var. coronata (Ehr.) W.Smith. A3, P
-the most common stalked diatom, on Utricularia, Oedogonium, twigs -etc.

Cymbella sp. A1
-amongst shore detritus.

Epithemia sp. A1
-amongst shore detritus.

Nitzschia sp. A1, P
-mostly free floating.

LIST OF ALGAL SPECIES (Cont.)
-4-

ORDER PENNALES (Cont.)

Odontidium sp. A
-amongst shore detritus

CLASS CHLOROPHYCEAE

ORDER VOLVOCALES

Chlamydomonas sp. A1, P
-free swimming unicells.

Gonium pectorale Muell. A1, P
-sparingly intermingled in some plankton samples.

Pandorina morum Bory A1, P
-similar to Gonium in numbers and distribution.

Eudorina elegans Ehr. A2, P
-the most common volvocalian form but never in great numbers.

Volvox globator L. A1, P
-as in the case of Gonium.

ORDER TETRASPORALES

Tetraspora gelatinosa (Vauch.) Desv. A2, P
-in the littoral zone mixed in with filamentous forms.

ORDER ULOTRICHALES

Ulothrix sp. A1
-in shallows - on soil - etc.

Stigeoclonium tenue (Ag.) Kutz. A1
-in littoral zone attached to debris - stones, etc.

Chaetophora incrassata (Huds.) Hazen A2
-in irregular laciniate gelatinous colonies attached to sticks, leaves, etc. in littoral zone.

Chaetophora elegans (Roth) Ag. A3
-in globose gelatinous masses associated with Rivularia and Gloeotrichia on same types of substrata.

Cladophora sp. A1
-attached to stones in littoral zone

Oedogonium sp. A2
-mixed with other filamentous forms and also covering stones; covered with all kinds of epiphytes.

LIST OF ALGAL SPECIES (Cont.)
-5-

ORDER ULOTRICHALES (Cont.)

Bulbochaete Brebissonii Kutz. A2
-affixed in the shallows to debris, etc.
Characium sessile Herm. A2
-growing as an epiphyte on other algae and also on higher plants.
Pediastrum Boryanum (Turp.) Menegh. A1, P
-free floating in plankton
Chlorella parasitica Brandt. A2
-symbiotic in the fresh water sponge, Heteromeyenia ryderi, and as common as it is.
Chlorella conductrix Brandt. A3, P
-symbiotic in the ciliate protozoan, Stentor pyriformis, one of the dominant plankton members.
Selenastrum sp. A, P
-noted but several times from the plankton
Kirchneriella sp. A, P
-similar in habit to Selenastrum
Scenedesmus bijugatus (Turp.) Kg. A1, P
-infrequently noted from plankton
Crucigenia rectangularis (Nag.) Gay. A, P
-infrequently noted from the plankton

ORDER ZYGNEMATALES

Mougeotia sp. A3, P
-commonly found mixed with other filamentous species especially Spirogyra to form large masses in the shallows;

Zygnema pectinatum (Vauch.) Agardh. A1, P
-filaments mixed in with those of Mougeotia and Spirogyra.
Spirogyra sp. A4, P (several species)
-one of the commonest of the filamentous algae; the several species undetermined due to lack of material bearing zygospores.
Gonatozygon aculeatum Hastings. A1, P
-free floating amongst littoral debris.
Spirotaenia condensata Breb. A1
-intermingled with other desmids amongst littoral debris.
Closterium toxon West. A2, P
-intermingled with other desmids amongst Utricularia whorls and littoral debris.
Closterium moniliferum (Bory) Ehrenb. A2, P
-intermingled with other desmids amongst Utricularia whorls and littoral debris.

LIST OF ALGAL SPECIES (Cont.)
-6-

Closterium Ehrenbergii Menegh. A2, P
-in situations similar to those of C.toxon
Closterium rostratum Ehrenb. A2, P
-in situztions similar to those of C.toxon
Closterium acerosum (Schrank) Ehrenb (?) A1, P
-in situations similar to those of C.toxon
Closterium abruptum West. (?) A1, P
-in situations similar to those of C.toxon
Penium sp. A2, P
-in situations similar to those of C.toxon
Pleurotaenium sp. A1
-in situations similar to those of C.toxon
Docidium baculum Breb. A2
-in situations similar to those of C.toxon
Euastrum sp. A2
-in situations similar to those of C.toxon
Cosmarium sp. A1
-in situations similar to those of C.toxon
Micrasterias apiculata (Ehrenb.) Menegh. A2, P
-in situations similar to those of C.toxon
Xanthidium antilopaeum (Breb.) Kutz. A2
-in situations similar to those of C.toxon
Staurastrum gracile Ralfs A2, P
-in situations similar to those of C.toxon
Hyalotheca dissiliens (Smith) Breb. A3, P
-one of the commonest filamentous forms; found in midsummer, draping submerged Chamaedaphne twigs.
Desmidium Aptogonum Breb. A2, P
-common in the plankton and benthos.
Gymnozyga moniliformis Ehr. A1, P
-chiefly from the littoral zone.

CLASS DINOPHYCEAE

SUBCLASS DINOFLAGELLATAE

Peridinium sp. A, P
-free swimming chiefly in plankton.
Ceratium hirundinella (O.F.M.) Schrank. A2, P
-chiefly planktonic and occuring sporadically in tremendous numbers, especially at station VIII

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